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WGEEL Country Reports 2017/2018

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

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.

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

1 Stock status summary

1.1 Stock status

1.1.1 EMP Progress Report summary table

Flanders

The stock indicators for Flanders have been estimated by Belpaire *et al.* (2018/ reporting period 2015–2017).

Flanders only:

2018	Area (ha)	Bo	Bbest	ΣF	ΣH	ΣA =ΣF+ΣH	Bcurrent =Bbest-ΣA	R	% actually escaping =Bcurrent/ B0
Flanders	19796	196,270	27,468	2,403	1,510	3,913	23,555	0	12,00%
	Area (ha)	Bo	Bbest	ΣF	ΣH	ΣA =ΣF+ΣH	Bcurrent =Bbest-ΣA	R	% actually escaping =Bcurrent/ B0
EMU Scheldt	18591	184,323	24,809	2,185	1,270	3,455	21,354	0	11,49%
EMU Meuse	1205	11,947	2,659	0,218	0,240	0,458	2,201	0	18,27%
				ΣF	ΣH	ΣA			
				Schelde	0,09	0,05	0,14		
				Maas	0,08	0,09	0,17		

Wallonia

No new assessment available.

Total stock indicators for Belgium as reported in the Tables required for the Eel Regulation.

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

Following table presents the data included in the Belgian Progress Report 2018.

EEL_TYP_ID	TYP_NAME	EEL_YEAR	EEL_VALUE	EEL_MISSVALUEQUA	EEL_EMU_NAMESHORT
B0_kg	Pristine spawning of silver eel B0 (kg)	2017	207 123		BE_Sche
B0_kg	Pristine spawning of silver eel B0 (kg)	2017	32 157		BE_Meus
Bbest_kg	Maximum potential biomass of silver eel (sumA=0) (kg)	2017	27 109		BE_Sche
Bbest_kg	Maximum potential biomass of silver eel (sumA=0) (kg)	2017	17 949		BE_Meus
Bcurrent_kg	Current biomass of silver eel (kg)	2017	23 429		BE_Sche
Bcurrent_kg	Current biomass of silver eel (kg)	2017	2331		BE_Meus

eel_typ_id	eel_year	eel_value	eel_missvaluequa	eel_emu_nameshort	eel_cou_code	eel_lfs_code	eel_hly_code	eel_area_division	eel_comment
SEE_com	2015–2017	0		BE_Sche	BE	S	AL		In Belgium there are no commercial fisheries on eel.
SEE_com	2015–2017	0		BE_Meus	BE	S	AL		In Belgium there are no commercial fisheries on eel.
SEE rec	2015–2017	2260		BE_Sche	BE	S	AL		There are no commercial fisheries on eel in Belgium. Recreational fisheries concerns only Flanders, in Wallonia there is a release obligation (2006–2016) or capture prohibition (2017) for eel. However, eel poaching was estimated in 2017 by multiplying the number of recreational fishermen in Wallonia by the proportion of controlled

eel_typ_id	eel_year	eel_value	eel_missvaluequa	eel_emu_nameshort	eel_cou_code	eel_lfs_code	eel_hly_code	eel_area_division	eel_comment
									anglers that illegally detained yellow and silver eels. This gave the annual number of anglers that detained illegally eels in Wallonia between 2007 and 2017. This number was then multiplied by the mean weight of illegally caught eels (0.5 kg/fisherman).
SEE rec	2015–2017	518		BE_Meus	BE	S	AL		There are no commercial fisheries on eel in Belgium. Recreational fisheries concerns only Flanders, in Wallonia there is a release obligation (2006–2016) or capture prohibition (2017) for eel. However, eel poaching was estimated in 2017 by multiplying the number of recreational fishermen in Wallonia by the proportion of controlled anglers that illegally detained yellow and silver eels. This gave the annual number of anglers that detained illegally eels in Wallonia between 2007 and 2017. This number was then multiplied by the mean

eel_typ_id	eel_year	eel_value	eel_missvaluequa	eel_emu_nameshort	eel_cou_code	eel_lfs_code	eel_hly_code	eel_area_division	eel_comment
SEE_hydro	2015– 2017	1420		BE_Sche	BE	S	AL		weight of illegally caught eels (0.5 kg/fisherman). SEE_hydro includes mortality from pumping stations and cooling water intakes. For the contribution of Flanders only pumping stations are taken into account since mortality from cooling water intakes and hydropower is not yet assessed because these factors will probably be insignificant. For the contribution of Wallonia mortality from hydropower and cooling water intakes is taken into account. For Wallonia the data from the previous report (data from the period 2011-2014, reported in 2015) are used because no recent data are available.
SEE_hydro	2015– 2017	15 100		BE_Meus	BE	S	AL		SEE_hydro includes mortality from pumping stations and cooling water intakes. For the contribution of Flanders only pumping stations

eel_typ_id	eel_year	eel_value	eel_missvaluequa	eel_emu_nameshort	eel_cou_code	eel_lfs_code	eel_hly_code	eel_area_division	eel_comment
									are taken into account since mortality from cooling water intakes and hydropower is not yet assessed because these factors will probably be insignificant. For the contribution of Wallonia mortality from hydropower and cooling water intakes is taken into account. For Wallonia the data from the previous report (data from the period 2011-2014, reported in 2015) are used because no recent data are available.
SEE_habitat	2015–2017	ND		BE_Sche	BE	S	AL		No data available
SEE_habitat	2015–2017	ND		BE_Meus	BE	S	AL		No data available
SEE_stocking	2015–2017	NP		BE_Sche	BE	S	AL		Restocking is effectively carried out in Belgium, but the effect is taken into account by the yellow eel surveys which are used to determine by model the silver eel escapement. The restocking with glass eels will after all contribute to the yellow eels stocks.

eel_typ_id	eel_year	eel_value	eel_missvaluequa	eel_emu_nameshort	eel_cou_code	eel_lfs_code	eel_h ty_code	eel_area_division	eel_comment
SEE_stocking	2015– 2017		NP	BE_Meus	BE	S	AL		Restocking is effectively carried out in Belgium, but the effect is taken into account by the yellow eel surveys which are used to determine by model the silver eel escapement. The restocking with glass eels will after all contribute to the yellow eels stocks.
SEE_other	2015– 2017		NP	BE_Sche	BE	S	AL		No data from 'other sources' known or relevant.
SEE_other	2015– 2017		NP	BE_Meus	BE	S	AL		No data from 'other sources' known or relevant

eel_typ_id	eel_year	Rate	eel_missvaluequa	eel_emu_nameshort	eel_cou_code	eel_lfs_code	eel_h ty_code	eel_area_division	eel_comment
SumF	2017	2260		BE_Sche	BE	S	AL		There are no commercial fisheries on eel in Belgium. Recreational fisheries concerns only Flanders, in Wallonia there is a release obligation (2006–2016) or capture prohibition (2017) for eel. However, eel poaching was estimated in 2017 by multiplying the number of recreational fishermen in

eel_typ_id	eel_year	Rate	eel_missvaluequa	eel_emu_nameshort	eel_cou_code	eel_lfs_code	eel_hly_code	eel_area_division	eel_comment
									Wallonia by the proportion of controlled anglers that illegally detained yellow and silver eels. This gave the annual number of anglers that detained illegally eels in Wallonia between 2007 and 2017. This number was then multiplied by the mean weight of illegally caught eels (0.5 kg/fisherman).
SumF	2017	518		BE_Meus	BE	S	AL		There are no commercial fisheries on eel in Belgium. Recreational fisheries concerns only Flanders, in Wallonia there is a release obligation (2006–2016) or capture prohibition (2017) for eel. However, eel poaching was estimated in 2017 by multiplying the number of recreational fishermen in Wallonia by the proportion of controlled anglers that illegally detained yellow and silver eels. This gave the annual number of anglers that detained illegally eels in Wallonia between 2007 and 2017. This number was then multiplied by the mean weight of illegally caught eels (0.5 kg/fisherman).
SumH	2017	1420		BE_Sche	BE	S	AL		SUM_H includes mortality from pumping stations and cooling water intakes. For the

eel_typ_id	eel_year	Rate	eel_missvaluequa	eel_emu_nameshort	eel_cou_code	eel_lfs_code	eel_hly_code	eel_area_division	eel_comment
									contribution of Flanders only pumping stations are taken into account since mortality from cooling water intakes and hydropower is not yet assessed because these factors will probably be insignificant. For the contribution of Wallonia mortality from hydropower and cooling water intakes is taken into account. For Wallonia the data from the previous report (data from the period 2011–2014, reported in 2015) are used because the estimated value is low (100 kg/year) and no new data are available.
SumH	2017	15 100		BE_Meus	BE	S	AL		SUM_H includes mortality from pumping stations and cooling water intakes. For the contribution of Flanders only pumping stations are taken into account since mortality from cooling water intakes and hydropower is not yet assessed because these factors will probably be insignificant. For the contribution of Wallonia mortality from hydropower and cooling water intakes is taken into account. For Wallonia the data from the

eel_typ_id	eel_year	Rate	eel_missvaluequa	eel_emu_nameshort	eel_cou_code	eel_lfs_code	eel_hly_code	eel_area_division	eel_comment
									previous report (data from the period 2011–2014, reported in 2015) are used because no recent data are available

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

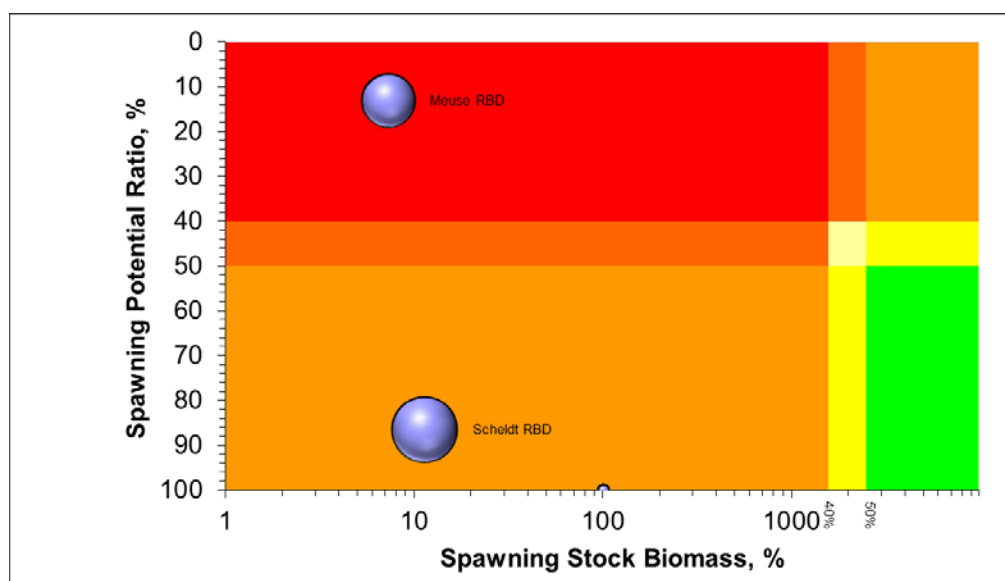
B_{best} = The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock (kg).

ΣF = mortality due to fishing, summed over the age groups in the stock (rate).

ΣH = anthropogenic mortality excluding the fishery, summed over the age groups in the stock (rate).

ΣA = all anthropogenic mortality summed over the age groups in the stock (rate).

1.2 Precautionary diagram



2 Overview of the stock and its management

2.1 Describe the eel stock and its management

2.1.1 EMUs, EMPs,

Four international RBDs are partly lying on Belgian territory: the Scheldt (Schelde/Escout), 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.

2.1.2 Management authorities

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 international 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/Escout 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.

2.1.3 Regulations

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.

2.1.4 Management actions

This section briefly lists actions related to management but also states some scientific or monitoring activities.

The Belgian EMP focuses on:

For the Flemish region

- making up an inventory of the bottle necks for upstream eel migration (priority and timing for solving migration barriers).

Specific action in 2014–2018

In Flanders, the network of watercourses allocated to first priority for the sanitation of fish migration barriers is about 800 km long, and includes 51 fish migration barriers, of which 90% (or 46 barriers) should be sanitized by December 31, 2015. These 46 barriers include 35 priority migratory barriers defined in the eel management plan. On December 31, 2016, a total of 22 of the 46 (48%) barriers of phase 1 were remediated. Of the 35 high priority barriers of the eel management plan, however, only 13 (37%) were sanitized (<https://www.inbo.be/nl/natuurindicator/>).

The update for 2017 is not yet available.

- for downward migration:

Specific action in 2014–2017

Several studies are ongoing to assess the impact of hydrostructures on Flemish water courses, including impact studies of pumps and turbines, and ship locks. Tagging studies have been realised or are in progress to better understand the migration behaviour of eels in the Scheldt system and the North Sea. We refer to the appropriate sections for more details (Sections 5 and 6).

The impact studies are believed to initiate adequate management measures which in the long term will be beneficial for eel and its migration possibilities.

- controlling poaching.

Specific action in 2017–2018

Actions to control illegal fishing activities on eels were continued.

In 2017, nine coordinated special actions for eel poaching took place. During seven actions, 26 illegal fykes were found and seized. 22 fines for eel poaching were issued.

In 2018 (until September) four coordinated special actions for eel poaching took place. Five fines for eel poaching were issued.

- Assessing the impact of the recreational fisheries in Flanders.

Specific action in 2016–2018

An amendment of the fisheries legislation will enter into force in Flanders on the 1st of January 2019. The use of fykes on the lower Scheldt River will be permanently prohibited. The bag limit for eels caught by anglers will be limited from five to three individuals.

An inquiry was organized in 2016 to assess the profile of recreational fishermen in Flanders including the assessment of their catch and yield (Agentschap voor Natuur en Bos, 2016). According to this inquiry, 7% of the anglers in Flanders fish mostly for eel: 6% fish with a regular rod with a line and a hook, and 1% practise bobber fishing (a rod and hookless line with a bunch of worms). Fishing for eel is mostly practised in the western part of Flanders. How much eel is taken home for consumption by Flemish anglers is discussed in part 3.1.2.2.

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

- Glass eel restocking programme.

Specific action in 2016–2018

In 2016, 385 kg of glass eel was stocked in Flanders. In 2017, the amounts of glass eel stocked was 225 kg. This year (2018) 280 kg were stocked in Flemish waters.

- Achieving WFD goals for water quality.

Specific action in 2010–2018

Flanders continues to work to the development of water treatment infrastructure to achieve the good ecological status and ecological potential for the WFD. A pilot program to monitor eel and perch quality with respect to their levels of contaminants for reporting to the WFD has been finalised (De Jonge *et al.*, 2014), and is now being implemented with new assessments (work in progress). Several reports have been issued with data on contaminants in perch and eel in Flanders (Teunen *et al.*, 2017; 2018). This work is to be continued in next years.

- Eel stock monitoring.

Specific action in 2016–2018

Glass eel: the monitoring of the glass eel recruitment at Nieuwpoort (River IJzer) has been continued in 2018, and will be continued in upcoming years. However, due to technical problems at the sluices, regular monitoring was not possible in 2016. Flanders is currently assessing the possibilities to develop a new permanent monitoring station at the Canal Veurne Ambacht making use of eel ladders in combination with a trap.

Yellow eel/silver eel: The eel monitoring on the River Scheldt estuary through fyke fishing has been continued. Since the 2017 report also midwater trawl fishing data gained from an anchored boat have been included in the report.

In the framework of the requirements of the Eel regulation, an assessment has been carried out to estimate the biomass of silver eel leaving Flanders.

- Eel quality monitoring.

Specific action in 2017

A review on the effects of contaminants and the role of pollution in the collapse of the eel stocks has been drafted (Belpaire *et al.*, 2016c).

Reports, within the requirements of the Water Framework Directive, have been issued with data on contaminants in perch and eel in Flanders in 2015 and 2016 (Teunen *et al.*, 2017; 2018).

- General status

The European eel is categorized as 'Critical Endangered' on the Red List of Fish in Flanders.

For the Walloon region

- Avoiding mortality at hydropower stations;

For a complete report of the situation until 2015, see Vlietinck and Rollin (2015).

An ambitious LIFE project "LIFE4FISH" was launched in 2018 for a period of 4.5 years (October 2017–March 2022) in the Belgian Lower Meuse between Namur and Lixhe, with a budget of 3.9 M€. Its main goal is to improve downstream migration to the sea of some important migratory fish, focusing on salmon smolt and silver eel. The project includes a characterization of populations and downstream migration routes along the Lower Meuse River, direct mortality rates evaluation of eels going through turbines as well as installation, implementation and monitoring of innovative solutions designed to facilitate passage through the hydropower facilities. The solutions consist of specific technologies (repulsive barriers and fish passes) and new hydropower control strategies accounting for the downstream migrating process.

- Sanitation of migration barriers on main waterways (especially in the Meuse catchment);

For a complete report of the situation until 2015, see Vlietinck and Rollin (2015).

In Wallonia, the total number of obstacles considered as "important", "major" or "impassable" for fish (in general) is about 3000 and the number of fish passes which were installed per year on the waterways identified as important for eel in Wallonia between 2007 and 2017 was of 146 (37 for the period 2015–2017).

- Eel stock monitoring.

Specific action in 2016–2017

Yellow eel: the monitoring of the eel recruitment at Lixhe (River Meuse) has been continued in 2018, and will be continued in upcoming years. See under the specific heading for results.

- Eel quality monitoring.

Specific action in 2017–2018

A study project co-financed by the European Maritime and Fisheries Fund and Wallonia was launched in 2017 for a period of three years (January 2017–December 2019, budget of 0.45 M€) in order to develop an attenuated recombinant eel Herpes virus vaccine. During this project, University of Liège and CER Group will check the sanitary

state of some French and UK-origin glass eels imported for restocking purposes in Wallonia.

- Glass eel restocking programme.

Specific action in 2018

250 kg of high-quality (0.5% mortality at reception) glass eel of French origin were restocked in 2018 mostly in the Meuse catchment (234 kg) and secondary in the Scheldt catchment (16 kg). See under the specific heading for detailed results.

- Controlling poaching.

Specific action in 2017

In Wallonia, since eel harvesting is prohibited since 2006, legal harvest is considered as null. However, poaching cannot be excluded and controls of fishermen are therefore organised. In 2017, the proportion of controlled anglers that illegally detained yellow and silver eels was small (0.2%). As well as the estimated biomass of illegally caught eels in Wallonia for 2017 (57 kg).

2.2 Significant changes since last report

Most significant changes are:

- Progress in the development of a glass eel monitoring station at Veurne Ambacht.
- Upcoming new fisheries legislation in Flanders (1st January 2019) with fully prohibition of the use of fykes on the river Scheldt and a moderate change in bag limit for eels caught by recreational fishermen.
- A new assessment of the silver eel biomass in Flanders (in line with the requirements of the Eel Regulation).
- A significant increase in glass eel stocking in Wallonia
- A number of papers (see Section 6) illustrate the significant progress in understanding the migration and colonisation behaviour of eel, both in Flanders and Wallonia.

3 Impacts on the stock

3.1 Fisheries

3.1.1 Glass eel fisheries

3.1.1.1 Commercial

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

3.1.1.2 Recreational

There are no recreational glass eel fisheries.

3.1.1.3 Proportion retained for restocking

Not relevant. No glass eel fisheries. In the pre-1980s the governmental glass eel fisheries/monitoring used their catches for restocking waterbodies over Belgium. Nowadays, with the current very low recruitment, the glass eel caught during monitoring surveys by the Flemish fisheries managers are released in the same river catchment.

3.1.1.4 Scientific monitoring

There is an ongoing monitoring of the glass eel recruitment at the mouth of River IJzer. See below in the Section 5.1 for details.

Development of a new permanent monitoring station to estimate glass eel recruitment in Flanders

Adjusted barrier management (ABM: limited 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 capacity was evaluated in spring 2016 (without applying ABM) and 2017 (with ABM) in the Veurne-Ambacht drainage canal connecting $\pm 20\,000$ ha polder area to the Yser estuary (Nieuwpoort). Glass eel migration was weekly monitored in both years (March–June) by means of two eel ladders installed on both sides of a pumping station located in the upstream part of the canal.

Even without applying ABM, glass eels were well able to actively colonize this canal (through gaps and cracks in the gate doors) as the catches in 2016 (23 677 ind.) demonstrated. In 2017 however, almost three times as many (66 963 ind.) glass eels were caught when applying ABM on a small scale (one out of eight sluice gates opened for 20 cm during flood tide). To further improve ABM at this site and in order to create a permanent solution for guiding glass eels around the pumping station, both eel ladders were extended with 5 m in spring 2018 by which means extra seawater (estimated at 21 600 m³) could be flushed in every flood tide compared to 2017. A similar monitoring program was executed to evaluate whether glass eels were still capable of climbing the extended eel ladders in high quantities. Moreover, two 24 hour experiments were conducted to reveal the diurnal patterns in glass eel climbing activity, each combined with a mark/recapture experiment (using rhodamine B stained glass eels) in order to estimate the efficiency of both eel ladders.

In total, 42 417 glass eels were captured with both eel ladders in 2018, about $\frac{1}{3}$ less than the previous year, but still double the amount compared to the 2016 season when no ABM was applied. The glass eels ascend the eel ladders almost exclusively at night, starting at maximal water level, about two hours after high tide in the estuary. About 55% of the colour-marked glass eels could be recaptured with the eel ladders within two weeks after release, indicating a high efficiency.

Both eel ladders will be used to guide glass eels around the pumping station into the polder area and a permanent monitoring program will be executed in the near future at this site, either by volunteers (catch and carry) or by a fully autonomous construction, depending on the amount of subsidies that can be applied.

3.1.2 Yellow eel fisheries

3.1.2.1 Commercial

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.

3.1.2.2 Recreational

Flanders

Only eel above the size limit of 30 cm are allowed to be taken home. In 2013 a new legislation on river fisheries went into force (Agentschap Natuur en Bos, 2013). The total number of fish (all species, including eel) which an angler is allowed to take with him on a fishing occasion is now limited to five. There is no indication to what extent this will have an impact on the total recreational biomass of eel retrieved by recreational fisheries.

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

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

An amendment of the fisheries legislation will enter into force in Flanders on the 1st of January 2019. Then, the total number of eels that an angler can keep in Flanders will be reduced from five to three. Within a few years a new inquiry will be held among anglers in order to determine if this measure has an impact on the total harvest of eel.

Professional coastal and sea fisheries

Marine eel catches through professional and coastal fisheries are negligible.

Estuarine fisheries on the Scheldt

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

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

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 and 63 545 in 2017. The time-series shows a general decreasing trend from 1983 (Figure 1), till 2006. However in 2007 there was again an increase in the number of Flemish anglers till 2014 when the number of anglers was 19% higher than in 2006. Since 2015 numbers are slightly decreasing again.

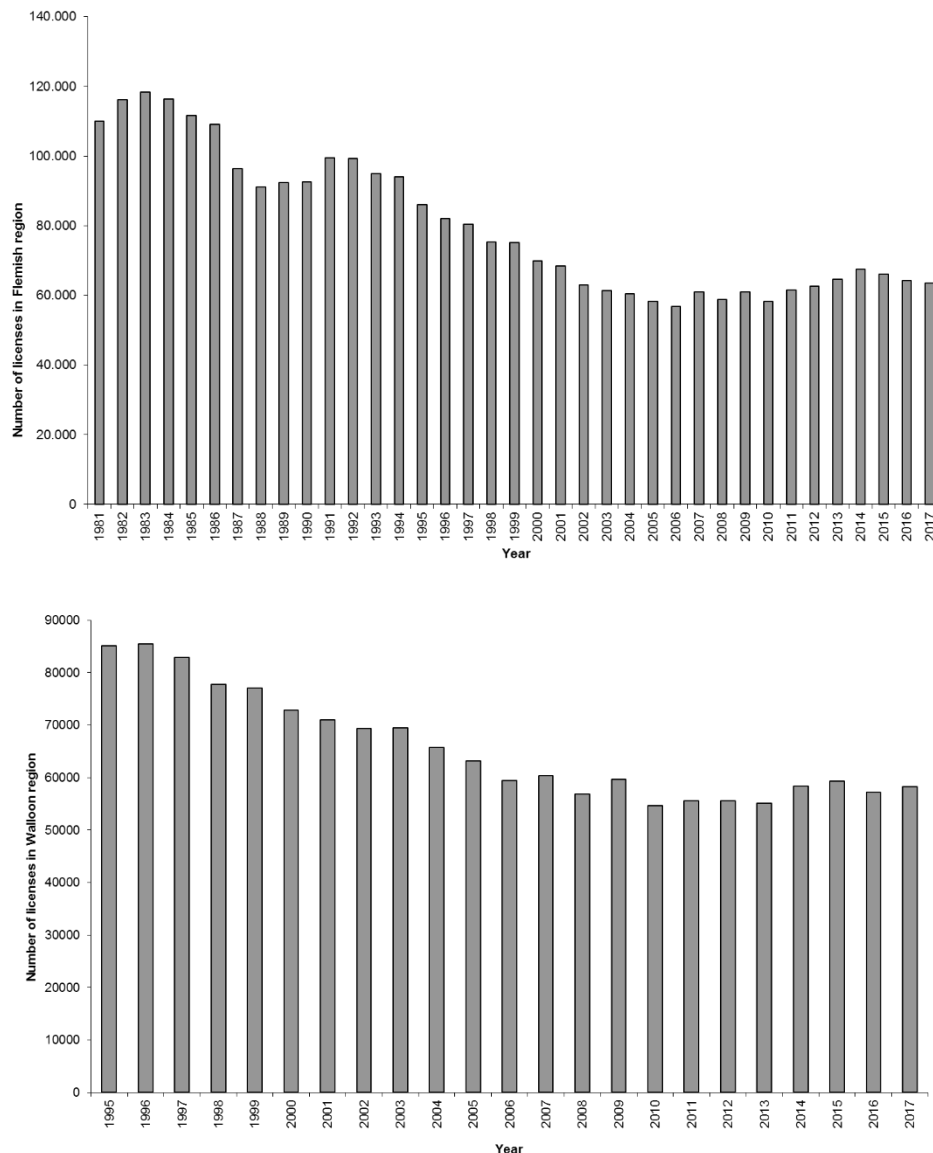


Figure 1. Time-series of the number of licensed anglers in Flanders (above) and Wallonia (below) since 1981 (Data Agency for Nature and Forests for Flanders and Nature and Fish Service of the Nature and Forests Department (DNF – DGARNE - SPW) for Wallonia.

Wallonia

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 pieces of illegal fishing equipment were seized. Regarding Fisheries Act Violation, the offence rate was of 7.5% during the day in 2017, but of 20.8% during the night of the same year. Offence rate is the ratio between the number of fishermen with a report (at least one offence (infraction)) and the total number of fishermen controlled, multiplied by 100. These values were stable compared to 2016. During the 2010–2016 period, the annual offence rate during the night decreased by about 5% per year and was highly correlated to control intensity (Rollin and Graeven, 2016).

Only a small minority of violations concerned eel poaching, mostly illegal eel detention and utilisation as live bait for silurid fishing. From 2017, the number and frequency of eel poaching is monitored in the annual “Plan Police Pêche”. Eel poaching was estimated in 2017 by multiplying the number of recreational fishermen in Wallonia (58 284 in 2017) by the proportion of controlled anglers that illegally detained yellow and silver eels (0.2%). This gave a rough estimation of the annual number of anglers that detained illegally eels in Wallonia in 2017 (114). 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), a rather negligible value.

Recreational fisheries in the Walloon Region

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 and 58 284 in 2017 (Figure 1). 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 2017 confirms this slight increase (+6.7% compared to the minimum in 2010). The proportion of eel fishermen in Wallonia is not documented, but is probably very small since it is forbidden to fish eels.

Brussels capital

Recreational fisheries in the Brussels capital

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

3.1.3 Silver eel fisheries

3.1.3.1 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.

3.1.3.2 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 Coussemont, 2000). So only glass eel is stocked from 2000 on (Figure 2). 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 2 and Table 1). In 2008 117 kg of glass eel from UK origin (rivers Parrett, Taw and Severn) was stocked in Flemish waterbodies. In 2009 152 kg of glass eel originating in France (Gironde) was stocked in Flanders. In 2010 (April 20th, 2010) 143 kg has been stocked in Flanders. The glass eel was originating in 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 in 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 in France.

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

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

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

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

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

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

The cost of the glass eel per kg (including transport but without taxes) is presented in Table 2.

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

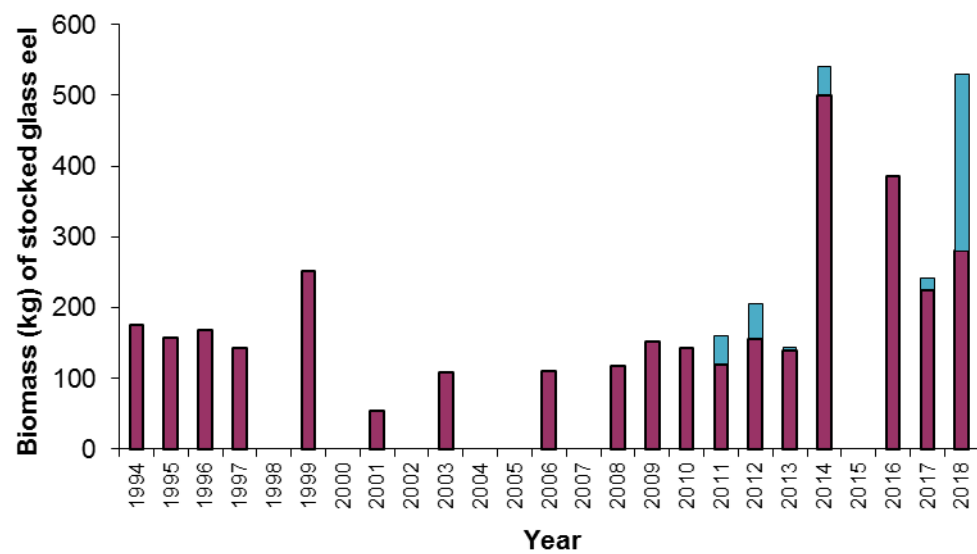


Figure 2 and Table 1. Restocking of glass eel in Belgium (Flanders and Wallonia) since 1994, in kg of glass eel. Flanders is represented in red and Wallonia in blue in the figure. * left Flanders/right Wallonia.

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

Table 2. Prices of restocked glass eel in Belgium (2008–2015).

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)

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 program was financed by European fisheries Fund (EFF, project code 32-1102-002) to test the efficiency of glass eel restocking in waterbodies of diverse typology. In May 2013, in total 4 kg of glass eel was stocked (1.5 kg in La Burdinale, 1.5 kg in River d'Oxhe and 1 kg in Mosbeux) (price per kg was 400 Euros). The origin of these glass eels was UK glass eels Ltd., 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 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=76 370) imported from a French company (Gurruchaga Maree, France) in six rivers (Hoegne, Wayai, Winamplanche, Berwinne, Gueule and Oxhe). Glass eels were released in 43 sites (Hoëgne: 3.9 kg 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 physico-chemically different. Preliminary assessments conducted six months after restocking in ten release sites (1–2 sites/river) revealed n = 323 individuals that were captured and pit-tagged. Density of young eel recruits varied between sites and was higher in more eutrophic site with bottom substratum 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 Meuse (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*, *Ichthyophthirius multifiliis*, *Anguillicola crassus*). Survival at reception was very good (maximum 0.5% mortality at stocking site).

Trend in restocking in Wallonia is presented in Figure 2 and Table 1.

More information on stocking details for Wallonia is presented in Table 2 and 3 (Cost of the glass eel, origin).

Table 3. Origin and amounts of glass eel restocked in Belgium (Flanders and Wallonia) between 2008 and 2018.

YEAR	REGION	ORIGIN	AMOUNT (KG)
2008	Flanders	UK	125
2009	Flanders	France	152
2010	Flanders	France	143
2011	Wallonia	UK	40
	Flanders	France	120
2012	Flanders	France	156
	Wallonia	France	50
2013	Flanders	France	140
	Wallonia	UK	4
2014	Flanders	France	500
	Wallonia*	France	40
2015	Flanders**	-	0
	Wallonia*	-	0
2016	Flanders	France	385
	Wallonia	-	0
2017	Flanders	France	225
	Wallonia	France	17.3
2018	Flanders	France	280
	Wallonia	France	250

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

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

3.3 Aquaculture

There is no aquaculture production of eel in Belgium.

3.4 Entrainment

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

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

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

risk. The obtained knowledge can contribute to efficient management such as improved fish passage and guidance solutions.

3.5 Habitat quantity and quality

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

3.6 Others

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

4 National stock assessment

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

We refer to these documents for detailed information

4.1 Description of method

4.1.1 Data collection

Flanders (Belpaire *et al.*, 2018):

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

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

Flanders recently started with monitoring the silver eel migration at one site (see also Section 5.3), which enables preliminary comparison of the two evaluation methods. A first analysis on a limited set of data from this test area (Polder Noordwatering Veurne) clearly shows the potential and added value of a combined approach with both model-based estimates and follow-up and quantification of direct monitoring of the silver eel. A SWOT analysis of both methods analysed the advantages and disadvantages and potentials of both methods. The silver eel production figures obtained by the two different methods confirmed each other, but the error margins in both calculations are very significant. However, this type of approach requires a specific plan-based approach with a statistically based experimental design. We recommend to further explore the comparison between the two methods through field experiments and a targeted pilot plan.

Wallonia

No new assessment available since the study of de Canet *et al.* (2014) in Vlietinck and Rollin (2015), except the estimation of caught eels related to poaching (see Section 3.1.2.2.).

4.1.2 Analysis

Flanders (Belpaire *et al.*, 2018)

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

Wallonia

No new assessment available.

4.1.3 Reporting

Flanders

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

Wallonia

No new assessment available.

4.1.4 Data quality issues and how they are being addressed

Flanders (Belpaire *et al.*, 2018)

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

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

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

Wallonia

No new assessment available. 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).

4.2 Assessment results

Flanders (Belpaire *et al.*, 2018)

The current figures for silver eel escapement estimated with the new calculation model based on the data collected between 2015 and 2017 are 11.5% for the EMU Scheldt and 18.3% for the EMU Maas. These are the same for the EMU Scheldt as those reported in 2015, but are significantly better for EMU Maas than the figures reported in 2015. Given the use of a new calculation model, no statement can be made about the evolution of the stocks. The improvement in EMU Maas is mainly due to the application of the new calculation model.

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

Wallonia

No new assessment available. The estimation of caught eels related to poaching (see 3.1.2.2.) seems negligible (57 kg in 2017) compared to other pressures of anthropogenic origin on yellow and silver eels populations in Wallonia.

5 Other data collection

5.1 Recruitment time-series

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).

Figure 3 and Table 4 give 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 2016.

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

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

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

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

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

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

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

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

to 2012, similar fishing effort (number of hauls), and similar year catches, but higher maximum day catch.

In **2014** fishing effort included 460 dipnet hauls over 23 fishing nights. The fishing was carried out between 24 February and 25 April. Total captured biomass of glass eel amounted 6717 g (or 17815 individuals). Maximum day catch was 770 g. So compared to 2013, same number of fishing nights, but 12% more hauls (increased fishing effort in number of hauls), and a 2.6 fold increase of the total year catches. Maximum day catch increased with 12% compared to the 2013 value.

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

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

In **2017** fishing effort was rather low compared to previous years, with 270 dipnet hauls over 18 fishing nights. The fishing was carried out between 10 February and 21 April. Total captured biomass of glass eel amounted 1697 g (or 4924 individuals). Maximum day catch was 607 g. So compared to 2014, 22% less fishing nights and 41% less hauls, and a decrease in total year catch of 75%. Compared to 2012, 2013 and 2015 total catch was reduced with ca. 32% in 2017, but considering the reduced fishing effort, the cpue (mean catch per haul) was 6.3 g per haul which is similar as in the period 2012–2016 (with the exception of 2014 where a significant higher cpue was recorded. Maximum day catch was within the range recorded in the 2012–2016 period.

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

in the period 2012–2017 (with the exception of 2014 where a significant higher cpue was recorded) (Figures 3A–D, and Table 4–5).

Table 4. Total year catches (kg) between 1964 and 2018. Data Provincial Fisheries Commission West-Vlaanderen. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes, nor for international stock assessment.

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

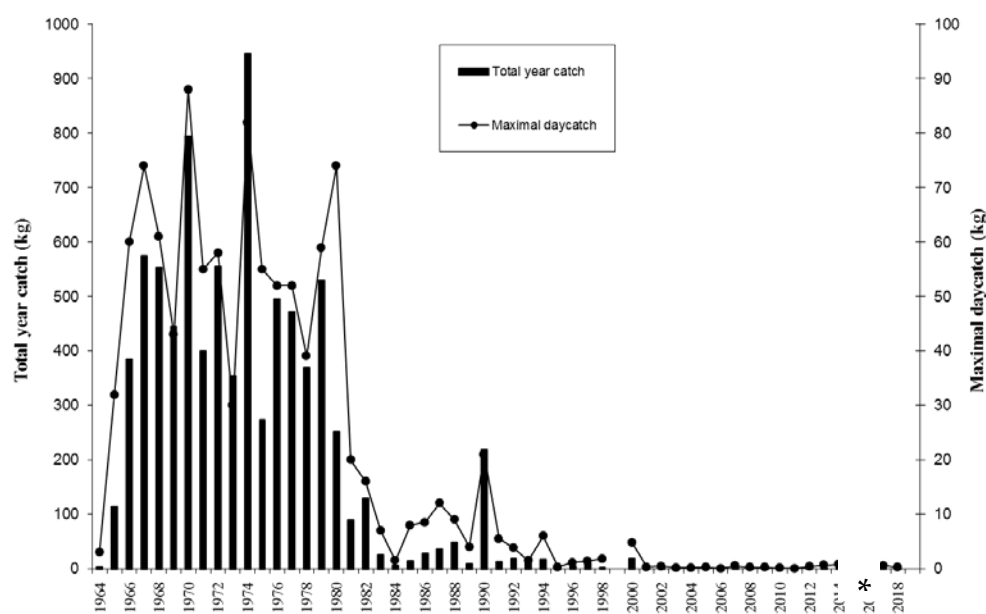


Figure 3A. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort (total year catches and maximum day catch per season), data for the period 1964–2018. * The data for 2016 are incomplete and not representative, due to technical problems at the sluices, and should not be used for statistical purposes, nor for international stock assessment.

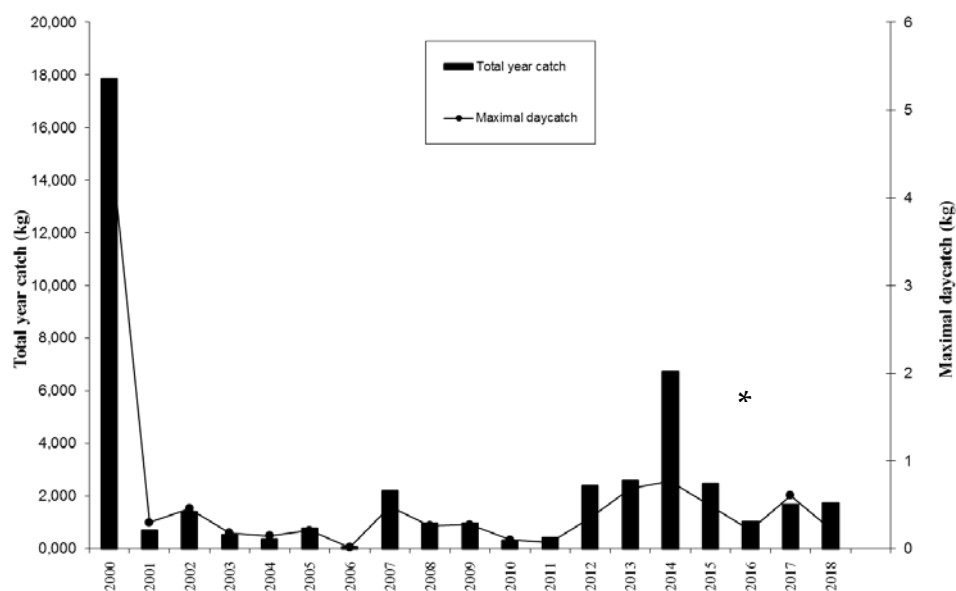


Figure 3B. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort (total year catches and maximum day catch per season), data for the period 2000–2018. * The data for 2016 are incomplete and not representative, due to technical problems at the sluices, and should not be used for statistical purposes, nor for international stock assessment.

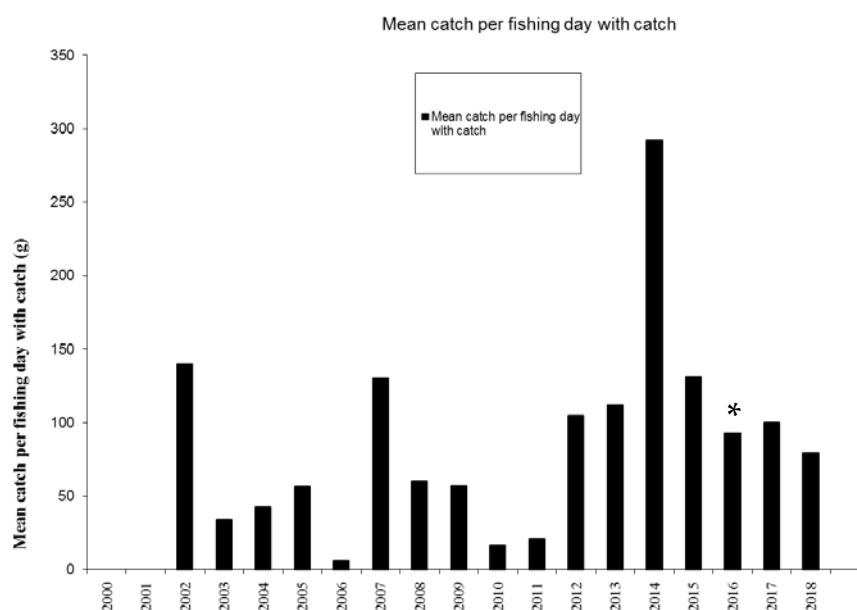


Figure 3C. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort) expressed as mean catches per fishing day with catch in g. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes, nor for international stock assessment.

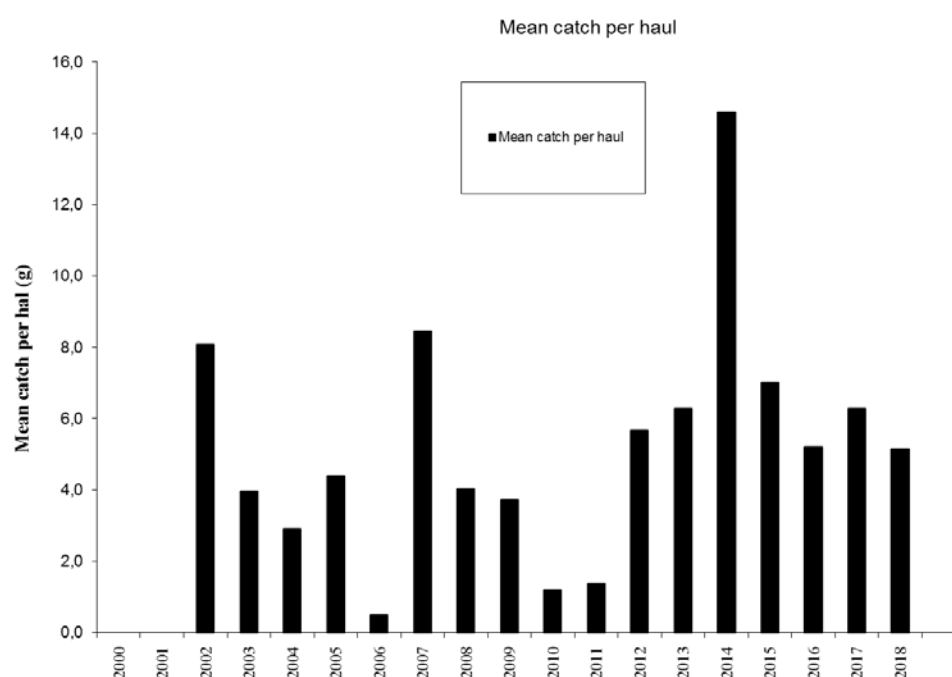


Figure 3D. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort), expressed as the mean catches per haul in g. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes, nor for international stock assessment.

Table 5. Temporal trend in catch per unit of effort for the governmental glass eel monitoring by dipnet hauls at the sluices in Nieuwpoort (River Yzer, 2002–2017). Cpue values are expressed as Kg glass eel caught per fishing day with catch and as Kg glass eel per haul. * The data for 2016 are incomplete and not representative, due to technical problems, and should not be used for statistical purposes, nor for international stock assessment.

YEAR	TOTAL YEAR CATCH	MAX DAYCATCH	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

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 2016 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 m³ 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 37415 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 4, Table 6). 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 to 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 smallest 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 up to 21 August, 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.

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 four-year study on the behaviour and life history of restocked eels during a four-year period will be soon published (Nzau Matondo *et al.*, 2018).

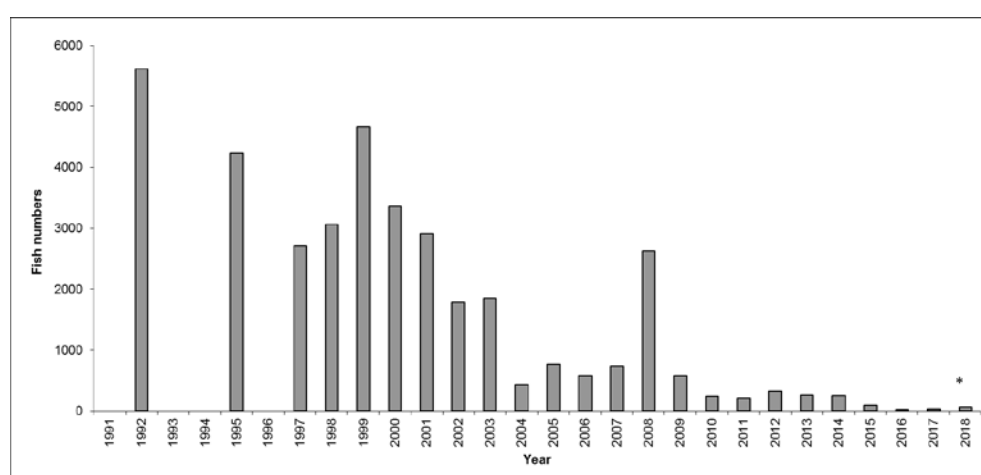


Figure 4. Variation in the number of ascending young yellow eels trapped at the fish trap of the Visé-Lixhe dam between 1992 and 2018. Data from University of Liège (Nzau Matondo *et al.*, 2015; Nzau Matondo and Ovidio, 2016). * Data for 2018 may be incomplete.

Table 6. Variation in the number of ascending young yellow eels trapped at the fish trap of the Visé-Lixhe dam between 1992 and 2018. 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 2018 may be incomplete.

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

5.2 Yellow eel abundance surveys

Trend analysis of eel catches in the Flemish Fish Monitoring Network

See 2016 country report (Belpaire *et al.*, 2016b) for a preliminary assessment of electro-fishing 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.

A new assessment has been performed in the framework of the 2018 progress report for the EU Eel Regulation (Belpaire *et al.*, 2018). The evaluation of the silver eel escapement is based on modelling the yellow eel abundance data. See Section 4 for more details.

Estuarine fish monitoring by fykes

A fish monitoring network by INBO has been put in place to monitor fish stock in the Scheldt estuary using paired fykenets (Figure 5). 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 below show the time-trend of eel catches in six locations along the Scheldt (Zandvliet, Antwerpen, Steendorp, Kastel, Appels and Overbeke) (Data Jan Breine, INBO; Breine and Van Thuyne, 2015).

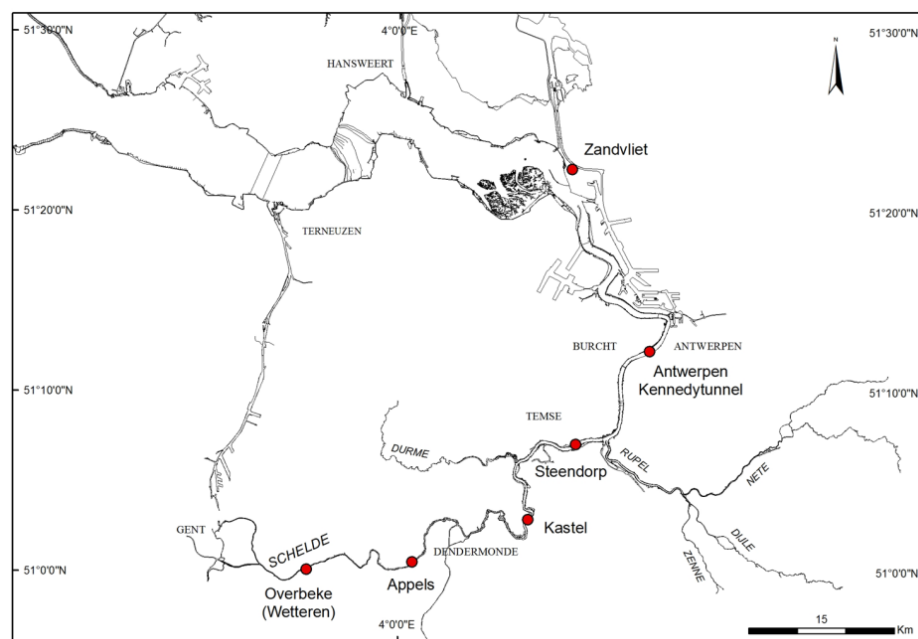


Figure 5. Locations sampled in the Zeeschelde estuary.

In the **mesohaline** zone (Zandvliet) catches are generally low. This could be due to the fact that eel moved since 2007 further upstream as since then the water quality improved in the oligohaline and freshwater parts of the estuary.

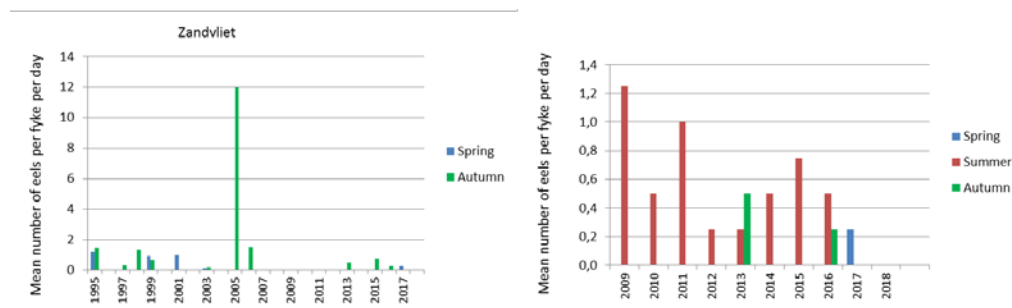


Figure 6. Time-trend of fyke catches of eel in Zandvliet. Numbers are expressed as mean number of eels per fyke per day. Left, data are split up in spring catches and fall catches (1995–2018) while right, summer catches are added (2009–2018). Years without monitoring data are excluded from the X-axis.

Eel is rarely caught in spring. Since 2009 eel is caught in small numbers during summer and once in autumn. The most recent data for Zandvliet are low compared to previous years (especially for summer data).

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 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.

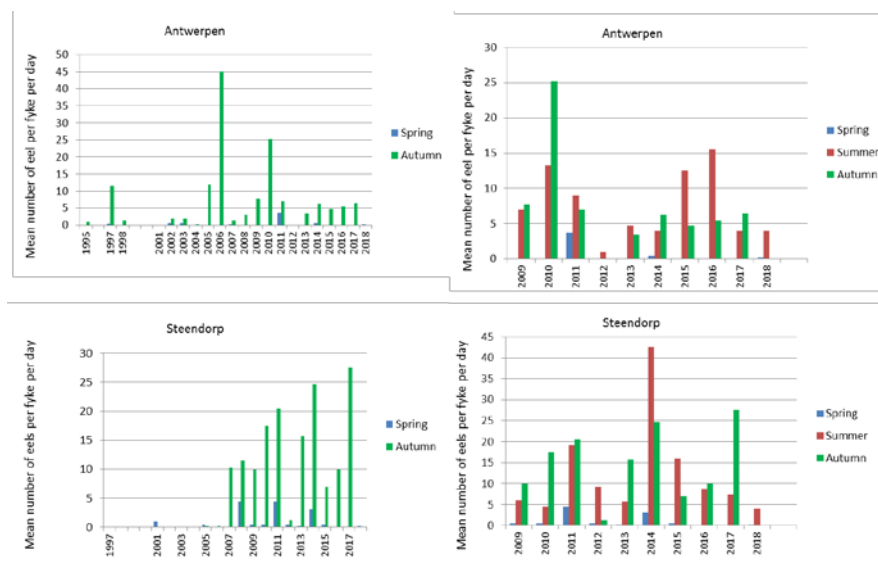


Figure 7. Time-trend of fyke catches of eel in Antwerpen and Steendorp. Numbers are expressed as mean number of eels per fyke per day. On the left, data are split up in spring catches and fall catches (1995–2018) while on the right, summer catches are added (2009–2018). Years without monitoring data 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.

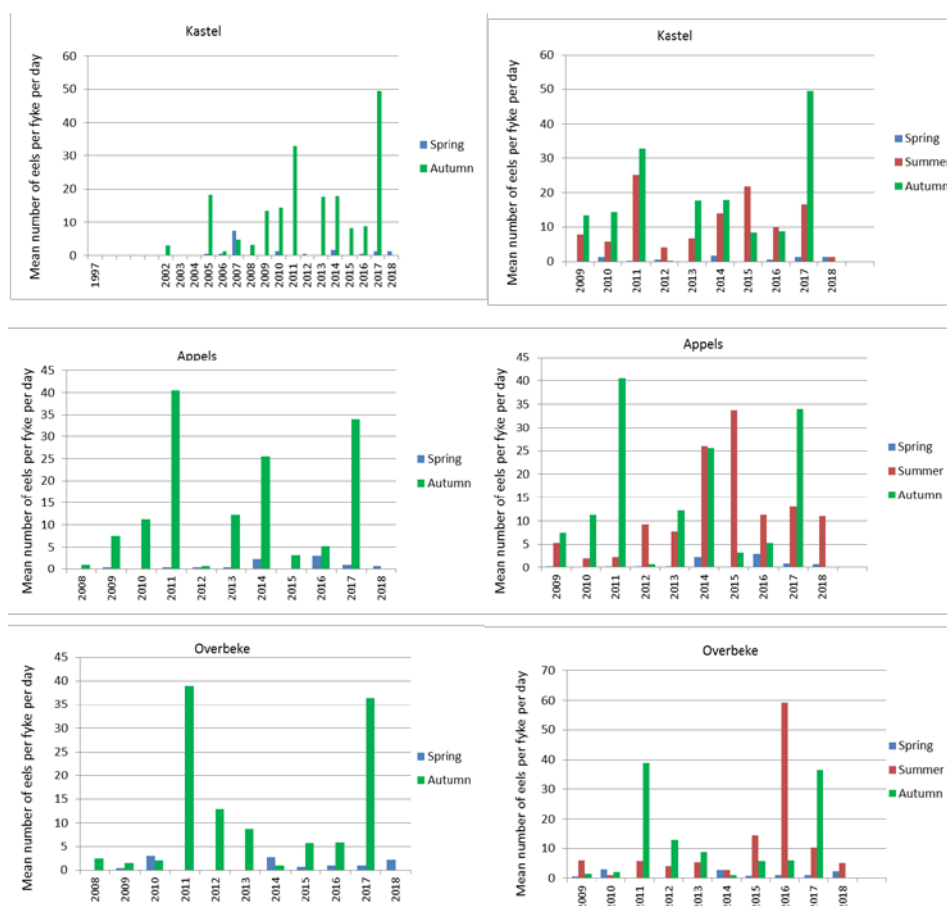


Figure 8. Time-trend of fyke catches of eel in Kastel, Appels and Overbeke. Numbers are expressed as mean number of eels per fyke per day. On the left, data are split up in spring catches and fall catches (1997 or 2008–2018) while on the right, summer catches are added (2009–2018). Years without monitoring data are excluded from the X-axis.

Compared to previous years the low summer catches at Overbeke and especially Kastel are notable, while the 2017 autumn catches are quite good in each of the three sites.

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 midwater beam trawl from an anchored boat, three times a year (Spring–Summer–Fall) at four sites (Doel, Antwerpen, Steendorp and Branst). Temporal data between 2012 and 2018 are shown in Figure 9. The data are expressed as number of eels per hour. The data show overall low densities for 2018, similar as for 2017.

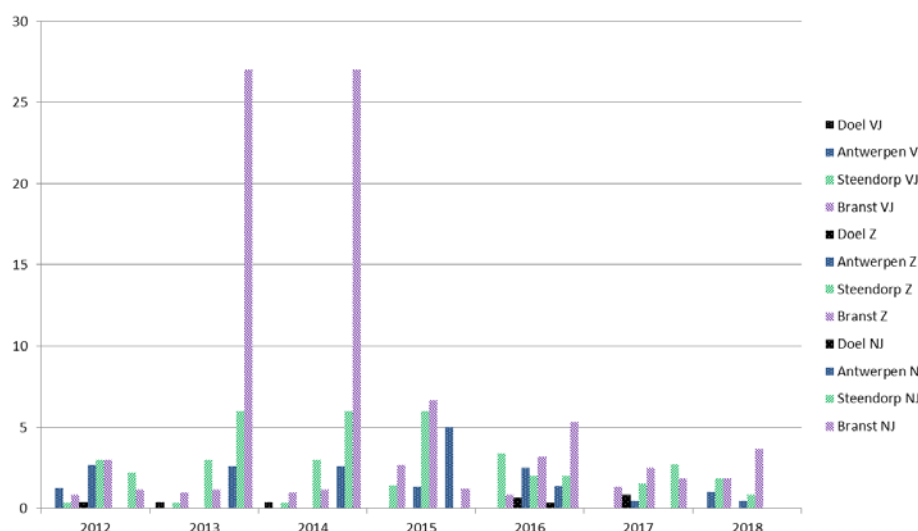


Figure 9. Time-trend of catches of eel in a midwater beam trawl from an anchored boat in Doel, Antwerpen, Steendorp and Branst along the Scheldt River. Numbers are expressed as mean number of eels per hour. Catch data of spring, summer and fall fishing is presented (except for 2018 including only spring and summer data). Data source Jan Breine, INBO, unpublished.

5.3 Silver eel escapement surveys

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

A research program by INBO, investigating possibilities for catching silver eels in autumn is running at the pumping station in the Veurne-Ambacht drainage canal in order to estimate silver eel escapement from the polder area. First tests with two fykenets placed in two out of four gravitary outflow canals in autumn 2016 appeared successful in capturing eels (146 within 24 hours: 143 silver eels, 20 males). Permanent monitoring between May–December 2017 with the use of both nets yielded 450 eels (440 silver eels, 10% males). The migration peak was situated between November 26th and December 7th, when 76% of the total eel catch was captured, obviously triggered by then occurring high discharges after a long dry period without water flow. Silver eel migration monitoring at the site will be repeated in autumn 2018, by screening all four gravitary outflow canals with fykenets. Effects of pumping activity on the silver eel migration and escapement will be investigated as well.

Silver eel tagging in the River Scheldt estuary

The European eel is a critically endangered fish species which migrates from coastal and freshwater habitats to the Sargasso Sea to spawn. However, exact migration routes and destination of European eel are still unknown.

To investigate the behaviour of silver eels in tidal rivers and estuaries, 30 eels were tagged in the River Scheldt estuary with acoustic transmitters in 2015 and in the three consecutive years, 30 eels will be tagged each year. The tagged fish can be detected by the permanent acoustic network in the Scheldt estuary and Belgian Part of the North Sea, funded by the LifeWatch ESRI observatory. Recently, acoustic tagged eels from Belgium, Germany and The Netherlands were detected in the Belgian part of the North Sea (Huisman *et al.*, 2016). As such, this is the first time to observe southward migrating silver eels in the North Sea. Therefore, at least part of the Western European eels mi-

grate towards the English Channel, in contrast to the Nordic migration route hypothesis. This different migratory route may affect the energy reserve available for spawning and therefore the contribution of these eels to the population. Results from this study might allow a better estimation of the quantification of the 40% silver eel escapement. Also, the results of this study will be useful for management measures for the conservation and restoration of the eel stocks.

In another study Verhelst *et al.* (2018) found strong evidence that silver European eels use selective tidal stream transport (STST) to efficiently migrate through strong tidal systems to complete their life cycle. The results illustrate that eels can distinguish between ebb and flood and suggest that tides play a role in orientation, either directly or indirectly (see chapter 6 for more details).

Silver eel tagging in the North Sea

The migration routes to the European eel's presumed spawning ground in the Sargasso Sea are still largely unknown. However, technological improvements related to telemetry allowed recent discoveries such as the tracking of silver eels from continental Europe till the Azores, the first evidence of European eels migrating through the Gibraltar Strait to leave the Mediterranean and the finding of both a Nordic and Southern migration route to exit the North Sea. The recent finding of the Southern migration route through the English Channel posed new questions related to bio-energetic efficiency. For instance, it is unknown if eels apply selective tidal stream transport or diel vertical migrations in the highly dynamic, shallow Channel. Consequently, migration speeds and the presumed arrival time at the spawning grounds for eels taking the Southern migration route are unknown as well. To cover these knowledge gaps, the Flanders Marine Institute, INBO and UGent will tag 100 silver eels with pop-up data storage tags this autumn as part of the Flemish contribution of the LifeWatch ESFRI observatory.

Silver eel tagging experiments in the Albert Canal (Flanders)

In Belgium, the Albert Canal connecting the Meuse River to the Scheldt Estuary, may offer migration opportunities for European eel.

In a recent study Verhelst *et al.* (2018) assessed the role of shipping canals in the migration of the eel. Only one third of 70 acoustically tagged silver eels completed migration through the Albert Canal, and did so at a very low pace (average $<0.06 \text{ m s}^{-1}$) due to delays at shipping locks and most likely also due to the disruption of water flow, which may impede successful migration.

The delay of eels at shipping locks has been further studied by Vergeynst *et al.* (submitted paper). During their downstream migration silver eels have to pass five intermediate-head navigation locks before reaching the estuary. The research of Verhelst *et al.* (2018), mentioned above, showed that silver eel escapement is largely unsuccessful and that eels are delayed extensively at the navigation lock complexes. To get a better understanding of the mechanisms behind these failures and delays, 62 silver eels were tagged and their movements were evaluated in a two-dimensional space by 2D-acoustic telemetry in an area of 4 hectares directly upstream of the shipping lock complex of Kwaadmechelen (Ham) on the Albert Canal. Evaluation of the 2D eel tracks give insight into the route choice of the eels and the mechanisms behind these choices. At the ship locks eels can pass through the locks, together with the ships, can pass through

the filling system of the locks or can pass through the hydropower plant, which is located on a channel by-passing the shipping locks. The study not only gives insight into the route choice, but also into the risks involved.

The risks involved in passing through the hydropower plant, are further investigated in detail in a parallel study on the impact of the Archimedes screws of the hydropower plant on four fish species, among which European eel (work in progress, submission planned for end of 2018). To evaluate the impact, mortality and injury of 900 European eel, 900 roach (*Rutilus rutilus*), 900 bream (*Abramis abramis*) and 900 rainbow trout (*Oncorhynchus mykiss*) was quantified after forced passage through the screws. Injury was defined as 'heavily injured' (cuttings, bruises, bleeding, swelling or scale loss >25%), 'slightly injured' (fin damage or scale loss <25%) or 'not injured'.

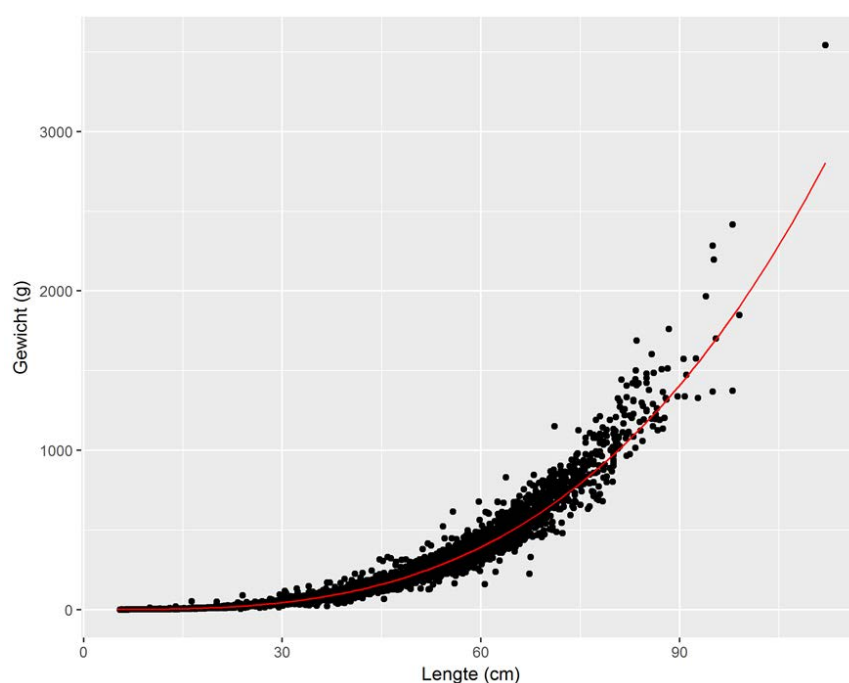
The results of these studies (see also Section 6), can support water managers to define adequate measures to improve eel migration in shipping canals and reduce the harmfulness of hydropower plants.

Assessment of the silver eel escapement in Flanders

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

5.4 Biological parameters

Belpaire *et al.* (2018) calculated the length–weight relationship in Flanders for 7093 eels captured through electrofishing and fyke fishing in Flanders in the period 2015–2017 (Figure 10).



$$W = 0,000987 L^{3,149} \text{ with } r^2 = 0,9825$$

Figure 10. Length–weight relationship in eel from Flanders (N= 7093 eels, electrofishing and fyke fishing, period 2015–2017, from Belpaire *et al.*, 2018).

5.5 Parasites and pathogens

We refer to the 2015 country report (Belpaire *et al.*, 2016a) for the latest information. No new information available.

5.6 Contaminants

Monitoring of eel pollution for the Water Framework Directive

Many aquatic ecosystems and waterbodies are under persistent stress of chemical pollutants, mainly of anthropogenic origin. High concentrations can harm entire ecosystems and be potentially toxic to humans. The European Water Framework Directive (WFD) defined quality standards that protect against detrimental effects of toxic compounds and obliges member states to monitor chemical compounds in surface waters. Generally, most of the target chemical compounds are able to be measured in water or sediment samples. However, the low water solubility of highly hydrophobic compounds precludes direct measurement in water. Accordingly, the WFD has formulated biota quality standards (biota EQS) for 11 priority compounds and their derivatives, in addition to the existing standards for surface waters. Depending on the compound, they have to be monitored in fish and/or bivalves (biota). Bioaccumulation of hexachlorobenzene (HCBz), hexachlorobutadiene (HCBd), mercury (Hg), polybrominated diphenyl ethers (PBDE), hexabromo-cyclododecane (HBCD), perfluorooctanesulphonate (PFOS) and its derivatives, dicofol, heptachlor and heptachlor epoxide, and dioxins and dioxin-like compounds were measured in muscle tissue of European perch (*Perca fluviatilis*) and European eel (*Anguilla anguilla*) originating in eleven different Flemish waterbodies. In addition, PCBs were measured in the muscle tissue of these fish. To date, no biota EQS is determined for PCBs.

Overall, higher concentrations per wet weight were detected in eel compared to perch. Nonetheless, after correction for lipid content, this trend was no longer present or even reversed with higher concentrations in perch muscle tissue, indicating the lipophilic properties of these compounds. This was true for all compounds – except for PFOS: in fact, this compound showed the exact opposite trend. Analysis of trophic level for perch and eel showed they can be considered top predators (TL often >3).

In general, the most important trends were in agreement with the results found in the campaign of 2015 (Teunen *et al.*, 2017). Accumulated muscle concentrations of Hg (Figure 11), PBDE, PFOS and probably (cis)-heptachlorepoxyde exceeded the biota EQS at almost every location. For HCBz, HCBd, HBCD and dicofol no exceedances were reported. Dioxins showed an exceedance in some sample locations (Teunen *et al.*, 2018).

See under Chapter 6 for more detailed information.

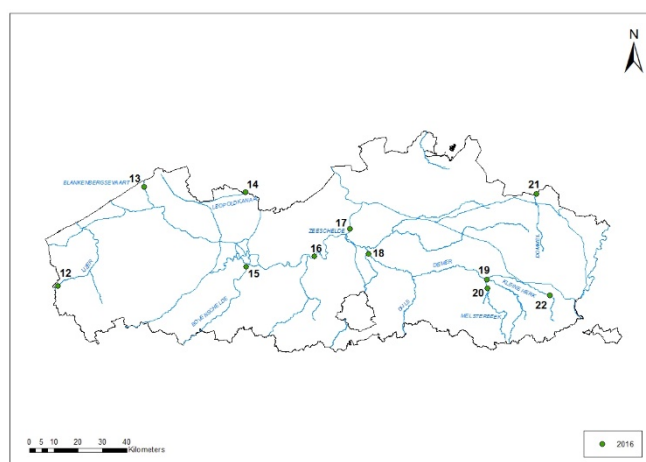
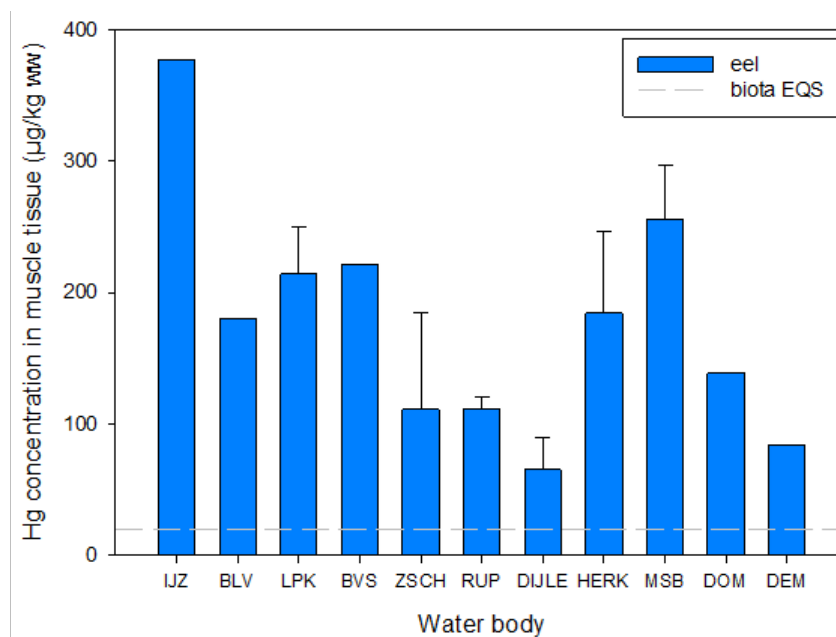


Figure 11. Mean Hg concentrations in muscle tissue of eel with standard deviation. IJZ: IJzer (12); BLV: Blankenbergse Vaart (13); LPK: Leopoldkanaal (14); BVS: Bovenschelde (15); ZSCH: Zeeschelde (16); RUP: Rupel (17); MSB: Melsterbeek (20); DOM: Dommel (21); DIJLE (18); HERK (19); DEM: Demer (22). Dashed line: Biota quality standard for Hg is 20 µg/kg wet weight. Numbers refer to sites on the map.

Pollutant accumulation is related to head dimorphism in eel

De Meyer *et al.* (2018) assessed the relation between pollutant accumulation and head dimorphism. At the yellow eel stage, the phenotypes are known to show a trophic divergence, with broad-headed eels consuming larger and harder prey, such as fish, while narrow-headed ones mainly feed on soft, small prey such as benthic invertebrates. The study confirmed that with increasing head width also the trophic position increased. Next, broad-headed eels contained higher concentrations of mercury and several lipophilic organic pollutants, compared to narrow-headed ones, irrespective of their fat content. This reveals that there is an important link between phenotypic disparity, its associated feeding ecology and the impact on pollutant accumulation in European eel. Results demonstrate that broad-headed eels are more vulnerable to

detrimental pollutant accumulation, which can compromise their successful contribution to the population's reproduction and its restoration. See also Chapter 6 for more details.

5.7 Predators

We refer to the 2015 country report (Belpaire *et al.*, 2016a) for the latest information. No new information available.

6 New information

This section briefly lists a number of recent papers or reports on eel research carried out in Belgium.

De Meyer, J.; Belpaire, C.; Boeckx, P.; Bervoets, L.; Covaci, A.; Malarvannan, G.; De Kegel, B.; Adriaens, D., 2018. Head shape disparity impacts pollutant accumulation in European eel. *Environmental Pollution* 240: 378–386.

Several aspects of the life cycle of the critically endangered European eel (*Anguilla anguilla*) remain poorly understood. One such aspect is the broad-vs. narrow-head dimorphism, and how this impacts their overall performance at different stages of their life cycle. At the yellow eel stage, the phenotypes are known to show a trophic divergence, with broad-headed eels consuming larger and harder prey, such as fish, while narrow-headed ones mainly feed on soft, small prey such as benthic invertebrates. In this study, 75 female yellow eels were analysed of which 26 were narrow-headed, 25 intermediate-headed and 24 broad-headed. Using a stable isotope analysis, we confirmed that with increasing head width also the trophic position increased. Next, it was investigated whether pollutant accumulation is affected by these observed differences in diet, linked to head shape. It was found that broad-headed eels contained higher concentrations of mercury and several lipophilic organic pollutants, compared to narrow-headed ones, irrespective of their fat content. This reveals that there is an important link between phenotypic disparity, its associated feeding ecology and the impact on pollutant accumulation in European eel. This raises further concerns about the eel's migratory and reproductive success. Considering that pollution is an important contributor to the European eel's decline, these results demonstrate that broad-headed eels are more vulnerable to detrimental pollutant accumulation, which can compromise their successful contribution to the population's reproduction and its restoration.

Nzau Matondo B. and 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>.

The upstream migratory behaviour of yellow-phase European eels was investigated in regulated inland rivers (>320 km upstream the sea), where the stock is in drastic decline. From 2010 to 2015, eels entering the Belgian Meuse River (n = 1357; total length, 231–755 mm) were caught in fish passes, tagged with a pit-tag and released. Their upstream movements were tracked during the next six consecutive years, using three detection stations installed in vertical-slot fish passes of the Meuse and its Ourthe tributary. Among the 1357 eels tagged, 27.6% (n = 374 individuals) were detected at one or more of the three upstream detection stations. Only 6.6% (n = 89) of tagged eels were detected at the two subsequent stations. In this last group, most of the detected eels continued to move upstream through the Meuse rather than leaving it for the Ourthe. Water temperature >13 °C, river flow 24–226m³/s, dark time 00:00–05:00 h and

the spring–summer seasons were the most important cues for upstream migration. Temperatures and flows at detection did not differ between size classes of ascending eels, while the detection period was earlier and daily speed was faster in large (>450 mm) eels. However, small (≤ 300 mm) eels moved further upstream at slow speeds because they alternated between short periods of movement and long stationary periods. This behaviour suggests the existence of a few nomad individuals and probably more home range dwellers in the entering population. Small eels were better suited to colonise upper rivers.

Nzau Matondo, B., J. P. Benitez, A. Dierckx, J. C. Philippart and 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.

Migration dynamics of incoming eels in Belgium via Lixhe in the Meuse River were investigated using two fish passes with different configurations net traps and automatic detection stations—as tools to distinguish resident and migrating eels. From April to September 2013, 435 eels (P50 length, 403 mm; range, 196–836 mm) were caught (daily maxima catch, 90 eels per day), 90% between 13 June and 1 August (50 days) and P50 on 19 July. Eels migrated mostly at 19–26°C (P50, 24.4°C), river discharge 65–314 m³ s⁻¹ (P50, 84 m³ s⁻¹), during the dark at 00:00–05:00 h and during both the waxing and waning phases of moonlight. From 396 eels tagged and released 0.3 km downstream of the Lixhe dam, 6.8% of them were recaptured, and 37.4% were detected. Migration flux was estimated at 7184 eels (0.863 t) using the mark–recapture method and decreased to 1156 eels (0.139 t) using automatic transponder detection. Most eels probably migrated through a sluice located downstream of Lixhe to reach the upper Meuse via the Albert Canal. Eels moved almost independently to the configuration of the fish passes and their location, but most eels displayed fidelity to the fish pass where they were captured. Migrant eels showed a wide range of size and life stages, with a larger proportion of eels (80%) belonging to the yellow eel stage. A smaller proportion of eels (6%) had a larger size and presented an advanced continental silvering process corresponding to the migrating stage before their transatlantic migration.

Van Wichelen J., Buysse D., Verschelde P., De Maerteleire N., Gelaude E., Robberechts K., Baeysens R., Pieters S., Pauwels I., Vermeersch S. and Coeck J. 2018. Opvolging van de palingstand in het Leopoldkanaal als evaluatie van het aangepast sluisbeheer in functie van een verbeterde glasaalmigratie (2014–2017). Rapporten van het Instituut voor Natuur- en Bosonderzoek 2018 (53). Instituut voor Natuur- en Bosonderzoek, Brussel. DOI: doi.org/10.21436/inbor.14216948 [in Dutch. “Follow-up of the eel status in the Leopold Canal as an evaluation of the adapted ship lock management in function of an improved glass eel migration”].

Since the 1980s, eel populations have dropped sharply in Europe and the European eel (*Anguilla anguilla* L.) is currently considered as ‘critically endangered’ according to the IUCN Red List of threatened species. The presence of many human-made barriers inhibiting the upstream migration of juvenile eels (glass eels and elvers) is considered one of the critical factors that put the whole eel population at risk. The tidal barriers at the Belgian ports and in the Scheldt river basin often form an impassable obstacle and hinder the colonization of rivers and other waterbodies by juvenile eels in Flanders. In the frame of the Belgian Eel Management Plan, adjusted tidal sluice management (ATSM) is implemented in order to enhance the eels’ upstream migration. During the glass eel season (March–April), tidal sluices at the Flemish ports are slightly opened during flood tide to allow seawater to flush into the upstream part of the rivers, thus enabling glass eels and other diadromous fish species to pass. The port of Zeebrügge acts as one of the main inland migration routes for glass eels. The route is however

blocked by a sluice complex regulating the drainage of two polder canals (Afleidingsskanaal van de Leie and Leopoldkanaal). Since 2014, ATSM is applied every spring in order to improve glass eel passage. In order to evaluate this mitigation measure, the eel density in the Leopoldkanaal is annually estimated based on a capture–mark–recapture method. For this purpose, fykes were placed in four sections of the canal in summer 2016 and 2017 and all trapped eels were subjected to a biometric analysis (length, weight, silver eel characteristics) and equipped with a PIT-tag. Compared to data that were collected the same way in 2014, the eel densities were slightly higher in 2016/2017. Differences were however not significant due to the large standard errors of the estimates. No clear increase in the proportion of undersized eel (<30 cm) was observed and eel density declined rapidly with distance to the sea indicating that the full capacity of the Leopoldkanaal is currently underemployed. On the other hand, the high growth rates observed for 28 individually tagged eels indicate that the Leopoldkanaal is a favourable growth habitat for eel. Given the time it takes for juvenile eels to grow to a more easily catchable size of 25–30 cm (3–4 years), the study period considered is currently too short to be able to draw better justified conclusions.

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.

Among the many man-made structures that facilitate shipping, navigable canals take an important position. These canals may offer energetically favourable migration routes for diadromous fish, but they may also obstruct fish migration, for instance at shipping locks. Because the use of shipping canals by, and their effects on, migrating fish remain unknown, we assessed whether these canals can play a significant role in the migration of the critically endangered European eel. Only one third of 70 acoustically tagged silver eels completed migration through a shipping canal, and did so at a very low pace (average <0.06 m s⁻¹) due to delays at shipping locks and most likely also due to the disruption of water flow. These delays may come at an energetic cost, hampering the chances of successful migration. Knowledge of the impact of shipping canals on diadromous fish is crucial to proper management regulations. For instance, the observation that eels mostly migrated at night and during spring and autumn can support water managers to define adequate measures to improve eel migration in shipping canals.

Teunen L., Belpaire C., Dardenne F., Blust R., Covaci A. en Bervoets L. 2018. Veldstudie naar de monitoring van biota in het kader van de rapportage van de chemische toestand voor de Kaderrichtlijn Water, 2016–2017. Universiteit Antwerpen (UA) in samenwerking met het Instituut voor Natuur- en Bosonderzoek (INBO), in opdracht van de Vlaamse Milieu-maatschappij (VMM). Antwerpen, België, 114 blz. [In Dutch. “Field study on the monitoring of biota in the context of reporting the chemical status for the Water Framework Directive, 2016–2017”]

Aquatic ecosystems and waterbodies are under persistent stress of chemical pollutants, mainly of anthropogenic origin. High concentrations can harm entire ecosystems and be potentially toxic to humans. The European Water Framework Directive (WFD) defined quality standards that protect against detrimental effects of toxic compounds and obliges member states to monitor chemical compounds in surface waters. Generally, most of the target chemical compounds are able to be measured in water or sediment samples. However, the low water solubility of highly hydrophobic compounds precludes direct measurement in water. Accordingly, the WFD has formulated biota quality standards (biota EQS) for 11 priority compounds and their derivatives, in addition to the existing standards for surface waters. Depending on the compound, they have

to be monitored in fish and/or bivalves (biota). In the present study, bioaccumulation of hexachlorobenzene (HCBz), hexachlorobutadiene (HCBd), mercury (Hg), polybrominated diphenyl ethers (PBDE), hexabromo-cyclododecane (HBCD), perfluoro-octaansulphonate (PFOS) and its derivatives, dicofol, heptachlor and heptachlor epoxide, and dioxins and dioxin-like compounds were measured in muscle tissue of perch (*Perca fluviatilis*) and European eel (*Anguilla anguilla*) originating in different Flemish waterbodies. In addition, PCBs were measured in the muscle tissue of these fish. To date, no biota EQS is determined for PCBs. Fluoranthene and benzo(a)pyrene were measured in zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena bugensis*), using active biomonitoring. In the present study 11 Flemish waterbodies were examined. In every sampling point at least one of both selected fish species could be collected. For fluoranthene an exceedance (max. factor 2) of the standard was observed in some sampling locations in zebra mussel. The highest concentration, 67 µg kg⁻¹ ww was found in the Herk. As for benzo(a)pyrene, there were some exceedances for both zebra and quagga mussel (max. factor 2). For both species the highest concentrations were measured in the Bovenschelde, respectively 9.5 and 6.5 µg kg⁻¹ ww. Dioxin concentrations exceeded the standard in the Zeeschelde, Rupel, Dijle and Herk in eel muscle tissue. The highest concentration of 0.0226 µg WHO-TEQ2005 kg⁻¹ ww was found in the Rupel. For PFOS, an exceedance of the standard (max. factor 14) was detected at almost every location for both fish species. The highest concentration for perch was measured in the Zeeschelde (43.1 µg kg⁻¹ ww), for eel in the Melsterbeek (132 µg kg⁻¹ ww). The biota quality standard for Hg and PBDE was exceeded in every sampling location and for both fish species, respectively with a factor 11 and 6700. As for mercury, the highest concentration in perch was measured in the Blankenbergse vaart, 144 µg kg⁻¹ ww. The eel pool with the highest mercury concentration was collected in the IJzer (232 µg kg⁻¹ ww). Both species accumulated the highest concentrations in the Bovenschelde, respectively 9.1 and 56.9 µg kg⁻¹ ww in perch and eel. One sample had PBDE concentrations below the quantification limit, which is more than ten times higher than the biota EQS. Concentrations of HCBd and dicofol were below the quantification limit. Furthermore no exceedances of the biota EQS were found for HCBz and HBCD. For heptachlor all measurements were below the quantification limits (40 times higher than the biota EQS), cis-heptachlor epoxide exceeded the quantification limit in all except one location in eel muscle tissue and in three locations in perch muscle tissue. The highest concentrations in perch was measured in the Demer, 0.6 µg kg⁻¹ ww, an exceedance of the biota EQS with factor 80. The highest concentration in eel was measured in the Melsterbeek, 16.1 µg kg⁻¹ ww, an exceedance with factor 2400. An overall trend of higher concentrations per wet weight in eel than in perch was detected. Nonetheless, after correction for lipid content, this trend was no longer present or even reversed with higher concentrations in perch muscle tissue, indicating the lipophilic properties of these compounds. This was true for all compounds – except for PFOS: in fact, this compound showed the exact opposite trend. Concentrations of PAHs were always higher in zebra mussel than in quagga mussel. This is possibly caused by the higher trophic position of the first, as indicated through isotopic analysis. Analysis of trophic level for perch and eel showed they can be considered top predators (TL often >3). Finally, calculated concentrations using the passive samplers, compared to existing literature, show promising applicability and incites further development of this tool.

In general, we can state that the most important trends we found in the campaign of 2015 are confirmed in the present study. For Hg, PBDE, PFOS and probably (cis)heptachlorepoxyde the biota EQS was exceeded at almost every location. For HCBz, HCBd,

HCBD and dicofol no exceedances were reported. PAHs and dioxins showed an exceedance in some sample locations (Teunen *et al.*, 2018).

De Meyer J, Herrel A, Belpaire C, Goemans G, Ide C, De Kegel B, Christiaens J, Adriaens D. 2018. Broader head, stronger bite: in vivo bite forces in European eel (*Anguilla anguilla*). *Journal of Fish Biology* (2018) 92, 268–273.

This work examined three different phenotypes of the yellow-eel stage of the European eel *Anguilla anguilla*, broad-heads, narrow-heads and eels with an intermediate head shape. The aim was to see whether broad-headed *A. anguilla*, which generally consume harder, larger prey, such as crustaceans and fish, exerted greater bite force than the narrow-headed variant, which mainly consume soft, small prey such as chironomid larvae. It was found that in 99 yellow *A. anguilla*, in vivo bite force of broad-heads are higher compared with narrow-heads and intermediates.

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. 2018. 260–268.

Different fish species use selective tidal stream transport (STST) to efficiently migrate through strong tidal systems to complete their life cycle, but the use of STST by silver European eels (*Anguilla anguilla* L.) is still controversial. In this study, we found strong evidence that silver European eels apply STST. The results illustrate that eels can distinguish between ebb and flood and suggest that tides play a role in orientation, either directly or indirectly. The general migration speed was higher in the downstream part of the estuary compared to the upstream part, while tidal migration speed was equal in both parts, indicating that eels migrated more consistently in the downstream part. The results of this study give insight in how a diadromous species migrates through an estuary and underline the importance of the tides.

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

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.

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Reporting Period: This report was completed in September 2018, and contains data up to 2017 and some provisional data for 2018.

1 Stock status summary

EMU_code	Assessed Area (ha)	B ₀ (kg)	B _{curr} (kg)	B _{best} (kg)	B _{curr} /B ₀ (%)	ΣF	ΣH	ΣA
Dk_inla	60.000	1.110.000	125.311	168.971	11.3	0.16	0.06	0.22

A = the sum of anthropogenic mortality equal 33.7 tonne. Predation from cormorants estimated 10 tonnes. Total mortality in freshwater is 43.7 tonne.

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 are treated together with community waters constituting 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 may use six fykenets or six hook lines but in a reduced period of the year. Fishing is closed from the 10th of May to 31 of July 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 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. Fishermen's licences are

provisionally issued until 31. 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.

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

3.1.2.1 Commercial

The commercial time-series on Yellow eel landing are shown below (see 3.3.1).

3.1.2.2 Recreational

Available information is reported below (see 3.3.2 recreational).

3.1.3 Silver eel fisheries

3.1.3.1 Silver eel landings

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 fishermen reported to the ministry. From mid-2009 landings are only reported from those having a licence to fish for eel.

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

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

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

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

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 and Storr-Paulsen, 2010).

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

Table 3.3.2.1. Recreational landings in tonne, based on interviews from people holding a recreational licence or are landowners.

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

3.2 Restocking

In 2018, a total of 1.091 million 2–5 gramme eels were stocked. In freshwater 0.98 million eel and in marine waters 0.13 million were stocked (Table 3.5.1 below).

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

Table 3.5.1. Restocking of elvers (2–5 g) in marine and freshwaters from 1987–2018. 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	2003	1.54	0.49	0.22	2.24
1988	0.11	0.24	0.4	0.75	2004	0.52	0.18	0.06	0.75
1989	0	0.24	0.17	0.42	2005	0.24	0.06	0	0.3
1990	2.46	0.49	0.51	3.47	2006	1.15	0.35	0.1	1.6
1991	2.3	0.44	0.32	3.06	2007	0.59	0.21	0.02	0.83
1992	2.94	0.81	0.11	3.86	2008	0.52	0.19	0.04	0.75
1993	2.97	0.76	0.23	3.96	2009	0.55	0.20	0.05	0.81
1994	6.12	0.61	0.67	7.4	2010	0.30	0.57	0.67	1.55
1995	6.83	0.72	0.9	8.44	2011	0.20	0.77	0.59	1.56
1996	3.58	0.58	0.44	4.6	2012	0.25	0.64	0.64	1.53
1997	2.02	0.29	0.22	2.53	2013	0.25	0.66	0.61	1.52
1998	2.35	0.53	0.1	2.98	2014	0.26	0.71	0.63	1.60
1999	3.38	0.56	0.18	4.12	2015	0.13	0.79	0.61	1.53
2000	3.02	0.55	0.25	3.83	2016	0.13	0.69	0.71	1.53
2001	1.2	0.38	0.12	1.7	2017	0.13	0.69	0.71	1.52
2002	1.66	0.47	0.3	2.43	2018	0.13	0.67	0.31	1.11

3.3 Aquaculture

Aquaculture production of eel in Denmark started in 1984. At present in 2017 the production takes place at three indoor, heated aquaculture systems, Table. 3.3.1.

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

Table 3.3.1. Annual aquaculture eel production.

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

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

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

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

of eel from the farm the same year. The retention time of eel in the farm differs by eel stage, e.g. eel for stocking is 3–12 month and eel for consumption is 18 months 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, Harte).

We have measured a loss of 0 and 60 % at two particular hydropower plant. At Tange Hydropower plant there is a significant bypass problem for eels, we have measured a loss of at least 60 % (Pedersen *et al.*, 2011). At Vestbirk hydropower the fish bypass ($1/4$ of the water discharge) in combination with 10 mm screens works well and the loss is close to zero. (Pedersen and Jepsen, 2012).

We have no data for other hydropower 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 Matstrup Å. The conclusion from these studies was that delay of eel migration due to low discharge was observed in some years, and the eels by pass the screens that were supposed to prevent eels and other species to enter the trout farm.

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

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

The conclusion from these studies is that migrating silver eels is likely to have migration delay at weirs, which may depend on the hydrological conditions (water discharge) at some weirs and at other the screens may be incorrect mounted, causing eels to be trapped at the trout farm. No mortality was observed but delay at weirs is likely to cause greater 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 since 2006 (see above) on quantity and quality are available.

It is assumed that about 10 tonnes of eel will die in connection with these weirs throughout the Danish fresh and coastal territory!

3.6 Others

Nothing to report.

4 National stock assessment

4.1 Description of Method

4.1.1 Data collection

- 1) Commercial fishermen are obliged to report through logbooks to the ministry of fisheries about their landings in kg separately for yellow and for silver eel.
- 2) Recreational fisheries catch are collected through yearly interview surveys. Currently a project RECREA is aiming to evaluate the actual catch by counting fykenets and collecting data on effort on site in selected areas. A project description is given in chapter 6.
- 3) Recruitment data are monitored in freshwater using eel pass traps and electrofishing.
- 4) Silver eel escapements from all 887 Danish river systems are surveyed using three index river systems. Two river systems with a silver eel trap and one river system with a commercial fisherman (Ribe Å).

Analysis

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

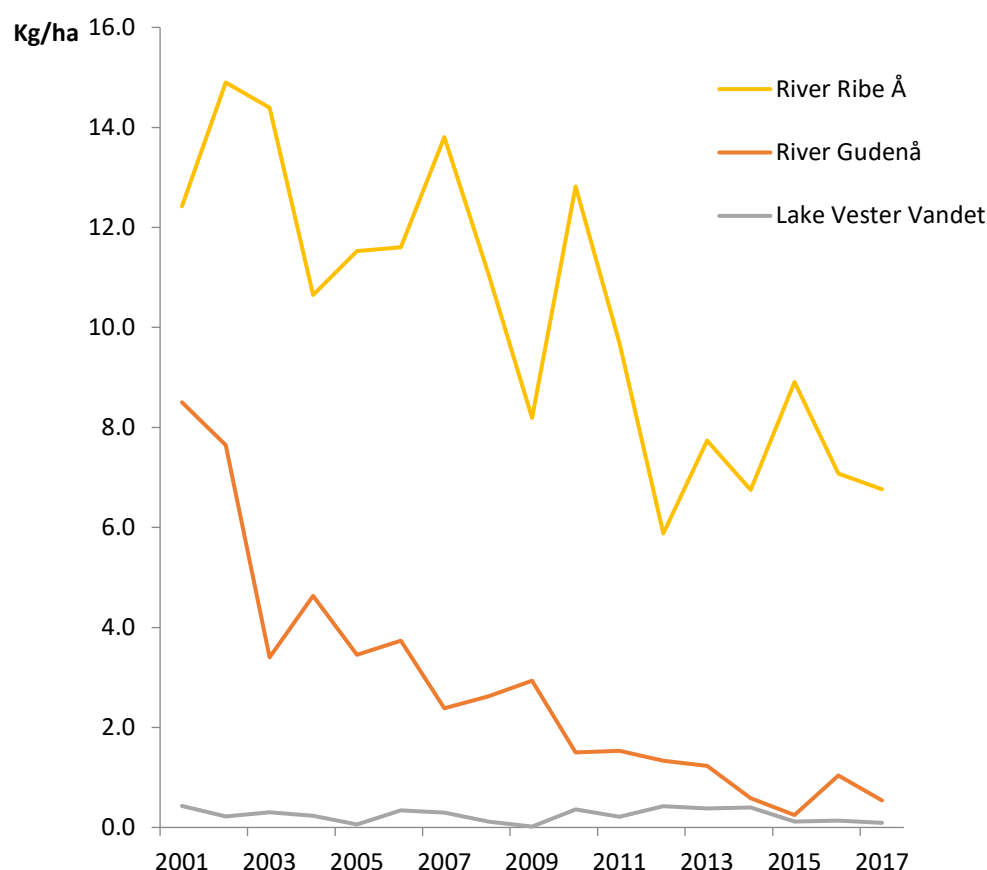
4.1.2 Reporting

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

4.2 Assessment results

Stock indicators

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



5 Other data collection

5.1 Recruitment time-series

5.1.1 Yellow eel recruitment

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

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

At **Harte Hydropower Station** the condition for monitoring recruitment at the eel ladder trap has changed. As part of a river restoration project in River Kolding Å, the water supply to Harte Hydropower station has been reduced by 60% since spring/summer 2008. The effect of lower water supply at the trapping site is a decrease in recruitment to the trapping site reflected in the data. This is the second time a major change to the eel monitoring in River Kolding Å has taken place since monitoring started in 1967. The first change was in 1991 where a trapping facility was terminated at the Stubdrup Weir. At that time a bypass stream was made at the Stubdrup Weir allowing eels to bypass the weir without being trapped. This change is also reflected in the recruitment data (Table 5.1.1).

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 trap has not been in operation in 2015–2017 and no data are available during this period.

Table 5.1.1. Recruitment data from Tange and Harte Hydropower Stations and Vester Vedsted brook. Mean density during the year and maximum density at any electrofishing occasion.

YEAR	TANGE	HARTE	VESTER VEDSTED BROOK		YEAR	TANGE	HARTE	VESTER VEDSTED BROOK		YEAR	TANGE	HARTE	VESTER VEDSTED BROOK	
			DENSITY EEL/M ²					DENSITY EEL/M ²					DENSITY EEL/M ²	
Year	Kg	Kg	Mean	Max (season)	Year	Kg	Kg	Mean	Max (season)	Year	Kg	Kg	Mean	Max (season)
1967		500	-	-	1985	315	446	-	-	2002	278	17	0.5	0.6
1968		200	-	-	1986	676	260	-	-	2003	260	9	0.6	0.7
1969		175	-	-	1987	145	105	-	-	2004	246	9	0.3	0.4
1970		235	-	-	1988	252	253	-	-	2005	88	7	0.5	0.5
1971		59	-	-	1989	354	145	-	-	2006	123	7	0.3	0.7
1973		117	-	-	1990	367	101	-	-	2007	62	7	0.4	0.5
1974		212	-	-	1991	434	44	-	-	2008	131	0.9	0.2	0.2
1975		325	-	-	1992	53	40	-	-	2009	20	1.3	0.2	0.2
1976		91	-	-	1993	93	26	-	-	2010	14	5	0.2	0.4
1977		386	-	-	1994	312	35	-	-	2011	84.6	3.6	0.3	0.3
1978		334	-	-	1995	83	23	2.6	2.6	2012	-	4.1	0.1	0.2
1979		291	2.8	6.5	1996	56	6	4.6	6.8	2013	47	1.4	0.1	0.2
1980	93	522	7	13	1997	390	9	0.7	1	2014	36	3.0	0.1	0.1
1981	187	279	7.8	13	1998	29	18	0.3	0.4	2015	ND	1.3	0.2	0.2
1982	257	239	-	-	1999	346	15	0.4	0.5	2016	ND	2.4	0.3	0.3
1983	146	164	-	-	2000	88	18	0.6	0.7	2017	ND	0.9	0.14	0.3
1984	84	172	-	-	2001	239	11	0.6	0.8	2018	NA	NA	0.47	0.59

5.1.2 Glass eel recruitment

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

Since 2008 three small brooks situated on the North Sea coast of Jutland were selected for monitoring. At each brook two stations of ca. 20 m length (close to the shoreline <1000 m) are electrofished at three different times from May to August and the population of eels at each station is calculated using the depletion 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.

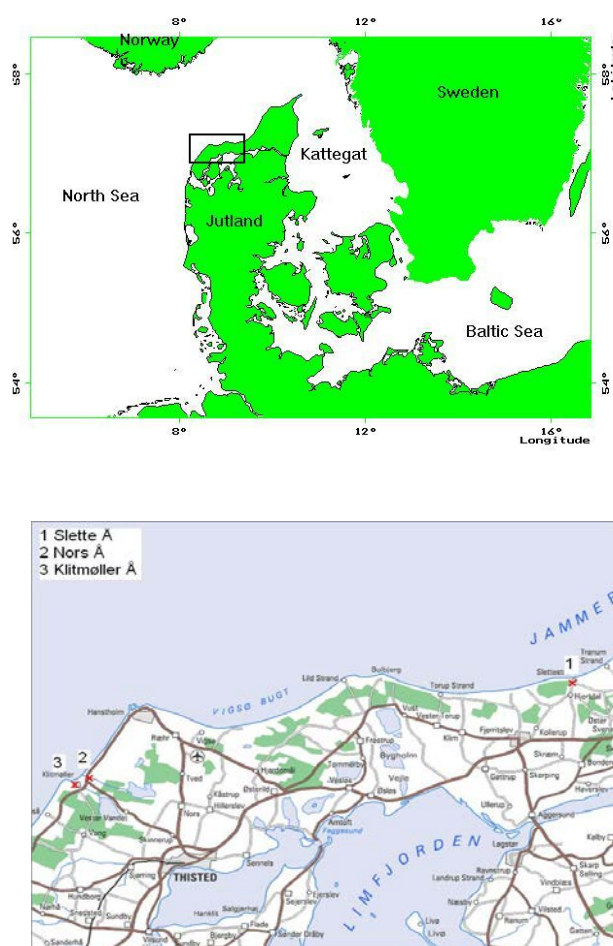
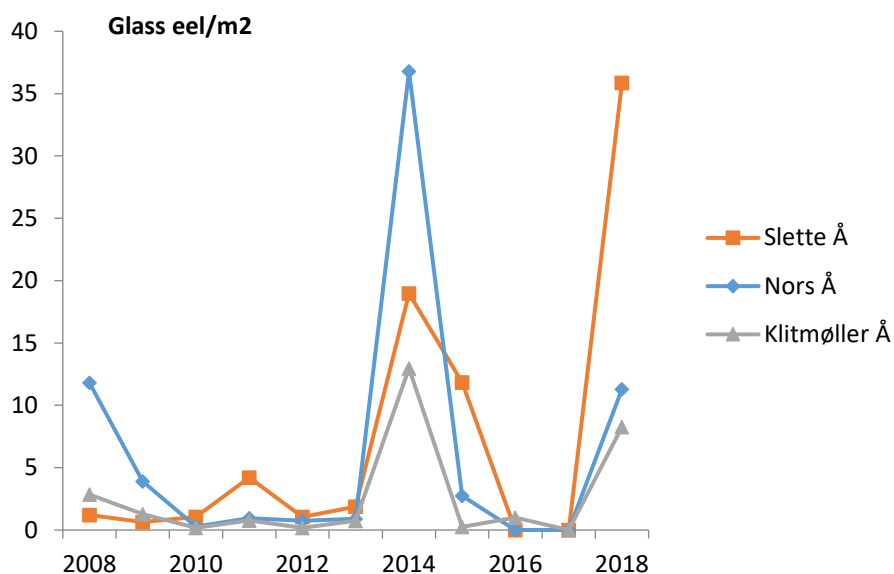


Figure 9.1. Map with new glass eel monitoring sites (1, 2 and 3) in the North Sea.

Table 9.1. Density of newly arrived glass eel pigmented glass eel (eel/m²) as a mean of three different times of electrofishing 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



Picture. Monitoring glass eel recruitment at Slette Å. Photo by Jan Skriver.

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 Chapter 4.

5.4 Parasites and pathogens

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

Table 11.2. *Anguillicola* monitoring data 2015.

Location	Salinity ppt	Coordinates	Year	Total	Infected	Prevalence	Intensity
Isefjord	18	55.50N;11.50E	2017	102	39	40	2.9
Ringk. Fjord	5–10	55.55N;08.20E	2017	84	49	58.3	5.7
Arresø	0	55.59N;11.57E	2017	105	70	66.7	6.0

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 autumn.

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 largest number of nests 42 481 was counted in colonies throughout Denmark. In 2017 a total of 33 171 nests were counted.

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

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

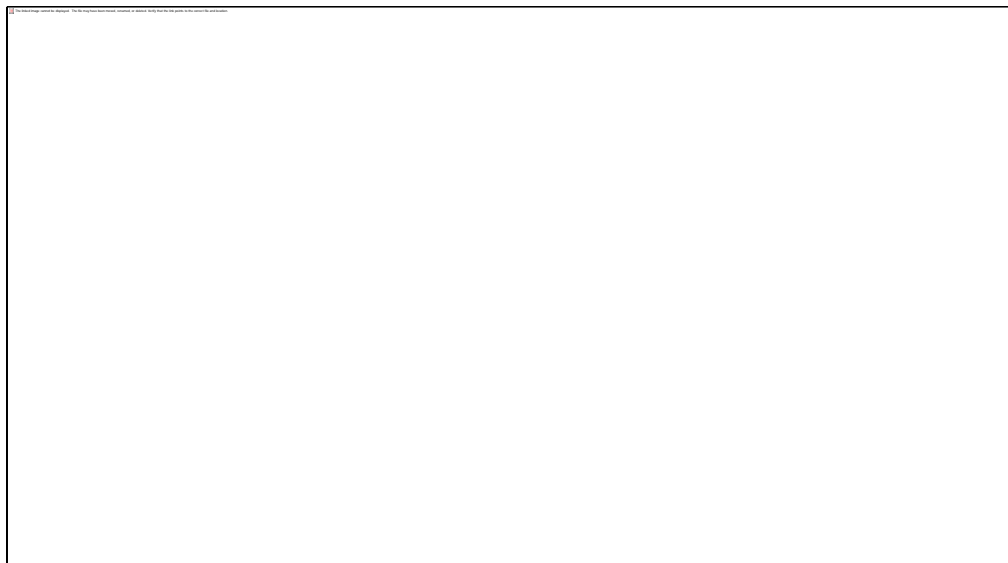


Figure 5.6. Number of cormorant nests in Denmark 1971–2017. Data from NERI. University of Aarhus.

6 New information

New papers

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 months duration were conducted in a series of shallow, open ponds of approximately 200 m². Wild and farmed eels were batch tagged, mixed and released in the ponds at an initial density of 0.5 individual /m². 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 eel and 3 g eels) may be determined through future studies.

Pedersen M.I. and G. H. Rasmussen. 2018. Fisheries regulation on European eel (*Anguilla anguilla*) for 2018; how big is the effect? (Internal paper).

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.

Christoffersen M. Svendsen J. C. Kuhn J. A. Nielsen A. Martjanova A. Støttrup J. G. 2018. Substrate selection in juvenile European eel (*Anguilla anguilla*): implications for coastal habitat management and restoration. *Journal of Fish Biology*, Accepted.

Abstract: The critically endangered European eel *Anguilla anguilla* depends on suitable habitat qualities over a vast geographical area. Although a significant proportion of the population never enters freshwater, the preferred benthic habitat is largely unknown in the marine environment. Examining substrate selection in *A. anguilla*, our results indicate that elvers prefer coarse gravel, suggesting that conservation efforts may benefit from targeting this type of substrate in marine coastal areas.

New project RECREA EEL

RECREA EEL is part of a larger project, The RECREA project, aiming at improving the basis for managing recreational fish stocks in Denmark. Project homepage: <http://www.rekrea-fisk.dk/english/Eng>

It is expected that the recreational eel fishery might constitute a significant part of the total eel catches in Denmark. Therefore it is critical that we increase our knowledge of this fishery in order to manage the fish stock more correctly. Currently the recreational fishery is estimated by way of a combined telephone and Internet surveys conducted twice a year by DTU Aqua (Sparrevohn and Storr-Paulsen, 2010).

RECREA EEL is first and foremost a project investigating possible ways of quantifying real-time recreational eel fishery over a longer coastline in Denmark. However, ultimately, the final goal is to quality assure the results of the current telephone and Internet survey.

The project investigates the recreational eel fishery in the Belt Sea (ICES area 22), more specifically in the Great Belt.

Catch data were collected via questionnaires sent to 1500 registered recreational fishermen with postal addresses closest to the coastline. The questionnaire aimed at obtaining real-time data on which days fykenets were deployed, how many fykenets were used per fishing trip and how many eels were caught and landed. Participation was voluntary but motivated with a gift card lottery.

To obtain biological data from the eels caught in the recreational fishery, the reported length collected by DTU Aqua's network of key fishermen in ICES area 22 was used (Støttrup *et al.*, 2018). The fishermen were also given instructions on how to identify silver eels and yellow eels, so that the developmental stage of the eels could be registered.

RECREA EEL also examined the potential of using overflying to identify the type and amount of fishing gear over longer coastlines. The coastline of the Great Belt was overflown six times during the project period in order to count the total number of fishing gear deployed. To evaluate the accuracy of the overflying, information about the number of fykenets per fishing gear was collected in the field in selected areas in collaboration with the Danish Fisheries Control.

The RECREA project will be finalized in a DTU Aqua report (in Danish) expected to be published winter 2018.

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

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.

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Reporting Period: This report was completed in September 2018, and contains data up to 2017.

1 Stock status summary

Estonia is divided into two different eel management units (EMUs):

- 1) Narva River Basin District – population of eel bases entirely on restocking;
- 2) West-Estonian Basin District (coastal waters and West-Estonian inland waterbodies) – mostly natural population of eel.

Both of Estonian EMUs have different management targets according to the Estonian Eel Management Plan (EMP; Järvalt, 2008). For Narva RBD the objective is to ensure a 40% silver eel escapement to the sea relative to the best estimate of escapement that would have existed if no anthropogenic influences had impacted the stock. In West-Estonian RBD however the management target was to decrease the fishing effort of eel specific gear by 50% by year 2013 (compared to the pre-2006 reference period).

In 2017 the management goals set by the Estonian EMP in both EMUs were fulfilled. In Narva RBD the silver eel escapement percentage compared to pristine levels was 46% however this value is mostly affected by ΣH . ΣH is the hydropower mortality indicator which derives from a study carried out in 2007 (Järvalt *et al.*, 2010) and has a high level of uncertainty. As stated in the 2017 report (ICES, 2017), ΣH in Narva RBD is most likely overestimated.

No stock assessment has been undertaken for West-Estonian RBD as the natural eel stock residing in the coastal waters is very low and it has been not possible to collect enough samples to make confidential conclusions on the size of the stock. Usage of fykenets (and other type of nets that could catch eels), gillnets and longlines in rivers and its tributaries which flow directly to the sea are prohibited in Estonia. This measure guarantees the escapement of silver eels from these waterbodies. However the number of these escaping eels is unknown and must be very low compared to the pristine conditions (Report of..., 2018).

EMU_code	Assessed Area (ha)	B ₀ (kg)	B _{curr} (kg)	B _{best} (kg)	B _{curr} /B ₀ (%)	ΣF	ΣH	ΣA
EE_Narv	1 887 800	90 000	41 581	77 001	46	0.06	0.4	0.61
EE_West	3 650 000	X	X	X	X	X	X	X

Key:

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

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

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).

ΣF=mortality due to fishing, summed over the age groups in the stock (rate).

ΣH=anthropogenic mortality excluding the fishery, summed over the age groups in the stock (rate).

ΣA=all anthropogenic mortality summed over the age groups in the stock (rate).

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

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

Professional eel fisheries in Estonia are roughly divided in two:

- 1) Freshwater eel fishery (10–20 t/year, 2006–2017) – occurs in Narva RBD. All of the eel caught is of restocked background. Occasionally eel is also reported from Lake Ermistu which has a possible connection with the sea in the West-Estonian Basin.
- 2) Coastal sea eel fishery (0.8–10 t/year, 2006–2017) – occurs in the coastal waters of Estonia. Eel is not targeted by the fishery and mostly registered as bycatch in fykenets. Eels both of natural and restocked origin are being fished.

Longlines with 100 hooks per line and harpoons are used in recreational eel fisheries. Recreational fisheries have a marginal importance in the coastal areas. Recreational landings in coastal waters have diminished over 90% in the period 2006–2017. In 2017, only 1 kg of eel was reported from the coastal recreational eel fishery. However 578 kgs of eel was reported from the freshwater recreational fishery in 2017. This is due to much higher stocking densities existing in the inland waterbodies.

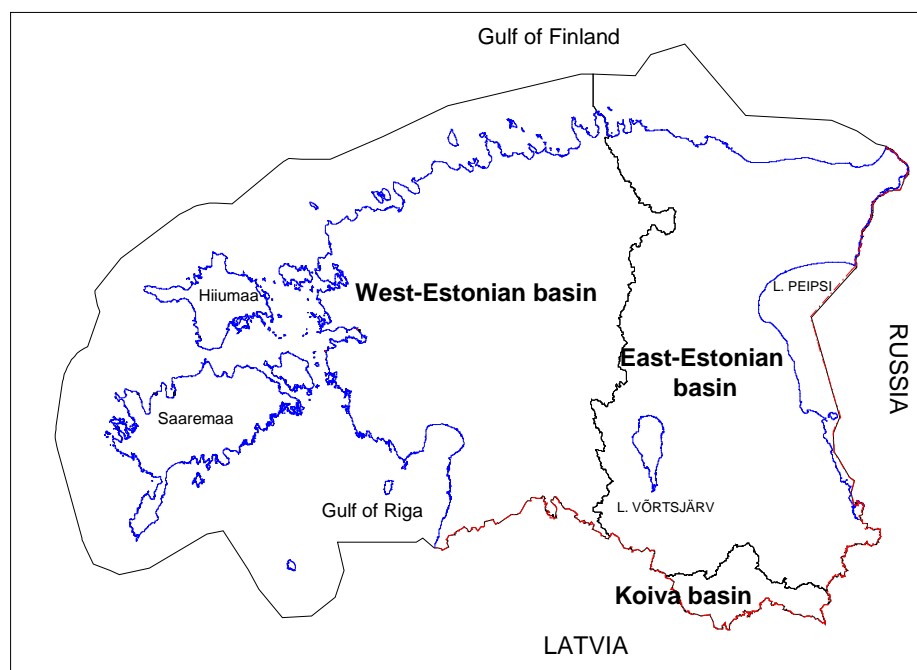


Figure 1. Map of basins. Note that East-Estonian basin and West-Estonian basin correspond to Narva RBD and West-Estonian RBD according to Estonian Eel Management Plan.

According to ordinance of government (RT I 2004, 48, 339) and Water Framework Directive the territory of Estonia is divided into three basins (Figure 1) and nine 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 ($\frac{1}{3}$ 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

No significant changes since last report.

3 Impacts on the stock

3.1 Fisheries

The total capacity of the coastal fishery in 2017 was 1079 commercial fishermen/companies. 112 commercial fishermen/companies of the coastal fishery reported eel in their catch in 2017. The total capacity of the freshwater fishery in 2017 was 316 commercial fishermen/companies. 66 commercial fishermen/companies of the freshwater fishery reported eel in their catch. This information is collected by the Estonian Ministry of Rural Affairs. Register is updated every year and available online at <http://www.agri.ee/et/eesmargid-tegevused/kalamajandus-ja-kutseline->

kalapuuk/puugiload-ja-puugivoimaluste-jaotus and <http://www.agri.ee/et/eesmargid-tegevused/kalamajandus-ja-kutseline-kalapuuk/puugiandmed> (both in Estonian). Records are kept over the number and type of gears used. Data from fishermen log-books are collected once a month and uploaded twice a year. Eel landings in Estonian waters are brought out in Table 1.

Table 1. Eel landings (tons) in different waterbodies of Estonia in 1993–2016 and proportion (%) of restocked eels in Narva RBD.

Year	Baltic Sea	L. Võrtsjärv	L. Peipsi	Other waterbodies	Total	Proportion (%) of restocked eels
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

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

3.1.1 Glass eel fisheries

No available data.

3.1.2 Yellow eel fisheries

No available data.

3.1.3 Silver eel fisheries

No available data.

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 2.) Depending on availability of finances and restocking material either glass eels or ongrown eels have been restocked. There was a plan to restock glass eels into the waterbodies of Narva RBD in 2017. Sarl Foucher-Maury from France won the state procurement for restocking of 628 kg of glass eels. However they were unable to deliver the amount initially agreed on so the public procurement had to be cancelled. The alternative was found in restocking of ongrown eels. A new procurement was made public and the winner was Interfish Balti AS with an offer of 1565 kg (~313 000 sp.) for 136 025.30 €. The ongrown eels were brought to Estonia from the Netherlands by Koman's Vishandel BV live fish truck (Figure 2). The restocking took place on 12.07.2017.

Table 2. Restocking of glass eel and ongrown eel in Estonia (in 10%).

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



Figure 2. Koman's Vishandel BV live fish truck at Lake Võrtsjärv, Narva RBD, Estonia.

3.3 Aquaculture

There were two operating eel farms in Estonia in 2017. Both of these farms were built as recirculating systems. The total production numbers are not available for the composers of this report. However one of the operating farms produced 50 tons of eel mostly for export in 2017. Ongrown or glass eels meant for cultivation are acquired

usually from the UK, France or Holland. Most of the production is exported to wholesalers in the Western Europe with a fraction being consumed locally. The data on production are brought out in electronic tables accompanying this report.

3.4 Entrainment

Narva RBD is the most abundant eel habitat in Estonia as the whole eel stock bases on annual restocking program. However there is a major obstacle on the silver eel escapement route of the RBD, River Narva. The Narva Hydroelectric Station (HES) blocks the upper course of River Narva (Figure 3) making the migrating eels pass through the power station turbines on their way to the Baltic Sea. The turbines are large with 3 m diameter and rotate slowly at 60 RPM.

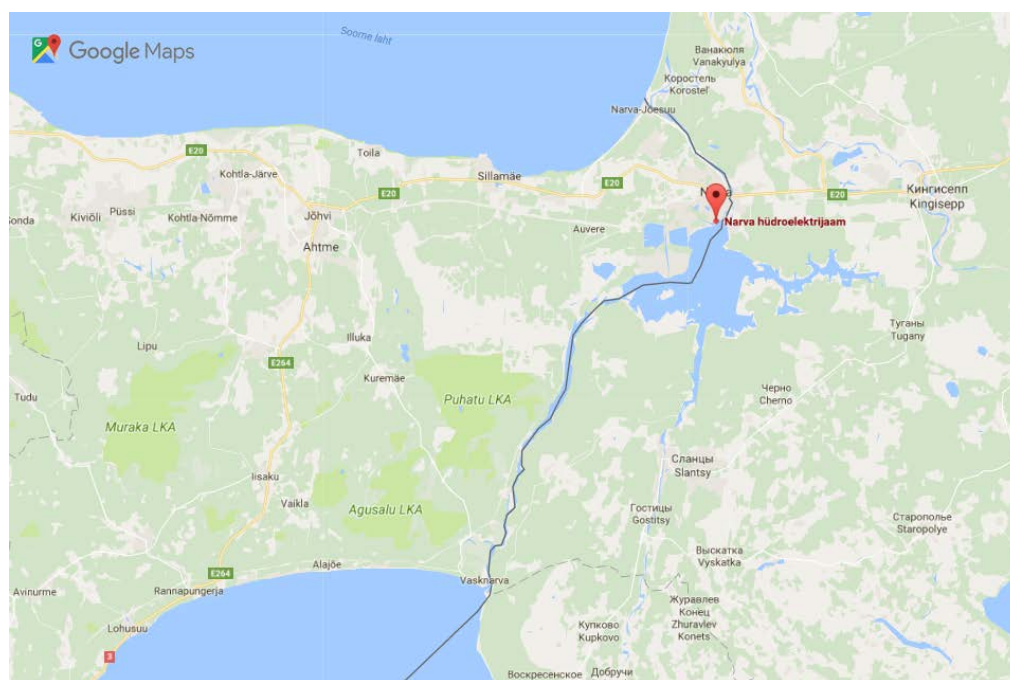


Figure 3. The location of Narva Hydroelectric Station on the silver eel escapement route from Narva RBD.

In 2007, behaviour of seven large eels (TL=73-97 cm) equipped with transmitters was observed after moving through the turbines alive. Eels, tagged with radio telemetric tags Lotek 3V Micro Beeper Fish Trans, MBFT 3A and MBFT 6 with frequency range 172.6–173.0 MHz, were stocked directly into the turbines. During the next two weeks the position of the eels in the river was tracked using ICOM Communication Receivers type IC-R 20. According to registration of signals all radio-tagged eels came through the turbines. Recapture results verified that four of seven came through the turbines alive and without any damage. (Järvalt *et al.*, 2010).

There have been recaptures of tagged eels from numerous spots in the Baltic Sea (Järvalt *et al.*, 2010,) verifying the penetrability of the Narva HES turbines. However right now a mortality value of $\Sigma H=0.4$ is used based on the pre-mentioned test carried out in 2007.

In 2018 a project an acoustic telemetry project will be carried out on River Narva. 50 silver eels will be tagged using Vemco V7 and V9 (<https://vemco.com/wp-content/uploads/2014/04/v7-coded.pdf>) coded transmitter tags and released upstream of Narva HES to measure the mortality caused by the turbines.

3.5 Habitat quantity and quality

Narva RBD is shared with Russian Federation (Figure 1) and the escapement of silver eel depends not only on measures put into practice in Estonia. The present EMP covers Estonian part of the basin and measures assure 40% of silver eel escapement applying only in territory under the jurisdiction of Estonia. The Narva RBD includes the fourth biggest lake in Europe, Lake Peipsi (Peipus) (355 500 ha), Lake Võrtsjärv (27 000 ha) and hundreds of small lakes and rivers. Most of the lakes in Narva RBD are relatively shallow and eutrophic, suitable habitats for eel. Feeding conditions are good and growth rate is rather rapid (6.9 cm/year in L. Võrtsjärv, Silm *et al.*, 2017). Lake Peipsi is located on the border of the Republic of Estonia and the Russian Federation and consists of three parts: the largest and deepest northern part L. Peipsi s.s. (area 261 100 ha, mean and maximum depth 8.3 and 12.9 m resp.), the middle part L. Lämmijärv (23 600 ha, 2.5 and 15.3 m) and the southern part L. Pihkva (70 800 ha 3.8 and 5.3 m). Altogether 157 000 ha belongs to Estonia. The catchments area 47 800 km² including the lake, covers territorial parts of Estonia (¹/₃) and Russia (²/₃) (Pihu and Haberman, 2001). There are about 240 inlets into L. Peipsi. The largest rivers are the Velikaya (in Russia) and the Emajõgi connecting L. Peipsi with L. Võrtsjärv. The only outflow, the Narva River runs its waters (12 km³ per year) into Gulf of Finland (Järvalt, 2008).

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

3.6 Others

4 National stock assessment

4.1 Description of method

4.1.1 Data collection

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

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

The enclosure fykenet system was used only on L. Võrtsjärv in 2017. The methodology is modified after Ubl and Dorow (2015). A random fishing area will be 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 will be set for at least a week in one sampling spot. All eels caught are measured and weighted. Sex and silvering stage is determined. Also the occurrence of parasites and the type of food ingested will be recorded. From

a select sample, otoliths are extracted for age reading and possible micro-chemical analyses. Samples were taken from May until the middle of October 2017, usually twice a week.

Burning and cracking method was used for age reading from otoliths up to 2016 (Silm *et al.*, 2017) but from 2017 otoliths are etched and stained with 1% HCl acid and neutral red solution according to the Swedish method (ICES, 2009).

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

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

4.1.2 Analysis

Up to 2015 a mark–recapture approach was used on Lake Võrtsjärv and small lakes in the RBD to estimate the relative abundance of eel in fresh waterbodies. However as there was a lack of recapture data for 2015 a new approach in stock abundance estimation was introduced from 2016. Enclosure fykenet system (Ubl and Dorow, 2015) was used to determine approximate number of eels per hectare in the lake. Escaping silver eel biomass was calculated using these variables:

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

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

F – commercial fishing mortality for given year

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

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

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

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

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

k – correlation coefficient

M – natural mortality

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

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

$$N_i = N_{i+1} \frac{F_i}{0.9}, \text{ if } i = 6 - 8 \text{ years}$$

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

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

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

Mortality caused by hydropower plant turbines (ΣH) was added to the escaping silver eel biomass estimation. ΣH was derived from results obtained in a silver eel escapement related study (Järvalt *et al.*, 2010) carried out in 2007. The biomass estimates based on both monitoring and commercial fisheries data are presented in Table 4. The pristine biomass indicator (B_0) is based on the earliest Estonian eel-related data available (commercial landings data from 1930s). The construction of the Narva Hydroelectric Station in the 1950s blocked all natural recruitment upstream of River Narva making annual restocking program necessary to conserve an eel population in Narva RBD. Both B_{curr} and B_{best} are calculated in annual restocking conditions while B_0 is the pristine indicator without restocking.

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 underreporting exists in commercial landings.

4.2 Assessment results

Occurrence of different age groups in L. Võrtsjärv commercial catch is constructed by using data obtained from survey fykenets over period 2013–2017 (Figure 4). Most abundant age group in fykenet catches during aforementioned period was nine years. It can be assumed that with increasing age (9+) intensifies also the migration out of the lake making it possible to estimate the escaping silver eel biomass (Table 3). The 2017 stock indicators were lower than in 2016 due to:

- 2016 stock indicator calculation based on eel abundance survey that did not cover the whole L. Võrtsjärv and therefore overestimated $B_{current}$ and B_{best} . The real biomass estimation for B_{curr}/B_0 values could be 6-8% smaller ($B_{curr}/B_0 = 54-56\%$).

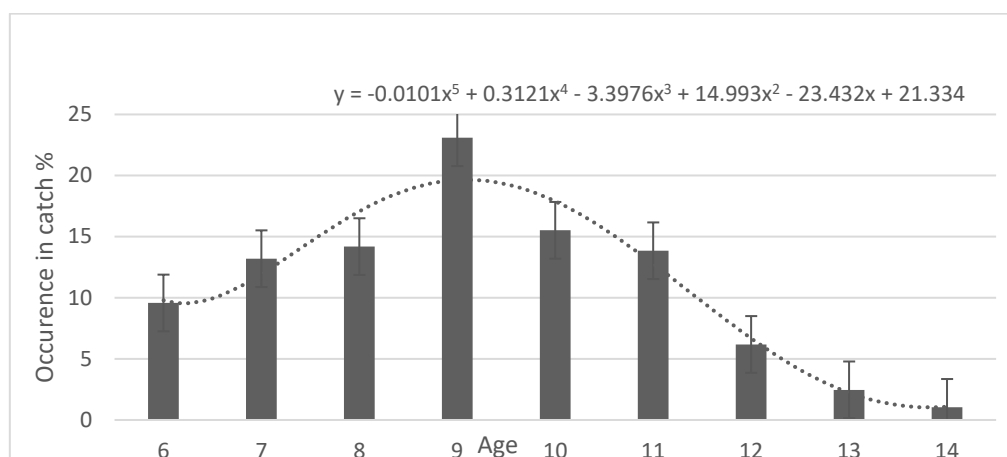


Figure 4. The probability of occurrence of different age groups of eel in the monitoring fykenets in period 2013–2017 in L. Võrtsjärv.

Table 3. Eel stock indicators in Estonian EMUs in 2016–2017.

	EMU_code	Assessed	B ₀	B _{curr}	B _{best}	B _{curr} /B ₀	ΣF	ΣH	ΣA
Year		Area	(kg)	(kg)	(kg)	(%)			
		(ha)							
2016	EE_Narv	1 887 800	90 000	56 011	101 839	62	0.05	0.4	0.59
2016	EE_West	3 650 000	X	X	X	X	X	X	X
2017	EE_Narv	1 887 800	90 000	41 581	77 001	46	0.06	0.4	0.61
2017	EE_West	3 650 000	X	X	X	X	X	X	X

5 Other data collection

5.1 Recruitment time-series

No available data.

5.2 Yellow eel abundance surveys

During period 04.08.2016–12.10.2017 a yellow/silver eel abundance survey was carried out on L. Võrtsjärv using an enclosure fykenet system. Methodology of this survey was described in point 4.1.1. The aim of this study was to find out approximate abundance of yellow eel in the lake and also to study eel movement. In total 1204 eels were caught during aforementioned period from whom 502 specimens were tagged with floy tags and released back into the lake and various analyses were carried out on the other 702 caught specimens.

Our results showed that at a mean restocking rate of 380 000 on-grown eels/year (during period 2002–2009) and fishing mortality $F=0.05$ roughly 62 tons of silver eel migrates out of L. Võrtsjärv. The size of fishable eel stock ($TL \geq 55$ cm) in L. Võrtsjärv is 502 000 specimens which mostly belong to age groups 6–14. It is known that the migration out of the lake intensifies at ages 9–10 (Järvalt *et al.*, 2017).

The official report of the survey (in Estonian language) is downloadable here: <http://pk.emu.ee/struktuur/hudrobioloogajakalandus/teadustoo/projektid/uudse-an-gerjamorrasusteemi-katsetamine-vortsjarvel/>

5.3 Silver eel escapement surveys

See chapter 4 and 5.2.

5.4 Biological parameters

See 4.1.1 for description of methods.

249 eels were caught from L. Võrtsjärv using regular survey fykenets in 2017 (Figure 5). The mean length and weight of caught specimens was TL=61.1 cm and TW=504 g respectively. Compared to 2016, mean length of caught specimens had decreased by 4% and mean weight by 8%. Most of the eels caught in 2017 derive from generations restocked as elvers. Mean Fulton condition factor K in the caught sample was the same as in previous year – $K=0.19$.

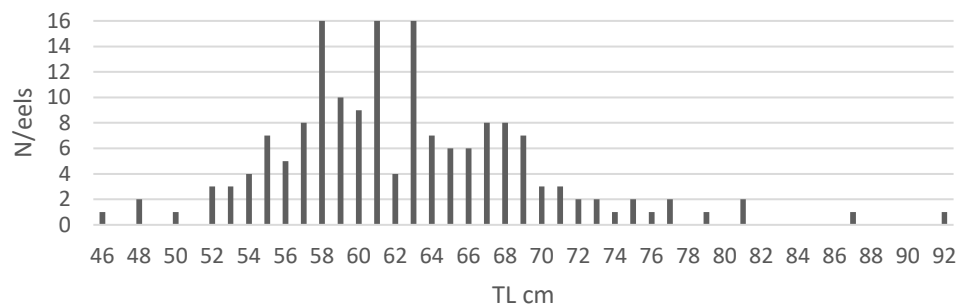


Figure 5. Length distribution of caught eels (N=249) from L. Võrtsjärv in 2017.

In 2017 most of the analysed eels (N=90) belonged to age groups 6, 7, and 8 (Figure 6). 8% of eels analysed were had reached silvering stage FIV and FV. According to age determination these eels belonged to age groups 10+ with a mean weight of TW=1kg.

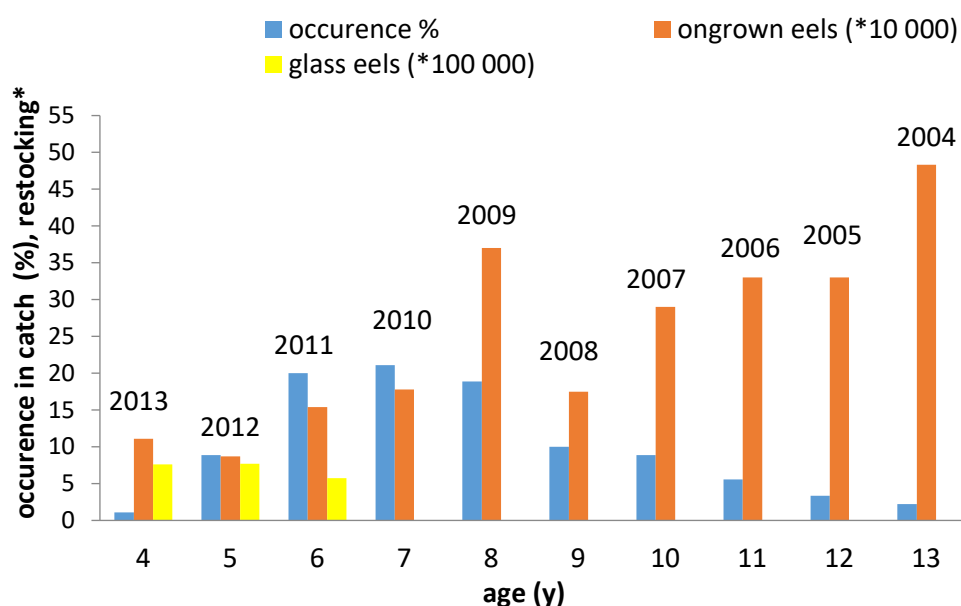


Figure 6. Age structure of eels (N=90) caught by survey fykenets in L. Vörtsjärv in 2017. Blue columns show the percentage of occurrence of certain age group in the catch. Yellow and brown columns present the number of glass eels (*10⁵) and on-grown eels (*10⁴) restocked along with the year of restocking. Each age group derives directly from certain year batch of restocked eels.

5.5 Parasites and pathogens

Samples (N=594) collected during the survey described in 5.2 shows that 54% (N=325) of the eels in L. Vörtsjärv were infected with *Anguillicola Crassus*. Mean intensity of the contagion was N=6 parasites/per specimen. This may affect the swimming speed of eels (Sperngel and Lüchtenberg, 1991) and also the possibility of reaching spawning grounds in the Sargasso Sea.

5.6 Contaminants

No available data.

5.7 Predators

See ICES, 2018.

6 New Information

In 2018 a project an acoustic telemetry project will be carried out on River Narva. 50 silver eels will be tagged using Vemco V7 and V9 (<https://vemco.com/wp-content/uploads/2014/04/v7-coded.pdf>) coded transmitter tags and released upstream of Narva HES to measure the mortality caused by the turbines.

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

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.

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Reporting Period: This report was completed in September 2018, and contains data up to 2017 and some provisional data for 2018.

1 Stock status summary

There are not available data to provide stock indicators of silver eel escapement biomass and mortality rates. In Finland, eels are on their northeastern limits of natural geographical distribution. Natural eel populations have probably always been very sparse, and the overall importance of the species has been low. In freshwaters only in few areas in southern parts of the country eel 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 1970s. During the years 1979–1988 it was not allowed to import eels because eel was detected to be a possible carrier of some viral fish diseases. For this reason it was decided in 1989 to carry on re-stockings only with glass eels reared in a careful quarantine. Since then glass eels originating in 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 south coast of Finland.

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

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:

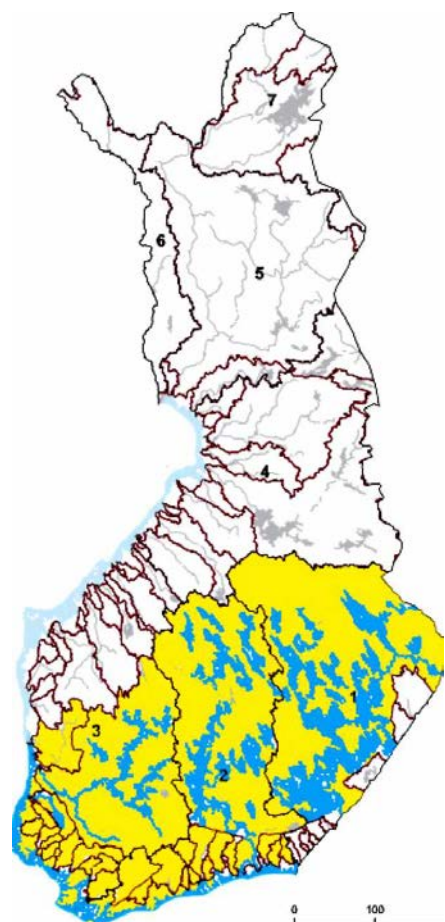
- a) Reserve area (the Bothnian Bay area) where eels exist, but for climatically and geographical reasons have always been very rare. Light blue area in the map. Total area is 1783 km².
- b) Main management area for the eel (the Gulf of Finland and the small undammed river basins running to it). Deep 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 20 509 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 seven years since then just about one million eels have been stocked in total. And of those 40–60% have been paid by private water owners to benefit the local fisheries in the sea or in the freshwaters.



2.2 Significant changes since last report

Eel is included in the EU Data Collection Programme in Finland since 2017.

3 Impacts on the stock

3.1 Fisheries

For the professional fisheries eel is of no importance. Some semi-professional fishermen may have minor income from eels mainly as a bycatch. Therefore the recreational fisheries mainly catch the eels. The number of recreational fishermen in Finland is high (1.6 million in 2014) but only a very small portion of those catch eels as a main target (with fykenets, longlines, angling, spears, etc.). For most of the people eel is a surprising bycatch. Illegal fishing is not significant because there is enough chance to catch eels legally if you wish.

3.1.1 Glass eel fisheries

There is no glass eel fisheries in Finland.

3.1.2 Yellow eel fisheries

There are no specific data on yellow eel fisheries. Since 2008 the total professional marine eel landings (yellow and silver together) have varied between 609–2300 kg/year based on annual logbook data. In the same time professional freshwater landings have been zero based on questionnaires made every second year to all professional freshwater fishermen. In recreational fisheries the landings in freshwater have varied between 3000–11 000 kg/year and in the sea between 2000–13 000 kg/year. In recreational fisheries landings are based on data collected by questionnaires every second year. Data are collected with a postal survey. The sample is taken from the population information system maintained by the Population Register Centre. Data are collected from household dwellings, the statistical unit of the survey. The big variation in the eel landings is mainly explained by the small sample size of only 6000–7000 households.

No available data on effort.

3.1.3 Silver eel fisheries

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

3.2 Restocking

In last 28 years glass eels have been imported and stocked into Finnish freshwaters and coastal waters through a Swedish quarantine (Scandinavian Silver Eel). Origin of those glass eels have been mainly England (River Severn estuary). After the Finnish EMP approval in 2010 1.2 million individuals (mean weight 1 g) have been stocked. Roughly a little bit more than half of the eels have been stocked into coastal waters where they can freely leave for spawning migration. About 20% of those stocked into freshwaters are stocked in lakes which are directly connected to the sea or there is only one small dam between them and free migration.

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. In 2016 and 2017 no glass eels were imported there anymore.

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

3.4 Entrainment

No available data.

3.5 Habitat quantity and quality

No available data.

3.6 Others

No available data.

4 National stock assessment

4.1 Description of method

4.1.1 Data collection

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 eel in Finland originates from restocking programs. It is possible to get limited number of eel samples from the fykenet fisheries bycatch.

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

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. Since 2017, samples are collected to estimate the share of yellow/silver eels and restocked/wild eels (on the basis of strontium chloride label, only for individuals from year class 2009 and later). Samples are collected in two locations in inland waters as well: Vesijärvi (Kymijoki watershed) and Kulovesi (Kokemäenjoki watershed), where all eel are supposed to be of restocked origin due to migration barriers.

An index for the silver eels migrating from Finland shall be obtained 1) from eel trap in the river running from Lake Vesijärvi. The eels caught in this trap are marked and released on the coast at Kymijoki estuary (below hydropower dams) 2) from echosounder in Kokemäenjoki under the lowest hydro-power dam.

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

4.1.2 Analysis

4.1.3 Reporting

4.1.4 Data quality issues and how they are being addressed

4.2 Assessment results

No available data.

5 Other data collection

5.1 Recruitment time-series

No precise data.

There is only occasional bycatch in lamprey fykenets and pots in rivers running to the Baltic Sea, but only few individuals a year.

In the river Kokemäenjoki on the west coast. Bycatch has been checked in 1902, 2001 and 2007 onwards.

In 1902, 165 small yellow eels were caught in autumn in lamprey pots.

In 2001, 35 small yellow eels were caught (during 15.8.–31.10.) in fykenets.

In 2014, one small yellow eel was caught (during 15.8.–31.10.) in fykenets.

In 2007–2013 no eels.

In 2015, not a single small yellow were caught (research during 1.6.–31.10. and commercial catch during 15.8.–31.10.) in same lamprey fykenets.

In 2016–2017 no eels.

5.2 Yellow eel abundance surveys

No available data yet.

5.3 Silver eel escapement surveys

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 powerplants. 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

5.4 Biological parameters

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

There were no routine biological sampling programmes or eel research projects during 1994–2005. Some occasional samples were taken in few lakes 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 re-stocked 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 FGFR. The main goal was to compile the facts and other biological data on 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 only in the most interesting locations.

5.5 Parasites and pathogens

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

5.6 Contaminants

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

5.7 Predators

No available data.

6 New information

7 References

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

Note to the reader the ICES data call on eel 2018 provides 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.

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1 Stock status summary

In Table 1, the most recent data on assessed areas and stock indicators for the relevant German RBD's are given. Source: Fladung and Brämick (2018).

Table 1. EMP Progress Report (2018) summary table for stock indicators of EMUs averaged from 2014–2016 (Fladung and Brämick, 2018).

EMU_code	Assessed area (ha)	B ₀ (t)	B _{curr} (t)	B _{best} (t)	B _{curr} /B ₀ (%)	ΣF	ΣH	ΣA
DE_Eide ⁴	468.783	1.708	638	659	37,34	0,01	0,01	0,03
DE_Elbe ²	201.019	1.553	101	38	6,48	1,15	0,27	1,42
DE_Ems ²	44.088	820	176	87	21,41	0,11	0,01	0,12
DE_Maas ¹	892	9	0	0	0,67	0,73	0,11	0,84
DE_Oder ²	80.366	373	91	82	24,48	0,20	0,00	0,21
DE_Rhei ¹	61.065	532	223	8	41,98	0,26	0,64	0,89
DE_Schl ³	333.379	4.205	2.038	2.029	48,47	0,03	0,00	0,03
DE_Warn ³	368.309	1.367	1.441	1.486	105,36	0,07	0,00	0,07
DE_Wese ²	55.472	730	130	47	17,81	0,34	0,20	0,54
DE_Total	1.313.373	11.299	4.838	4.438	42,82	0,14	0,04	0,18

Key:

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

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

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).

ΣF=mortality due to fishing, summed over the age groups in the stock (rate).

ΣH=anthropogenic mortality excluding the fishery, summed over the age groups in the stock (rate).

ΣA=all anthropogenic mortality summed over the age groups in the stock (rate).

¹: Inland waters.

²: Inland and transitional waters.

³: Inland and coastal waters.

⁴: Inland, transitional and coastal waters.

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

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

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

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

2.1.1 EMUs, EMPs,

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

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



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

2.1.2 Management authorities

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

2.1.3 Regulations

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

2.1.4 Management actions

The main measures proposed in the EMPs are:

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

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

Table 2. Implementation of management measures in the EMU Eider.

EMU CODE	ACTION TYPE	ACTION	LIFE STAGE	PLANNED	OUTCOME
DE_Eide	Com Fish	Increase minimum size limit	Yellow	EMP	Implemented
		Close stationary eel traps	Mixed	Other	Partially implemented
	Rec Fish	Increase minimum size limit	Yellow	EMP	Implemented
	Hydropower & Pumps	Trap & Transport	Silver	EMP	Not implem.
		Upgrade hydropower installations to protect fish and improve connectivity	Mixed	EMP	Partially implemented
	Restocking	no	---	---	---
	Other	Predator control	Mixed	EMP	Implemented
		Participation in European cormorant management	Mixed	EMP	Partially implemented
		Improve longitudinal connectivity	Mixed	Other	Partially implemented
		Scientific studies and monitoring and data collection	Mixed	EMP/Other	Implemented
		Legal framework	Mixed	EMP	Implemented
		Improve means of fishery control	Mixed	Other	Implemented

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

EMU CODE	ACTION TYPE	ACTION	LIFE STAGE	PLANNED	OUTCOME
DE_Elbe	Com Fish	Increase minimum size limit	Mixed	EMP	Partially implemented
		Close stationary eel traps	Silver	EMP	Partially implemented
		Reduction of fisheries intensity in coastal waters	Mixed	EMP	Partially implemented
		Introduction of regional fishing limitations	Mixed	Other	Implemented
	Rec Fish	Increase minimum size limit	Mixed	EMP	Partially implemented
		Introduction of bag size limit for eel anglers	(Yellow)/Mixed	Other	Implemented
		Closing fishery at night for anglers	(Yellow)/Mixed	Other	Implemented
	Hydropower & Pumps	Recovery of patency at important dams/weirs	Silver	EMP	Partially implemented
	Restocking	Stabilize/increase amount stocked	Glass-, ongrown eels	EMP	Partially implemented
	Other	Improve longitudinal connectivity	Mixed	EMP/Other	(Partially) implemented
		Scientific studies and monitoring and data collection	Mixed	EMP	Implemented
		Legal framework	Mixed	EMP	Partially implemented

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

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

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

EMU CODE	ACTION TYPE	ACTION	LIFE STAGE	PLANNED	OUTCOME
DE_Maas	Com Fish	Increase minimum size limit	Yellow	EMP	Implemented
	Rec Fish	Increase minimum size limit	Yellow	EMP	Implemented
	Hydropower & Pumps	No permission for new hydropower facilities	Silver/Mixed	EMP	No action needed.
	Restocking	Stabilize/increase amount stocked (30 000 glass eels and 30 000 on-grown eels)	Glass	EMP	Implemented
		Supply financial support for stocking	Glass	Other	Implemented
	Other	Improve longitudinal connectivity	Mixed	Other	Partially implemented
		Scientific studies and monitoring and data collection	Mixed	Other	Implemented
		Include eel in existing species protection programmes	Mixed	Other	Implemented
		Legal framework	Mixed	EMP	Implemented

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

EMU CODE	ACTION TYPE	ACTION	LIFE STAGE	PLANNED	OUTCOME
DE_Oder	Com Fish	Increase minimum size limit	Yellow	EMP	Implemented
		Close stationary eel traps (but no concrete targets)	Silver	EMP	Not implemented
	Rec Fish	Increase minimum size limit	Yellow	EMP	Implemented
		Introduction of bag size limit	Mixed	Other	Implemented
	Hydropower & Pumps	Hydropower mortality is circumstantial in the German part of the RBD Oder. There is no need for special measures.			
	Restocking	Stabilize/increase amount stocked	Glass	EMP	Implemented
	Other	Improve longitudinal connectivity	Mixed	Other	Implemented
		Scientific studies, monitoring and data collection	Mixed	EMP	Implemented
		Legal framework	Mixed	EMP	Implemented

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

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

Table 8. Implementation of management measures in the EMU Schlei/Trave.

EMU CODE	ACTION TYPE	ACTION	LIFE STAGE	PLANNED	OUTCOME
DE_Schl	Com Fish	Increase minimum size limit	Yellow/Silver	EMP	Implemented
		Reduction of fisheries intensity in coastal waters	Mixed	EMP	Implemented
		Close stationary eel traps	Mixed	Other	Partially implemented
		Restrictions for longline fisheries	Mixed	Other	Implemented
	Rec Fish	Increase minimum size limit	Yellow/Silver	EMP	Implemented Implemented
	Hydropower & Pumps	Trap & Transport	Silver	EMP	No information
		Upgrade hydropower installations to protect fish and increase connectivity	Mixed	EMP	Partially implemented
	Restocking	Stabilize/increase amount stocked	Glass	EMP	Mostly implemented
	Other	Improve longitudinal connectivity	Mixed	Other	Partially implemented
		Predator control	Mixed	EMP	Implemented
		Participation in European cormorant management	Mixed	EMP	Partially implemented
		Scientific studies and monitoring and data collection	Mixed	EMP/Other	Partially implemented
		Legal framework	Mixed	EMP	Implemented
		Improve means of fishery control	Mixed	Other	Implemented

Table 9. Implementation of management measures in the EMU Warnow/Peene.

EMU CODE	ACTION TYPE	ACTION	LIFE STAGE	PLANNED	OUTCOME
DE_Warn	Com Fish	Increase minimum size limit	Mixed	EMP	Implemented
		Reduction of fisheries intensity in coastal waters	Mixed	EMP	Implemented
		Close stationary eel traps	Mixed	Other	Partially implemented
		Introduce a closed season	Mixed	EMP	Implemented
	Rec Fish	Increase minimum size limit	Yellow	EMP	Implemented
		Introduce a closed season	Mixed	EMP	Implemented
	Hydropower & Pumps				
	Restocking	Stabilize/increase amount stocked	Glass	EMP	Partially implemented
	Other	Improve longitudinal connectivity	Mixed	Other	Partially implemented
		Predator control	Mixed	EMP	Partially implemented
		Scientific studies and monitoring and data collection	Mixed	EMP/other	Implemented
		Legal framework	Mixed	EMP	Implemented

Table 10. Implementation of management measures in the EMU Weser.

EMU CODE	ACTION TYPE	ACTION	LIFE STAGE	PLANNED	OUTCOME
DE_Wese	Com Fish	Increase minimum size limit	Yellow	EMP	Partially implemented
		Reduction of fisheries intensity in coastal waters	Mixed	EMP	Not implemented (sobordiante importance since no coastal eel fisheries are currently active)
		Establish or prolong closed season for eel fishery	Mixed	Other	Implemented
	Rec Fish	Increase minimum size limit	Yellow	EMP	Partially implemented
	Hydropower & Pumps	Introduce trap and transport programme and/or turbine management	Silver	Other	Implemented
	Restocking	Stabilize/increase amount stocked	Glass	EMP	Implemented
		Supply financial support for stocking	Glass	Other	Implemented
	Other	Scientific studies and monitoring and data collection	Mixed	Other	Implemented
		Legal framework	Mixed	EMP	Partially implemented

2.2 Significant changes since last report

The past reports were marked by a lack of information on vital population characteristics in EMUs other than the Elbe and Warnow/Peene. In accordance with EU Regulation 1100/2007, data from the Elbe was therefore used in any case where system-specific data were not available.

In the present report, for the first time since the implementation of the EMPs, system-specific growth curves of female (all EMUs) and male (Eider inland waters, Ems, Weser) eels were used. Growth curves were derived by length back-calculation from silver eel otoliths sampled within the EU DCF, following the protocol described by Simon (2015). While significantly improving the current stock assessment, the newly implemented data also led to considerable changes in some of the model outputs. Accordingly, model related data from the current and previous report(s) are not directly comparable due to methodological changes.

3 Impacts on the stock

3.1 Fisheries

Commercial fisheries in Germany usually are mixed fisheries, which catch different species and also both stages, yellow and silver eel (though some gears primarily target one of the stages). Landings of yellow and silver eels have not been reported separately in the past. Though separate reports have recently been implemented in some states, these numbers were not available (except for Warnow/Peene). Therefore, in the following all data are given combined for yellow and silver eels. The data were taken from the EMPs (for 2007, commercial fishery) and from the 2018 EMP progress report (Fladung and Brämick, 2018) to the European Commission (anglers). It is assumed that the data have not changed considerably since 2007 for commercial fisheries; yet, it should also be noted that more recent data are available for fishing effort (see further below), which are more relevant to assess the intensity of the fishery. Furthermore, in Mecklenburg-Pomerania, fishing pressure on the European eel was notably reduced, especially in coastal areas with 255 full-time and 128 part-time fishermen in 2016 (Dorow and Lill, 2014; Dorow *et al.*, 2017). It is expected that this downward trend will continue in future, particularly since it is uncertain who will succeed retired fishermen.

No data on catches are available in Germany. Landings for commercial and recreational fisheries are given in the 2018 ICES data call on eel.

EMU Eider

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

EMU Elbe

- 413 full- and part-time fishermen / fishing enterprises, (11 102 fykenets, 31 stow nets, 24 electrofishing gears, 38 stationary eel traps in 2007)
- 412 370 anglers (in 2016, Fladung and Brämick, 2018, data were renewed in 2018 progress report)

EMU Ems

- four full-time and five part-time fishermen (using fykenets and stow nets)

- 50 811 anglers (in 2016, Fladung and Brämick, 2018)

EMU Maas

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

EMU Oder

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

EMU Rhein

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

EMU Schlei/Trave

- coastal fishery: 142 cutters (124 full-time, 18 part-time), 107 boats (full-time) and 379 boats (part-time fishermen); in total 628 fishing vessels of different size; 808 hobby fishermen (allowed to use 3232 fykenets and 80 800 hooks on longlines)
- inland fishery: 16 fishing enterprises
- about 23 711 anglers (in 2016, Fladung and Brämick, 2018)

EMU Warnow/Peene

- coastal fishery: 345 full-time fishermen, 138 part-time fishermen, 261 hobby-fishermen (in total 846 fishing vessels <12 m and 34 vessels >12 m)
- inland fishery: 41 fishing enterprises with 125 vessels (using ca. 1800 fykenets or eel trap chains, ten seines, seven electrofishing gears, four stationary eel traps, longlines with 25 000 hooks)
- 76 873 anglers (in 2016, Fladung and Brämick, 2018)

EMU Weser

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

3.1.1 Glass eel fisheries

There is no glass eel fishery in Germany.

3.1.2 Yellow/Silver eel fisheries

3.1.2.1 Commercial

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

3.1.2.2 Recreational

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

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

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

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

3.1.2.3 Fishing effort

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

Fisheries in Germany usually are mixed fisheries, which catch different species and also both stages of eel, yellow and silver eel (although some gears are more specialized for one of the stages). Therefore, fishing effort cannot be presented separately for yellow and silver eels. Hence, Table 11 gives the data on total fishing effort on both stages.

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

Table 11. Fishing effort with the most relevant eel fishing gears of commercial and semi-commercial fisheries in German waters in 2016 and change (%) in relation to the 2008-data. Data are presented as *gear * days used*.

EMU	Small fykes	Large fykes	Longlines (eel line 100 at hooks)	Aalpuppen ("Hook buoy"?)	Stow nets	Stationary eel traps	Electro fishing
Eider	7.985	6.268	0		127	0	0
Elbe*	230.486	287.902	171	4.180	1.618	255	49
Ems	2.552	5.609	0		3.995	0	0
Maas	0	0	0		0	0	0
Oder	195.460	26.534	3.354	5.626	240	2	55
Rhein	126.199	5.990	45		217	0	349
Schlei/Trave	418.150	7.450	415		0	20	0
Warnow/Peene	2.724.110	51.365	114.574	2.591	0	264	14
Weser	130.803	2.834	0	0	710	0	0
Total	3.835.745	393.952	118.559	12.397	6.907	541	467
Change from 2008 to 2016 (%)*, **	-38	-8	-36	-69	-37	-77	-24

*Without Hamburg, because no data were reported.

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

3.1.2.4 Economic importance

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

3.1.2.5 Underreporting and illegal catches

No data available.

3.2 Restocking

Available data on eel stocking are provided in the ICES data call on eel 2018. The information for 2017 and 2018 is not yet complete (see electronic tables). Hence, the complete and summarized data for 1985–2016 are given here. It is likely that the order of magnitude was the same in 2017 and 2018. Generally, restocking intensity is influenced by glass eel price, funding and the contribution of commercial and recreational fishermen.

3.3 Aquaculture

3.3.1 Aquaculture seed supply

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

Table 12. 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

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

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

Table 13. Overview on aquaculture production and use/life stage of eels (YS = yellow/silver eel at marketable size, mostly human consumption, OG = on-grown, used for stocking) in Germany.

Year	Donor country	life stage	Quantity (kg)
2007	Germany	YS, OG	774.000
2008	Germany	YS, OG	749.400
2009	Germany	YS, OG	667.000
2010	Germany	YS, OG	681.000
2011	Germany	YS, OG	692.000
2012	Germany	YS, OG	744.000
2013	Germany	YS, OG	758.000
2014	Germany	YS, OG	926.000
2015	Germany	OG	29.000
2015	Germany	YS	1.147.000
2016	Germany	OG	38.000
2016	Germany	YS	1.061.000
2017	Germany	YS, OG	1.202.162

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. Summarized Hydropower mortalities are given in the electronic tables accompanying this report.

According to the position of the obstacles and the known or estimated mortality rates at each location, the RBD's can be divided into several subareas, 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 subareas of similar turbine mortality. This way of modelling makes it easy to study the effect of improvement of the migration capacity of water power stations because the influenced area will be added to another subarea.

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

3.5 Habitat quantity and quality

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

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

3.6 Others

No further impacts are assessed.

4 National stock assessment

4.1 Description of method

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

The model incorporates the weight and sex of eel as well as the mean water temperature to estimate the natural mortality. Natural mortality was estimated based on Bevaqua *et al.* (2011). In addition, three density levels of the eel stock are taken into account to determine natural mortality. The areas given in the EMPs and in the reports include all habitats, which would be potential eel habitats under undisturbed conditions; only some habitats e.g. in the trout region, far away from the coast may have been excluded, because these areas don't form a typical eel habitat. Areas above impassable anthropogenic barriers are also included in the calculation of escapement. In agreement with the eel regulation, coastal waters have been included in some cases but not in others. When they were not included, fisheries should be decreased by 50% outside the areas covered by the EMP.

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

Restocking applies in all German RBD's except for the River Eider. In the calculation of B_0 and B_{best} , restocking is not included. $B_{current}$ includes the effect of restocking in all RBD's, 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 model are: fisheries yield (commercial (from national landing statistics), recreational), stocking and estimates for natural immigration based

on the ICES recruitment time-series, predation by cormorants, mortality by hydropower (turbines, etc.), growth functions and length–mass relationships. For details see Oeberst and Fladung (2012).

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

4.1.2 Analysis

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

4.1.3 Reporting

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

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

The data, which are obtained in the frame of the DCF, are regularly reported to the EU.

4.1.4 Data quality issues and how they are being addressed

The quality of the available data is not easy to assess. There is no long history of eel stock assessment in Germany and hence the results are based on landing statistics, estimates and model calculations. The reliability of the landing statistics has not been evaluated so far. The model used to calculate the different population parameters of eel in German waters (Oeberst and Fladung, 2012), has been further developed (GEM III) and has also been tested in the frame of the POSE project. Meanwhile, 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 future. The reliability of the results will also be enhanced by increasingly using river-specific data obtained in the frame of the DCF sampling.

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

4.2 Assessment results

In absolute terms, mortalities due to fisheries (i.e. landings) and hydropower (i.e. eels lost to turbines and cooling water intakes) was reduced in all German EMUs from 2005–2007 to 2014–2016 (Tables 14 and 15). In some EMUs, however, (modelled) fishing and other anthropogenic mortality rates actually increased in the observed time period (Table 16). This contradiction is partly attributed to the fact that the modelled decrease in the abundance of eels in the fished population (i.e. above minimum landing size) or exposed to hydropower mortality (i.e. silver eels) was higher than the observed de-

crease in catches. Yet, the overall fishing effort also decreased (Table 11), which suggests a decrease in both, absolute and relative mortalities. It is, however, hardly possible to standardize fishing effort considering the large differences between the gears used. Thus, the overall decrease in fishing effort does not necessarily entail a decrease in fishing mortality rates since gears might vary with respect to fishing efficiency. Furthermore, the decrease in effort was not consistent for all gears and/or EMUs (yet, some areas did show a notable decrease in fishing intensity, e.g. the southern Baltic coastal areas, see above). Accordingly, the presented results remain somewhat inconclusive and it is unclear to which degree they are related to uncertainties in the model and/or respective input data.

It should be further noted, that although other anthropogenic mortalities are presumed to be almost exclusively caused by hydropower, ΣH (Table 16) is not considered a good indicator for the development of mortality at hydropower plants and pumping stations. A detailed explanation is given by Fladung and Brämick (2018). Briefly, anthropogenic mortalities were calculated for every year separately (and not for a given cohort) and are thus linked to yearly recruitment. Accordingly, the effect of measures will only be fully represented in these figures, once the stock is fully comprised of cohorts that are affected by these measures and the results refer to the whole stock. To get a more realistic picture, hydropower losses were calculated separately based on the fraction of silver eels only, which revealed that hydropower mortality remained constant over the observed time period (Fladung and Brämick, 2018).

Table 14. Eel landings from commercial and recreational fishing (in tons) in Germany by EMU, expressed as silver eel equivalents. Change is calculated as the average from 2005–2007 to the average of 2014–2016.

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

Table 15. Losses of eels due to hydropower and cooling water intakes (in tons) in Germany by EMU, expressed as silver eel equivalents. Change is calculated as the average from 2005–2007 to the average of 2014–2016.

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

Table 16. Development of anthropogenic mortalities after the implementation of eel management plans.

EMU	ΣF			ΣH			ΣA		
	2005– 2007	2014– 2016	Change (%)	2005– 2007	2014– 2016	Change (%)	2005– 2007	2014– 2016	Change (%)
Eider	0,02	0,01	-1	0,01	0,01	-3	0,03	0,03	-2
Elbe	0,60	1,15	93	0,27	0,27	0	0,87	1,42	64
Ems	0,13	0,11	-12	0,01	0,10	0	0,14	0,12	-11
Maas	0,69	0,73	6	0,11	0,11	0	0,80	0,84	5
Oder	0,18	0,20	9	0,02	0,00	-88	0,20	0,21	1
Rhine	0,30	0,26	-15	0,75	0,64	-15	1,05	0,89	-15
Schlei/Trave	0,06	0,03	-40	0,00	0,00	-64	0,06	0,03	-41
Warnow/Peene	0,06	0,07	31	0,00	0,00	-51	0,06	0,07	30
Weser	0,30	0,34	14	0,19	0,20	6	0,49	0,54	11
Total	0,13	0,14	8	0,06	0,04	-34	0,19	0,18	-5

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

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

5 Other data collection

5.1 Recruitment time-series

At present, three German recruitment time-series are included in the international assessment (Frische Grube, Wallensteingraben, Dove Elde eel ladder). A summary of available recruitment time-series is given in the ICES data call accompanying this report.

Since the early 2000s, immigration and upstream migration of young eels have been monitored on some locations in Mecklenburg-Pomerania (Ubl and Dorow 2010; Frankowski, 2015), as summarized in earlier WGEEL reports and the 2018 ICES data call.

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

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

Further monitoring activities have been started in the recent years in the EMUs Ems (Salva, 2013; Salva *et al.*, 2014; 2015; 2016; Simon *et al.*, 2016) and Rhine (pers. comm. Karin Camara). However, these new activities are so far not considered 'time-series'.

Summarized data of all monitoring activities will be available through the WGEEL database and was reported in the 2017 and 2018 ICES data calls on eel.

5.2 Yellow eel abundance surveys

In 2014, 2016 and 2017, an abundance survey for eel in the Schleswig-Holstein part of the Baltic Sea was carried out, using a standardized catching method that catches eel >36 cm quantitatively using an enclosure approach of Ubl and Dorow (2015). Two years of survey do not yet allow deducing trends or changes over time.

The enclosure monitoring approach is running in the coastal waters of Mecklenburg-Vorpommern since 2008. In 2015 and 2016 an experimental evaluation of the fishing efficiency of the enclosure-fykenet system was conducted (Dorow *et al.*, in press)

5.3 Silver eel escapement surveys

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

continued in order to gain information about the effects of the opening of the Haringvliet sluices (Rhine-Meuse Delta) in 2018.

A scientific stow net is used to monitor the silver eel escapement in the River Warnow (EMU Warnow/Peene). Since 2009, the stow net is fished in standardized way (Reckordt *et al.*, 2014). After a decrease in the catch rates till 2015, an increase of the silver eel escapement were observed in 2016. High escapement rates were also detected in 2017 compared to the same time period of the years before (2012–2015).

5.4 Biological parameters

Eel data collection under the DCF

Sampling of European eels in freshwater is mandatory under the DCF started in spring 2009. Data were collected according to commission decision 2008/949/EC and the respective national work plan of Germany. Though, following the ratified national work plan, data collection was only mandatory for 600 eels from the Baltic and 300 eels from the North Sea, sampling aimed at fulfilling the target set by the Commission decision. Hence, biological parameters (i.e. length, weight, age, sex and maturity) were collected in all RBDs except Meuse (no commercial fisheries) and Danube (no natural habitat of *A. anguilla*), aiming at the collection of 100 yellow- and silver eels per EMU, if possible. Some additional parameters were and will be analysed, such as *Anguillicola crassus* infestation and concentration of some contaminants. However, these additional investigations are not mandatory under the DCF.

With the implementation of the multiannual program for the collection, management and use of fisheries data (EU MAP, EU 2016/1251) in 2016, the data collection was renewed. Since large parts of the required data can only be provided through modelling, sampling is now focused on providing system-specific data on local eel subpopulations in order to improve input data for the GEM and validate the results. The respective data requirements (mostly data related to silver eel escapement) were elicited on a national level in close cooperation with national authorities and in accordance with end-user needs (e.g. ICES Data call, EMP progress reports, management authorities). Furthermore, sampling is conducted in a way that minimizes the amount of sacrificed fished to a required minimum, thus age readings are only conducted if directly required by relevant end-users. Details on the data collection for the period from 2017–2019 are specified in the National Workplan for Germany.

At present, no data on the fishery itself are sampled within the DCF. This was decided, because a lot of these data have to be obtained in the frame of the Eel Management Plans and the formal and administrative requirements of the EU Council Regulation 1100/2007.

To this day, a total of 7526 eels were analysed within the DCF.

Since 2015 a project with the aim of comparing the performance (survival, growth) of stocked glass eels and stocked farm eels has been carried out in parts of the Schleswig-Holstein Baltic Sea, which was finished in 2018 (at the time of this report no complete summary of the results was available). This project also investigates the infection with the Herpes virus anguillae (HVA) (Kullmann *et al.*, 2017a/b).

Aiming to evaluate the efficiency of glass eel stocking in coastal waters of the southern Baltic a scientific stocking experiment was started in the coastal waters in 2014 (Dorow and Saarschmidt, 2014). First recaptures of stocked eels marked with Alizarin red indicate high growth rates compared to nearby inland waters during the first period of the

continental life phase in brackish coastal waters (Simon *et al.*, 2017). Furthermore, growth differences between natural immigrants and stocked eels were detected where three year aged stocked eels showed higher total lengths compared to three year aged natural immigrants (Wichmann *et al.*, 2018).

5.5 Parasites and pathogens

Several studies on eel parasites and pathogens have been conducted during the recent years, but usually not on a regular basis. Though, in the course of the DCF-sampling, the infestation with *Anguillicola crassus* is monitored regularly, results have not been published yet.

Here a short description of the results of studies in this field from the recent years is given to allow an overview about the general situation in German waters.

Leuner (2013) studied the infestation with *A. crassus* in eels in Lake Starnberger See. In 2013, the swimbladders of 90 eels were investigated in September and October and a prevalence of 87% was found (for comparison: 1998: 91%, 2006: 61%, 2012: 81%). Most recent results (Leuner, 2015) indicate that the prevalence of *A. crassus* declined to 61%. Infection intensity was highest in 1998 (12 nematodes per swimbladder) and varied between five and nine parasites per swimbladder in the following years. In 2013, the value was six parasites per swimbladder. The proportion of swimbladders showing callosity was 18% in 1998 and increased to 100% in the following years. In 2012 (55%) and 2013 (56%) smaller proportions of callosity were documented, possibly because younger eels had been studied. Most recent results (Leuner, 2015) indicate that the prevalence of *A. crassus* declined to 61%.

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

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

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

found. Information on the *A. crassus* infection in two lakes in the state Mecklenburg-Vorpommern including the infection rate of wrongly stocked American eels (Frankowski *et al.*, 2013) are provided by Thieser *et al.* (2013).

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

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

5.6 Contaminants

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

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5.7 Predators

In Table 17, the estimates for predation of eels by cormorants for the German RBD's between 2005 and 2010 are given. Since then, predation has been included in the term “natural mortality”. The order of magnitude has probably not changed drastically since 2010. Estimates are based on numbers of cormorants in the relevant regions and proportion of eels in the diet of cormorants. The most recent EMP progress report (Fladung and Brämick, 2018) further highlights that predation by cormorants is most relevant in age groups 2–4, causing ~15–26% of the overall mortality (average of all EMUs between 2014–2016).

Table 17. Estimates of predation on eels by cormorants for the German EMUs (t).

RBD	2005	2006	2007	2008	2009	2010
Eider	26	27	28	29	29	28
Elbe	127	111	97	93	82	75
Ems	4	4	3	3	3	2
Maas	<1	<1	<1	<1	<1	<1
Oder	33	24	21	21	21	19
Rhine	16	15	13	13	12	12
Schlei/Trave	82	86	81	81	83	79
Warnow/Peene	11	8	8	8	7	6
Weser	5	5	5	9	9	9
Total	303	281	268	257	246	231

6 New information

A study by Kullmann *et al.* (2018) presented an approach for mass marking of glass eels with ARS and Sr, investigating the effect of marking on mortalities. The presented approach had no significant effect on mortality and is thus considered a practicable approach for future investigations on stocked eels.

Simon *et al.*, 2018 investigated different approaches for holding glass eel in captivity, in case conditions for stocking are unfavourable (e.g. low temperatures, ice covers). They concluded that for time spans of <four weeks, glass eels should be kept in farms at low temperatures (4–5°C, preferably unfed), while case of longer periods, they advise to increase temperatures to 12–14°C, feed eels and conduct regular size gradings in order to minimize mortalities.

In 2018, Pohlmann *et al.* published a methodical paper comparing different approaches for the determination of fat content in European eels. The findings raised general concerns about the fat contents derived by current standard methods, particularly with

differences between yellow and silver eels. Furthermore, a correction factor is provided for the Distell Fatmeter, improving the use of the device for non-lethal estimation of fat contents (Pohlmann *et al.*, 2018).

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

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1 Stock status summary

The calculation of the indicators was based on the data provided by the General Directorate for Fisheries of the Ministry of Rural Development and Food, as in 2017 due to bureaucratic issues the procedures for funding the Universities of Ioannina and Patras for gathering all the needed data for the assessment of the species in EMU 1 and 2 were not completed.

EMU_code	Assessed Area (ha)	B ₀ (kg)	B _{curr} (kg)	B _{best} (kg)	B _{curr} /B ₀ (%)	ΣF	ΣH	ΣA
GR_NorW	18,158.98	100,297.00	21,749.4	53,275.30	21.69	0.84	0.04	0.88
GR_WePe	6,567.84	5,300.00	22,217.70	22,217.70	419.20	4.77	0.24	5.01
GR_EaMT	18,240.00	72,240.00	1,876.70	2,410.70	2.60	0.176	0.009	0.185
GR_CeAe	22,472.80	0.00	0.00	0.00		0.000	0.000	0.000
GR_Total	65,439.62	177,830.00	45,843.70	77,903.60	25.78	0.060	0.003	0.063

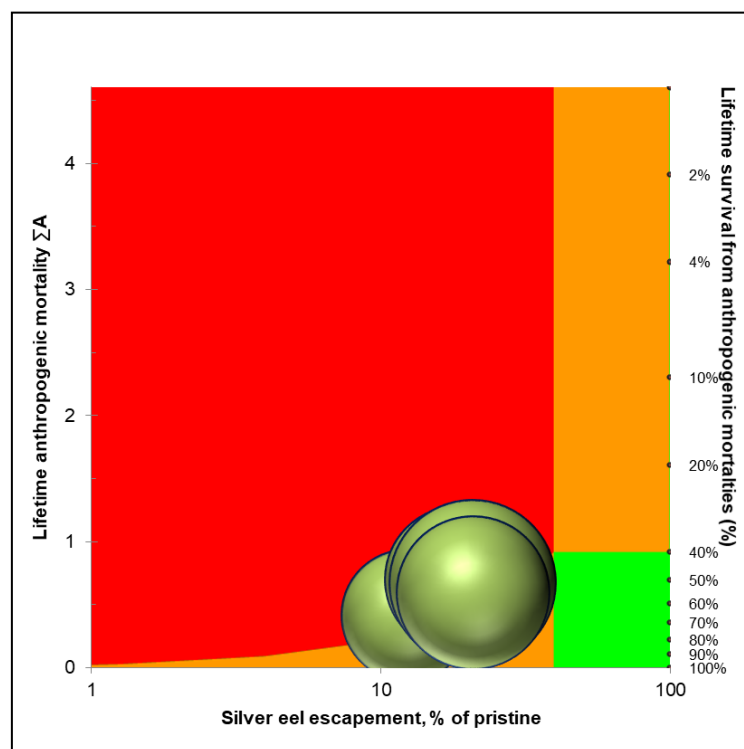


Figure 1. Status of the stock and the anthropogenic impacts, for total Greek EMUs in 2017 (average 2014–2017). For each, the size of the bubble is proportional to B_{best} , the best achievable escapement given recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the stock status related to pristine conditions while the vertical axis represents anthropogenic mortality.

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

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

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

EMU-01 (seven Prefectures, three Regions) is located in northwestern Greece. It comprises 70% of the total Hellenic lagoons surface and 45% of the lakes surface. Despite

the considerable decrease of the EMU-01 landings (180 t in mid-1980, 50 t the recent years), the unit remains the most important eel producer.

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

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

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

The eel fishery usually is performed with traditional traps, which catch live eels during their reproduction migration carried from September to January every year. The fykenets are also used in certain lagoons, where no permanent installed traps exist or during the year except the period of migration. The 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 be declared 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 (fykenets). However, this fishing method, due to the fact that catches have declined significantly during the last decades, has almost disappeared. However, after the implementation of the Ministerial Decision 643/39462/01-04-13 (in the implementation of the European Regulation 1100/07) an eel fishery with fykenets is also banned.

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

One of the first measures implemented was the release by the fishermen of 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 licences are needed for eel exports, the concealing of real catches decreased.

Also, other important measures for the protection of the species is the ban of eel fisheries in rivers and estuaries with any type of gear and the ban of fisheries with fykenets

inside the lagoons. In addition all the eels that are going to be exported in other EU countries or transported inside the country are allowed only after the issue of licence in accordance to the regulations of CITES.

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

2.2 Significant changes since last report

Since the last report, there weren't any significant changes.

3 Impacts on the 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 fykenets 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 is implemented by using fixed fishing installations in the lagoons, the fishing effort is considered stable during the years, changing only by the number of lagoons, where fishing is applied. Due to the specific fishing methodology, the fishing capacity is equal to fishing effort, since it is a passive fishing device and the fishing effort is not affected by any other factor such as fuel consumption.

3.1.1 Glass eel fisheries

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

3.1.2 Yellow eel fisheries

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

3.1.3 Silver eel fisheries

Most of the eels are caught in the lagoons using fixed barrier fish traps. The lagoons are leased and operated by 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.

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

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

The total landings in 2017 for the three EMUs (EMU-1, EMU-2 and EMU-3) were 62.171 t. In EMU-1 (GR_NorW) the landings recorded were 45 037 kg, in EMU-2 (GR_WePe) the total landings were 16 600 kg and finally in EMU-3 (GR_EaMT) the landings were 534 kg.

3.2 Restocking

According to the Greek EMP, 10% of the imported glass eels for rearing must be used in stocking actions in selected ecosystems. Since 2009 that the HEMP was officially accepted this action is taking place every year. According to the CITES office, in 2017, two (2) permissions were issued for the import of 496 kg of glass eel from UK, 49.6 kg of which were released in estuaries.

Moreover, the fishing cooperatives that manage the lagoons are obliged by CITES to release the 30% of the annual silver eels catches in order to get a permission to export silver eels to other EU countries. For 2017, the total biomass of silver eels that were released was 18 827.00 kg, which corresponds to a 30.28% of the total annual silver eels catches, while the limit that was set by the HEMP was 30%.

3.3 Aquaculture

The eel exporting licence from Greece during 2017, as reported by CITES, were 17 and 445 870 kg of alive eel were exported. Eleven (11) licences were issued for exporting live eel to Italy, five (5) to the Netherlands and one (1) to Spain.

3.4 Entrainment

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

3.5 Habitat quantity and quality

No data.

3.6 Others

No 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 is an important biometric measurement usually associated with other biological and ecological parameters of the species. Finally, for the determination of the age, the method of age determination through otolith reading was used.

4.1.2 Analysis

Age analysis

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

During 2017, there were further efforts to finalize the method in development. The method that provided the best results was a modification of the Crack and Burn and the Swedish staining procedure (ICES, 2009). Despite the fact that the modified methodology resulted in the better resolution of the annual rings, but still there are questions for some of them.



Fecundity

Within the framework of Fisheries Data Collection Program, determination of eel's sample fertility was carried out. The gonads were examined macroscopically following Tesch (2003) to determine the sex. Pectoral fin length and eye diameter were measured (to the nearest 0.01 mm) to classify eels into silvering stages according to Durif *et al.* (2009). The weight of the gonads has, also, been measured to the nearest 0.01 gr. These measurements were taken to confirm the maturation stage of each specimen of the sample, based on the GSI and Eye index.

Gonadosomatic index (GSI) was calculated as:

$$\text{GSI} = (\text{gonad weight} / \text{body weight}) \times 100$$

and eye index (Pankhurst, 1982), based on the relationship between body length and the mean size of both eyes, was calculated as:

$$\text{Eye index} = [(\text{right horizontal eye diameter} + \text{right vertical eye diameter}) / 4] \times (\text{left horizontal eye diameter} + \text{left vertical eye diameter}) / 4] \times (\pi / \text{body length}) \times 100$$

To ensure eels were sufficiently mature, and to facilitate comparison with other studies (i.e. MacNamara & McCarthy 2012), only eels with an eye index >6.5 (Pankhurst, 1982) and GSI >1.2% (MacNamara *et al.*, 2013) were considered for fecundity analysis. Gonads were treated according to the protocols described by MacNamara and McCarthy (2012).

4.1.3 Reporting

The results of the above mentioned analysis are reported both in the DCF report (STECF, 2015) and also in the country report submitted to the WGEEL.

4.1.4 Data quality issues and how they are being addressed

Assessment results

No data.

5 Other data collection

5.1 Recruitment time-series

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

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

5.2 Yellow eel abundance surveys

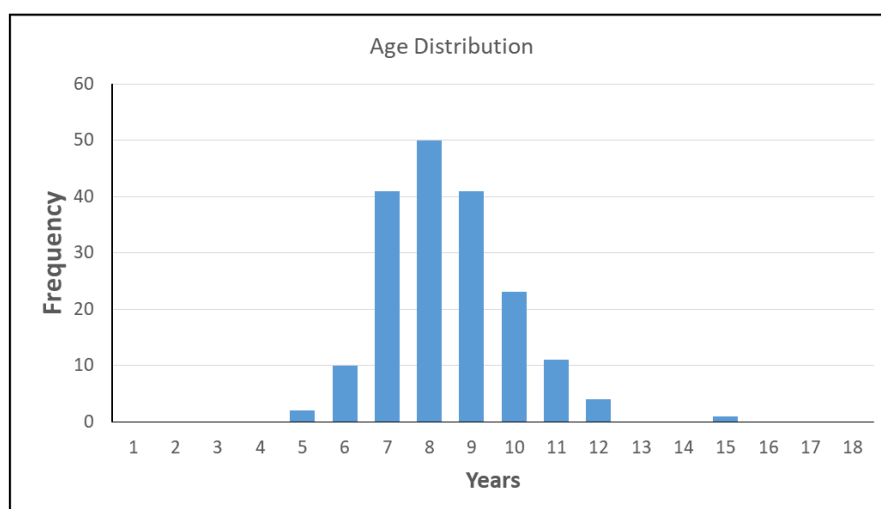
No data.

5.3 Silver eel escapement surveys

No data.

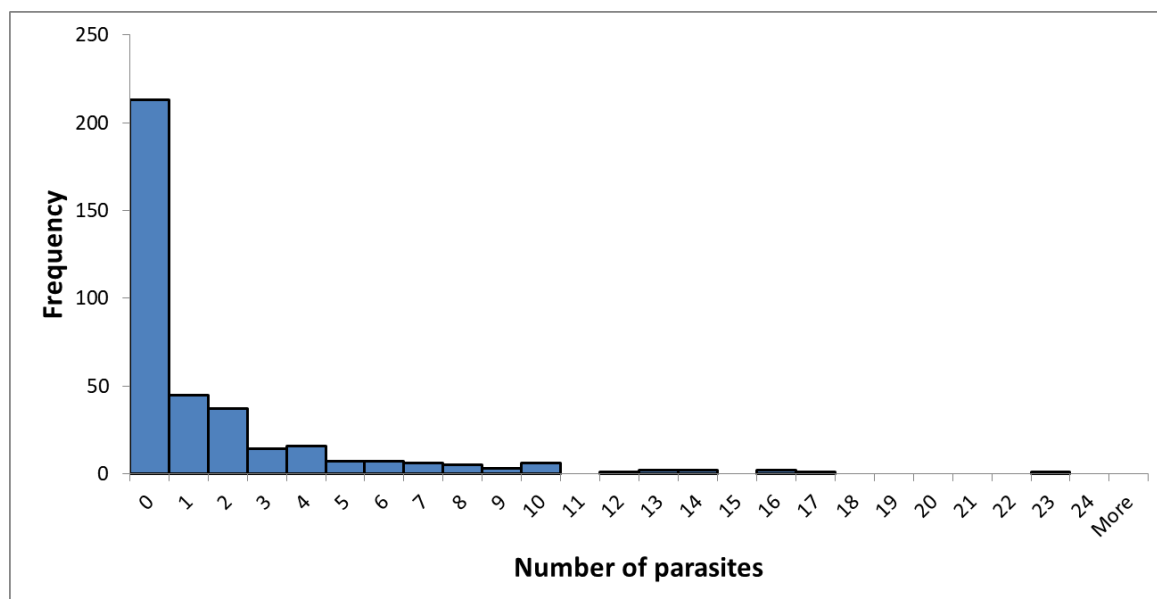
5.4 Biological parameters

The age was determined using otoliths from 183 samples collected from EMU 3. The youngest eels were five years old and the oldest one 15 years old. However, the most abundant class was the eight year olds, and the second most frequent the seven and nine year olds.



5.5 Parasites and pathogens

In two 2017, 57.88% of the eel samples examines were not infected by the parasite *Anguillicola crassus*, and 42.12% were infected by the parasite (one parasite and up to 23 were counted).



5.6 Contaminants

No data.

5.7 Predators

There is insufficient information about the presence of predators or about the impacts that their presence could induce to the populations of eels. The only large predator is the Great Cormorant (*Phalacrocorax carbo*), a fish-eating bird that consumes about 400–500 g of fish per day (Volponi, 1997; Bonetti *et al.*, 1998).

In Greece the Great Cormorant breeds in at least four different regions (Axios and Evros Deltas, in Lake Kerkini and in Lake Prespa), and its population amounts to approximately 4300 pairs. Their population increases during the winter period (ranging from 12 000 to 22 000 individuals) due to individuals traveling to Greece for wintering from northern countries. The majority of the travelling birds are distributed in major wetlands (Evros, Porto Lagos, Amvrakikos, Messolonghi).

6 New information

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

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

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Reporting Period: This report was completed in August 2018, and contains data up to 2017 and some provisional data (recruitment) for 2018.

Contributors to the report:

Electricity Supply Board

Inland Fisheries Ireland

Irish Standing Scientific Committee for Eel

Marine Institute

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Note:

The data presented in this report have been drawn from various sources including the Irish Standing Scientific Committee on Eel Report to IFI/DCENR (2017), the annual IFI Eel Monitoring Programme Annual Reports (O'Leary *et al.*, 2009–2017), annual reports to the ESB and the SSCE by NUIG on Silver Eel Research and trap and transport monitoring (McCarthy *et al.*, 2009–2017), ESB annual data on recruitment and silver eel trap & transport activity, Marine Institute annual stock assessments for the Burrishoole and the 2012, 2015 and 2018 Irish Reports to the EU on the Progress of Implementation of the Eel Management Plans and the accompanying Stock Annex for the Assessment of the Eel Stock in Ireland, including the transboundary IE_NorW (NWIRBD).

1 Stock status summary

The most recent stock status data were completed in 2018. All the available data were included in the EU report data sheets and in the ICES data call 2018.

2 Overview of the stock and its management

This report continues the sequence of reporting annual national eel data to the EIFAAC/ICES/GFCM Working Group on Eel (WGEEL) but under a new electronic format being tested by the WGEEL.

2.1 Describe the eel stock and its management

2.1.1 EMUs, EMPs

The Eel Management Plans were established and implemented for River Basin Districts as defined in Directive 2000/60/EC and in accordance with Article 2 of the Eel Regulation. Ireland submitted a National Report encompassing five River Basin EMPs and one transboundary EMP. These are the Eastern EMP, South Eastern RBD EMP, South Western RBD EMP, Shannon IRBD EMP, Western RBD EMP and the transboundary

North Western IRBD EMP (Figure 2.1). Figure 2.1 also shows the transboundary agreement for the Eastern RBD and Neagh Bann RBDs.

All Irish EMUs are in the ICES Celtic Seas EcoRegion (E).

Inland and estuarine eel fisheries in Ireland were managed by seven Regional Fisheries Boards, divided into Fisheries Districts, and the Loughs Agency. Fisheries District boundaries largely conformed to the arrangement of river catchments. Fisheries management is now undertaken by Inland Fisheries Ireland using the WFD boundaries.

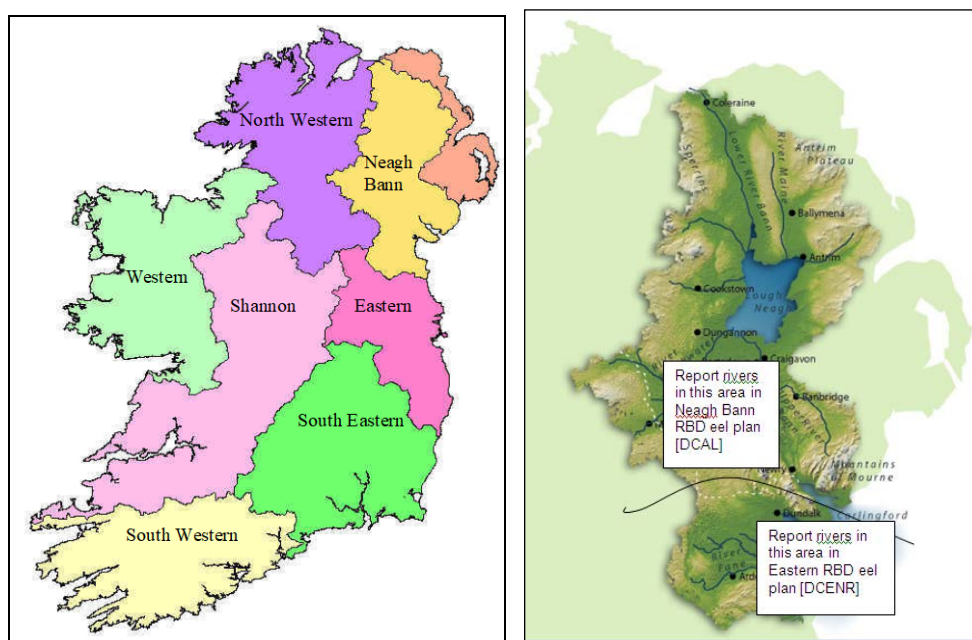


Figure 2-1. Map (left) showing the River basin Districts and the map (right) showing the transboundary agreement between the Neagh/Bann RBD and the Eastern RBD.

2.1.2 Management authorities

The Irish National Programme is conducted in close cooperation between the following organisations.

Department of Communications, Climate Action and Environment

The Department of Communications, Climate Action and Environment is responsible for communications, Climate Action, Environment, broadcasting, energy, natural resources and postal services.

DCCA is the main governmental department with responsibility for inland fisheries policy, management, control and enforcement.

Department of Culture, Heritage and the Gaeltacht (DCHG)

The Department of Culture, Heritage and the Gaeltacht oversees the protection and presentation of Ireland's heritage and cultural assets. Our goals are to promote and protect Ireland's heritage and culture, to advance the use of the Irish language, and to support the sustainable development of the islands.

The Marine Institute (MI) - DAFM

The MI is a semi-state marine research organisation with national responsibility for the provision of scientific advice on eel and the collection of scientific data on the fisheries

sector and the implementation of the module on evaluation of inputs, fishing capacities and fishing effort and the module of evaluation of catches and landings as defined in the Application Regulation of EU Council Regulation 1543/2000.

Inland Fisheries Ireland - DCENR

Inland Fisheries Ireland (IFI) was formed in 2010 following the amalgamation of the Central Fisheries Board and the seven former Regional Fisheries Boards into a single agency. Inland Fisheries Ireland is responsible for the protection, management and conservation of the inland fisheries resource across the country, including implementation and monitoring of the Irish eel Management Plans. Ireland has over 70 000 kilometres of rivers and streams and 144 000 hectares of lakes all of which fall under the jurisdiction of IFI. The agency is also responsible for sea angling in Ireland.

National Parks & Wildlife – DCHG

The National Parks and Wildlife Service (NPWS) section of the Department manages the Irish State's nature conservation responsibilities under national and European law. A particular responsibility of the NPWS is the designation and protection of Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and Natural Heritage Areas (NHAs). NPWS is responsible for CITES.

Electricity Supply Board (ESB)

The ESB is a state owned utility company that generates, supplies and sell electricity in Ireland. As part of the generation portfolio, the ESB has a statutory role in preserving and developing the Shannon fishery, since the establishment of a hydroelectric scheme on the river when the government transferred all fishing rights to the company in 1935. Under the Eel management Plan, the ESB is responsible for implementing the silver eel trap and transport schemes on the Shannon, Erne and Lee along with the recruitment trapping and transport upstream of juvenile eel (which form an important part of the recruitment time-series).

The Loughs Agency

The Loughs Agency aims to provide sustainable social, economic and environmental benefits through the effective conservation, protection, management, promotion and development of the fisheries and marine resources of the Foyle and Carlingford Areas.

Department of Agriculture Environment & Rural Affairs (DAERA, formerly DCAL)

In Northern Ireland, overall responsibility for the implementation of Eel Management Plans (including the trans-boundary North West International RBD) and the supervision and protection of eel fisheries rests with the Department of Agriculture Environment & Rural Affairs (DAERA, formerly DCAL). The Agri-Food and Biosciences Institute for N. Ireland (AFBI) are employed by DAERA to provide the scientific basis for eel management in the relevant Northern Ireland and associated trans-boundary EMP's.

Standing Scientific Committee on Eel

The Standing Scientific Committee on Eel (SSCE) was established under Section 7.5 (a) of the 2010 Inland Fisheries Act. The purpose of the committee is to provide independent scientific advice to guide IFI in making the management and policy decisions required to ensure the conservation and sustainable exploitation of the Ireland's eel stocks. The SSCE is comprised of representatives from the relevant State Agencies, and its ToR is to define and oversee a programme of monitoring, stock assessment and post-evaluation of management measures and to provide advice on eel.

In 2017, a North–South Standing Scientific Committee was established to provide advice on relating to the conservation and sustainable exploitation of the inland fisheries resource. As part of this process, the SSCE was discontinued and a new Technical Expert Group on Eel (TEGE) is being established in 2018.

2.1.3 Regulations

The target set for the Irish Eel Management Plan 2012–2014 was to have zero fishing mortality and reduce illegal capture and trade to as near zero as possible.

In May of 2009 Eamon Ryan, Minister for Communications, Energy and Natural Resources passed two Bye laws closing the commercial and recreational eel fishery in Ireland. The byelaw which prohibited the issuing of licences was continued. However, on expiry of Bye law C.S. 312 of 2012, a new byelaw was required to prohibit the fishing for eel, or possessing or selling eel caught in a Fishery District in the State for a further period until June 2018.

- Bye-Law No 858, 2009 prohibits the issue of eel fishing licences by the regional fisheries boards in any Fishery District.
- Bye-law No C.S. 303, 2009 prohibits fishing for eel, or possessing or selling eel caught in a Fishery District in the State until June 2012. (Revoked).
- Bye-law No C.S. 312, 2012 prohibits fishing for eel, or possessing or selling eel caught in a Fishery District in the State until June 2015. (Revoked).
- Bye-law No C.S. 312, 2015 prohibits fishing for eel, or possessing or selling eel caught in a Fishery District in the State until June 2018.

It should be noted that since EU Commission ratification of the Ireland/UK NWIRBD transboundary plan in March 2010, the fishery in the NI portion of the Erne was closed from April 2010.

Following a public consultation in June 2015, Minister McHugh signed a new byelaw (C.S. 319/2015) on the 23rd November 2015 prohibiting fishing for eel, or the possession or sale of eel caught in Ireland.

2.1.4 Management actions

Eel management plans were submitted to the EU in early January 2009 and these were accepted by the EU in early July 2009 and implemented by Ireland in 2009. The plans were continued through 2009–2011, for 2012–2014 and again for 2015–2017. The only modification in 2012 being how the target for the silver eel trap and transport programme on the Erne was determined. The following is the Executive Summary from the National Report (Irish EMPs) to the EU (2008) updated where relevant with new information.

There are four main management actions aimed at reducing eel mortality and increasing silver eel escapement in Irish waters. The four main management actions were as follows;

- a cessation of the commercial eel fishery and closure of the market;
- mitigation of the impact of hydropower, including a comprehensive trap and transport plan to be funded by the ESB;
- to ensure upstream migration of juvenile eel at barriers;
- to improve water quality.

Under the EC Regulation (EC No. 1100/2007), each Member State shall report to the Commission initially every third year until 2018 and subsequently every six years, addressing the following;

- monitoring;
- the effectiveness and outcome of the Eel Management Plans;
- contemporary silver eel escapement;
- non-fishery mortality;
- policy regarding enhancement/stocking.

2.1.5 Eel management plan

Ireland established a National Working Group on eel management in 2006, in advance of the agreement of the Regulation (EC) No. 1100/2007, in order to begin the preparatory work required and Irish scientists participated in Working Groups and EU projects (i.e. EU SLIME) in developing methodologies and data collection and modelling for eel stock assessment.

2.1.5.1 Description of the Eel Management Units

Current management of migratory species in Ireland, salmon and sea trout, has been at the catchment level and it is therefore logical to expand this to encompass the management of eel. A GIS based data model was established for the quantification of the freshwater salmon habitat asset and for the determination of the quantity of habitat available to migratory salmonids. 261 discrete migratory salmonid 'Fishery Systems' were identified. Four Northern Ireland catchments have now been included in this quantification in support of the NWIRBD transboundary management plan. It is likely that eels are present in the majority or all of these systems. Commercial fishing probably only takes place in 4.6% of the catchments, although this accounts for some 71% of the total wetted area.

The estimated total wetted area of the 265 lake, river and stream habitat accessible to migratory fish (including 1st order streams) in Ireland (including the Northern Ireland part of the Erne and the Loughs Agency Rivers in the Foyle and Carlingford areas) is 153 881 ha. The 265 "migratory" systems were estimated to contain 132 275 ha of lake habitat and 21 606 ha of fluvial habitat, of which 2826 ha is estimated to be 1st order stream. The ShIRBD, WRBD and NWIRBD are dominated by lacustrine habitat.

The catchments have been characterised on the basis of their underlying geology, specifically in terms of the proportion of the surface area comprising calcareous and non-calcareous types. This catchment characterisation led to a continuous summary variable for catchment freshwaters, i.e. the proportion of wetted area comprising non-calcareous geology. Lacustrine habitat dominates Ireland's freshwaters, comprising more than 85% of the wetted area. Similarly, calcareous habitat heavily dominates overall.

Water quality in Ireland is generally good and compares favourably with other Member States. The main challenge for water quality is to deal with eutrophication arising from excess inputs of nutrients from all sources. The extent of eutrophication has been increasing persistently since the 1970s and is probably the most serious environmental pollution problem in Ireland. Poor water quality impacts on the potential of rivers to produce salmon. It is unknown whether similar poor water quality levels have an effect on eel. Nationally (RoI), the current water quality in 82.7% of the habitat available for salmon production is unpolluted, a further 12.8% is considered slightly polluted

and the remaining 4.5% is considered to be moderately or seriously polluted. In general, persistent organic pollutants were relatively low in the Irish eels sampled to date.

Anguillicola crassus continues to spread and more than 70% of the wetted area is now infested (Beccera-Jurado *et al.*, 2014).

Six catchments in Ireland have major hydropower installations in the lower catchments. 46% of the available wetted habitat is upstream of major barriers, although there is a greater proportion (53%) of the potential silver eel production when the differences in relative productivity are taken into account. An average mortality of 28.5% per turbine installation (ICES, 2003) was used in assessing the impact of hydropower for the purpose of setting up the EMPs. This mortality figure has since been updated for both the Erne and the Shannon with catchment specific estimates reported in the 2012 and 2015 Reports to the EU (Anon, 2012, 2015). Immediate measures were put in place to mitigate against turbine mortality, including silver eel trap and transport on the Erne, Shannon and Lee, with the aim of establishing long-term 'engineered' solutions to reduce HPS mortality. These measures are outlined in the management actions section of the National Eel Management Plan (2008). It is also recommended that all new hydropower turbines and potential barriers to upstream migration should be evaluated in Environmental Impact Assessments for potential impacts on eel.

Natural mortality of eels is a major, but relatively unknown, factor in the population dynamics of eels and mortality caused by predation is one of the factors contributing to natural mortality. There are few data on the level of predation on eel in Ireland or on the impact on the eel stock. The most recent census of cormorants in Ireland (Seabird 2000 breeding survey) reports that the Irish coastal population has remained stable since the previous census (1985–1988). Other legislation must be complied with when considering possible actions against predators.

2.1.5.2 The eel fishery

Glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act). The commercial eel fishery involved harvesting both yellow and silver eel in freshwater and in estuarine or tidal waters. Yellow eel were fished using a variety of techniques, the most common of which are baited longline, fykenets and baited pots. When silver eel were migrating downstream are caught in fykenets and stocking-shaped nets called "coghill nets" which are attached to fixed structures in the river flow, often at "eel weirs". The declared commercial eel catch in the Irish Republic, 2001–2007, ranged from 86 t to 120 t involving about 150–200 part-time fishermen, but inadequate reporting and illegal fishing makes this difficult to quantify accurately and it maybe a substantial underestimate. A total maximum of 278 licences were issued in 2006 and a maximum of 182 of these were actively fished in 2005. The value of the reported catch was therefore in the order of €0.5 million to €0.75 million.

In May 2008, a byelaw was introduced (Conservation of Eel Fishing (Annual Close Season) Bye-law No. C.S. 297, 2008) restricting the fishing season for both yellow and silver eel. Analysis of the impact of implementing a Yellow eel fishing season from 1st June to 31st August and a Silver eel season from the 1st of October to 31st December showed the impact of the reduced fishing season would have been different in each Region with the level of reduction ranging from 7 to 42% in yellow eel catch and 0–40% in silver eel catch.

Recreational eel fishing is only carried out by a minority of rod anglers and there is no legal, or voluntary, declaration of catch which is probably relatively small. There is no

legislation protecting eels from angling. All other fishing engines, including, fykenet and baited pots, are authorized under the commercial legislation.

There is no eel culture in Ireland at the present time and none is envisaged in the near future.

NOTE: the commercial eel fishery was closed in Ireland in 2009 and possession of eel caught in the State was deemed illegal. Eel captured in the recreational fishery (angling) should be released.

2.1.5.3 Escapement–local stock modelling

The Irish Management Plans will include a time period for detailed data collection and a parallel program of stock assessment, including silver eel escapement estimates, and model development. In the interim, the three options proposed in the Eel Regulation were used to make preliminary estimates of pristine production and current escapement. The approach outlined in Article 2 of the Eel Regulation (EC No. 1100/2007) was followed to calculate pristine and current escapement and a simple model was proposed to project the impact of management actions on escapement from freshwaters.

No estimates of truly pristine escapement exist for Irish eel freshwater catchments. Historical production of silver eels was calculated (for freshwaters only) using catch series for four catchments (where the fishery efficiency was estimated) for periods prior to 1980. These data were calibrated using eel growth rates for 17 catchments and a regression model was developed relating production to catchment geology, a proxy for productivity. This gave historic production rates of 0.93 kg/ha (Burrishoole–unproductive) to 5.5 kg/ha (Moy–productive) and total historic silver eel potential production (without anthropogenic mortality) of 589.4 t per annum.

Current production estimates were calculated for inland waters for each year from 2009 and for averages for the 2009–2011, 2012–2014 and 2015–2017 periods using the regression model relating production to catchment geology, a proxy for productivity (IMESE).

No assessments were made of the stock indicators for coastal waters. A preliminary assessment was made in 2018 of possible eel production from transitional waters, not previously reported on, using a combination of field cpue data, physical characterisation of types of transitional waters and annual eel production rates from freshwater.

These data are reported in the electronic tables to the EU and the ICES data call.

Due to the last 20+ years of low and declining recruitment, regardless of which management actions are taken, achieving the 40% EU target in the long term will require a recovery of recruitment arising from concerted international action and cannot be achieved in Ireland alone. It was difficult to assess a time frame for recovering the predicted downward trend in escapement in the absence of knowing what the European recruitment levels will be in future and in the absence of a clear time frame from the EU. To facilitate setting a time-scale to recovery it was decided to adopt the approach used by Astrom and Dekker (2007) in predicting the recovery time for recruitment under different reduced levels of mortality. Two assumptions were made: the first that Europe responds in a similar fashion to reducing mortality and the second, that as recruitment recovers towards historical, the Spawning–Stock Biomass is recovering towards the target. Therefore, recruitment recovery is used as an alternative target towards the escapement target. It is also possible that the EU biomass escapement target may be reached in a shorter time-scale than will full historical recruitment.

2.1.5.4 Stocking

Purchase of glass eel for stocking from outside the state has not taken place in the last 20 years (at least) and does not currently take place. Assisted migration of upstream migrating pigmented elvers takes place in the Shannon (Ardnacrusha) and Erne (Cathaleen's Fall) and of pigmented young eel (bootlace) on the Shannon (Parteen Regulating Weir). Prior to 2009, small amounts of glass eel and elver were taken in the Shannon estuary and in neighbouring catchments and these were stocked into the Shannon above Ardnacrusha and Parteen HPSs. Given the widespread presence of *Anguillicola* and the move towards risk averse management strategies at low recruitment levels, this practice was **discontinued**.

2.1.5.5 Monitoring and post-evaluation

The national plan describes a comprehensive programme of monitoring and evaluation of management actions and their implementation, and also a programme of eel stock assessment to establish a stock baseline, estimate silver eel escapement and monitor the impact of the management actions on the local stocks.

Ireland is committed to compliance with the Data Collection Framework. Given the cessation of the fishery there was no obligation to undertake sampling under the DCF in 2009–2011.

Ireland has submitted the 2012 and 2015 Reports to the EU with annexed science reports on the status of the eel stock in Ireland. The scientific assessment for 2015–2017 was completed in May 2018 and the 2018 report to the EU has been drafted (June 2018).

2.2 Stock status

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

The estimation of pristine and current (2008 based on the average of 2001–2007) silver eel biomass being produced and escaping was fully described in the National Eel Plan (2008, Ch.5) and in ICES (2008, page 47). The calculation of pristine productivity for exploited catchments requires estimates of silver eel escapement along with historic silver and yellow eel catches, raised to account for unreported and also illegal catches. Historical catch records for silver eel fisheries were available for the five catchments of the Corrib, Moy, Garavogue, Burrishoole and Erne. The efficiencies of the fisheries had been previously estimated for the Shannon, Corrib and Erne silver eel fisheries. Where fishery efficiency was not measured an approximately average value of 33% was used to calculate escapement. In addition to the catch at the recording station and escapement past the recording station the yellow eel and silver eel catches made upstream were included to estimate pristine productivity. In the absence of historic data for these latter parameters (yellow and silver eel catches upstream of the recording station) it was assumed that the yields were equal to those currently observed (2001–2007). A similar process was used to calculate the 2008 production, based on the average of 2001–2007, and escapement using data from four catchments, the Shannon, Corrib, Burrishoole and Lough Ennell (estimate based on depletion fishing surveys by NUIG).

In the EMP (2008) for those catchments with hydropower at the lower end of the catchment (Shannon, Erne, Liffey and Lee), an estimate of the impact was derived by imposing a 28.5% mortality per turbine passage (ICES, 2003). Therefore, the probability of surviving passage through 'n' number of hydropower installations is $(0.715)^n$. In the

2012 and 2015 reports to the EU, we have recalculated these estimates using the newly available HP mortality data.

Silver eel production was determined for the other catchments by using a habitat-based approach. The method involved determining the relationship between productivity and the geological characteristics of the catchment.

In the EMP and the 2012 report to the EU, growth rates of eel were available for 17 catchments (Moriarty, 1988; Poole, pers com., WFD). The wetted area within each catchment was quantified using a geographical information system and classified according to the proportion of the catchment area comprising non-calcareous geology. For 17 catchments growth rate was found to be closely negatively related to the proportion of the catchments comprising non-calcareous geology. This allowed the estimation of silver eel production to be made on the basis of geology (natural productivity) and growth rate.

The growth rate data were updated in 2014 with new validated data collected during the 2009–2012 surveys. These data were used in this report to reanalyse the 2008 and 2009–2011 extrapolations and to calculate the production in 2012–2014 and these are reported here.

2.2.1 EMP Progress Report summary data

As set out in the EU template for the National Report 2012, the following definitions are adhered to:

B_0 The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock.

B_{current} The amount of silver eel biomass that currently escapes to the sea to spawn.

B_{best} The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock.

ΣF The fishing mortality rate, summed over the age groups in the stock, and the reduction effected.

ΣH The anthropogenic mortality rate outside the fishery, summed over the age groups in the stock, and the reduction effected.

R The amount of glass eel used for restocking within the country.

ΣA The sum of anthropogenic mortalities, i.e. $\Sigma A = \Sigma F + \Sigma H$.

Stock indicator and mortality data are presented in the Ireland reports (2012, 2015, 2018). The following text is extracted from the 2018 EU Report Stock Annex.

2.2.2 Historic silver eel biomass (B_0)

Estimates of historic biomass were presented for each Eel Management Unit (EMU). During the course of 2009–2011 and the 2012 review, two errors were identified in the calculations, one in the Corrib historic escapement and one in the Erne historic escapement. This changed the estimated production in the Corrib from 3.38 kg/ha to 3.57 kg/ha and in the Erne from 4.50 kg/ha to 4.14 kg/ha. The corrected data for the two catchments are given in Table 2.3.

When the corrected data were inserted into the model for determining historic production for all the catchments, it made only a small difference in the overall silver eel production biomass estimate for each EMU and for the % escapement and this was reported in 2012 (Anon, 2012a) (Table 4.4).

It is not known how accurate the historic estimates of B_0 are, as there was a lack of information on historical fishing catches and levels of undeclared catches. It is now appearing likely that these catches were underestimated and that B_0 estimates were set too low.

2.2.3 Current (2008) silver eel biomass (B_{best} , $B_{2001-2007}$), pre-EMP

The production (B_{best}) and escapement ($B_{2001-2007}$) estimates presented in the EMPs are shown in Tables 2.3 and 2.4. The escapement was determined by subtracting the fisheries catch, raised to account for illegal and unreported, and then the remaining silver eel production was subjected to hydropower mortality at 28.5% per hydropower station where these occurred. The escapements in 2008 were recalculated using the estimates of HPS mortality determined between 2009 and 2011, on the Shannon (21.1% and 17.8% bypass) and the Erne (cumulative 23%) and this was reported in 2012 (Anon, 2012a).

2.2.4 Current (2009–2014) silver eel biomass (B_{best} , $B_{2009-2014}$), Freshwaters

The silver eel biomass produced and escaping during 2009 to 2014 in the monitored index catchments is given in Table 2.10.

These index data were then used to calibrate the IMESE model. The new growth data were used and the new estimates were quite close to those presented in the 2012 report (See Stock Annex 2015b). Where direct estimates of production were available for individual catchments, these were used instead of a modelled figure. It should be noted that the silver eel index locations were all on the west coast in 2009–2014. This may lead to inconsistencies when extrapolating to the east and south coast catchments. While a similar scenario existed for setting up the EMP, it is hoped to include at least one silver index on the east coast in the next three year period.

2.2.5 Current (2015–2017) silver eel biomass (B_{best} , $B_{2015-2017}$), Freshwaters

The silver eel biomass produced (B_{best}) and escaping ($B_{current}$) during 2015 to 2017 in the monitored index catchments were fully described in Chapter 3 of this report and in Table 2.10.

For the assessment of the 2015 to 2017 period, the IMESE model was run as in the previous years, using the Shannon (2016–2017), the Erne (2015–2017) and the Burrishoole as reported in Chapter 3 as index catchments. The model was also run including a new Index catchment, the Fane, which is situated on the East coast (IE_East). This addresses a previously identified criticism that all the indices were on the west coast. However, the inclusion of the Fane changes the model outputs. For consistency, outputs from IMESE are presented with, and without, the new index and the midpoint between the two values is reported for 2015–2017. The trends of the two model outputs are similar, but it is not known whether the extrapolation to the data-poor catchments should be made at the higher or lower level. Also the volatile nature of silver eel migrations due to floods (2015) and droughts (2016) has made the interpretation of IMESE difficult.

The Biomass indicators (B_0 , B_{best} , $B_{current}$) for each EMU as calculated using the original index catchments (without the Fane) are presented in Table 2.3 and the level of escapement relative to B_0 is presented in Table 2.4. The data for 2015–2017 are presented in Table 2.5 and 2.6, with and without the Fane as an east coast index. The Fane is a relatively small highly productive (eutrophic) catchment with 0% siliceous geology and therefore, in the growth rate/geology regression, the relatively small catchment has considerable influence over the relationship at the left end of the regression where a considerable proportion of the eel production occurs (~70%).

It was with this in mind, the TEGE decided to show both datasets in the Stock Annex (Tables 2.5 and 2.6) and to report the mind-point between the two estimates to the EU in the data reporting templates.

Current escapements are presented in Table 2.3 and expressed as a percentage of the historic production (Table 2.4), given for 2008, for the 2009–2011, 2012–2014 and 2015–2017 periods as averages. The positive effect of the implemented management measures (fishery closure and silver eel trap and transport) can be further seen by the total %SSB increasing from 25.6% (2008) to 36.7% (2009–2011) to 54.5%; some 14.5% above the EU target confirming that Ireland is contributing significantly to the eel stock recovery. However, in 2015–2017 using the original model, this has dropped to 37.7%. Including the Fane gives a figure of 45.8% and the midpoint is 41.8% (Table 2.6).

Of particular note (see also Chapter on the Index Rivers), the production in the IE_Shan fell in 2016 and 2017 to less than 20% of B_0 . The production in the East, SouE, SouW and West all fell back to similar rates observed in the 2009–2011 period, the exception being the IE_NorW where current production was maintained at over 50% of B_0 .

2.3 Eel Management Plan escapement biomass (transitional waters)

2.3.1 Introduction to transitional waters

There is a requirement to calculate the production of eels from the transitional (saline) water habitat as distinct from the freshwater habitat. One method is to apply the production value (kg/ha) for an Inland freshwater catchment and extrapolate it to the respective transitional waters. However this method does not take into account the extreme change in habitat and potential productivity due to salinity and other habitat and ecological features. In order to investigate an alternative method to applying the freshwater production value 'blindly' to the transitional waters, it was decided to utilise the fykenet surveys undertaken as part of the Water Framework Directive monitoring and to come up with a classification for the different types of transitional waters in Ireland that reflected the cpue from the fykenets.

2.3.2 Methodology

From 2008 to 2017 149 fykenet surveys within transitional waters around Ireland were available. These surveys were undertaken by Inland Fisheries Ireland's Water Framework Directive and Eel Monitoring Programme and the Marine Institute's long-term monitoring in Lough Furnace. These surveys were distributed around the country.

The aim of the analysis was to investigate if there was a link between number of eels and catch per unit of effort and the physical characteristics of the transitional waters. These physical characteristics do not change with time and are available for all transitional waters around the country. There are a lot of environmental variables that are important to classify a waterbody but they require monitoring and therefore were not

included in this analysis as they were not widely available. The physical characteristics investigated are as follows:

1) Drying (drying (0), non-drying (1) and partial drying (2)).

There are a number of transitional waters in Ireland that are stripped of suitable habitat when the tide is out (every 12 hours) and therefore it is deceptive to think that the whole wetted area is available for production when it is only the area permanently inundated with water that is available for the eels to inhabit. All lagoons were considered non-drying.

2) Coast (east(1), south(3), west(2))

The distribution of glass eels and elvers to Ireland is influenced by the distribution of glass eels in the current in the ocean. The hot spots of elver recruitment are recorded by the extensive fisheries located in the Severn (UK) and the Bay of Biscay (France). This indicates that the plume of glass eels may be passing Ireland by the west and south coast. Therefore, we included coast in order to determine if the east coast is affected by the distance from the distribution plume. The Shannon, Southwest and Southeast RBD are classified as South coast, the Eastern and NeaghBann RBD are classified as East coast, the Western and NorthWestern IRBD are classified as west coast.

3) Coast (east (1), west(2))

A variation of the 3 category coast mentioned above, a 2 category option was included to distinguish between east and west, splitting the country down the middle. The Southwest RBD was classified as west and the Southeast RBD was classified as east coast.

4) Exposure (sheltered (0), semi exposed(1))

The area exposed to the coastal waters, which is the point of interaction between transitional waters and the coastal waters, was measured and each transitional water in Ireland was classified as either sheltered or semi exposed. The sheltered waters had an opening <1.5 km coast to coast. The semi-exposed waters had an opening greater than 1.5 km coast to coast. As the glass eels enter the transitional waters at this point did the size of the opening influence the attraction of eels into the catchment. Transitional waters nested inside a second transitional water was assigned based on the transitional water located at the coast water boundary.

5) Area (ratio of TW to RBD; four categories)

The proportion of a transitional waters compared with the upstream freshwater habitat was classified in order to distinguish between the areas with small transitional waters but large freshwater habitat and those of large transitional waters and low freshwater wetted area.

6) Category (lagoon, river)

Fykenet data and historical fishery data suggest that lagoons are good locations for eels with large numbers recorded. Therefore we distinguished between a lagoon and a riverine estuary. A lagoon was also classified as sheltered under a separate category.

2.3.3 Analysis

Data exploration was carried out using the guidelines from Zuur *et al.* (2009) This involved 1) checking for Outliers in the response variable and all variables, 2) checking for collinearity among the variables, 3) checking the relationship between the response

variable and variables, 4) assessing spatial and temporal dependence, 5) Interactions between variables, 6) checking for zero inflation, and 7) checking the sample size for all categorical covariates.

A negative binomial distribution was used due to the large variance in the data. Year was included as a random factor; count of eels was the dependent variable with effort included as an offset. A negative binomial mixed model analysis was carried out on 19 models with different combinations of the variables listed above (Table 2.1). Model selection was carried out using the Information Theoretic approach. Models were compared using the AIC and the weighted AIC (Table 2.1). There were seven models with an AIC within two units of the lowest model. The simplest model with the lowest AIC was Model 15 with variables exposure and drying.

The simpler model was used as the basis for categorising all transitional waters around Ireland and using the model to estimate a count of eels. This resulted in six categories of increasing number of eels/cpue (Table 2.2). This model suggested that there was a difference in catch of eels between sheltered and semi-exposed estuaries and also between drying, non-drying and partial drying estuaries. The modelled cpue of eels per transitional waters were then classified as either a low or high production for eels. There were four combinations of drying and exposure that were assigned a low production value for eels and two combinations that were assigned a high production value for eels.

From the Freshwater eel production model IMESE, a high kg/ha value and low kg/ha value per year was then assigned to each transitional water from 2008 to present, using the midpoint values for the 2015–2017 years as follows:

Year	High	Low			High	Low
	kg/ha	kg/ha			kg/ha	kg/ha
B ₀	4.676	1.846		Av 09–11	2.528	0.418
2008	4.042	0.672		Av 12–14	3.517	0.587
2009	3.557	0.587		Av 15–17	2.801	0.466
2010	2.620	0.430				
2011	2.394	0.394				
2012	3.359	0.559				
2013	3.634	0.604				
2014	3.558	0.588				
2015	3.230	0.534				
2016	2.522	0.422				
2017	3.215	0.530				

Table 2-1. Binomial mixed model analysis carried out on 19 models and associated AIC values.

Model	Model - Year Random Effect, Effort offset	d.f.	AIC	AIC min	AIC weighted
Mneg1.13	coast3+Category+exp+Dry	9	1162.933		0.207
Mneg1.15	exp+Dry	6	1163.41	0.477	0.163
Mneg1.6	coast3 + exp + Dry	8	1164.204	1.271	0.11
Mneg1.12	Category+exp+Dry	7	1164.393	1.46	0.1
Mneg1.4	coast2+ coast3+exp+Dry	9	1164.433	1.5	0.098
Mneg1.3	coast2+ coast3+Category+exp+Dry	10	1164.528	1.595	0.093
Mneg1.14	Dry*exp	8	1164.899	1.966	0.077
Mneg1.5	coast2+exp+Dry	7	1165.402	2.469	0.06
Mneg1.11	coast2+Category+exp+Dry	8	1166.075	3.142	0.043
Mneg1.2	coast2+ coast3+Category+exp+Dry+Area	13	1166.277	3.344	0.039
Mneg1	coast2+ coast3+Category+exp*Dry+Area	15	1169.31	6.377	0.009
Mneg1.8	coast3 + Dry	7	1172.397	9.464	0.002
Mneg1.7	coast2 + Dry	6	1175.581	12.648	0
Mneg1.18	Dry	5	1178.107	15.174	0
Mneg1.10	coast3 + exp	6	1184.5	21.567	0
Mneg1.17	coast3	5	1185.983	23.05	0
Mneg1.19	exp	4	1188.642	25.709	0
Mneg1.9	coast2 + exp	5	1188.962	26.029	0
Mneg1.16	coast2	4	1193.347	30.414	0

Table 2-2. Six categories of Transitional Waters with modelled cpue.

	exposure	drying	ExpDry	Modelled value	Cateogry
sheltered and drying	0	0	0_0	0.283087	low
semi exposed and drying	1	0	1_0	0.69677	low
sheltered and partial drying	0	2	0_2	0.781922	low
sheltered and non drying	0	1	0_1	1.41199	low
semi exposed and partial drying	1	2	1_2	2.011137	high
semi exposed and non drying	1	1	1_1	3.475367	high

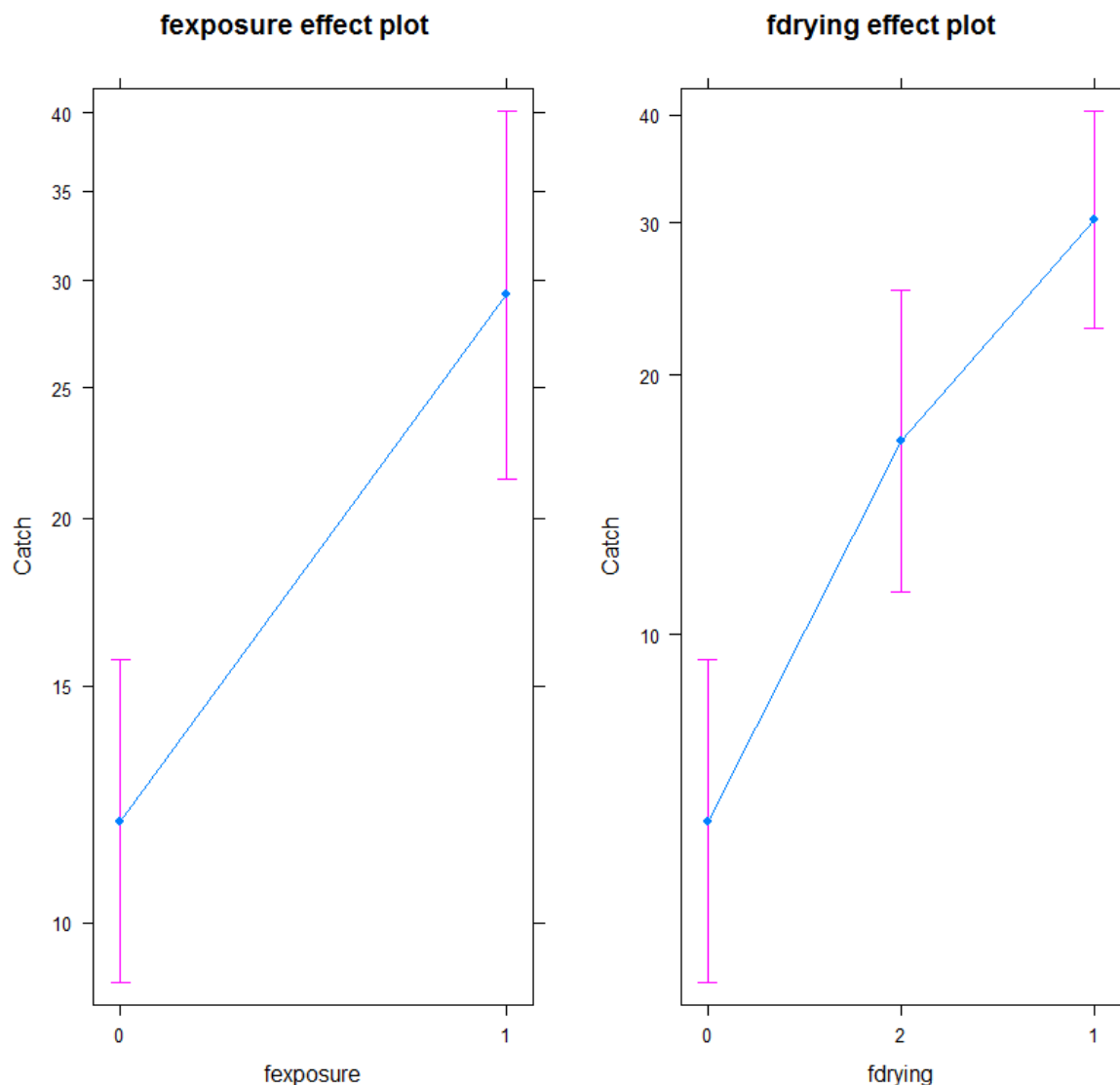


Figure 2-2. Plot of effect of exposure (0 = sheltered, 1 = semi exposed) and drying (0 = drying, 2 = partial drying, 3 = non-drying) on eel catches.

2.3.4 Current (2015–2017) Silver eel biomass (B_{best} , $B_{2015-2017}$), Transitional waters

Transitional Waters have not been directly assessed, and it is not known what the rates of silver eel production are from the yellow eel stocks inhabiting these waters. For the 2018 EU Report, silver eel production from transitional waters has been estimated by categorising each waterbody into one of two med-high or one of four medium to low eel habitats, based on physical characteristics, and yellow eel cpue from WFD and other eel fykenet surveys. These categories were then applied to the IMESE production rates (maximum and minimum) for each year and retrospectively for B_0 . We report these estimates in the 2018 report (see 2015 stock Annex for the classification analysis and the 2018 Stock Annex for the estimated production) and these should be treated with caution as preliminary results.

Current production of silver eels was estimated at 159 812 kg for 2008 and 126 952 kg in 2017. Fishing mortality can't be accurately assessed before the fishery closure as catches were reported along with the freshwater catch. Fishing mortality has been zero

since 2009. Tables 2.7 and 2.8 give the B_0 , B_{best} and $B_{current}$ for the Transitional Waters. Current escapement was on average for 2015–2017 estimated at 50% of B_0 .

2.4 Eel Management Plan escapement biomass (Coastal waters)

The coastal waters of Ireland were not been assessed in 2012, 2015 or 2018. It is thought that eel production in coastal waters is low, and there was never a commercial or recreational eel fishery in coastal waters.

2.5 Anthropogenic mortality

The Eel Regulation sets a limit for the escapement of (maturing) silver eels, at 40% of the natural pristine escapement B_0 (that is: in the absence of any anthropogenic impacts and at historic recruitment). The EU Regulation thus sets a clear limit for the spawning-stock biomass, B_{lim} , as a percentage of B_0 . However, no explicit limit on anthropogenic impacts A_{lim} is specified. A value for A_{lim} of 0.92 has been proposed (ICES, 2011a,b), i.e. the sum of all anthropogenic impacts over the entire continental lifespan should not exceed 0.92. Below B_{lim} ($B_{MSY-trigger}$), the mortality target should be reduced correspondingly (ICES, 2011b).

The Eel Regulation specifies a limit reference point (40% of pristine biomass B_0) for the size of the spawning stock in terms of biomass. For long-lived species (such as the eel) with a low fecundity (unlike the eel), biological reference points are often formulated in terms of numbers, rather than biomass. For reference points based on biomass rather than on numbers, the relationship between relative spawner escapement (%SPR) and mortality (ΣA) is much more complex, but numerical simulation indicates that the relationship comes close to a reference point based on numbers (ICES, 2011b).

Table 2.9 presents the mortality data calculated using biomass ($-\ln(B_{current}/B_{best})$). In Figures 2.3 and 2.4, the mortality data are calculated using biomass as follows:

$$F = -\ln(\text{what comes out} / \text{what goes in}) \text{ or } = -\ln(B_{best-catch})/B_{best}$$

$$H = \text{idem, but } B_{best} \text{ is not what goes into hydropower. } (B_{best-catch}) \text{ is what goes in, and } (B_{best-catch-hydrokill}) \text{ is what comes out, or } H = -\ln(B_{best-catch-hydrokill})/(B_{best-catch})$$

The two EMUs where the impacts were severest with both fisheries and hydropower were the IE_Shan (ShIRBD) and IE_NorW (NWIRBD). In the IE_Shan the mortality (ΣA) went from 1.48 to less than 0.2 and in the IE_NorW the mortality (ΣA) went from 0.77 to less than 0.2.

Total mortality for Ireland (sum of fisheries, hydropower and other anthropogenic) has fallen from 0.83 in 2008 to less than 0.06 since 2009. This is considerably lower than the A_{lim} of 0.92 and underlines Ireland's commitment to achieving the recovery in the fastest time possible.

NOTE: In the past, fisheries landings were reported under the inland fisheries legislation and catches were not clearly separated for freshwaters and transitional waters. Ireland has reported Fishing Mortality and Hydropower Mortality rates based on its assessment of freshwaters and not including transitional waters.

2.6 Biomass and mortality overview

No assessments were made of the stock indicators for coastal waters. A preliminary assessment was made in 2018 of possible eel production from transitional waters using

a combination of field cpue data, physical characterisation of types of transitional waters and annual eel production rates from freshwater (See Section 2.3.4).

In this report, the Irish eel stock in inland waters has been quantified. The diagrams below (Figures 2.4 and 2.5) plot the most recent stock assessments (2009–2011, 2012–2014 and 2015–2017), along with those data presented in the EMP (2008). The original index time-series are presented along with the midpoint version for the EU Report.

In the IE_East, the IE_Shan, IE_West and IE_NorW, the mortality was clearly reduced as indicated by the downward direction of the bubbles and this led to increased escapement up to 2014 as shown by right hand horizontal movement towards the 40% target. In some cases anticipated increases in spawner escapement did not always materialise. This may be due to some yellow eel still to feed through increasing the %SSB and moving the bubbles to the right in coming years. Or the negative impact of falling recruitment may now be leading to lower silver eel production, or there may be problems with some of the estimates as mentioned previously.

There is some anecdotal evidence to suggest higher than previously thought yellow eel exploitation. It is also possible that the historical production without anthropogenic mortality (B_0) may be too low. The estimates for undeclared or illegal catches included in the historical model were 40% of the declared catch but anecdotal information would suggest that this could have been as high as 200% or 300%. Fixing a value for B_0 is fundamental to determining a realistic %SSB although this has always been a challenge.

In general, we have demonstrated an increase in biomass of silver eel escaping and a marked reduction in fishing and hydropower mortality. While further reduction in mortality is unlikely, it is possible that additional biomass from the closure of the yellow eel fishery will continue to feed through in the coming years (ca. five years). However, it is unclear how the collapse in recent recruitment will impact on silver eel biomass and whether density-dependent effects (change from small males to larger proportions of larger females) will buffer the collapse in recruitment by temporarily increasing biomass of silver eels, even with falling numbers. Low production was noted in some catchment in the last three years, especially the Shannon and Burrishoole.

2.7 Summary of individual EMU targets

No direct assessments were made of the stock indicators for transitional or coastal waters. Preliminary analysis indicated that it would be unwise to extrapolate directly from freshwater into the transitional zone. Eel production was indirectly estimated using a combination of IMESE derived production rates, physical characteristics of transitional waters and fykenet cpue catches of eels.

With the exception of the IE_Shan (ShIRBD) all other EMUs were above the EU target in 2015–2017. It is not expected that this can be sustained due to the history of recruitment, although density-dependent changes to some of the stocks, such as sex ratio change to female and increase in eel size, are making it difficult to project further into the future.

The Fane (IE_East) was included in the 2015–2017 analysis as a calibrating site. This is described in Chapters 2.2.5. In this chapter, the original time-series of B_{best} production using only the Shannon, Erne and Burrishoole calibrating indices is presented along with the outcome of running the model including the Fane as a fourth index river. This addresses a previously identified criticism that all the indices were on the west coast.

However, the inclusion of the Fane changes the model outputs. For consistency, outputs from IMESE are presented with, and without, the new index and the midpoint between the two values is reported for 2015–2017. The trends of the two model outputs are similar, but it is not known whether the extrapolation to the data-poor catchments should be made at the higher or lower level. Also the volatile nature of silver eel migrations due to floods (2015) and droughts (2016) has made the interpretation of IMESE difficult.

In the previous reports (2012, 2015), silver eel production from transitional waters was not estimated. In this report, silver eel production from transitional waters has been estimated for 2015–2017 by categorising each waterbody into one of two med-high or one of four medium to low eel habitat, based on physical characteristics, and yellow eel cpue from WFD and other eel fykenet surveys. These categories were then applied to the IMESE freshwater production rates (maximum and minimum) for each year and retrospectively for B₀. We report these estimates in the 2018 report and these should be treated with caution as the results are preliminary.

In 2008, the total for all EMUs was projected into the future to peak at 36% before falling again due to lack of recruits; the average for 2009–2011 was 36.7%. This increased to 54.5% average for 2012–2014 period but fell to 37.7% in 2015–2017 (or 41.5% midpoint estimate).

The stock status plots for each Index River are given in Figure 2.3 and these indicate a fall in escapement in all catchments, least so in the Erne.

In Figure 2.4, each EMU is plotted separately. The size of the bubble indicates the relative production of that EMU. Three of the EMUs (IE_East, IE_SouE, IE_SouW) have low wetted areas (See Figure 3.4 of the National Eel Management Plan) and relatively modest production compare to the other three. Escapement was relatively high in 2015 and 2017 and was lower in 2016. However, on average for the last three year period, production and escapement was lower in all EMUs than reported for the 2012–2014 period, even when using the higher values determined with the Fane as an index, or when using the midpoint value as reported to the EU in the e-tables.

Table 2-3. Freshwater historic (B_0) and current annual silver eel production (B_{best}) (kg) and escapement ($B_{current}$) (kg) for 2008–2017 and average production and escapement for the 2009–2011, 2012–2014 and 2015–2017 reporting periods, calculated using the IMESE model (without the Fane) and inserting actual catchment data where they exist.

EMU Code	EMU Name	Bo Prod	Production (B_{best})										Av 2009– 2011	Av 2012– 2014	Av 2015– 2017
		kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
IE_East	EEMU	20,517	16,768	14,755	10,865	9,928	13,936	15,079	14,756	10376	10117	11228	10,484	14,592	10,142
IE_NorW	NWIRBD	135,732	102,502	57,295	52,447	52,956	82,099	89,376	87,747	87657	74743	79292	52,883	86,286	80,043
IE_Shan	SHIRBD	201,401	95,979	83,464	75,608	71,669	76,507	89,250	80,151	76449*	45657	40379	76,073	81,855	42,404
IE_SouE	SERBD	14,836	11,229	9,877	7,271	6,645	9,333	10,098	9,878	6227	7673	6787	7,018	9,774	6,560
IE_SouW	SWRBD	24,577	15,914	13,975	10,274	9,395	13,230	14,312	13,978	8820	10883	9606	9,932	13,864	9,292
IE_West	WRBD	192,377	101,892	83,128	98,543	90,029	126,447	136,795	133,872	84216	103972	91964	69,545	132,404	88,863
	Total	589,440	344,285	262,494	255,010	240,623	321,553	354,910	340,382	273,744	253,046	239,255	225,936	338,776	237,303
		kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
IE_East	EEMU	20,517	9,557	14,561	10,722	9,798	13,753	14,881	14,562	10,254	9,966	11,095	10,346	14,401	10,007
IE_NorW	NWIRBD	135,732	47,787	47,554	49,348	50,515	71,817	80,494	81,817	81,228	63,193	68,972	50,035	77,921	70,613
IE_Shan	SHIRBD	201,401	21,636	79,369	67,398	63,996	67,412	80,055	72,213	68,704*	39,969	37,431	69,414	73,112	36,944
IE_SouE	SERBD	14,836	9,867	9,877	7,271	6,645	9,333	10,098	9,878	6,227	7,673	6,787	7,018	9,774	6,560
IE_SouW	SWRBD	24,577	15,379	13,576	10,067	9,389	12,910	14,189	13,807	8,752	10,563	9,520	9,767	13,659	9,149
IE_West	WRBD	192,377	46,546	83,128	98,543	90,029	126,447	136,795	133,872	84,216	103,972	91,964	69,545	132,405	88,863
	Total	589,440	150,771	248,064	243,350	230,372	301,673	336,512	326,149	259,381	235,336	225,769	216,126	321,272	222,136

* = Shannon River Index estimated due to flooding.

Table 2-4. The freshwater % $B_{current}/B_0$ (%EU target) for each EMU and for the total production (calculated without the Fane), for 2008 to 2017 and for the average for the 2009–2011, 2012–2014 and 2015–2017 reporting periods. The data come from Table 2.3.

EMU Code	EMU Name	Bo Prod	%Bcurrent/Bo (EU Target)										Av 2009– 2011	Av 2012– 2014	Av 2015– 2017
		kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
IE_East	EEMU	20517	46.6	71.0	52.3	47.8	67.0	72.5	71.0	50.0	48.6	54.1	50.4	70.2	48.8
IE_NorW	NWIRBD	135732	35.2	35.0	36.4	37.2	52.9	59.3	60.3	59.8	46.6	50.8	36.9	57.4	52.0
IE_Shan	SHIRBD	201401	10.7	39.4	33.5	31.8	33.5	39.7	35.9	34.1	19.8	18.6	34.5	36.3	18.3
IE_SouE	SERBD	14836	66.5	66.6	49.0	44.8	62.9	68.1	66.6	42.0	51.7	45.7	47.3	65.9	44.2
IE_SouW	SWRBD	24577	62.6	55.2	41.0	38.2	52.5	57.7	56.2	35.6	43.0	38.7	39.7	55.6	37.2
IE_West	WRBD	192377	24.2	43.2	51.2	46.8	65.7	71.1	69.6	43.8	54.0	47.8	36.2	68.8	46.2
	Total	589,440	25.6	42.1	41.3	39.1	51.2	57.1	55.3	44.0	39.9	38.3	36.7	54.5	37.7

Table 2-5. Freshwater historic (B_0) and current silver eel production (B_{best}) (kg) and escapement ($B_{current}$) (kg) for 2015–2017 and average production and escapement for 2015–2017, calculated using the IMESE model (without and without the Fane) and the midpoint in the data. * = Shannon River Index estimated due to flooding.

EMU Code	EMU Name	Bo Prod	Production (B_{best})									Av 2015– 2017	Av 2015– 2017	Av 2015– 2017
			ex Fane	ex Fane	ex Fane	inc Fane	inc Fane	inc Fane	midpt	midpt	midpt	ex Fane	inc Fane	midpt
		kg	2015	2016	2017	2015	2016	2017	2015	2016	2017			
IE_East	EEMU	20,517	10,376	10,117	11,228	17,431	8,412	16,740	13,903	9,265	13,984	10,142	13,287	11,715
IE_NorW	NWIRBD	135,732	87,657	74,743	79,292	96,110	72,706	85,893	91,884	73,724	82,592	80,043	83,838	81,941
IE_Shan	SHIRBD	201,401	76,449*	45,657	40,379	81,489	44,439	44,317	78,969	45,048	42,348	42,404	44,648	43,526
IE_SouE	SERBD	14,836	6,227	7,673	6,787	11,706	6,349	11,067	8,966	7,011	8,927	6,560	9,006	7,783
IE_SouW	SWRBD	24,577	8,820	10,883	9,606	16,564	9,018	15,652	12,692	9,951	12,629	9,292	12,773	11,032
IE_West	WRBD	192,377	84,216	103,972	91,964	158,166	86,102	149,744	121,191	95,037	120,854	88,863	121,836	105,349
	Total	589,440	273,744	253,046	239,255	381,465	227,026	323,414	327,605	240,036	281,334	237,303	285,388	261,346
			ex Fane	ex Fane	ex Fane	inc Fane	inc Fane	inc Fane	midpt	midpt	midpt	ex Fane	inc Fane	midpt
		kg	2015	2016	2017	2015	2016	2017	2015	2016	2017			
IE_East	EEMU	20,517	10,254	9,966	11,095	17,201	8,287	16,522	13,728	9,127	13,809	10,007	13,110	11,559
IE_NorW	NWIRBD	135,732	81,228	63,193	68,972	89,642	61,166	75,546	85,435	62,180	72,259	70,613	74,455	72,534
IE_Shan	SHIRBD	201,401	68,704*	39,969	37,431	73,744	38,751	41,369	71,224	39,360	39,400	36,944	39,188	38,066
IE_SouE	SERBD	14,836	6,227	7,673	6,787	11,706	6,349	11,067	8,967	7,011	8,927	6,560	9,006	7,783
IE_SouW	SWRBD	24,577	8,752	10,563	9,520	16,258	8,755	15,381	12,505	9,659	12,451	9,149	12,521	10,835
IE_West	WRBD	192,377	84,216	103,972	91,964	158,166	86,102	149,744	121,191	95,037	120,854	88,863	121,836	105,350
	Total	589,440	259,381	235,336	225,769	366,717	209,410	309,629	313,049	222,373	267,699	222,136	270,116	246,126

Table 2-6. The freshwater % B_{current}/B_0 (%EU target) for each EMU and for the total production (calculated with and without the Fane) and the midpoint in the data, for 2015–2017 and average production and escapement for 2015–2017. The data come from Table 2.5.

EMU Code	EMU Name	Bo Prod	%Bcurrent/Bo (EU Target)									Av 2015–2017	Av 2015–2017	Av 2015–2017
			ex Fane	ex Fane	ex Fane	inc Fane	inc Fane	inc Fane	midpt	midpt	midpt	ex Fane	inc Fane	midpt
		kg	2015	2016	2017	2015	2016	2017	2015	2016	2017			
IE_East	EEMU	20,517	50.0	48.6	54.1	83.8	40.4	80.5	66.9	44.5	67.3	48.8	63.9	56.3
IE_NorW	NWIRBD	135,732	59.8	46.6	50.8	66.0	45.1	55.7	62.9	45.8	53.2	52.0	54.9	53.4
IE_Shan	SHIRBD	201,401	34.1	19.8	18.6	36.6	19.2	20.5	35.4	19.5	19.6	18.3	19.5	18.9
IE_SouE	SERBD	14,836	42.0	51.7	45.7	78.9	42.8	74.6	60.4	47.3	60.2	44.2	60.7	52.5
IE_SouW	SWRBD	24,577	35.6	43.0	38.7	66.2	35.6	62.6	50.9	39.3	50.7	37.2	50.9	44.1
IE_West	WRBD	192,377	43.8	54.0	47.8	82.2	44.8	77.8	63.0	49.4	62.8	46.2	63.3	54.8
	Total	589,440	44.0	39.9	38.3	62.2	35.5	52.5	53.1	37.7	45.4	37.7	45.8	41.8

Table 2-7. Transitional Water historic (B_0) and current silver eel production (B_{best}) (kg) and escapement ($B_{current}$) (kg) for 2008–2017 calculated using the IMESE model midpoint outputs (maximum and minimum production rates).

EMU Code	EMU Name	Bo Prod	Production (B_{best})									
		kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
IE_East	EEMU	14,263	4,055	3,545	2,597	2,379	3,373	3,648	3,547	3,223	2,546	3,202
IE_NorW	NWIRBD	35,558	26,513	23,320	17,168	15,690	22,035	23,841	23,323	21,171	16,552	21,078
IE_Shan	SHIRBD	83,443	60,510	53,211	39,165	35,795	50,294	54,415	53,219	48,309	37,786	48,093
IE_SouE	SERBD	38,488	29,505	25,961	19,117	17,469	24,521	26,532	25,964	23,566	18,415	23,465
IE_SouW	SWRBD	41,594	16,506	14,469	10,621	9,719	13,726	14,847	14,474	13,146	10,339	13,072
IE_West	WRBD	38,105	22,723	19,964	14,683	13,424	18,889	20,436	19,968	18,128	14,202	18,042
	Total	251,450	159,812	140,471	103,352	94,475	132,838	143,718	140,495	127,542	99,840	126,952
IE_East	EEMU	14,263		3,545	2,597	2,379	3,373	3,648	3,547	3,223	2,546	3,202
IE_NorW	NWIRBD	35,558		23,320	17,168	15,690	22,035	23,841	23,323	21,171	16,552	21,078
IE_Shan	SHIRBD	83,443		53,211	39,165	35,795	50,294	54,415	53,219	48,309	37,786	48,093
IE_SouE	SERBD	38,488		25,961	19,117	17,469	24,521	26,532	25,964	23,566	18,415	23,465
IE_SouW	SWRBD	41,594		14,469	10,621	9,719	13,726	14,847	14,474	13,146	10,339	13,072
IE_West	WRBD	38,105		19,964	14,683	13,424	18,889	20,436	19,968	18,128	14,202	18,042
	Total	251,450	-	140,471	103,352	94,475	132,838	143,718	140,495	127,542	99,840	126,952

Table 2-8. The transitional water % $B_{current}/B_o$ (%EU target) for each EMU and for the total production (calculated using the midpoint production 2015–2017), for 2009–2017. The data come from Table 2.7.

EMU Code	EMU Name	Bo Prod	%Bcurrent/Bo (EU Target)									
		kg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
IE_East	EEMU	14,263	-	24.9	18.2	16.7	23.6	25.6	24.9	22.6	17.8	22.5
IE_NorW	NWIRBD	35,558	-	65.6	48.3	44.1	62.0	67.0	65.6	59.5	46.5	59.3
IE_Shan	SHIRBD	83,443	-	63.8	46.9	42.9	60.3	65.2	63.8	57.9	45.3	57.6
IE_SouE	SERBD	38,488	-	67.5	49.7	45.4	63.7	68.9	67.5	61.2	47.8	61.0
IE_SouW	SWRBD	41,594	-	34.8	25.5	23.4	33.0	35.7	34.8	31.6	24.9	31.4
IE_West	WRBD	38,105	-	52.4	38.5	35.2	49.6	53.6	52.4	47.6	37.3	47.3
	Total	251,450	-	55.9	41.1	37.6	52.8	57.2	55.9	50.7	39.7	50.5

Table 2-9. Annual fishing (kg & ΣF), other anthropogenic (kg & ΣH) and total mortality (kg & ΣA) rates for each freshwater Eel Management Unit and the total annual mortality rates for all EMUs. B_{best} and $B_{current}$ 2015–2017 are based on the midpoint between the two modelled outputs for freshwater.

YEAR	EMU	F'water	F'water	Biomass	Biomass	Biomass	Biomass	Rate	Rate	Rate	Rate
		BBEST	BCURRENT	F	H	OTHER	A	F	H	OTHER	A
2008	EEMU	16768	9590	6991	187	0	7178	0.539	0.019	0.000	0.559
2009	EEMU	14755	14561	0	194	0	194	0.000	0.013	0.000	0.013
2010	EEMU	10865	10722	0	143	0	143	0.000	0.013	0.000	0.013
2011	EEMU	9928	9798	0	131	0	131	0.000	0.013	0.000	0.013
2012	EEMU	13936	13753	0	183	0	183	0.000	0.013	0.000	0.013
2013	EEMU	15079	14881	0	198	0	198	0.000	0.013	0.000	0.013
2014	EEMU	14756	14562	0	194	0	194	0.000	0.013	0.000	0.013
2015	EEMU	13,903	13727	0	176	0	176	0.000	0.013	0.000	0.013
2016	EEMU	9,265	9127	0	138	0	138	0.000	0.015	0.000	0.015
2017	EEMU	13,984	13809	0	176	0	176	0.000	0.013	0.000	0.013
2008	NWIRBD	102502	47466	45349	9687	0	55036	0.584	0.186	0.000	0.770
2009	NWIRBD	57295	47554	0	9741	0	9741	0.000	0.186	0.000	0.186
2010	NWIRBD	52447	49348	0	3099	0	3099	0.000	0.061	0.000	0.061
2011	NWIRBD	52956	50514	0	2442	0	2442	0.000	0.047	0.000	0.047
2012	NWIRBD	82099	71817	0	10282	0	10282	0.000	0.134	0.000	0.134
2013	NWIRBD	89376	80494	0	8450	432	8882	0.000	0.099	0.005	0.105
2014	NWIRBD	87747	81817	0	5930	0	5930	0.000	0.070	0.000	0.070
2015	NWIRBD	91,884	85435	0	6449	0	6449	0.000	0.073	0.000	0.073
2016	NWIRBD	73,724	62179	0	11545	0	11545	0.000	0.170	0.000	0.170
2017	NWIRBD	82,592	72258	0	10334	0	10334	0.000	0.134	0.000	0.134
2008	ShIRBD	95979	21801	68209	5969	0	74178	1.240	0.242	0.000	1.482

YEAR	EMU	F'water	F'water	Biomass	Biomass	Biomass	Biomass	Rate	Rate	Rate	Rate
		BBEST	BCURRENT	F	H	OTHER	A	F	H	OTHER	A
2009	ShIRBD	83464	79369	0	4095	0	4095	0.000	0.050	0.000	0.050
2010	ShIRBD	75608	67398	0	8210	0	8210	0.000	0.115	0.000	0.115
2011	ShIRBD	71669	63996	0	7673	0	7673	0.000	0.113	0.000	0.113
2012	ShIRBD	76507	67412	0	9095	0	9095	0.000	0.127	0.000	0.127
2013	ShIRBD	89250	80055	0	9195	0	9195	0.000	0.109	0.000	0.109
2014	ShIRBD	80151	72213	0	7595	343	7938	0.000	0.100	0.005	0.104
2015	ShIRBD	78,969	71224	0	7745	0	7745	0.000	0.103	0.000	0.103
2016	ShIRBD	45,048	39360	0	5688	0	5688	0.000	0.135	0.000	0.135
2017	ShIRBD	42,348	39400	0	2948	0	2948	0.000	0.072	0.000	0.072
2008	SERBD	11229	9867	1362	0	0	1362	0.129	0.000	0.000	0.129
2009	SERBD	9877	9877	0	0	0	0	0.000	0.000	0.000	0.000
2010	SERBD	7271	7271	0	0	0	0	0.000	0.000	0.000	0.000
2011	SERBD	6645	6645	0	0	0	0	0.000	0.000	0.000	0.000
2012	SERBD	9333	9333	0	0	0	0	0.000	0.000	0.000	0.000
2013	SERBD	10098	10098	0	0	0	0	0.000	0.000	0.000	0.000
2014	SERBD	9878	9878	0	0	0	0	0.000	0.000	0.000	0.000
2015	SERBD	8,966	8966	0	0	0	0	0.000	0.000	0.000	0.000
2016	SERBD	7,011	7011	0	0	0	0	0.000	0.000	0.000	0.000
2017	SERBD	8,927	8927	0	0	0	0	0.000	0.000	0.000	0.000
2008	SWRBD	15914	15082	89	743	0	832	0.006	0.048	0.000	0.054
2009	SWRBD	13975	13576	0	399	0	399	0.000	0.029	0.000	0.029
2010	SWRBD	10274	10066	0	208	0	208	0.000	0.020	0.000	0.020

YEAR	EMU	F'water	F'water	Biomass	Biomass	Biomass	Biomass	Rate	Rate	Rate	Rate
		BBEST	BCURRENT	F	H	OTHER	A	F	H	OTHER	A
2011	SWRBD	9395	9389	0	6	0	6	0.000	0.001	0.000	0.001
2012	SWRBD	13230	12910	0	320	0	320	0.000	0.024	0.000	0.024
2013	SWRBD	14312	14189	0	123	0	123	0.000	0.009	0.000	0.009
2014	SWRBD	13978	13807	0	171	0	171	0.000	0.012	0.000	0.012
2015	SWRBD	12,692	12505	0	187	0	187	0.000	0.015	0.000	0.015
2016	SWRBD	9,951	9659	0	292	0	292	0.000	0.030	0.000	0.030
2017	SWRBD	12,629	12450	0	179	0	179	0.000	0.014	0.000	0.014
2008	WRBD	101892	46546	55346	0	0	55346	0.783	0.000	0.000	0.783
2009	WRBD	83128	83128	0	0	0	0	0.000	0.000	0.000	0.000
2010	WRBD	98543	98543	0	0	0	0	0.000	0.000	0.000	0.000
2011	WRBD	90029	90029	0	0	0	0	0.000	0.000	0.000	0.000
2012	WRBD	126447	126447	0	0	0	0	0.000	0.000	0.000	0.000
2013	WRBD	136795	136795	0	0	0	0	0.000	0.000	0.000	0.000
2014	WRBD	133872	133872	0	0	0	0	0.000	0.000	0.000	0.000
2015	WRBD	121,191	121191	0	0	0	0	0.000	0.000	0.000	0.000
2016	WRBD	95,037	95037	0	0	0	0	0.000	0.000	0.000	0.000
2017	WRBD	120,854	120854	0	0	0	0	0.000	0.000	0.000	0.000

YEAR	EMU	F'water	F'water	Biomass	Biomass	Biomass	Biomass	Rate	Rate	Rate	Rate
		BBEST	BCURRENT	F	H	OTHER	A	F	H	OTHER	A
2008	Total	344285	150353	177346	16586	0	193932	0.724	0.105	0.000	0.828
2009	Total	262494	248065	0	14429	0	14429	0.000	0.057	0.000	0.057
2010	Total	255010	243350	0	11660	0	11660	0.000	0.047	0.000	0.047
2011	Total	240623	230371	0	10252	0	10252	0.000	0.044	0.000	0.044
2012	Total	321553	301672	0	19880	0	19880	0.000	0.064	0.000	0.064
2013	Total	354911	336513	0	17966	432	18398	0.000	0.052	0.001	0.053
2014	Total	340382	326149	0	13890	343	14233	0.000	0.042	0.001	0.043
2015	Total	327605	313048	0	14557	0	14557	0.000	0.045	0.000	0.045
2016	Total	240036	222373	0	17663	0	17663	0.000	0.076	0.000	0.076
2017	Total	281334	267698	0	13636	0	13636	0.000	0.050	0.000	0.050

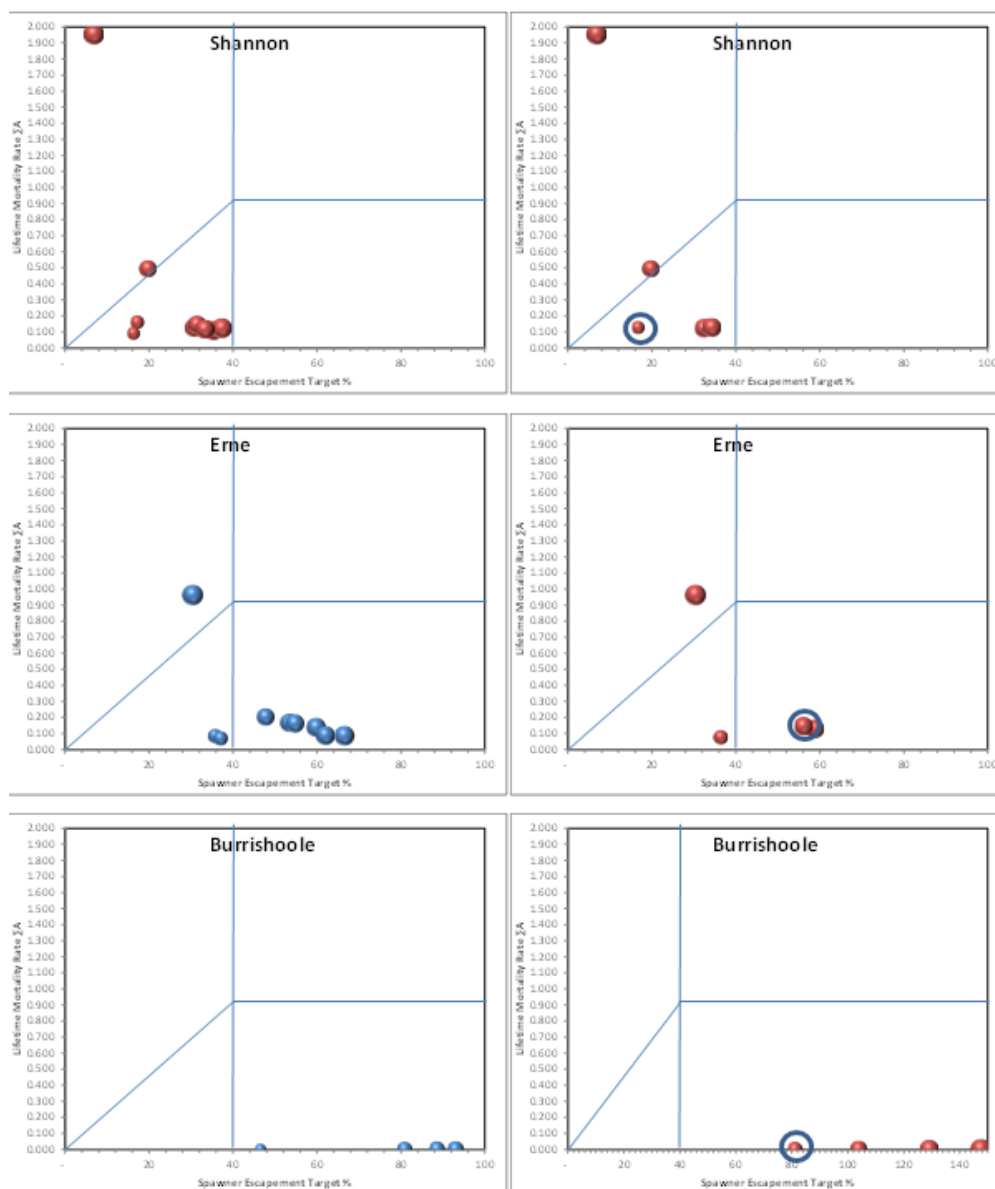


Figure 2-3. Status of the stock and the anthropogenic impacts, for the Rivers Shannon, Erne, Burrishoole and Fane as presented in the Eel Management Plans in 2008 (average 2001–2007), for 2008–2014 (left hand graphs), and for the 3-year averages (right hand graphs; 2015–2017 is circled). For each, the size of the bubble is proportional to B_{best} , the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.

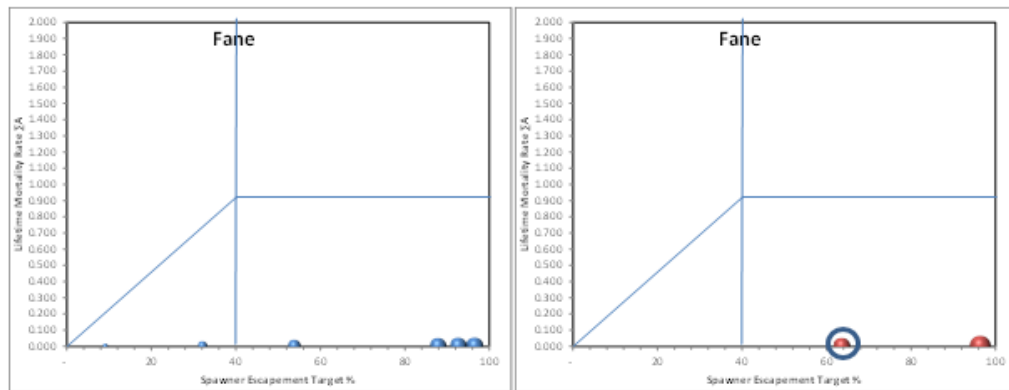


Figure 2-3. Continued. Status of the stock and the anthropogenic impacts, for the Rivers Shannon, Erne, Burrischoole and Fane as presented in the Eel Management Plans in 2008 (average 2001–2007), for 2008–2014 (left hand graphs), and for the 3-year averages (right hand graphs; 2015–2017 is circled). For each, the size of the bubble is proportional to B_{best} , the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.

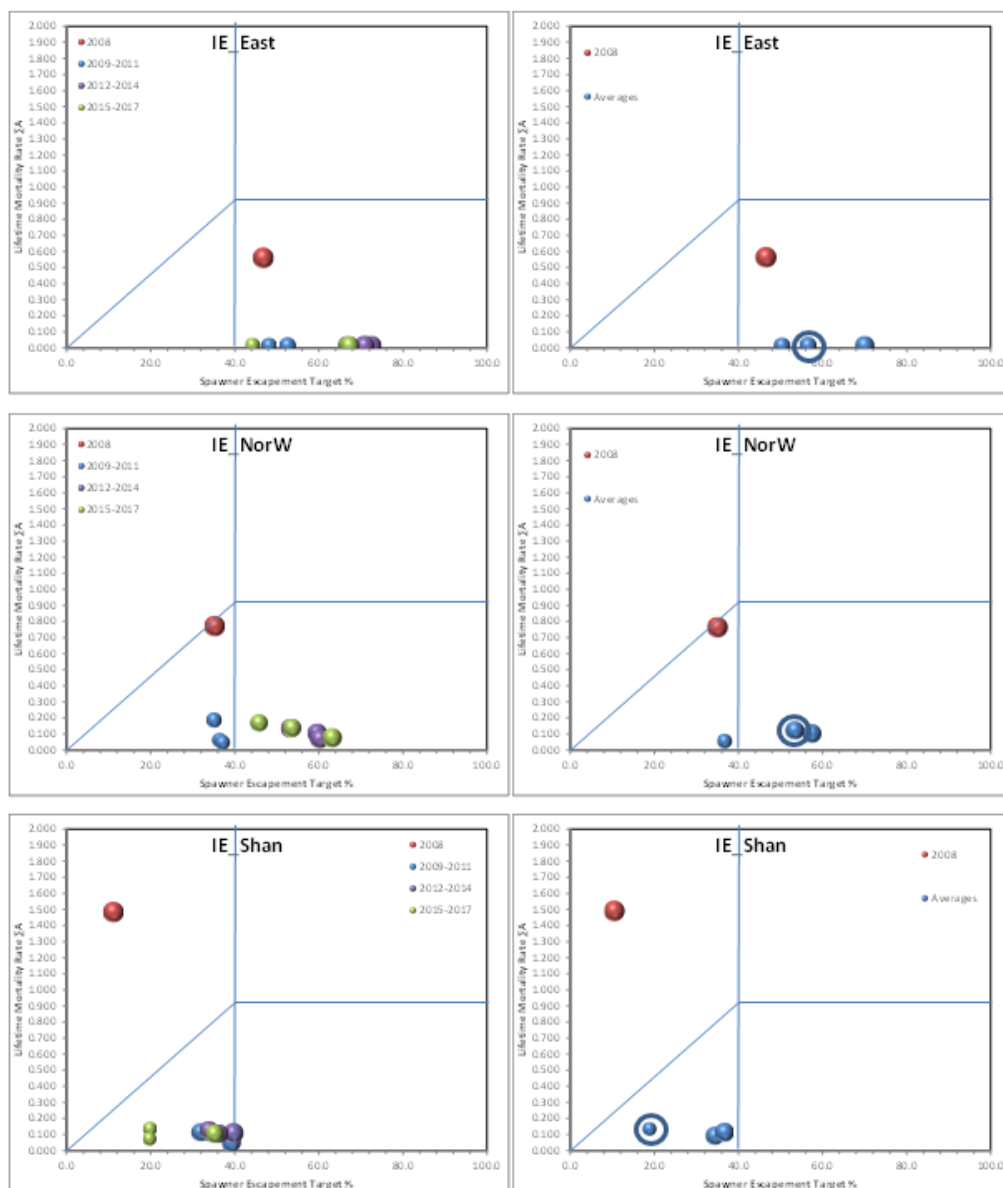


Figure 2-4. Status of the stock and the anthropogenic impacts, for the EMUs as presented in the Eel Management Plans in 2008 (average 2001–2007), for 2008–2017 (left hand graphs), and for the average of 2001–2007, 2009–2011, 2012–2014 and 2015–2017 (right hand graphs; 2015–2017 is circled). These graphs represent the midpoint between the model outputs for 2015–2017. For each, the size of the bubble is proportional to B_{best} , the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.

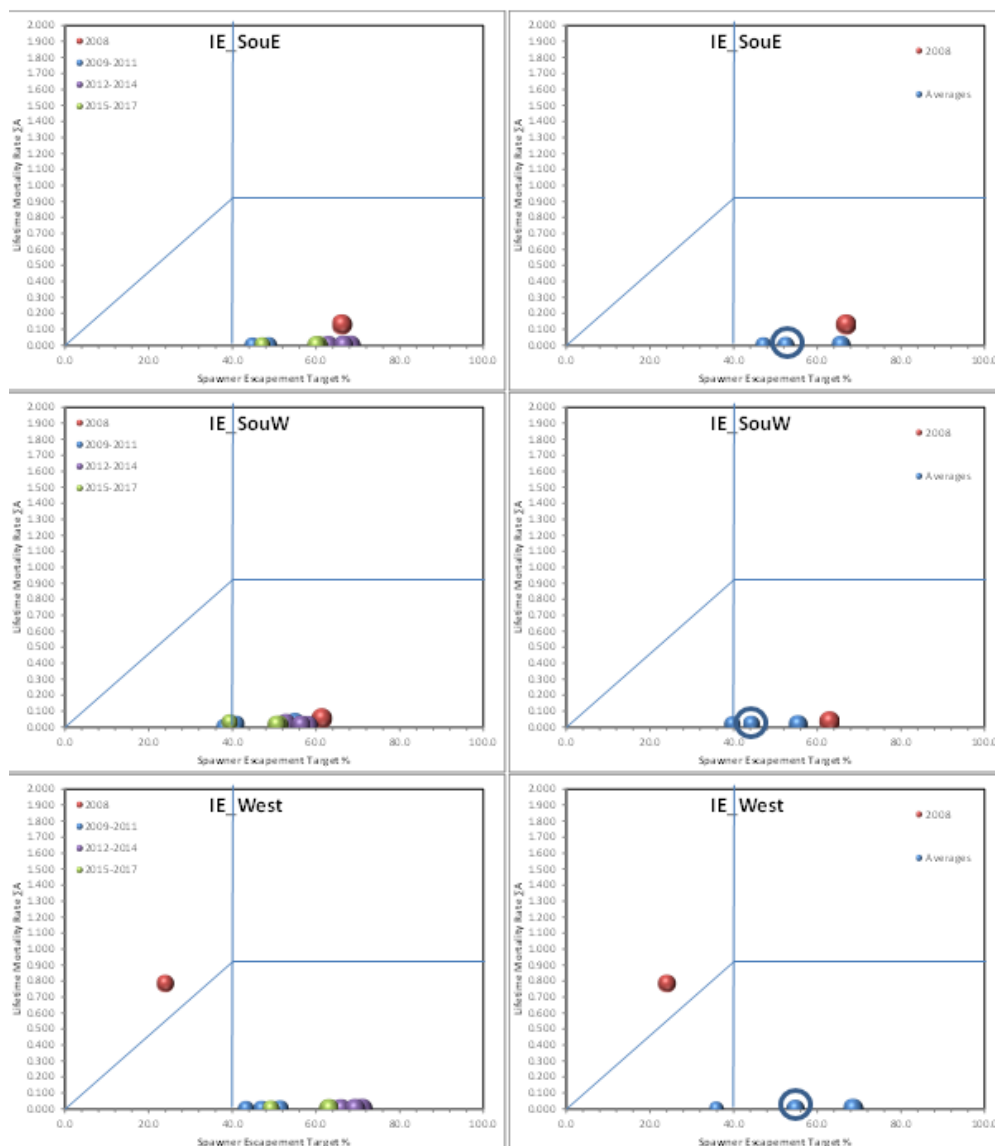


Figure 2-4. Continued. Status of the stock and the anthropogenic impacts, for the EMUs as presented in the Eel Management Plans in 2008 (average 2001–2007), for 2008–2017 (left hand graphs), and for the average of 2001–2007, 2009–2011, 2012–2014 and 2015–2017 (right hand graphs; 2015–2017 is circled). These graphs represent the midpoint between the model outputs for 2015–2017. For each, the size of the bubble is proportional to B_{best} , the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.

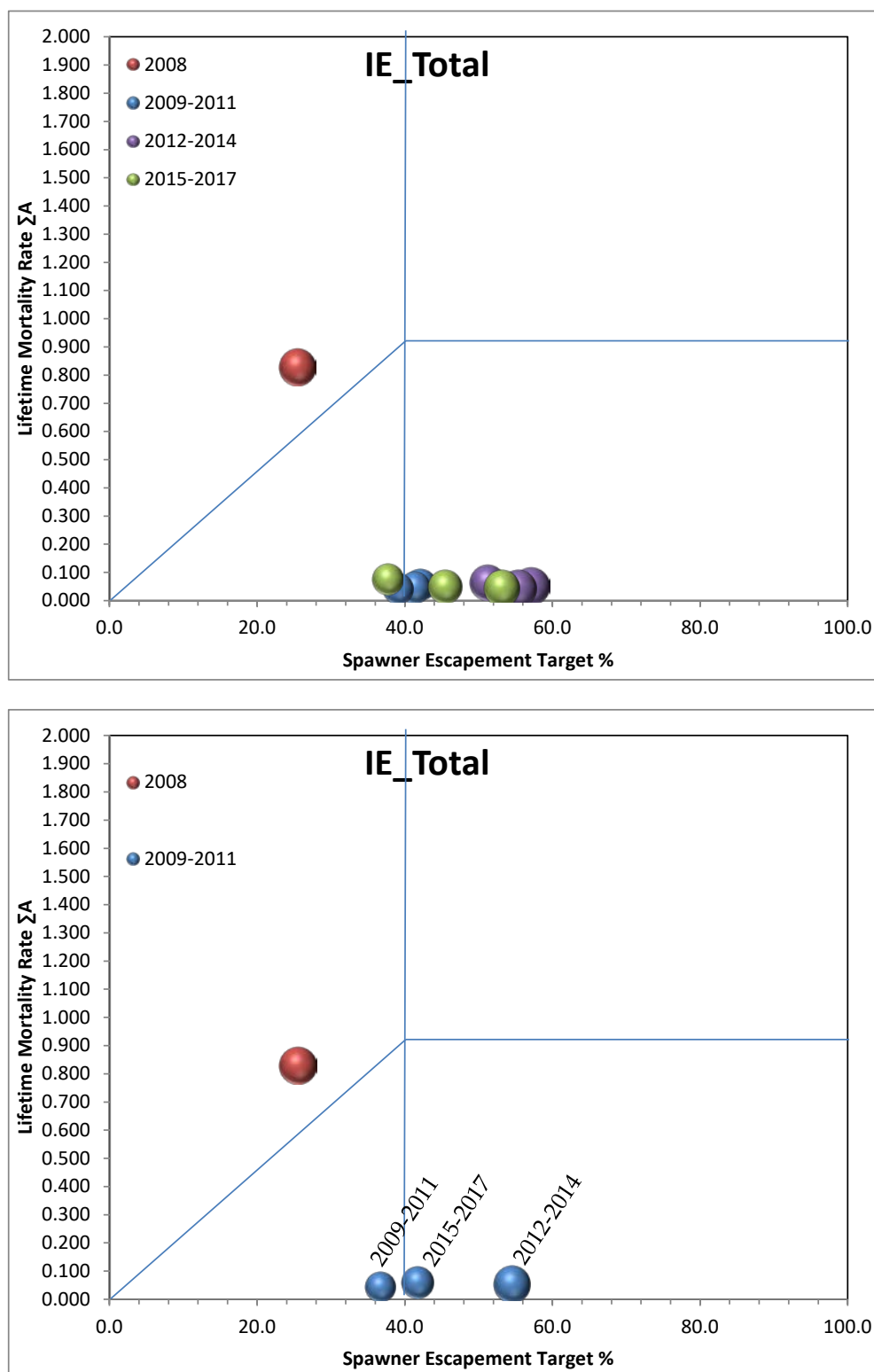


Figure 2-5. Status of the stock and the anthropogenic impacts, for the TOTAL of the EMUs as presented in the Eel Management Plans in 2008 (average 2001–2007), for 2008–2017 (top), and for the average of 2001–2007, 2009–2011, 2012–2014 and 2015–2017 (bottom). These graphs represent the mid-point between the model outputs for 2015–2017. For each, the size of the bubble is proportional to B_{best} , the best achievable spawner escapement given the recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality.

2.8 Significant changes since last report (2015)

Index Rivers: In 2015/2016 the production and escapement in the Erne increased and in the Burrishoole it fell to about 30% of that of 2014 (Table 2.10). Strange weather patterns during winter of 2016/2017 with unusually low water levels made assessments difficult and may also have influenced the runs of silver eels. Production and escapement in both the Erne and Shannon fell, while in Burrishoole production doubled compared to 2015 (Table 2.10).

The Shannon, Erne and Burrishoole all showed a decrease in silver eel production (B_{best}) in the 2015–2017 period compared to the previous three years (Table 2.10).

Silver eel production in the Shannon increased from 1.64 kg/ha in 2009–2011 to 1.72 kg/ha in 2012–2014 with a peak of 1.9 kg/ha in 2013. Production fell to 0.91 and 0.80 kg/ha in 2016 and 2017 respectively. The escapement biomass in the Shannon increased 2012 and 2013, was 33% of B_0 in 2014 and was considerably lower in 2016 and 2017 (17.4% and 16.5%).

The Erne increased from 1.62 kg/ha in 2009–2011 to 2.91 kg/ha in 2012–2014 with a peak of 3.29 kg/ha in 2014, an increase that was more or less expected due to previous recruitment patterns and the closure of the fisheries. The Erne production dropped a little in 2016 but rose again in 2017 from 2.4 to 2.7 kg/ha. The escapement biomass in the Erne also increased until 2015 (66.7%), and was lower, but still above the EU target in 2016 and 2017.

The Burrishoole increased from 0.96 kg/ha in 2009–2011 to 1.19 kg/ha in 2012–2014 with a peak of 1.22 kg/ha in 2014. However, a poor run occurred in 2015 with only 0.44 kg/ha being recorded and another poor run of relatively small eels was recorded in 2017 with 0.8 kg/ha production. The escapement in Burrishoole fell considerably in the 2015–2017 period to 46% in 2015 and 89% in 2017.

The escapement in the Fane ranged from 139% in 2013 to 9.2% in 2016.

National Silver Eel Production, Escapement and Mortality: Current escapements expressed as a percentage of the historic production. The positive effect of the implemented management measures (fishery closure and silver eel trap and transport) can be seen by the total %SSB increasing from 25.6% (2008) to 36.7% (2009–2011). This increased to 54.5% average for 2012–2014 period but fell to 37.7% in 2015–2017 (or 41.5% midpoint estimate).

The two EMUs where the impacts were severest with both fisheries and hydropower were the IE_Shan (ShIRBD) and IE_NorW (NWIRBD). In the IE_Shan the %SSB went from 10.7% to 34.5% (2009–2011) to 36.3% (2012–2014) to 18.9% (2015–2017).

In the IE_NorW the %SSB went from 35.2% to 36.9% (2009–2011) to 57.4% (2012–2014) and 53.4% (2015–2017), also reflecting the anticipated increase in output due to past recruitment history in the Erne in the mid-1990s.

The total escapement from freshwater relative to the historic B_0 was 25.6% in 2008, it increased to 36.7% in 2009–2011, further to 54.5% in 2012–2014 but fell again to 38.7% in 2015–2017 (without Fane) or 41.5% as the midpoint between the two model outputs.

A preliminary assessment of production from transitional waters was made, indicating a possible production ranging from a B_0 of 251 450 kg to a minimum of 99 840 kg in 2016. This production as estimated to be approximately 40% of the freshwater production in the 2015–2017 period and was on average 47% of B_0 .

While Ireland has reduced its anthropogenic mortality to low levels, it is unlikely that the increase in biomass in the last three years can be sustained much into the future due to the legacy of poor recruitment.

Table 2-10. Silver Eel production, escapement and mortality figures for the Erne, Shannon, Burrishoole and Fane catchments. *proxy figure for Shannon due to flooding.

	Shannon			Erne			Burrishoole			Fane		
Year	Prod	Escap	Mortality	Prod	Escap	Mortality	Prod	Escap	Mortality	Prod	Escap	Mortality
Bo	189079	189079	0	107388	107388	0	440	440	0			0
2008	85700	12163	73537	85140	32542	52598	649	649	0			0
2009	74382	66788	7594			0	602	602	0			0
2010	68920	60170	8750	41232	37942	3290	414	414	0			0
2011	65558	57885	7673	42855	40011	2844	355	355	0	868	868	0
2012	67931	58836	9095	67666	57366	10300	546	546	0	1450	1450	0
2013	79970	70775	9195	73762	64285	9477	572	572	0	3725	3725	0
2014	70725	62980	7745	72493	66525	5968	611	611	0	2580	2580	0
2015*	70725	65798	4656	78034	71650	6384	206	206	0	2362	2362	0
2016	38608	32920	3897	62871	51377	11494	480	480	0	246	246	0
2017	34139	31191	2948	68810	58539	10271	391	391	0	2492	2492	0

3 Impacts on the stock

3.1 Fisheries

All management regions confirmed total closure of the eel fishery for the period 2009 to 2014 with no commercial or recreational licences issued. In the transboundary region, there were no licences and no legal fishery in the Foyle and Carlingford areas from 2009 to 2016. The Northern Ireland portion of the Erne fishery has remained closed from April 2010 to date.

Annual returns from each of the EMUs have indicated levels of illegal eel fishing activity to have remained low or very low over the period from 2009 to 2016. Over the past three years there has been some evidence of an increase in levels of illegal activity from the lower Shannon and Upper Erne areas as confirmed by periodic detection and seizure of illegal fykenets, longlines and coghill nets in these fisheries.

All commercial fisheries remained closed in 2017 and recreational fisheries, confined to angling, were obliged by law to release all eels caught.

3.1.1 Glass eel

3.1.1.1 Commercial

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

3.1.1.2 Proportion retained for restocking

None. Only within catchment assisted upstream migration around barriers.

3.1.1.3 Recreational

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

3.1.2 Yellow eel

There are no true index series for yellow eel landings. Most of the data were aggregated by RBD.

3.1.2.1 Commercial

There are no new landings data since 2008 as the commercial fisheries were closed in 2009.

3.1.2.2 Recreational

There are no data available for yellow eel caught by recreational fishermen (only rod angling). Rod angling catches are required by law to be released alive.

3.1.3 Silver eel

3.1.3.1 Commercial

Commercial Silver Eel Fisheries were closed in 2009 and remain closed each year until 2018.

3.1.3.2 Recreational

None.

3.2 Restocking and aquaculture

3.2.1 Amount stocked

Stocking has not taken place in Ireland between 2009 and 2018. Currently stocking is not included in the Irish Eel Management Plan.

3.2.2 Aquaculture Seed supply

Not relevant.

3.2.3 Glass eel use

Not relevant

3.3 Entrainment

3.3.1 Large-scale Hydropower and major barriers

3.3.1.1 Description

Six catchments in Ireland have major hydropower installations in the lower catchments (Figure 3.1) (NOTE: since the EMP was written, other catchments have new, or smaller HP schemes and these will need evaluation for inclusion in future plans). The Shannon also has flow regulation throughout the catchment. These will be dealt with in detail in the respective RBD EMPs and are as follows:

The Shannon	(ShRBD)
The Erne	(NWIRBD)
The Liffey	(EEMP)
The Lee	(SWRBD)
The Clady/Crollly	(NWIRBD)
The Ballysadare	(WRBD)

Table 3.1 gives the wetted areas in each catchment with major hydropower. Almost 50% of the available wetted habitat is above major barriers (Figure 3.2), although there will be a greater proportion of the potential silver eel production when the differences in relative productivity are taken into account. This is included in the Regional EMPs and in the estimates of pristine and current escapement.

Table 2-11. Wetted areas (ha) for lakes and fluvial area above major hydropower installations.

	Lake area (ha)	Fluvial area (ha)		Total wetted area	Pristine escapement
		>1st order	1st order	ha	kg/ha
Total wetted area	132 275	18 780	2826	153 881	594 408
Total impacted	66 844	5203	959	73 006	265 427
Shannon	38 771	3304	391	42 466	200 839
Erne	24 848	1098	251	26 197	116 633
Ballisadare	1556	29	227	1812	8239
Liffey	-	424	39	464	2012
Clady/Crollly	391	20	5	416	505
Lee	1278	327	46	1651	753

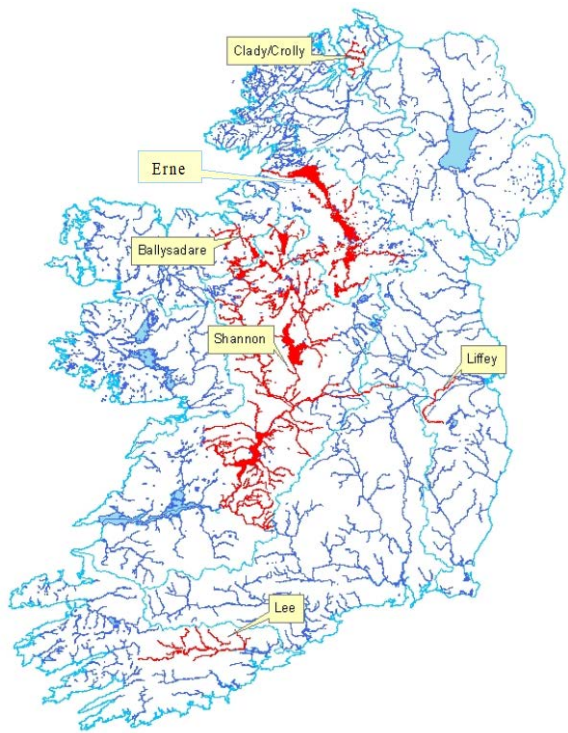


Figure 2-4. Map showing location of catchments where major hydropower installations occur. Waterbodies upstream of hydropower stations are shown in red.

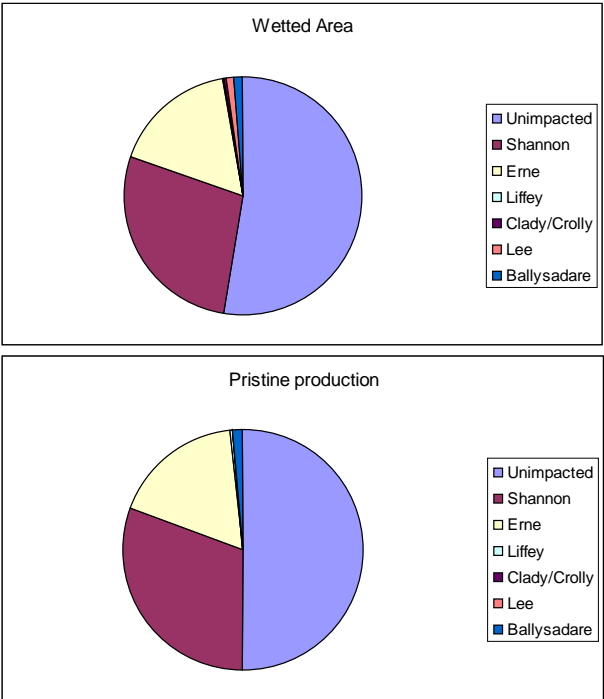
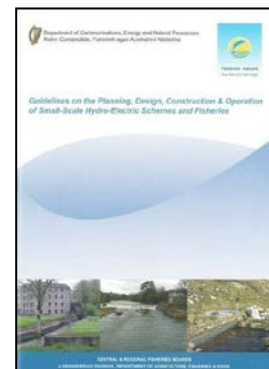


Figure 2-5. Proportions of wetted area and estimated pristine production for the catchments above major hydropower installations.

3.3.2 Small-scale hydropower schemes

3.3.2.1 National recommendation

Guidelines for the location, planning, design, construction, operation and impact evaluation of new small-scale hydro-schemes have been prepared (Anon. 2007). These guidelines require a site-specific approach to evaluating and minimising the impact of existing installations. The Environmental Impact assessment for any new barriers and/or turbines should include an evaluation of their potential impact on direct and indirect mortality of eels. Design criteria and best practice design for eel and elver passes have been published by the Environment Agency (UK) (Solomon & Beach 2004). Efficiency of screens should be monitored for at least the first three years after installation and where necessary modified.



Other obstructions to upstream eel passage include water level regulating weirs, road culverts, abstraction weirs for potable water supplies and weirs for supply of water to mills. A full inventory of these will be presented in the NDP Habitat database and a barriers evaluation tool will be inserted in the Eel GIS. The impact of such obstructions to upstream eel migration is currently unknown in Ireland.

3.3.3 Estimating impact

Acoustic tag telemetry was used to determine migration routes and mortality of migrating silver eel at ESB hydropower stations on both the Shannon and the Erne. Studies were conducted on the Shannon between 2006 and 2011 and on the Erne in 2010 and 2011 (Table 3.2).

Shannon

Summarising the annual data (Table 3.2a) gives mortality ranges of 16.6% to 25% and an overall average mortality of $21.15 \pm 8\%$ for 104 tagged eel arriving at Ardnacrusha HPS. This average has been used in the assessments for 2012–2014 and 2015–2017.

In the Eel Management Plan, a figure of 30% was used to account for the amount of eel potentially using the bypass route down the old river channel and around Ardnacrusha HPS. For 2009–2011, the actual amount of eels recorded to have used the bypass route was 59%, 4.4% & 12.5% respectively. A general figure for eels estimated to use the bypass in recent years is 17.8%. Between 2012 and 2014, 1.6%, 24.3% and 15.9% respectively were estimated to have used the bypass channel.

The mortality of silver eels at Ardnacrusha power station was estimated to be 4666 kg in 2015/2016, 3062 kg in 2016/2017 and 2948 kg in 2017/2018.

Erne

Summarising the data (Table 3.2b) from 2009 to 2011 for the Erne gives mortality ranges for Cliff HPS of between 6.9% and 8.5% and an average of $7.8\% \pm 5\%$ and mortality for Cathaleen's Fall of 22% (nine tags) in 2009. In 2010 and 2011, one turbine was removed for renovation at Cathaleen's Fall HPS and therefore the mortalities were lower at 6.1% and 7.7%. It is likely that mortality rates will at least double when both turbines return to full operation which will necessitate further assessment to confirm site-specific mortality rates.

During the 2013 and 2014 silver eel seasons the patterns of generation and spillage at the River Erne hydropower stations were similar. In the analyses of eel hydropower

passage, varying mortality levels were incorporated, per calendar day, into the escape-ment model. These were based on dusk-dawn hydrometric data, power generation activity and results of previous years silver eel acoustic telemetry. Generation protocols and associated mortality rates have been described in previous reports. For the 2013 and 2014 seasons different mortality rates were applied as follows: *Cliff HPS* (0%, only spillage); 7.9% (Generation plus spillage) and 26.7% (Only generation), *Cathaleen's Fall HPS*: 0% (only spillage); 7.7% (spillage plus half generation load); 15.4% spillage plus full generation load); 27.3% (only generation).

During the 2016/2017 silver eel migration season the discharge in the lower River Erne was exceptionally low. This impacted directly on the pattern of silver eel migration, causing seasonal delays, and indirectly via the pattern of hydropower generation at the two dams. Nocturnal electricity generation was frequently interrupted due to low water levels, as well as an increasing reliance on wind generation for electricity supply to the national grid. Spillage levels were very low for the entire 2016/2017 season.

For the 2016/2017 season mortality rates applies as follows: *Cliff HPS* 0% (no flow or only spillage); 7.9% (Generation plus spillage) and 26.7% (Only generation), *Cathaleen's Fall HPS*: 0% (no flow or only spillage); 7.7% (spillage plus half generation load); 15.4% spillage plus full generation load); 27.3% (only generation). It was estimated that the cumulative mortality represented 18.3% mortality of the total River Erne silver eel production or 46.7% of the migrating eels reaching the dams during the season. Estimated mortality at the dams was 11 494 kg in 2016/2017 calculated using the cumulative mark/recapture method, or 8204 kg when calculated using four individual mark-recapture experiments (see chapter 5.4.2 for full explanation).

For the 2017/2018 season, the estimated mortality at the dams was 10 271 kg. It was estimated that the cumulative mortality represented 14.9% mortality of the total River Erne silver eel production or 40.5% of the migrating eels reaching the dams during the season.

Currently there is no solid information about the proportions of eel that migrate via spillways compared to via the turbine passages. There may be selective migration towards the spillways, especially at Cliff, which may help to explain the low HPS mortality levels observed on the Erne to date. On return to full generation protocols additional work will be needed to confirm eel migration routes and overall HPS mortality rates on the Erne.

Table 2-2a. Summary mortality data for acoustic telemetry on the R. Shannon (mortality and by-pass).

	Year	Number tagged eel	Mortality*	Number of tagged Eel	Mortality**	% using bypass
Shannon	2006					
	2007					
	2008					
	2006–2009	44	20.4%	-	-	59%
	2010	40	22.5%	-	-	4%
	2011	20	20.6%	-	-	13%
	Average		21.15%			
	2012	No direct assessment, 21.15% used in estimating escapement				1.6%
	2013	No direct assessment, 21.15% used in estimating escapement				24.3%
	2014	No direct assessment, 21.15% used in estimating escapement				15.9%
	2015	No direct assessment, 21.15% used in estimating escapement				56.5%
	2016	No direct assessment, 21.15% used in estimating escapement				8.5%
	2017	No direct assessment, 21.15% used in estimating escapement				19.9%

* Ardnacrusha HP station on the R. Shannon.

Table 2-2b. Summary mortality data for acoustic telemetry on the Erne (two stations- Cliff and Cathaleen's Fall HP stations).

		Number tagged eel	Mortality*	Number of tagged Eel	Mortality**	
		Cliff HPS		Cathaleen's Fall		
Erne	2009	13	7.7%	9	22	
	2010	29	6.9%	26	7.7	one turbine
	2011	60	8.5%	49	6.1	one turbine
	2012	30	26.7%	No assessment; 8% used in estimating escapement		
	2013		26.7%/7.9%/0% used***	0%/7.7%/15.4%/27.3% used****		
	2014		26.7%/7.9%/0% used***	0%/7.7%/15.4%/27.3% used****		
	2015		26.7%/7.9%/0% used***	0%/7.7%/15.4%/27.3% used****		
	2016		26.7%/7.9%/0% used***	0%/7.7%/15.4%/27.3% used****		
	2017		26.7%/7.9%/0% used***	0%/7.7%/15.4%/27.3% used****		

* Cliff HP station on the R. Erne.

** Cathaleen's Fall HP station on the R. Erne.

*** Cliff HP station- Estimates applied with and without spillage, no direct assessment.

**** Cathaleen's Fall HP station- Estimates applied with and without spillage, no direct assessment.

3.4 Habitat quantity and quality

Section 3.4 is extracted from Ireland's 2018 draft report to the EU.

The improvement of water quality in Ireland is primarily being dealt with under the work programme for the implementation of the Water Framework Directive (WFD). The objective of the Water Framework Directive (WFD) is to protect all high status waters, prevent further deterioration of all waters and to restore degraded surface and ground waters to good status by 2015 (www.wfdireland.ie). The first cycle of the WFD ran from 2009–2015, and the second cycle runs from 2016–2021 (www.catchments.ie).

National regulations for implementing the directive were put in place in 2003. A major monitoring programme began in December 2006 to inform the first cycle of the WFD. A detailed report on the results of the first cycle of WFD monitoring is not available to date (mid-2017). In the interim period, the Environmental Protection Agency (EPA) compile statistics on water quality in Ireland, the most recent of which covers the period 2010–2012 (Bradley *et al.*, 2015). For that period, 53% of rivers, 43% of lakes, 45% of transitional waters, 93% of coastal waters and 99% of groundwater were satisfactory at good or high status. Rivers monitored, using the biological Q value scheme, were in high or good condition along 73% of the monitored river channels. This was up 4% from the last monitoring period (2007–2009), and includes an overall increase in high status sites. Serious pollution of rivers reduced to 17 km from 53 km since last reporting period. There was a 5% reduction (ten lakes) in the high or good status categories, and a corresponding increase in the moderate or worse status category compared to 2007–2009.

Before the publication of the interim reports, much of the monitoring data are available through the www.catchments.ie data portal, including the monitoring data for the period 2010–2015. The extended results for the period 2010–2015 are roughly similar to

those reported for 2010–2012 (Bradley *et al.*, 2015). Most rivers, lakes and coastal waters are classified as having good status, and most transitional waters are classified as moderate (Table 3.3, Figure 3.3). The results from 2010–2015 are fairly similar to those recorded in 2007–2009, with 45% of surface waters being classified as having good ecological status.

The Irish EPA data (summarised above) refer to waterbodies within seven RBDs (Eastern, Neagh Bann, North Western, South Eastern, Shannon, South Western and Western). The Neagh Bann, Shannon and North Western RBD's are transboundary with Northern Ireland. Only a very small portion of the Shannon RBD is in Northern Ireland, while the Neagh Bann RBD is not included in the Irish Eel Management reports. Therefore, the implementation of the WFD in the Northern Irish portion of the North Western RBD is also of interest in this report, as it is the major international RBD which is considered in this eel management report. The status classification for 2015 for surface waters in NWiRBD shows that 46% are at good or better status. This can be broken down to 46% of rivers, 25% of lakes, and 33% of transitional and coastal waterbodies (by numbers) at good or better (NIEA, 2015).

Table 2-3. Trend in Surface Water quality over the first cycle of the WFD monitoring program. Data accessed from <https://www.catchments.ie/data> (April 2017).

Period	High	Good	Moderate	Poor	Bad
2007–2009	13%	44%	27%	14%	1%
2010–2012	14%	44%	26%	15%	1%
2010–2015	11%	45%	27%	17%	1%

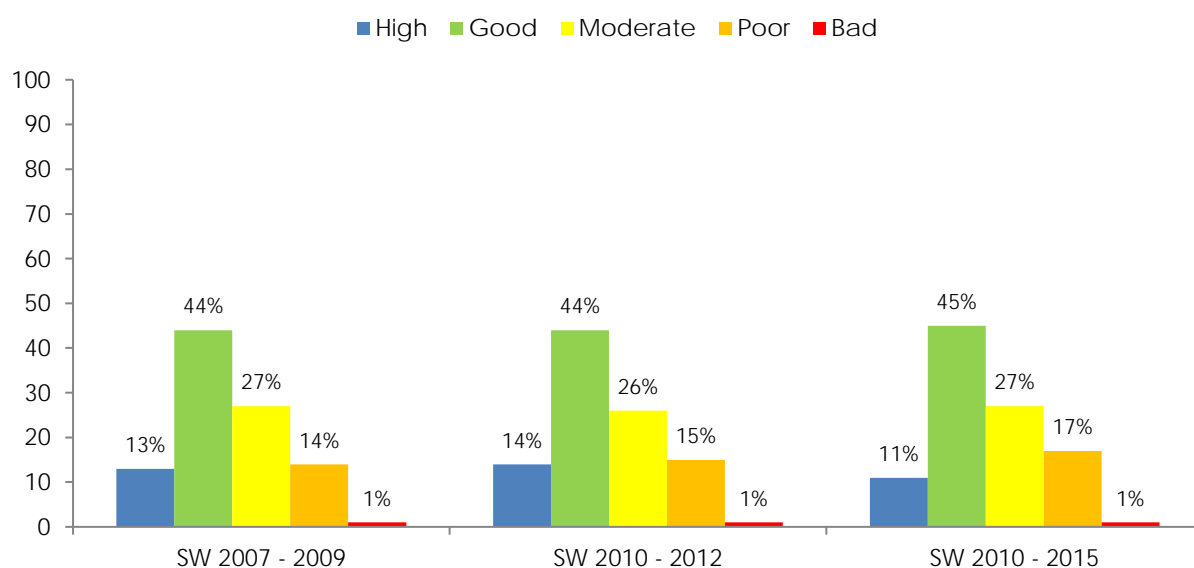


Figure 2-6. Trend in surface water quality over the first cycle of the WFD monitoring program. Data accessed from <https://www.catchments.ie/data> (January 2018).

3.4.1 WFD monitoring, fish

Inland Fisheries Ireland (IFI) is responsible for delivering the fish monitoring element of the WFD in Ireland. Eel are included in the WFD (fish) monitoring of rivers, lakes and transitional waters. Summary reports are available for all sites surveyed (www.wfdfish.ie). The most recent of these summary reports is the report for 2016 (Kelly *et al.*, 2017). In 2016, a comprehensive fish surveillance monitoring programme was conducted, with 197 river sites, 19 lakes and 11 transitional waters successfully surveyed throughout the country. Eel are ubiquitous across all sites, and were found in 94% of lakes surveyed, 35% of river sites and 87.5% of transitional water sites (Tables 3.4 and 3.5).

3.4.2 Fish kills

A total of 23 fish kills were recorded by Inland Fisheries Ireland (IFI) in 2015, 31 in 2016 and 17 in 2017. While none of these fish kills refer specifically to eel and the impact on eel has not been quantified, it is likely that where conditions result in a kill of any fish species, there are likely to be detrimental impacts on all species in the waterbody.

Year	Number of fish kills recorded
2007	22
2008	34
2009	16
2010	34
2011	31
2012	10
2013	52
2014	22
2015	23
2016	31
2017	17

3.4.3 Action 4b: Fish health and biosecurity issues

3.4.3.1 Toxins

The EPA carried out surveillance monitoring in 2007–2009 of 180 river sites and 76 lake sites for what are known as dangerous substances (i.e. priority substances and priority hazardous substances). Monitoring was undertaken at each site with a frequency of 12 times per year once the programme commenced in mid-2007. Generally, the occurrence of environmentally significant metals was found to be low in Ireland. In addition, the levels of priority pollutants (plant protection products, biocides, metals and other groups such as combustion by-products, polycyclic aromatic hydrocarbons (PAHs), and the flame retardants polybrominated diphenyl ethers (PBDEs)) were generally very low with very few exceedances being found (McGarrigle *et al.*, 2011). These data confirm that bioaccumulation of toxins of eels in Ireland is likely to be less significant than that observed in many other EU countries.

3.4.3.2 *Anguillicola crassus*

The swimbladder parasite, *Anguillicola crassus*, was first detected in Ireland in the Waterford Harbour in 1997 (McCarthy *et al.*, 1999) and later in the Erne System (Evans and

Matthews, 1999). The introduction of the parasite into the Republic of Ireland was most likely through the eel trade. Transport of live eels and potentially contaminated water was commonplace into and out of commercial eel fisheries areas. Since that time, the parasite has spread prolifically across the country and currently infestations are to be found in at least 75% of the wetted area of the Republic of Ireland (Becerra-Jurado *et al.*, 2014), with only small coastal catchments and a few areas in the northwest and southwest of the country remaining parasite-free. On average, across yellow and silver eel populations sampled, percentage prevalence of the parasite is between 60–80% with mean infection intensities of between 4–6 worms per eel. Infection of a system begins with low prevalence and intensity values which quickly expand. Within just a few years, values increase to those reminiscent of a system infected for several years. Prevalence and intensity can often fluctuate for many years afterwards until the infestation becomes established, after which time, the percentage prevalence and intensity of infection will often remain quite stable. In 2011, Lough Ballynahinch and Lough Inchiquin both showed very low prevalence of the parasite (13% and 1%, respectively). These were noted as some of the lowest prevalence values gained to date. However, on resampling both lakes in 2015, the prevalence had increased to higher levels (86% and 13%, respectively). This indicates that the parasite is continuing to spread within catchments.

Since 2013, two swimbladder tissue health indices have been applied to the retained samples of eels in order to monitor the potentially increasing degree of damage due to infection - The Swimbladder Degenerative Index (SDI), (Lefebvre *et al.*, 2002) and the Length-Ratio Index (LRI), (Palstra *et al.*, 2007). Despite the high rates of prevalence and intensity recorded during surveys, these indices have reported, on average, slight to moderate damage in swimbladder tissue of eels captured in the Republic of Ireland. The reasonably low degree of swimbladder damage may be a result of 1) the high dependence of *A. crassus* on specific temperature ranges to complete its entire life cycle and 2) the ability of eels to regenerate tissue damage in times of low parasite infection rates. These elements are currently the focus of an ongoing research study by the IFI's Eel Monitoring Programme.

3.4.3.3 Biosecurity

Closure of the commercial eel fishery has significantly reduced the biosecurity issues associated with eel dealers moving from catchment to catchment. Strict biosecurity protocols are followed by both IFI survey crews and by ESB contracted silver eel fishermen as a condition of the DCENR authorisation issued to the ESB in respect of silver eel trap and truck operations.

The National Scientific Committee for Eel has issued the advice:

*Due to concerns relating to the possible introduction of pathogens and/or non-invasive species to Irish waters, the Standing Science Committee on Eel **advises against any introductions of live eel** imported from outside Ireland and especially from the continent. The SSCE **also advises against inter-catchment translocations** of live eel and/or water to minimise the spread of already introduced non-native species. The SSCE recommends that this advice should apply to the island of Ireland, especially in relation to transboundary catchments.*

Table 2.4. Interim assessment of Irish waterbodies according to fish metrics 2007–2014 as part of the WFD monitoring program carried out by Inland Fisheries Ireland (Kelly *et al.*, 2014).

Period	Components monitored		No. of sites surveyed	% High	% Good	% Moderate	% Poor	% Bad	Source	Number of fish kills reported to IFI
2007–2009	Fish only	Rivers	134	8	49	40	2	1	IFI	
		Lakes	70	14	30	49	6	1		
		Transitional	72	1	51	32	13	3		
2010	Fish only	Rivers	43	9	39	42	0	0	IFI	34
		Lakes	25	24	32	4	4	40		
		Transitional	25	0	52	36	8	4		
2011	Fish only	Rivers	65	12	32	43	9	2	IFI	31
		Lakes	29	28	34	17	24			
		Transitional	2	0	50	50	0	0		
2012	Fish only	Rivers	58	14	59	26	9		IFI	10
		Lakes	23	43	17	13	17	9		
		Transitional	3	0	33	66				
2013	Fish only	Rivers	63	10	41	44	5	0	IFI	52
		Lakes	24	25	33	4	25	8		
		Transitional	10	0	60	40	0	0		
2014	Fish only	Rivers		10	46	25	18	1	IFI	22
		Lakes		11	35	33	12	8		
		Transitional		13	19	49	15	5		

Table 2.5. Interim assessment of Irish waterbodies for the full suite of metrics carried out by the Environmental Protection Agency (McGarrigle *et al.*, 2011).

Period	Components monitored		No. of sites surveyed	% High	% Good	% Moderate	% Poor	% Bad	Source	Number of fish kills reported to IFI
2007–2009	Full suite	Rivers	1564	13	39	28	19	1	EPA	
		Lakes	222	9	38	41	9	<1		
		Transitional	121	16	30	51	3			
2010–2012	Full suite	Rivers	2278	14	46	25	15	0	EPA	75
		Lakes	225	10	35	33	14	9		
		Transitional	80	5	26	52	17	0		
2010–2015	Full suite	Rivers	2345	10	46	25	18	0	EPA	172
		Lakes	225	11	35	33	12	8		
		Transitional	80	13	19	49	15	5		

4 National stock assessment

4.1 Description of method

These sections are a synthesis of the methods described in the Irish Eel Management Plan and in the 2012, 2015 and 2018 Irish Management Reports to the EU.

4.1.1 Data collection

4.1.1.1 Surveys

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

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

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

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

4.1.1.2 Method summary

The Irish assessment is built around the use of index catchments, where the silver eel escapement and mortality is assessed directly using mark-recapture (Shannon, Erne, Fane), DIDSON (Erne, Shannon), acoustic tracking for mortality assessment (Shannon, Erne) or by total trap (Burrishoole). A comprehensive wetted area database of habitat is used along with the index catchments and eel growth data from 18 catchments to extrapolate to other catchments where there are no eel data.

The index catchments (Shannon, Erne, Fane and Burrishoole) contribute to 45% of the total freshwater wetted area.

The transitional and coastal waters have not been assessed for silver eel production. Transitional waters are being surveyed using fykenets under the National Eel Monitoring Programme and for the WFD, but these yellow eel data have not yet been incorporated in an assessment.

4.1.1.3 Local stock assessment

A national database is in the process of being compiled and this contains local stock assessment data. The main assessments included in the database are, single pass electrofishing surveys, multispecies 3 fishing depletion electrofishing surveys, boat electrofishing multispecies surveys, fykenet and electrofishing surveys under the Water Framework Directive and eel specific fykenet surveys.

A national programme of stock assessment and monitoring is outlined in the Eel Management Plan and in the Irish report to the EU. Index catchment have been intensively studied (Shannon, Erne, Corrib, Burrishoole) and these have been used to calibrate a wider assessment of data-poor catchments. The stock surveys were all reported in the Irish Reports to the EU 2012 and 2015.

These data were used for a first application of the French Eel Density Analysis model (EDA) and the years 2009–2011 were analysed and reported (deEyto *et al.*, 2015).

4.1.1.4 Life stages

Glass Eel/ Elver life stages are determined using the pigmentation classification published by Elie *et al.* (1982).

Yellow eel and silver eel are categorised by a combination of capture method and season, colouration and eye size. Silver eels are generally captured during their downstream migration, or can be recognised in the yellow eel catch by the enlarged eyes and onset of coloration change.

4.1.1.5 Age and growth analysis

Age determination: burning and cracking, annual inter-agency verification. Age analysis of eel in Ireland has generally followed the methodology of burning & cracking (Christensen, 1964; Cullen and McCarthy, 2003; Hu and Todd, 1981; Moriarty, 1983; Poole and Reynolds, 1996b; Vollestad *et al.*, 1988). Otoliths are extracted as described by Moriarty (1973), stored dry and prepared by burning in either gas or spirit flame. There is no formal validation or quality control in Ireland. Some cross validation and double reading has been carried out between projects and between agencies and this has ensured some degree of continuity between samples and surveys, (i.e. Moriarty, 1983; Poole *et al.*, 1992; Matthews *et al.*, 2001; Matthews *et al.*, 2003). Comparisons have also been made between age derived growth (back-calculations) and tag/mark recapture determined growth, thereby validating the use of burning & cracking otoliths for age and growth determinations in slow growing Irish eel (Poole and Reynolds, 1996a; Moriarty, 1983).

Ireland is using the recommendations and manual of the ICES Workshop on Eel Age WKAREA 2009 and 2011. An initial training workshop was held in Inland Fisheries Ireland in February 2010, using the WKAREA information as a guideline and a follow-up workshop was held in the Marine Institute in February 2012. Further intercalibration took place in 2014.

4.1.1.6 Sex

Sex determination: macroscopic on specimens sacrificed for ageing, statistically by length for silver eel.

Yellow eel <25 cm are problematical to sex and >25 cm up to 45 cm are sexed by dissection.

Silver eel are sexed by length and some studies have carried out dissections on eels between ~38 cm and 48 cm in order to determine the length overlap between the sexes. Histological verification has not been used to any extent in Ireland.

4.1.1.7 Silver eel production

Production and escapement is estimated in data-poor rivers using extrapolation based on eel growth and geology.

In future, it is hoped to use a combination of EDA and the extrapolation method for estimation silver eel production.

4.1.2 Analysis

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

Eel production in transitional waters was estimated using cpue from fykenet surveys to calibrate an analysis of transitional waterbody types and habitat (see Chapter 2.3) and this was applied retrospectively back to 2009.

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

4.1.3 Reporting

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

4.1.4 Data quality issues and how they are being addressed

Data are reported to the SSCE on an annual basis and any issues are discussed and the agencies responsible notified.

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

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

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

4.2 Assessment results

See chapter 2.8 and the 2018 Stock Annex.

4.2.1 Habitat quantities

Refer to electronic table.

4.2.2 Silver eel biomass indicators

Refer to electronic table and Tables 2.3–2.8.

Stock indicator and mortality data unchanged from Ireland (2012, 2015, 2018) reports.

4.2.3 Anthropogenic mortality rates

Refer to electronic table and Table 2.9.

5 Other data collection

5.1 Recruitment

Many studies have focused on sampling the active phase of elver migration into fresh-water (Gollock *et al.*, 2011; Jessop, 2000; Knight and White, 1998; Moriarty, 1986; Naismith and Knights, 1988; O'Connor, 2003; Piper *et al.*, 2012; Reynolds *et al.*, 1994). Elvers exhibit countercurrent behaviour once they start actively migrating upstream. This means that instead of moving with the current as they do in the estuary, they now avoid the river current which will carry them downstream. To avoid the current the elvers migrate along the banks of the river and seek out slack water. At this time the elvers are congregated in schools near the bank of the river where they can be trapped.

The sites monitored are shown in Figure 5.1.

The elver traps used on the Erne and the Shannon by the ESB are permanent brush ladders, based on the fixed ramp style traps designed by O'Leary and reported in an EIFAC technical paper on 'Eel Fishing gear and techniques in 1971, leading to holding boxes fitted with freshwater supplies. They are sited at the main hydro installations at Ardnacrusha and Parteen on the Shannon, Cathaleen's Fall on the Erne and Iniscarra Dam on the Lee. They are described in more detail in the Irish SSCE reports.

The elver traps used by IFI are also based on the fixed ramp-style traps. They have been cited in various studies with modifications being made to the traps (Gollock *et al.*, 2011; Jessop, 1995; Jessop, 2000; Moriarty, 1986; Naismith and Knights, 1988). Elvers and young yellow eels will encounter the ramp and ascend due to the flow of water attracting them upstream. The elver migration season extends from April to August, with migration influenced by water temperature and river discharge. White and Knights (1997) reported not catching juveniles eels in any numbers until temperatures rose above 15–16°C in mid-June /early July, peaking at >20°C. The pattern of distribution across a season has been described as waves of runs of short duration but repeated over the season (Jessop, 2000). Where possible the traps are located downstream of a structure (e.g. weir or waterfalls) in order to get a flow of water to feed the traps. The structure also acts as a bottleneck restricting the ability of elvers utilising the whole river to ascend.

Elver traps on the Burrishoole (IE_West) and the Liffey (IE_East) are O'Leary type bristle ramp traps with gravity fed water supplies.

The aim of the long-term monitoring programme is to set up a number of sites as an index of recruitment in order to get an understanding of changes to recruitment since the implementation of the Eel Regulation. It is not intended to make assumptions on the whole catch entering the river as the proportion of elvers avoiding the traps is not known and is difficult to quantify. The elver traps sample a proportion of the elver migration in a standardised way and when operating for a number of years a trend in recruitment is recorded.

There is no authorised commercial catch of juvenile eel in Ireland, but some fishing has been authorised in the past under Section 18 of the Fisheries Act for enhancement of the fisheries. Catches are made at impassable barriers and this is reported in the relevant Regional Eel Management Plans.

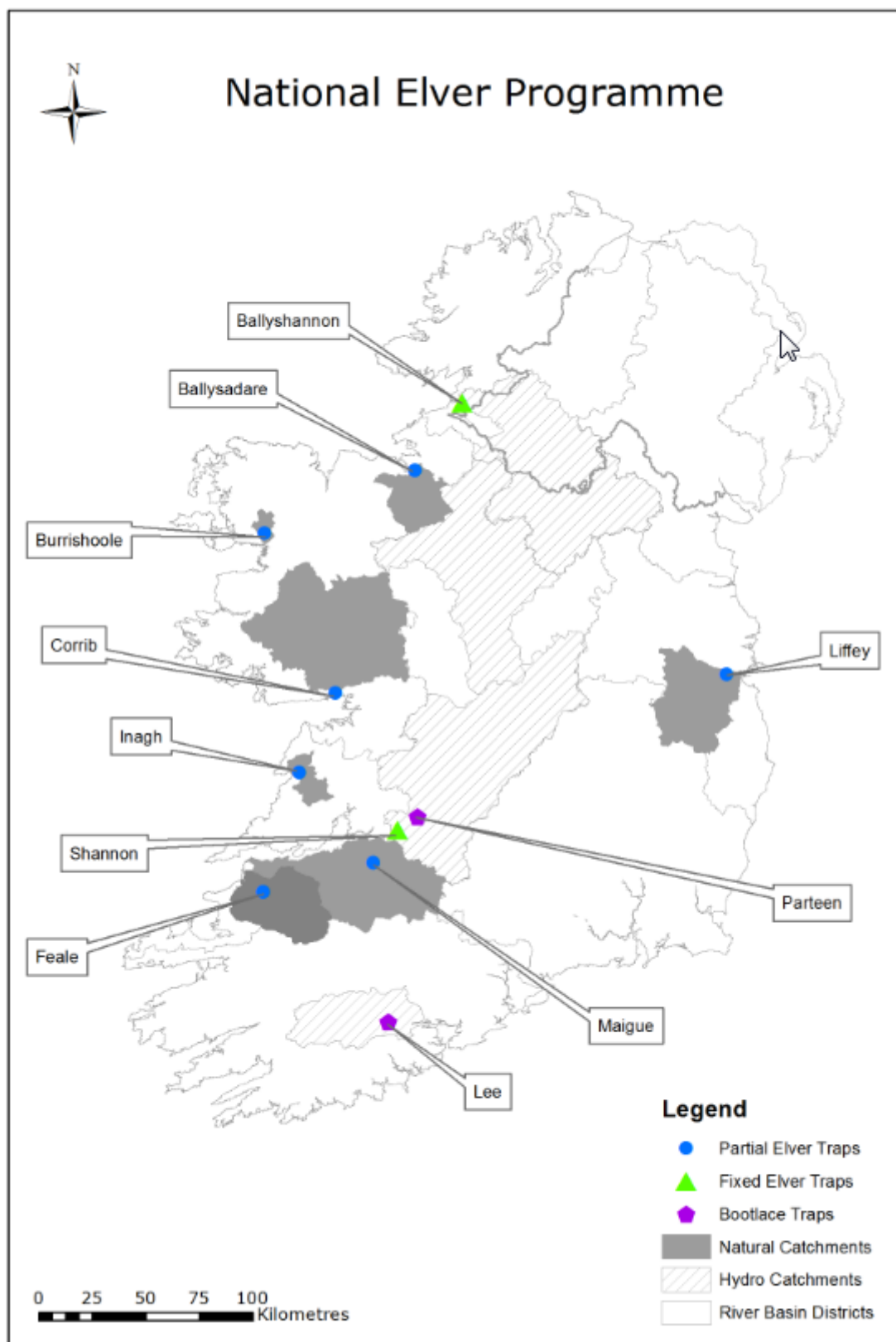


Figure 2-7. Location of recruitment monitoring stations in Ireland.

5.1.1 Shannon and Erne

Long-term monitoring of elver migrating at Ardnacrusha (Shannon) and Cathaleen's Fall (Erne) is undertaken by the ESB (Figure 5.2).

In the Erne recruitment has shown an increase each year since 2011 with the highest catch in 2018 since 1995.

Major refurbishment of the Erne elver traps was undertaken in early 2015 and this may have improved the efficiency of the Erne traps thereby likely introducing a discontinuity into the time-series. A third new trap was also installed and the data for this trap are being handled and reported separately in order to preserve the original time-series.

Data for the Ardnacrusha Shannon trap have been low in recent years. 2016 saw a marked improvement in recruitment in the Shannon in both glass eel (elvers) and young yellow eel.

Major refurbishment of the Shannon Ardnacrusha trap took place in early 2017 with a new water supply and brushes on the ladder.

5.1.2 Other locations

Long-term monitoring of migrating elvers also takes place at on the Feale, Inagh and Maigue Rivers and fishing was also previously undertaken in the Shannon Estuary for glass eels.

Note: Data were not available for the Feale, Maigue and Inagh for 2018.

5.1.3 Summary

Recruitment for the 2015 season indicated that there was a general decrease in the recruitment levels to Ireland in 2015 compared to 2014. The Erne was the only location to show an increase but it should be noted that this site also received considerable refurbishment of the traps.

Recruitment for the 2016 season showed a general increase in the recruitment levels to Ireland in 2016 compared to 2015, particularly on the West coast. There was a marked improvement on the Shannon. There was little change in the catch in the Liffey traps on the east coast.

Recruitment for the 2017 season showed a general drop in the recruitment levels to Ireland in 2017 compared to 2016, despite many of the elver traps receiving upgrades, new climbing media, etc.

Recruitment for the 2018 season showed a mixture with a marked increase in the Erne and the Liffey, but decreases in the Shannon and the Burrishoole. (Note the Shannon young yellow eel recruitment increased; See Chapter 5.2).

In 2018, extreme drought and low water levels may have increased the efficiency of some traps where weirs dried and made the trapping location more attractive to young eels, such as on the Liffey.

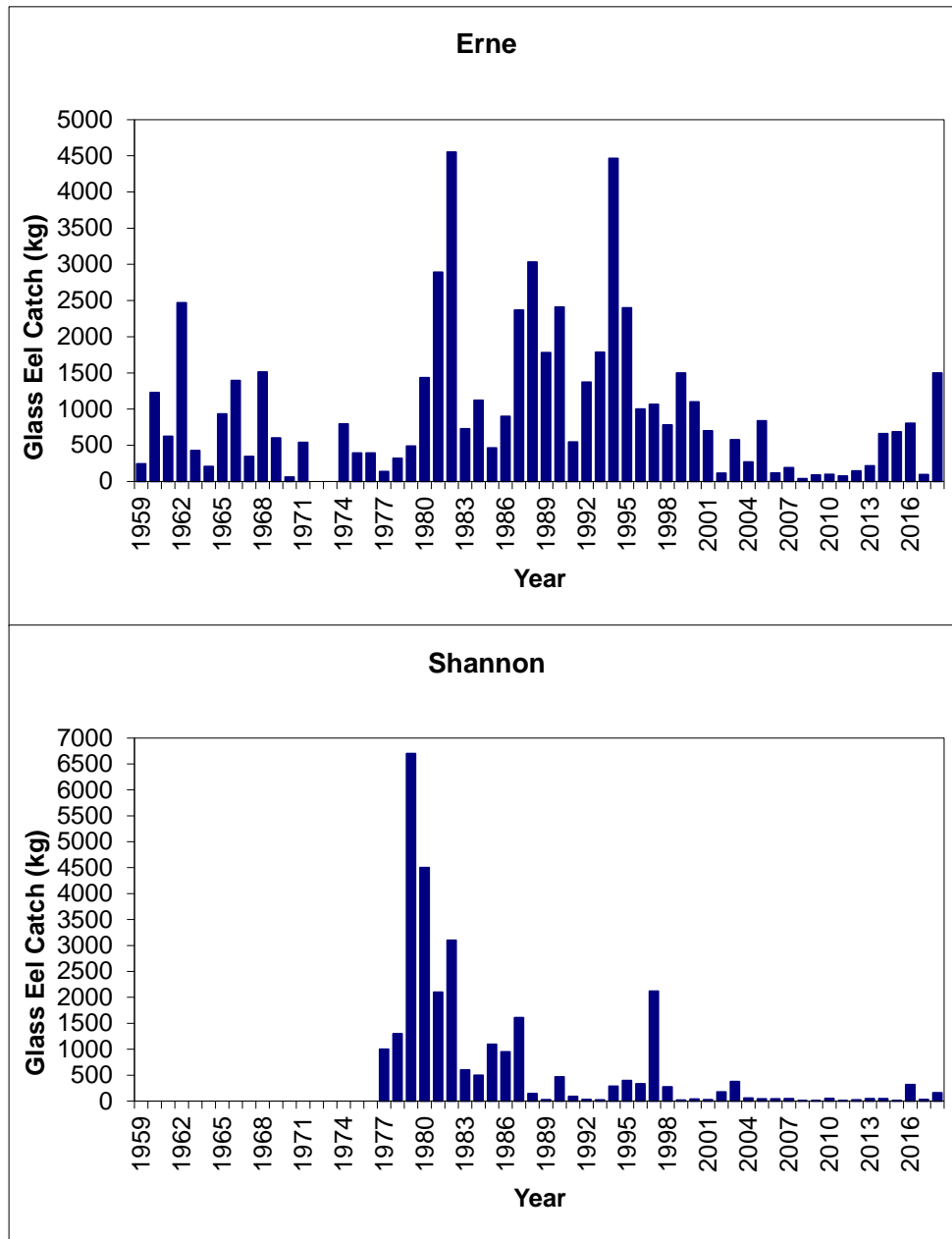


Figure 2-8. Annual elver catches (t) in the traps at Ardnacrusha (Shannon) and Cathaleen's Fall (Erne); data from ESB. Full trapping of elvers took place on the Erne from 1980 onwards. Erne 2015 onwards does not include the additional new trap.

5.2 Other recruitment time-series

Monitoring of juvenile yellow eel migrating at Parteen Regulating Weir (Shannon) and Inniscarra on the R. Lee takes place using fixed brush traps.

The data for Parteen are presented in Figure 5.3 and the electronic tables. In 2009 and 2010, due to maintenance work by ESB at the Parteen regulating weir the discharge patterns were less favourable than in 2008. This may partly account for the poor catches recorded in 2009 and 2010. However, catches in the original Parteen hatchery trap continued to decline in 2011, 2012 and 2013. The catch in 2015 was 301.1 kg and in 2016 it was 890 kg.

A new trap was installed in 2012 on the Shannon at Parteen, on the opposite bank (Co Clare). The catch was 6.6 kg and 6.8 kg in 2013 and 7.8 kg in 2014. The Co Clare trap and a new one installed in 2015 near the hatchery (Tipperary) trapped 26.95 kg in 2015 and 23.1 kg in 2016.

In Parteen in 2017, the main catch was 121 kg and the new traps catch was 15 kg.

In Parteen in 2018, the main catch was 1338 kg and the new traps catch was 2.4 kg.

In 2010, less than 1 kg was recorded in the Inniscarra trap on the River Lee and in 2011, 48 kg were recorded. The catch has declined since 2011 with only 0.6 kg recorded in 2014 and 0.94 kg in 2015. The catch remained low in 2016 (1.1 kg) and in 2017 it was 13.8 kg.

In 2018, the Inniscarra trap only trapped 0.8 kg, likely due to low water levels and closure of the fish pass.

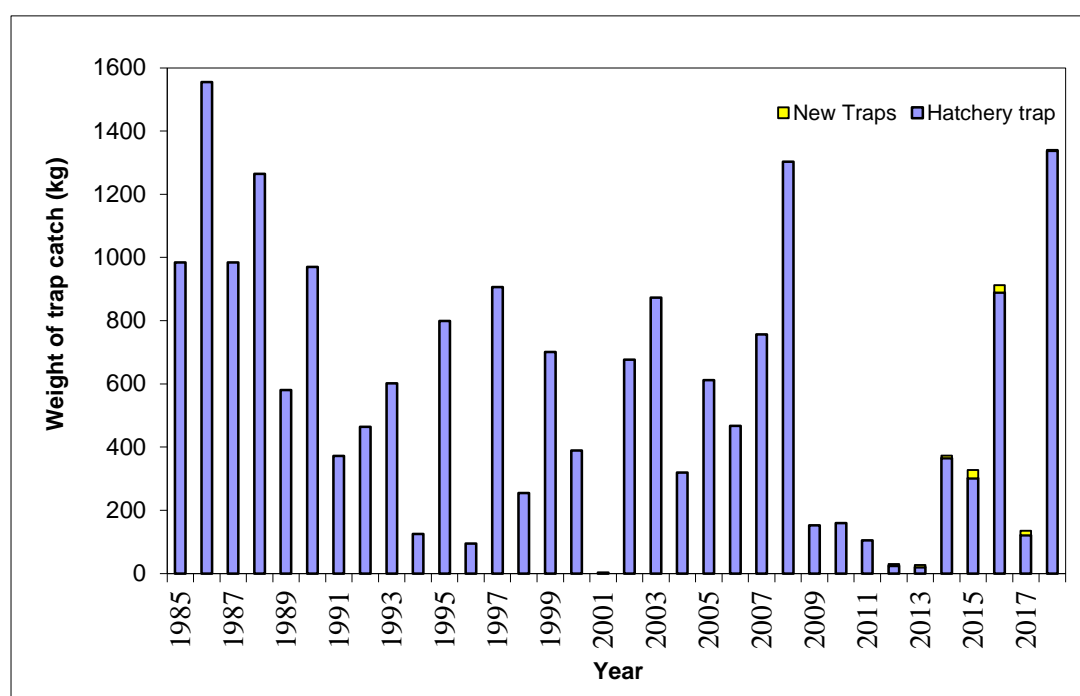


Figure 2-9. Juvenile yellow eel catches (kg) at Parteen Weir, 1985 to 2018. From 2012, a second trap was installed on the opposite bank (Clare) and another in 2015 near the hatchery (Tipperary) and these data are included in the graph as separate bars.

5.3 Yellow eel 2017

Yellow eel surveys took place in seven lakes, three transitional waters and one sub-catchment of the Barrow (Figure 5.4). The lakes surveyed were Lough Corrib (Upper and Lower), Lough Conn, Lough Cullin, Lough Muckno and Lough Ramor by IFI, and two lakes in Burrishoole (by MI). The transitional waters were Waterford Estuary, the Munster Blackwater Estuary (by IFI) and Lough Furnace in Burrishoole (by MI). A semi-quantitative electric-fishing survey was also undertaken in three subcatchments of the River Barrow (Tully, Pollmounty and Aughnavaud subcatchments) in order to determine the eel distribution in the rivers around the main channel.

The yellow eel surveys need to meet a number of objectives, to monitor the impact of fishery closure on yellow eel stock structure, compare with historic eels surveys, establish baseline dataset, evaluate impedance of upstream migration and determine parasite prevalence within Ireland. Samples of eels are measured for length, weight, and INDICANG style morphological features associated with silvering (eye measurements, pectoral fin measurements, and pigmentation). At selected locations eels are retained for further analysis in the laboratory. These analysis include age, growth, sex determination, parasite prevalence and diet.

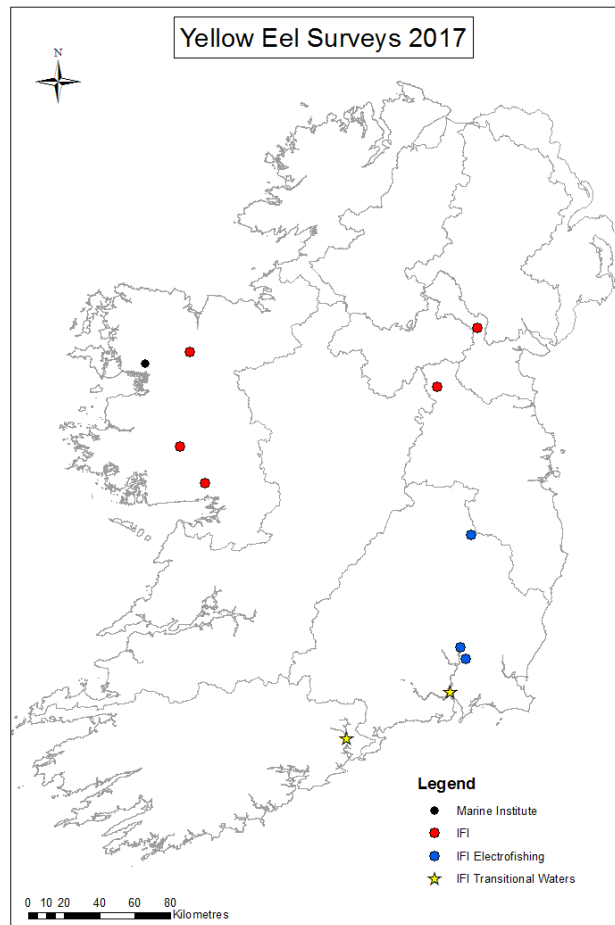


Figure 2-10. Locations of yellow eel survey locations, 2017.

5.3.1 Upper Lough Corrib

Lough Corrib is situated in Co. Galway in the Corrib catchment. The lake has a total surface area of 16 439 ha and a maximum depth of approximately 39 m. It is divided in two for surveying purposes. Both upper and lower Lough Corrib was sampled in 2017.

5.3.1.1 2017 survey

A repeat fykenet survey of the lake was performed in 2017 over eight nights (four nights in July and four nights in August (Figure 5.5)). An additional one night survey (eight chains of five fykenets) was conducted in the Salhouse Bay in September in the week between the full moon and the new moon.

A total of 2159 eels were captured within the lake as a whole giving a cpue of 5.59. While this catch was very high, the majority of these eels (1659) were captured in Salthouse Bay. This bay was of interest following large catches in 2016 ($n = 1970$) and a targeted survey was carried out to further investigate the local eel fisherman's knowledge that the greatest numbers of eels were to be captured here during the August dark moon phase. The bay was fished for eight nights with between two and four chains of fykenets (10–20 nets) in July and August, with all eight chains set in the bay over the one night in September (40 nets). All eels captured and processed ranged in length from 30.7 cm to 83.2 cm and in weight from 0.050 kg to 1.104 kg, with a total catch weight of 392.7 kg (Table 5.3 and Figure 5.6). The Upper Corrib survey was hampered on the first sampling occasion by high winds, with eight chains of nets being left in for two nights due to poor weather conditions. On the last nights survey the lake rose quite substantially from heavy rainfall, which may have hindered catch figures.

The abundance of eels in Salthouse Bay was investigated over the three sampling occasions in 2017 (Table 5.1). In 2016, the large number of eels in the bay occurred during the August new moon ($n = 1970$), in 2017 the equivalent large numbers occurred in the July new moon ($n = 1291$) with lower catches during the August new moon ($n = 302$) and the first quarter moon phase in September ($n = 66$). This indicates that there is a temporary accumulation of eels within the bay based on local environmental conditions.

One theory to explain the large numbers of eels in the bay during the new moon phase in August 2016 and July 2017 was that these were silver eels congregating in the bay before migrating downstream. A look at the maturation stage for the eels taken during both 2016 and 2017 does not show a large number of migrant eels classified using the Durif classification (Table 5.2, Figure 5.7). In August, 2016 96% of the samples taken in the bay were of resident eels and 4% were pre-migrant. In July 2017, 75% were resident eels and 20% were pre-migrant eels.

During the single nights survey in Salthouse Bay in September a total of 66 eels were captured ranging from 0 to 19 eels within a chain. The resultant cpue was 1.65. This leads us to believe that eels do indeed congregate in the bay during certain periods of summer and not at any other time of the year. If and why they are moving into the bay from the local bog lands through the Cross River and the many sink holes within the bay or in from the main lake, will have to be investigated further.

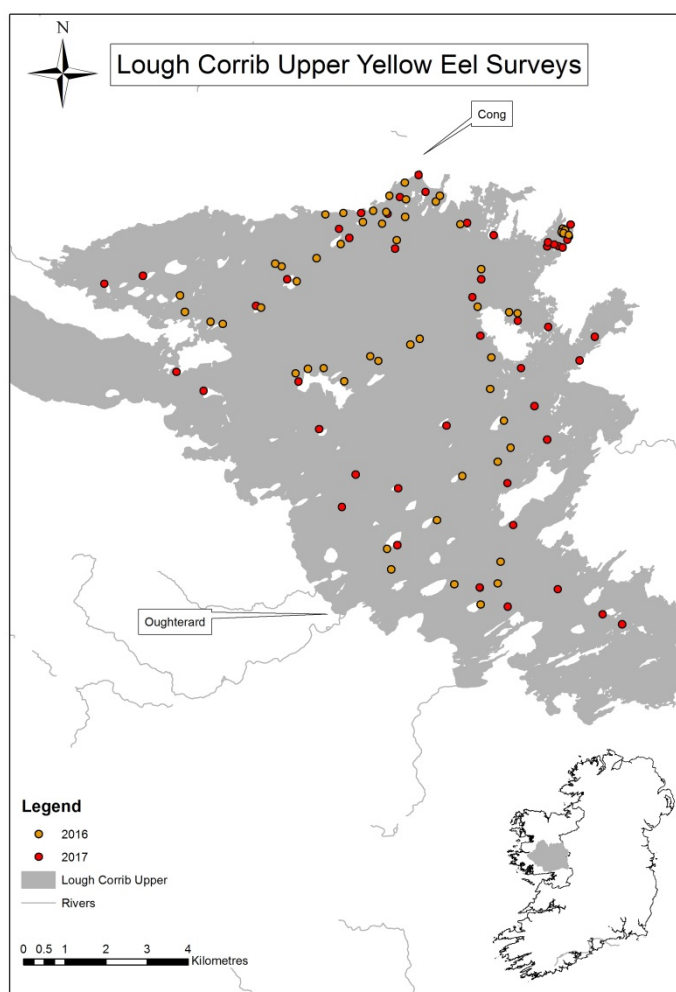


Figure 2-11: Locations of fykenets sampled on L. Corrib Upper, 2016–2017. (Inset: Map of Ireland with Corrib catchment (shaded) and Western River Basin District (outlined)).

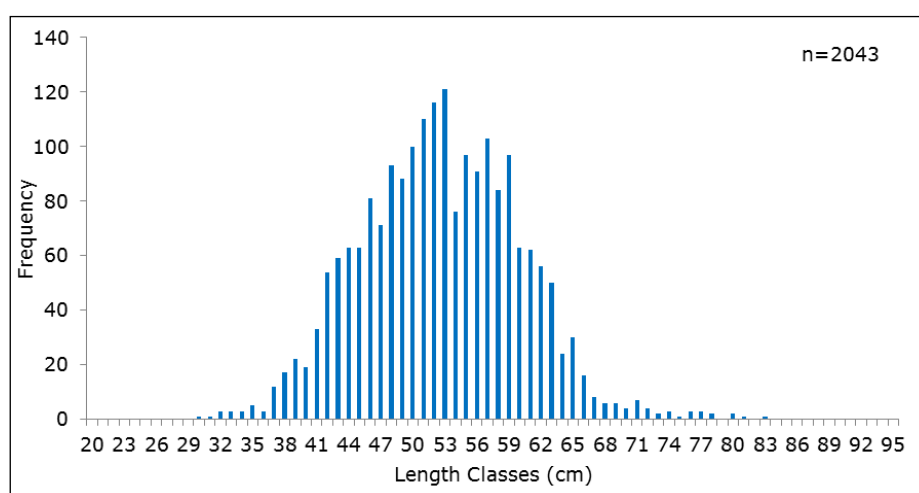


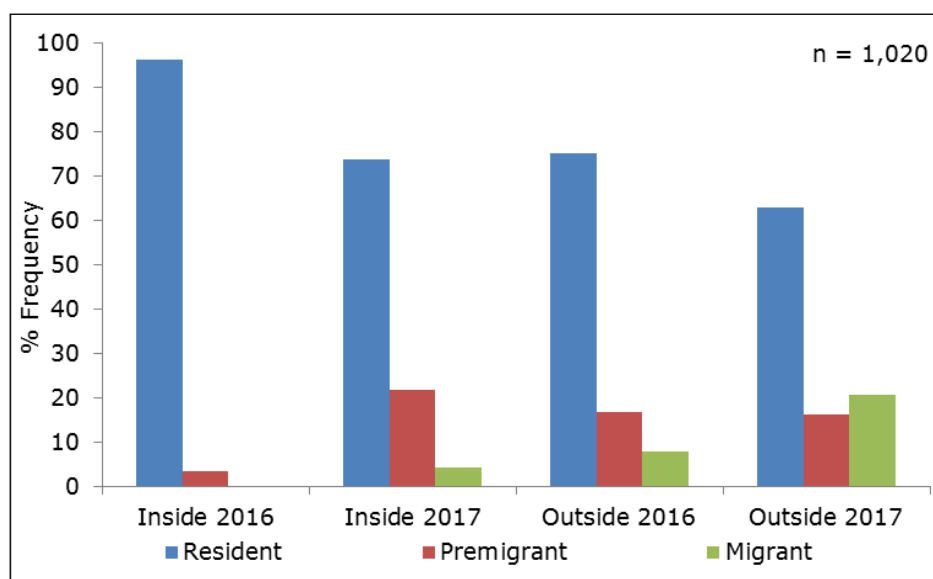
Figure 2-12. Length frequency of yellow eels captured at L. Corrib Upper, 2016 and 2017.

Table 2-12. Number of eels captured in 2016 and 2017 inside and outside Salthouse Bay.

Sampling Period	Count Inside Bay	Count Outside Bay
July 2016	0	101
August 2016	1484	53
July 2017	1311	291
August 2017	302	209
September 2017	66	0

Table 2-13. Showing the number and percentage of eels classified as per the Durif classification, for inside vs. outside Salthouse Bay, 2016 and 2017.

Location	Month	Year	% Resident	% Pre- migrant	% Migrant
Inside	August	2016	96	4	0
Outside	July	2016	75	24	8
Inside	July	2017	75	20	5
Inside	August	2017	79	17	5
Outside	August	2017	63	16	21
Inside	September	2017	60	40	0

**Figure 2-13. Graph showing the Durif classification applied to eels measured inside and outside the Salthouse Bay in 2016 and 2017.**

5.3.2 Lower Lough Corrib

Lough Corrib is situated in Co Galway in the Corrib catchment. The lake has a total surface area of 16 439 ha and a maximum depth of approximately 39 m. It is divided in two for surveying purposes. Both upper and lower Lough Corrib was sampled in 2017.

A repeat survey was carried out in 2017 over eight nights (four nights in June and four nights in August), (Figure 5.8). A total of 507 eels were captured giving a cpue of 1.59.

The eels ranged in length from 32.4 cm to 70.3 cm and in weight from 0.054 kg to 0.584 kg, with a total catch weight of 81.880 kg (Table 5.3 and Figure 5.9). No eels were retained for further analysis in 2017.

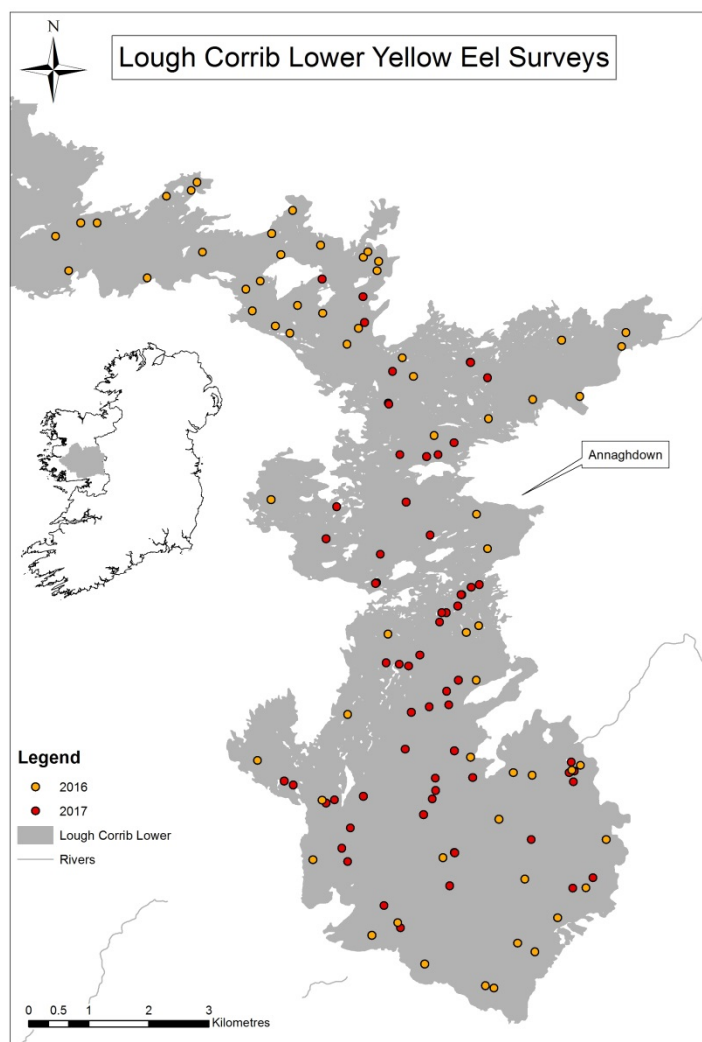


Figure 2-14. Locations of fykenets sampled on L. Corrib Lower, 2016–2017. (Inset: Map of Ireland with Corrib catchment (shaded) and Western River Basin District (outlined)).

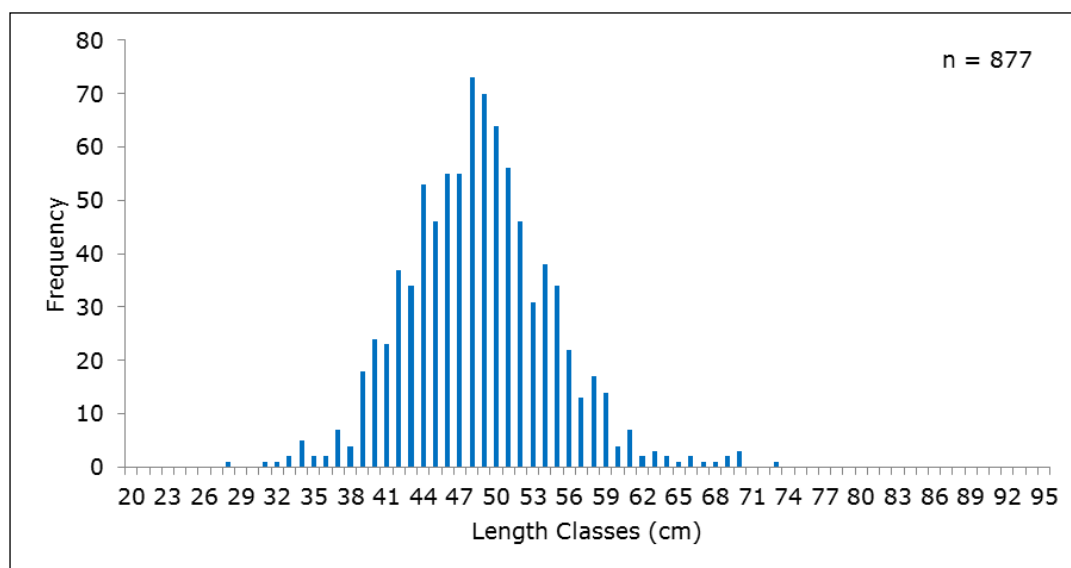


Figure 2-15. Length frequency of yellow eels from L. Corrib Lower (n = 877, measured eel), combined 2016 and 2017.

5.3.3 Lough Conn

Lough Conn is located in Co Mayo on the Moy catchment, with a surface area of 4704 ha. A repeat survey was carried out in 2017 over eight nights (four nights in July and four nights in August), (Figure 5.10). A total of 886 eels were captured (including batch weighed eels) giving cpue of 1.35. The eels ranged in length from 30.6 cm to 93.7 cm and in weight from 0.052 kg to 1.139 kg, with a total catch weight of 119.083 kg (Table 5.3 and Figure 5.11).

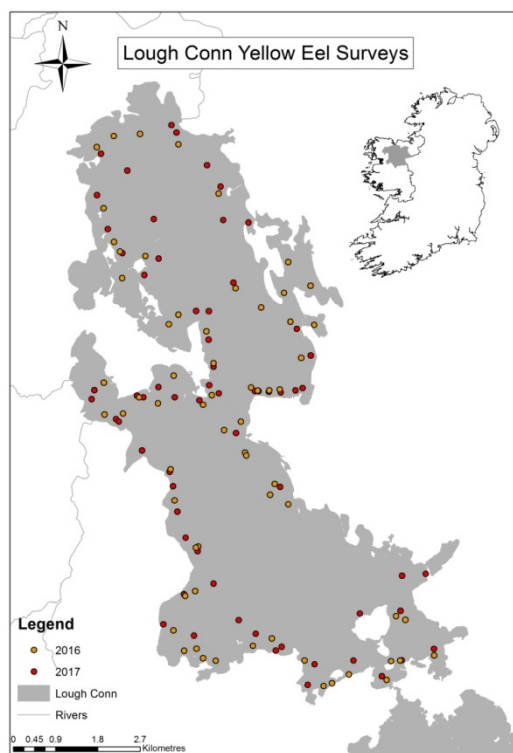


Figure 2-16. Locations of fykenets sampled on L. Conn, 2016–2017. (Inset: Map of Ireland with Moy catchment (shaded) and Western River Basin District (outlined)).

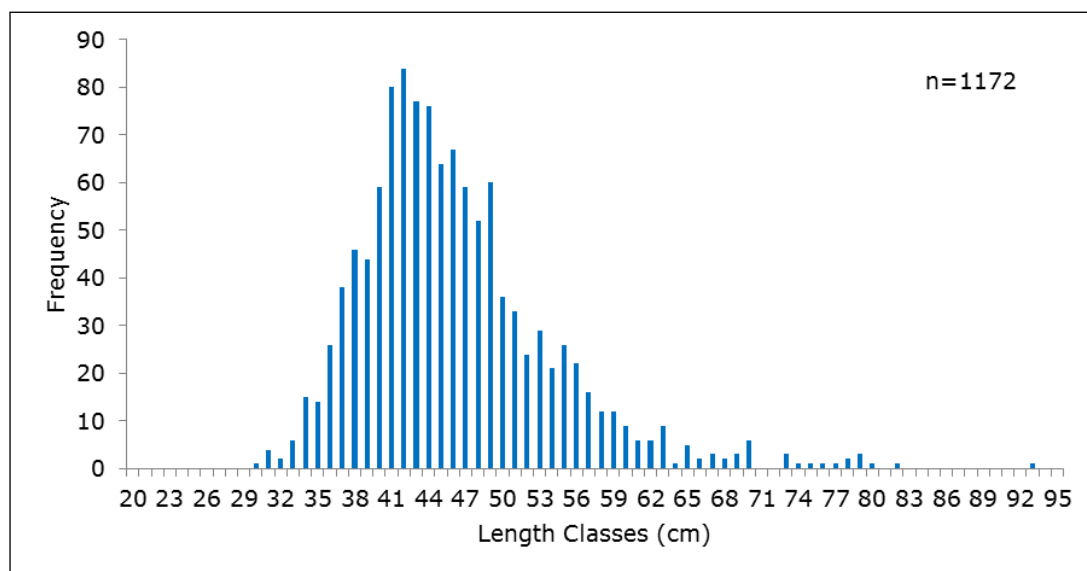


Figure 2-17: Length frequency of yellow eels captured at L. Conn, (n = 1172 eels measured) 2016–2017.

5.3.4 Lough Cullin

Lough Cullin is a large, shallow lake situated to the west of Foxford, which is connected to Lough Conn by a narrow inlet at Pontoon, Co Mayo. The outflow from the lake discharges directly into the River Moy southwest of Foxford (NPWS, 2004). Lough Cullin has a surface area of 1019 ha with a maximum depth of approximately 3 m (O'Reilly,

2007). Though adjacent to and connected to Lough Conn, Lough Cullin has a completely different type of bedrock geology. It lies completely on granite while Lough Conn lies mostly on limestone apart from the very southwest corner which sits on granite. The lake was sampled for the first and only time in 2017 during the three year cycle.

5.3.4.1 Surveys

An intensive fykenet survey was carried out over two nights in July (Figure 5.12). A total of 146 eels were captured giving a cpue of 1.83. The captured eels ranged in length from 31 cm to 66 cm and in weight from 0.048 kg to 0.577 kg, with a total catch weight of 26.446 kg (Table 5.3 and Figure 5.13). Lough Cullin was last surveyed for eels in 2009 with a total catch of 431 eels and a cpue of 1.959. The eel length ranged from 29 cm to 82 cm.

5.3.4.2 Biology

A total of 49 eels were sacrificed from this lake, 86% of which were female and 14% were male (Table 5.4 and Figure 5.14). This is the highest occurrence of males in a lake during this three year cycle. There was a parasite prevalence of 73% recorded and a mean Infection Intensity 6.25 (Table 5.4 and Figure 5.15). The high prevalence of male eels maybe due to the shallow nature of the lake, which has a maximum depth of 3 m and an average depth of 1.4 m where the fykenets were set throughout the lake. Unlike its sister lake, L. Conn which has a maximum depth of 34 m and an average depth of 5 m where fykenets were set throughout the lake and had only a 2% males in the sample taken. The Swimbladder Degenerative Index (SDI) and Length Ratio Index (LRI) were applied to the 49 sacrificed eels from L. Cullin in order to assess swimbladder condition. Both indices suggested only slight/moderate damage to the swimbladder, with an SDI average result of 2 and an LRI average of 0.15 (Figures 5.16 and 5.17). The examinations of stomach contents of the sacrificed eels suggested that *Asellus* sp. and small fish made up the largest element of the diet of the L. Cullin population.

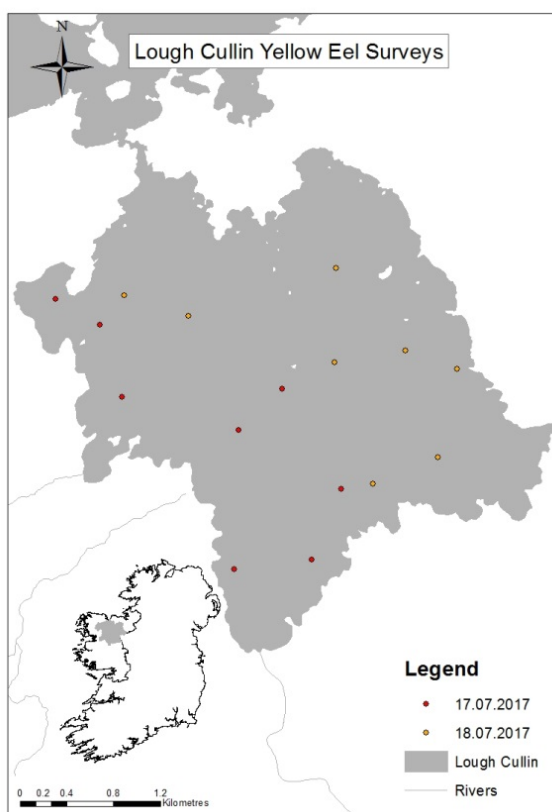


Figure 2-18. Locations of fykenets sampled on Lough Conn, 2017. (Inset: Map of Ireland with Moy catchment (shaded) and Western River Basin District (outlined)).

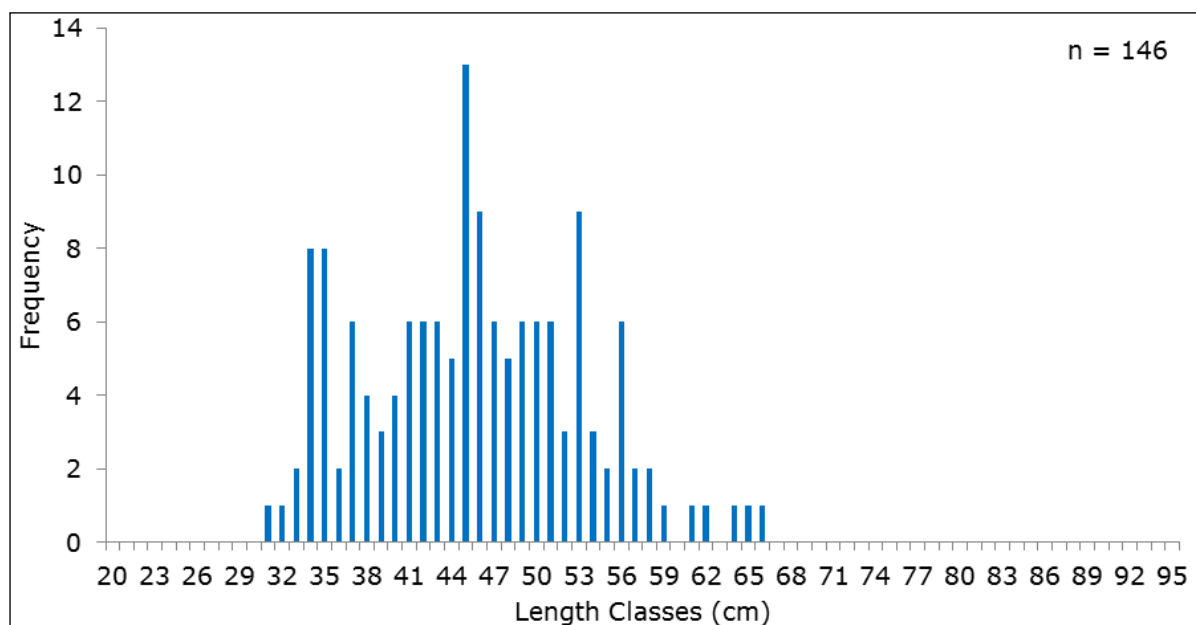


Figure 2-19. Length frequency of yellow eels captured at L. Cullin, (n = 146, measured eel) 2017.

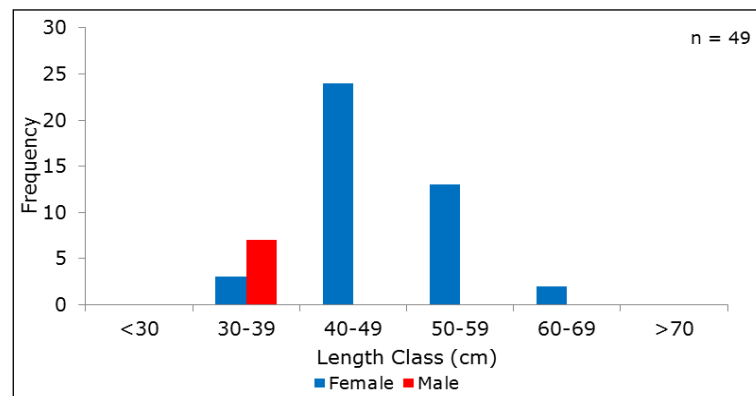


Figure 2-20. Sex distribution of sacrificed yellow eels in L. Cullin, 2017.

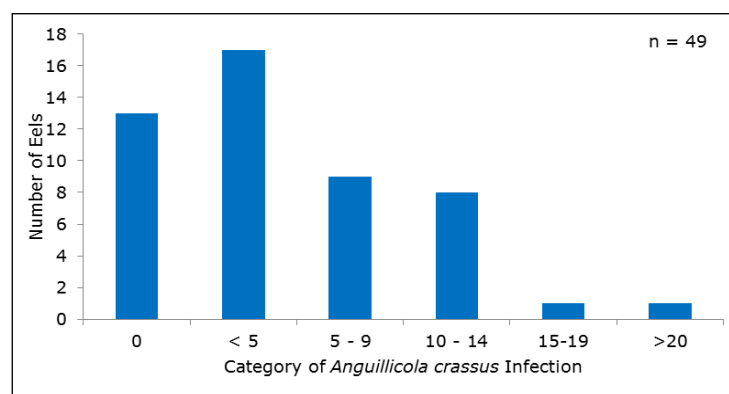


Figure 2-21. *Anguillicola crassus* infection intensity for sacrificed yellow eels from L. Cullin, 2017.

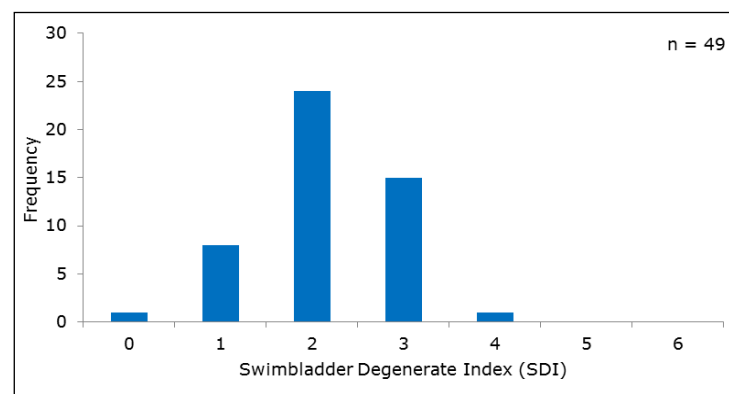


Figure 2-22. Swimbladder Degenerative Index (SDI) results for swimbladder health L. Cullin eels, 2017.

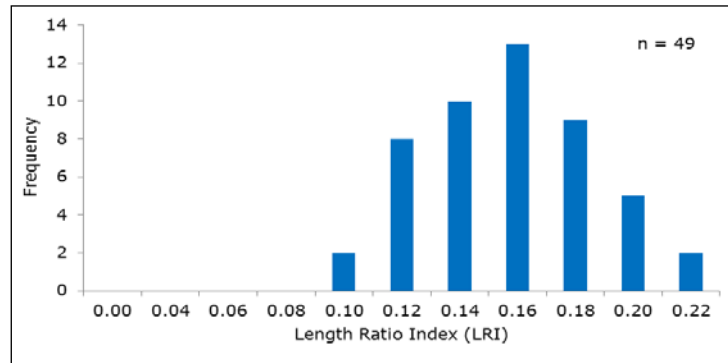


Figure 2-23. Length Ratio Index (LRI) results for swimbladder health among L. Cullin eels, 2017.

5.3.5 Lough Ramor

Lough Ramor is a shallow glacial lake located near Virginia (Co Cavan) in the Boyne catchment. It has a surface area of 712 ha. The outflow of Lough Ramor is the Kells Blackwater River which discharges into the River Boyne.

The fykenet survey of Lough Ramor was repeated during summer of 2017 (Figure 5.18). On this occasion the net positions were fixed as opposed to a random distribution around the lake and revisited on each survey occasion as part of an ongoing parasitology study. The lake was surveyed for one night each in May, June, July and early and late August so investigate the levels of parasitology and swimbladder damage with time. In total, 940 eels were captured with a cpue of 4.7 (Table 5.3). The eels ranged in length from 27.5 to 83.8 cm and in weight from 0.051 to 1.188 kg, with a total catch weight of 242.534 kg (Table 5.3 and Figure 5.19).

5.3.5.1 Biology

In 2017, a total of 80 eels were sacrificed from this lake, 100% of which were female (Table 5.4 and Figure 5.20). There was a parasite prevalence of 72.5%, with a mean Infection Intensity was 5.48 (Table 5.4 and Figure 5.21). The Swimbladder Degenerative Index (SDI) and Length Ratio Index (LRI) were applied to the sacrificed eels as a whole from L. Ramor in order to assess swimbladder condition. Both indices suggested only slight/moderate damage to the swimbladder, with an SDI average of 2 and an LRI average of 0.16 (Figures 5.22 and 5.23). The diet preference on all sampling occasions was for *Asellus* sp. with some larger females supplementing their diet with small fish.

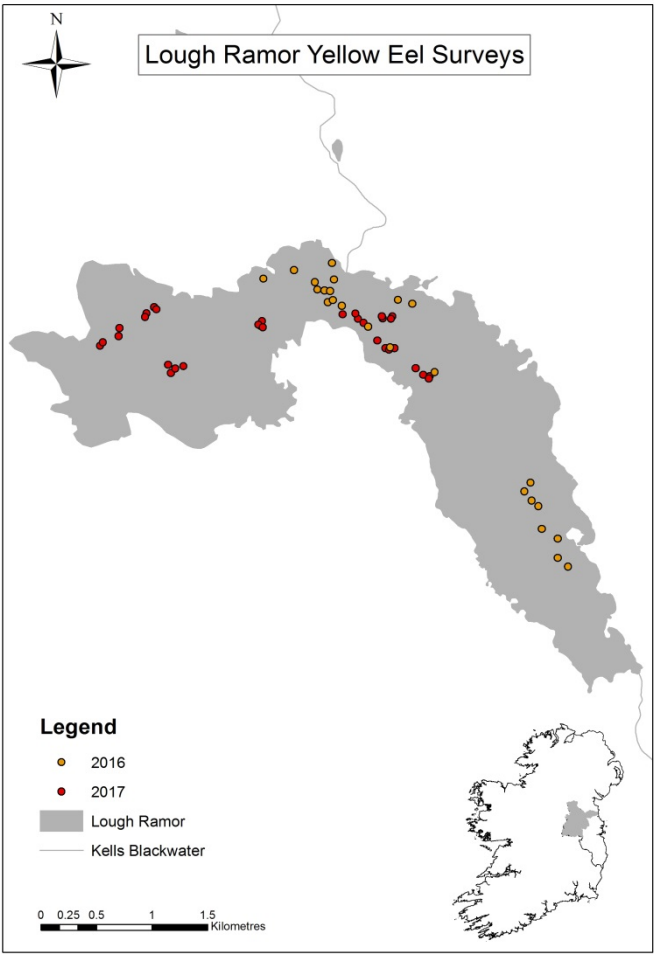


Figure 2-24. Locations of fykenets sampled on L. Ramor, 2016–2017. (Inset: Map of Ireland with Boyne catchment (shaded) and Eastern River Basin District (outlined)).

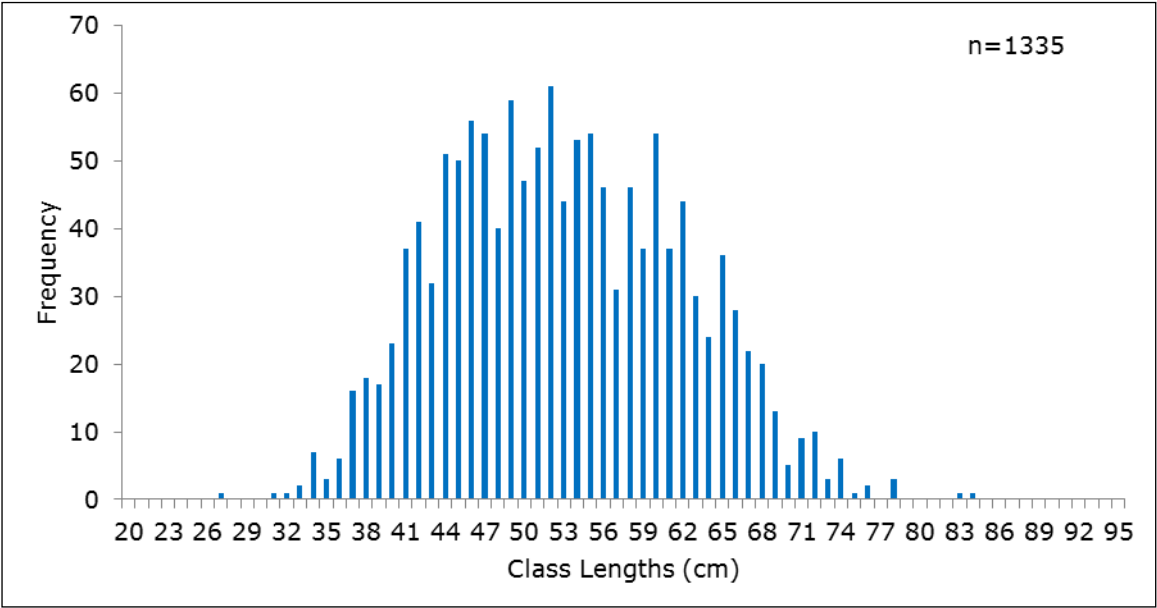


Figure 2-25. Length frequency of yellow eels captured at L. Ramor between 2016–2017.

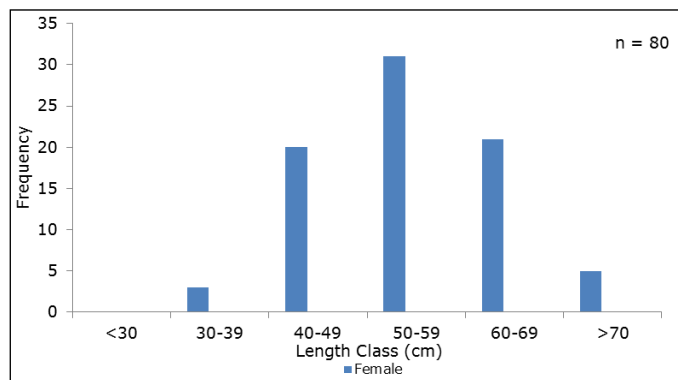


Figure 2-26. Sex distribution of sacrificed yellow eels in L. Ramor, 2017.

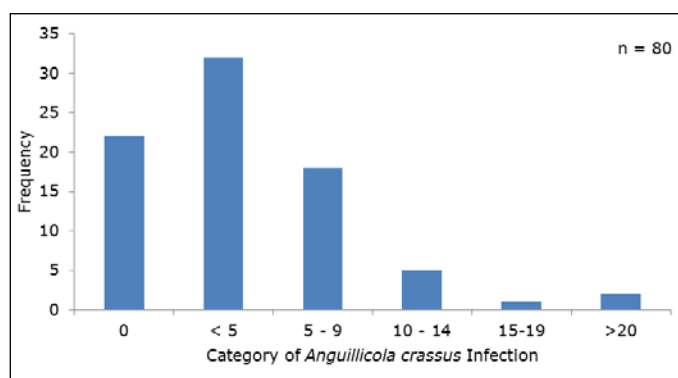


Figure 2-27. *Anguillicola crassus* infection intensity for sacrificed yellow eels from L. Ramor, 2017.

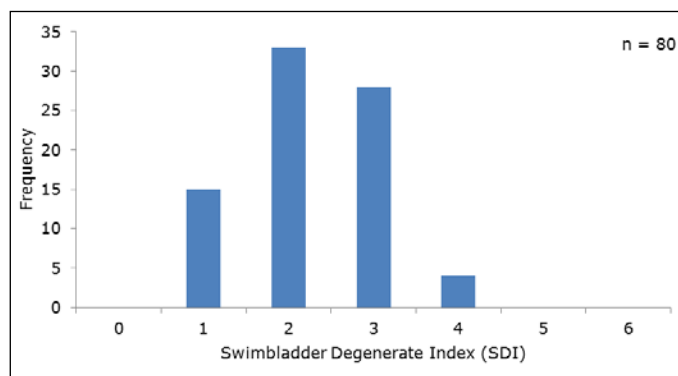


Figure 2-28. Swimbladder Degenerative Index (SDI) results for swimbladder health among eels from L. Ramor, 2017.

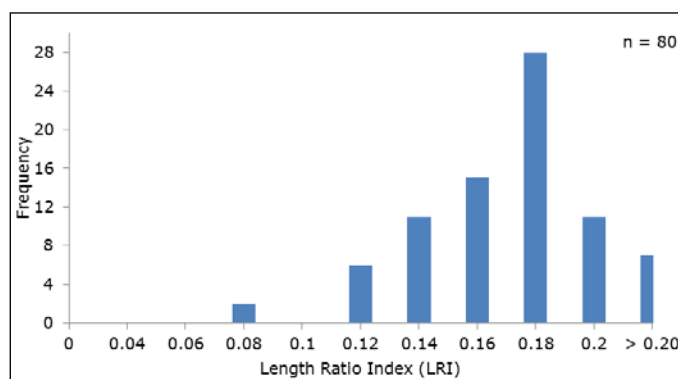


Figure 2-29. Length Ratio Index (LRI) results for swimbladder health among eels from L. Ramor, 2017.

5.3.6 Lough Muckno

Lough Muckno is located on the east coast within the Fane catchment. It has a surface area of 325 ha and depths reaching up to 20 m. The lake had been sampled by the EMP in 2012, 2013 and 2014 before the most recent survey in 2016, which included a full mark-recapture study.

In 2017, the mark-recapture survey was repeated in conjunction with a parasitology study looking at the impact of temperature and parasite prevalence within the North Bay (Figure 5.24). The bay was surveyed for one night in May, June, July, August and September. In total 703 eels were captured resulting in a cpue of 3.52 (Table 5.3). The eels ranged in length from 26.5 to 88.1 cm and in weight from 0.026 to 1.673 kg, with a total catch weight of 148.842 kg (Table 5.3 and Figure 5.25).

5.3.6.1 Biology

In 2017, a total of 80 eels were sacrificed from within North Bay, 96% were female and 4% were immature (Table 5.4 and Figure 5.26). There was a parasite prevalence of 79% with a mean Infection Intensity of 5.43 (Table 5.4 and Figure 5.27).

A larger proportion of <30 cm (0.57% of overall catch) eels (Figure 5.25) were captured during the 2016 and 2017 surveys than is normally seen from the whole lake surveys carried out in previous years. This may be due to the surveys only targeting the North Bay area. The habitat and environment within a shallower sheltered bay may be favoured by smaller eels than the larger deeper lake as a whole which is generally the habitat preference of larger female eels.

The Swimbladder Degenerative Index (SDI) and Length Ratio Index (LRI) were applied to all L. Muckno eels in order to assess swimbladder condition. Both indices suggested only slight/moderate damage to the swimbladder for both years, with an SDI average of 3 and 2 and an LRI average of 0.17 for both years due to *A. crassus* infections (Figures 5.28 and 5.29). The diet preference was for *Chironomid* sp. and Insect remains.

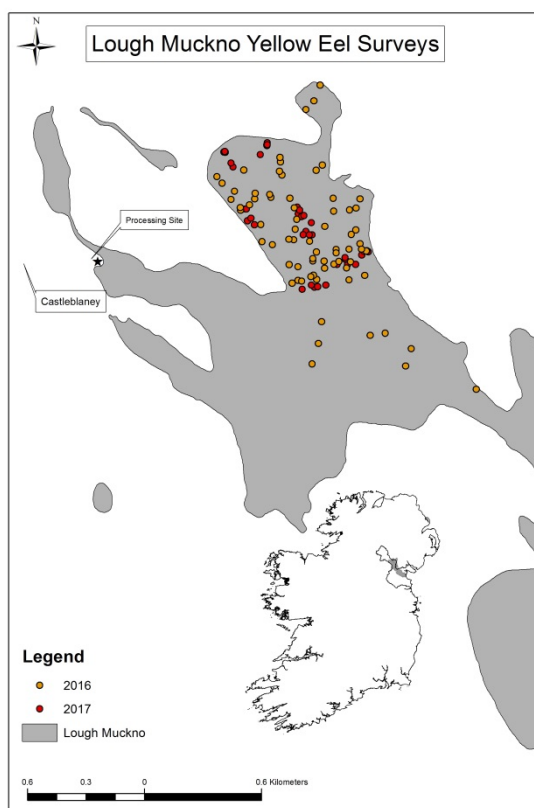


Figure 2-30. Locations of fykenets sampled on L. Muckno, 2016–2017. (Inset: Map of Ireland with Fane catchment (shaded) and Neagh-Bann District (outlined)).

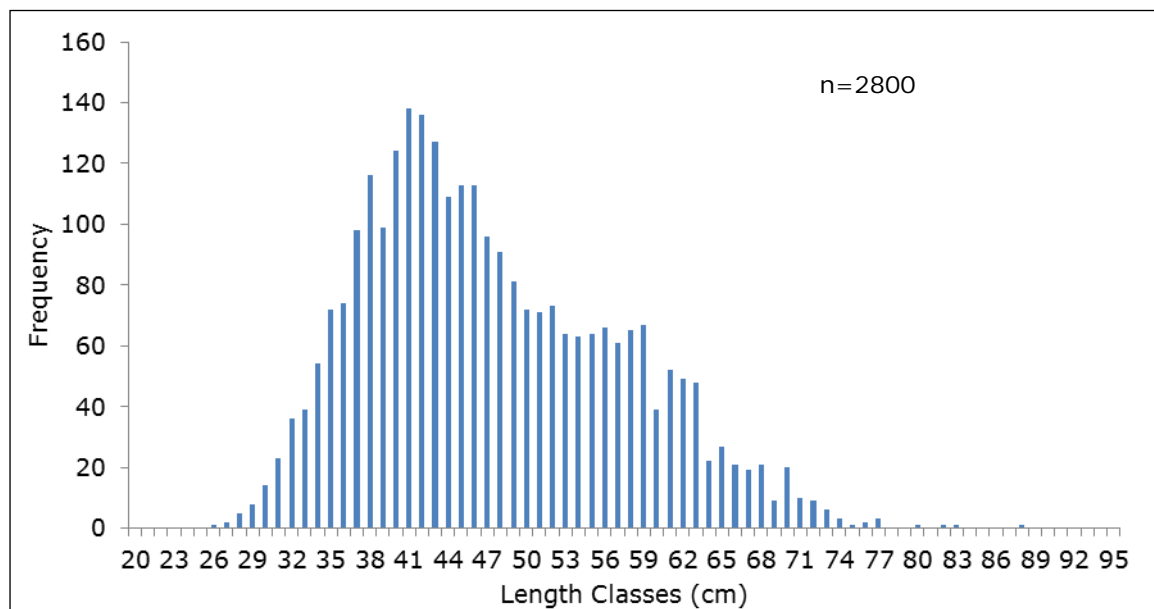


Figure 2-31: Length frequency of yellow eels captured at L. Muckno 2016–2017.

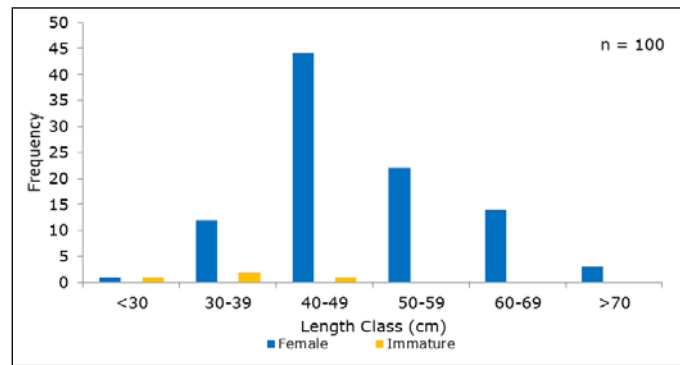


Figure 2-32. Sex distribution graphs of sacrificed yellow eels in L. Muckno 2017.

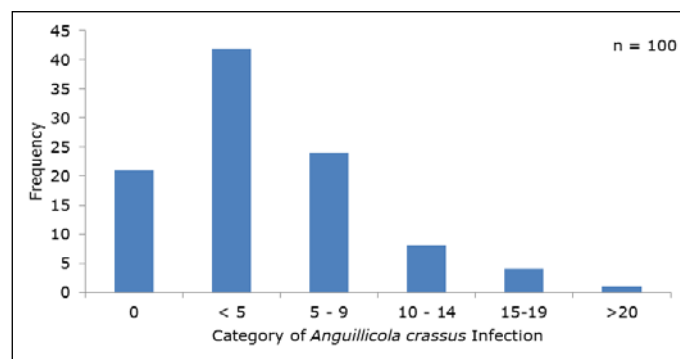


Figure 2-33. *Anguillicola crassus* infection intensity for sacrificed yellow eels from L. Muckno 2017.

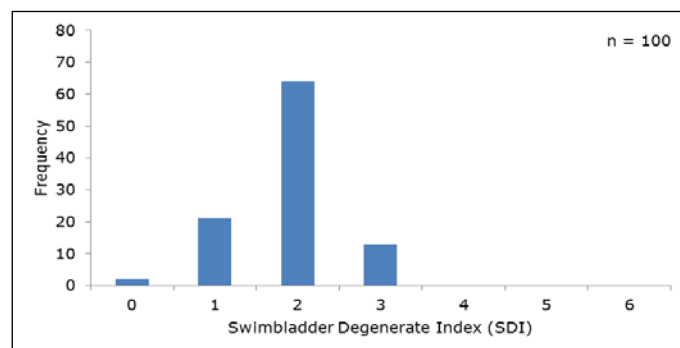


Figure 2-34. Swimbladder Degenerative Index (SDI) results for swimbladder health in eels from L. Muckno 2017.

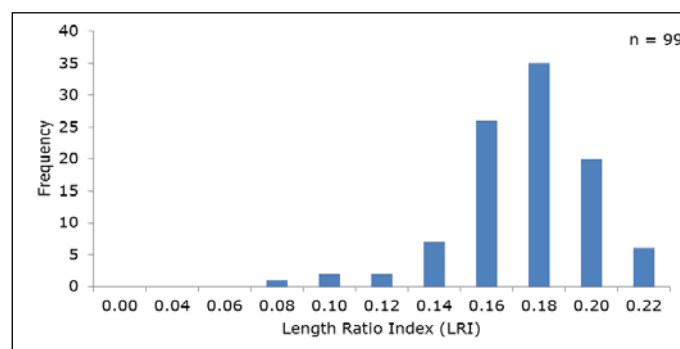


Figure 2-35. Length Ratio Index (LRI) results for swimbladder health in eels from L. Muckno 2017.

5.3.7 Burrishoole

Bunaveela Lough is located in the upper reaches of the catchment (Figure 5.30). It has a surface area of 42 ha and a maximum depth of 23 m. Bunaveela L. was fished in the traditional style (sets of ten nets perpendicular to the shore) in 2017 (18 July 2017), with chains of ten nets fished at three sites. In total, eight eels were caught with a catch per unit of effort of 0.27 eels/net/night (Table 5.3). The average length was 48.1 cm and ranged in length from 40.4 cm to 59.5 cm. Eight eels were PIT tagged and no recaptures were made of previously tagged fish.

Lough Feeagh has a surface area of 395 ha and an average depth of 14.5 m (with several areas >35 m in depth). L. Feeagh was fished in the traditional style (sets of ten nets perpendicular to the shore) in 2017 (11–12 July 2017), with chains of ten nets fished at six sites for one night each. In total, 40 eels were caught with a catch per unit of effort (cpue) of 0.67 eels/net/night (Table 5.3). The average length of eels was 43.4 cm and ranged in length from 31.3 cm to 59.9 cm (Figure 5.31), with a total weight of 6.130 kg caught in the two nights. Most of the catch (34) was PIT tagged and one previously tagged eel was recorded.

Six eels were sacrificed in this survey. Four of the six (66.7%) of the eels contained *A. crassus* with an infection intensity of 6.8. This is the first recording of *A. crassus* in yellow eels in freshwater in Burrishoole.

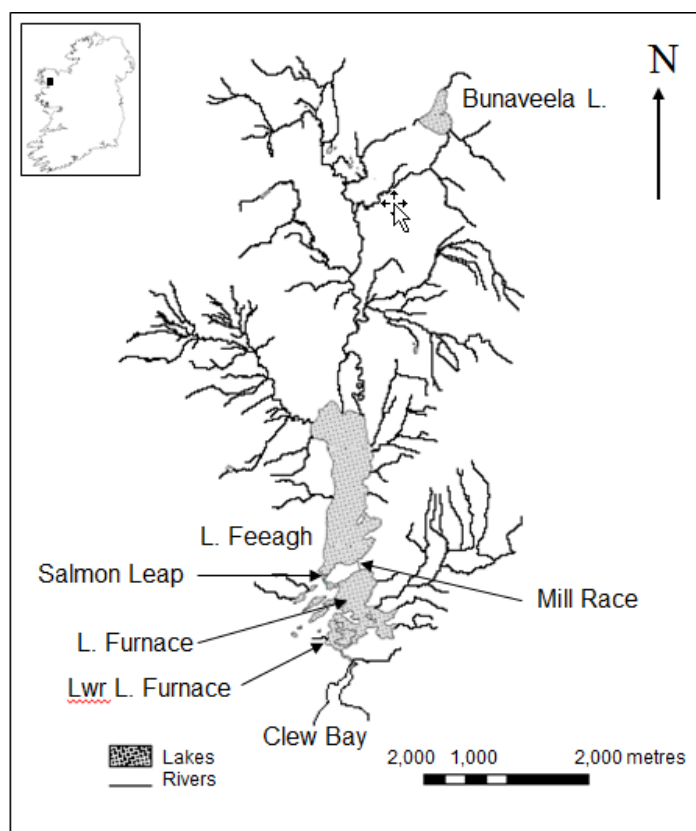


Figure 2-36. Map of Burrishoole showing the lakes surveyed.

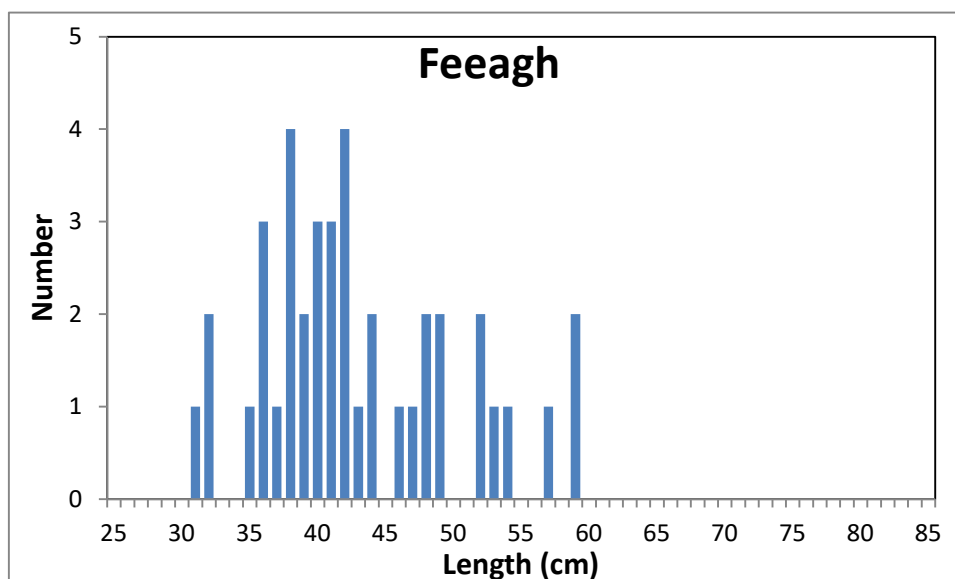


Figure 2-37. Length frequency of yellow eels captured at L. Feeagh, 2017.

5.4 Yellow River Survey 2017

5.4.1 Munster Blackwater River

The AMBER project, which stands for Adaptive Management of Barriers in European Rivers, seeks to raise awareness of the problems posed by stream fragmentation, the pressures on freshwater ecosystems and the need for innovative solutions to restore river connectivity. Colleagues within the Amber project were carrying out riverine surveys on the stretch of water above the Clondulane weir on the Munster Blackwater to assess the current fish population above the weir before its proposed removal. As this river is an eel Index catchment the two programmes collaborated to carry out a mark-recapture study on eels in the impounded section. Clondulane Weir is located 25 km upstream of the tidal limit of the Munster Blackwater (MBW). The height of the weir coupled with the rivers gradient has resulted in an impounded zone extending for 4 km upstream of the weir almost to Fermoy town, making an ideal habitat for eels.

5.4.1.1 Survey

The 4 km impounded section of the Munster Blackwater above the weir was split into three sections for fishing (Figure 5.32). A single chain of five fykenets was fished in each zone per night over the six nights. A total of 698 eels were captured over the duration of the survey giving a cpue of 7.76 (Table 5.3). The eels ranged in length from 25.6 cm to 86.6 cm, and weight 0.029 kg to 1.442 kg with a total catch weight of 128.84 kg (Figure 5.33). Over the five nights 498 eels were tagged, with 34 eels recaptured resulting giving a recapture rate of 6.8%. The largest catch was in zone 3 just above the weir with 392 eels caught compared with 168 in zone 2 and 138 in zone 1; catches of eels dropping with distance upstream from weir. The large catch over six nights in the impounded section of the River is in stark contrast to the 540 eels caught after 15 nights fishing in the estuary.

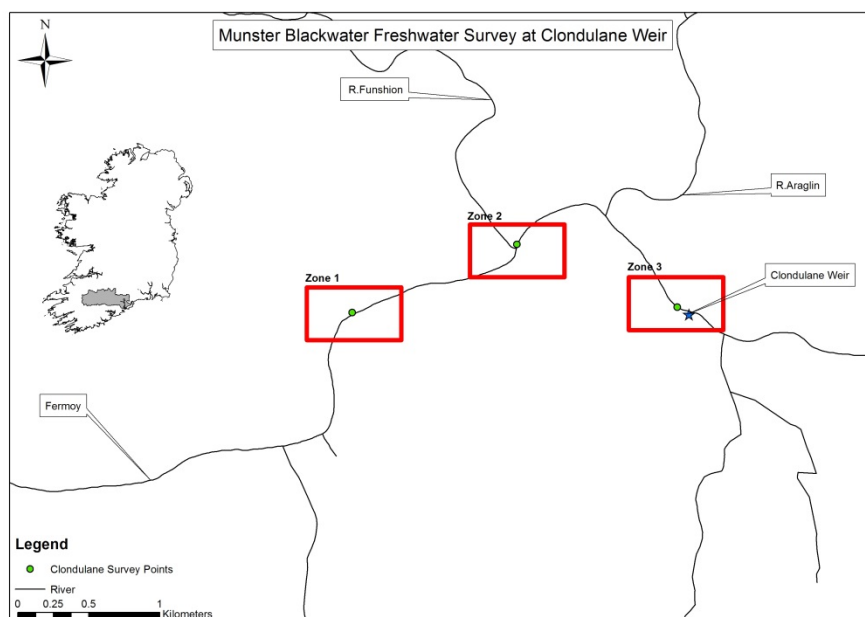


Figure 2-38. Locations of survey zones and points sampled on Munster Blackwater above Clondulane Weir, 2017. (Inset: Map of Ireland with Munster Blackwater catchment (shaded)).

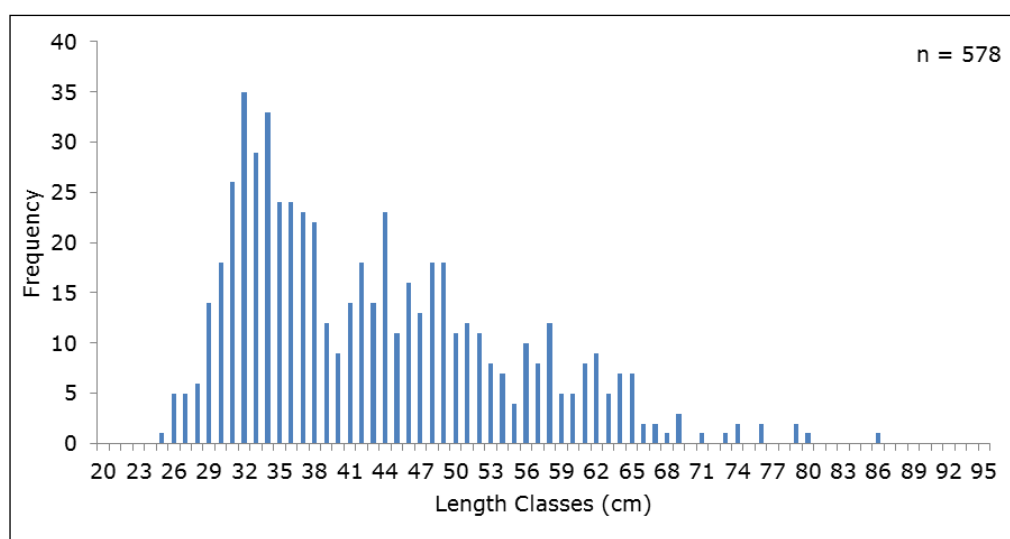


Figure 2-39. Length frequency of yellow eels captured at Clondulane Weir.

5.4.2 Barrow Canal (at Levitstown)

A total of two sites were fished using fykenets (two chains of ten nets) on the Barrow Canal at Levitstown in September 2017 (Figures 5.34 and 5.35). The survey replicated the methodology of a previous 2012 survey carried out by the EMP and corresponded to historical data available from the Fisheries Research Centre (FRC) from 1975 and 1979.

In 2012, a total of 94 eels were captured during the study, however the 2017 survey located only 27 eels (21 of which were retained for dissection and are to be included in a future ICP-Analysis). The captured eels ranged in length from 33.9 to 63.5 cm and in weight from 0.054 to 0.497 kg. The length–frequency for this catch is shown in Figure 5.36.



Figure 2-40. Barrow Canal, Levinstown near Athy.

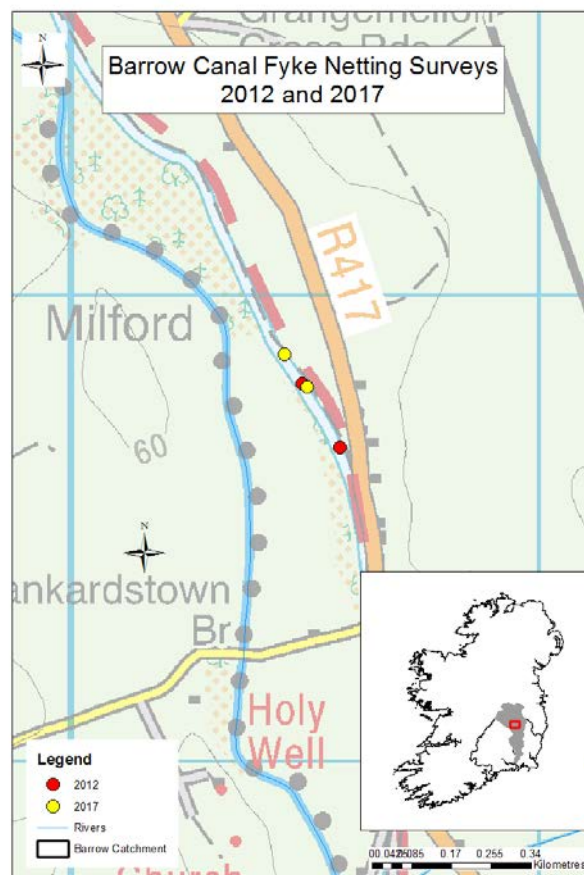


Figure 2-41. Fykenetting locations on Barrow Canal (Levinstown) in 2012 and 2017 (Inset: Map of Ireland with Barrow catchment (shaded) and South Eastern River Basin District (outlined). Red square denotes location of netting.

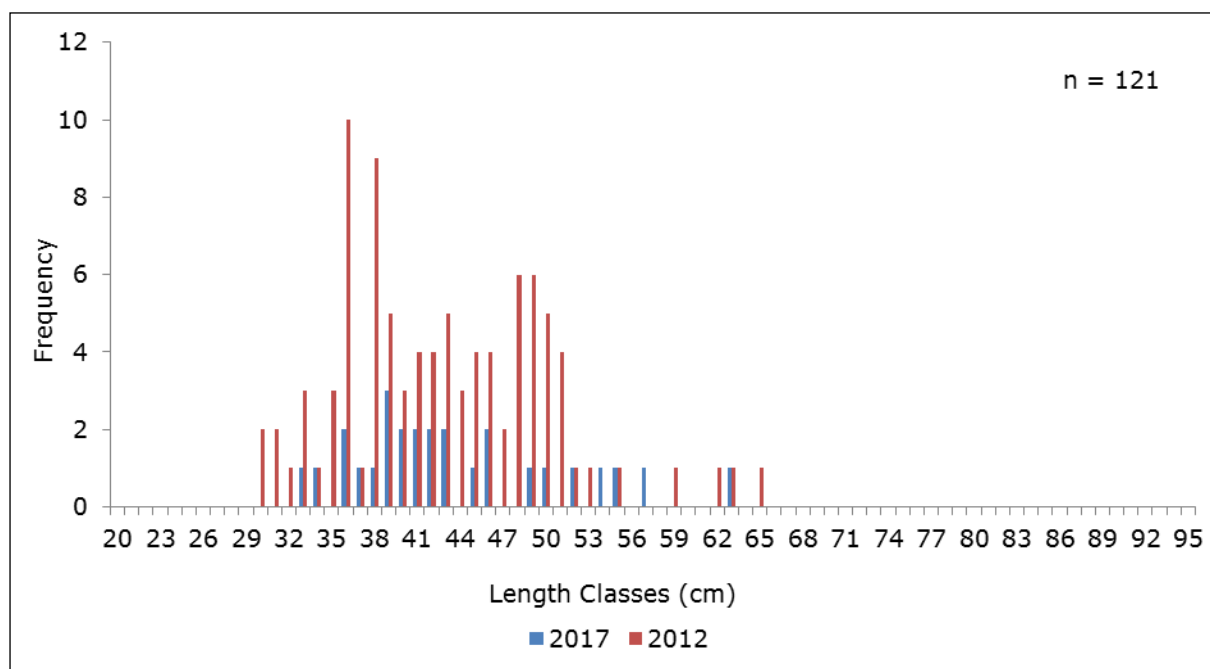


Figure 2-42. Length–frequency of yellow eels captured on the Barrow Canal (Levitstown), 2012 and 2017.

5.5 Transboundary yellow eel

No surveys were carried out in 2017.

5.6 Transitional waters yellow eel

5.6.1 Burrishoole transitional waters

Lough Furnace, the tidal lough, has a surface area of 125 ha north of Nixon’s Island and 16 ha between Nixon’s Island and the mouth of the estuarine river (Lower Lough Furnace) (Figure 5.30). The main lough has a maximum depth of 21.5 m. Furnace is heavily stratified with significant areas of deoxygenated water in the main basin. L. Furnace was fished in the traditional style (sets of ten nets perpendicular to the shore) in 2017 (20–21 July 2017), with chains of ten nets fished at six sites in one night each and one night (7 July 2017) with two chains of nets at the Back of the House, which is a shallow tidal area between the lough and the estuarine river.

In L. Furnace, only nine eels were caught with a catch per unit of effort (cpue) of 0.15 eels/net/night (Table 5.3). The average length was 46.4 cm and ranged in length from 33.9 cm to 71.1 cm (Figure 5.37). A total weight of 1.83 kg was caught.

In the Lower Lough Furnace, only nine eels were caught with a catch per unit of effort (cpue) of 0.45 eels/net/night (Table 5.3). The eels average length was 40.7 cm and ranged in length from 33.1 cm to 52.9 cm, with a total weight of 1.01 kg caught.

The catches in the 2017 survey were particularly poor and the absence of large eels was notable. In 2017, large inundations of jelly fish caused problems with the survey. The impact on the eel stock of huge densities of jellyfish on the bottom on the eel stock is unknown.

Six eels were sacrificed in this survey from Lough Furnace. Four of the six (66.7%) of the eels contained *A. crassus* with an infection intensity of 20.8. *A. crassus* has been established in the lough since about 2011.

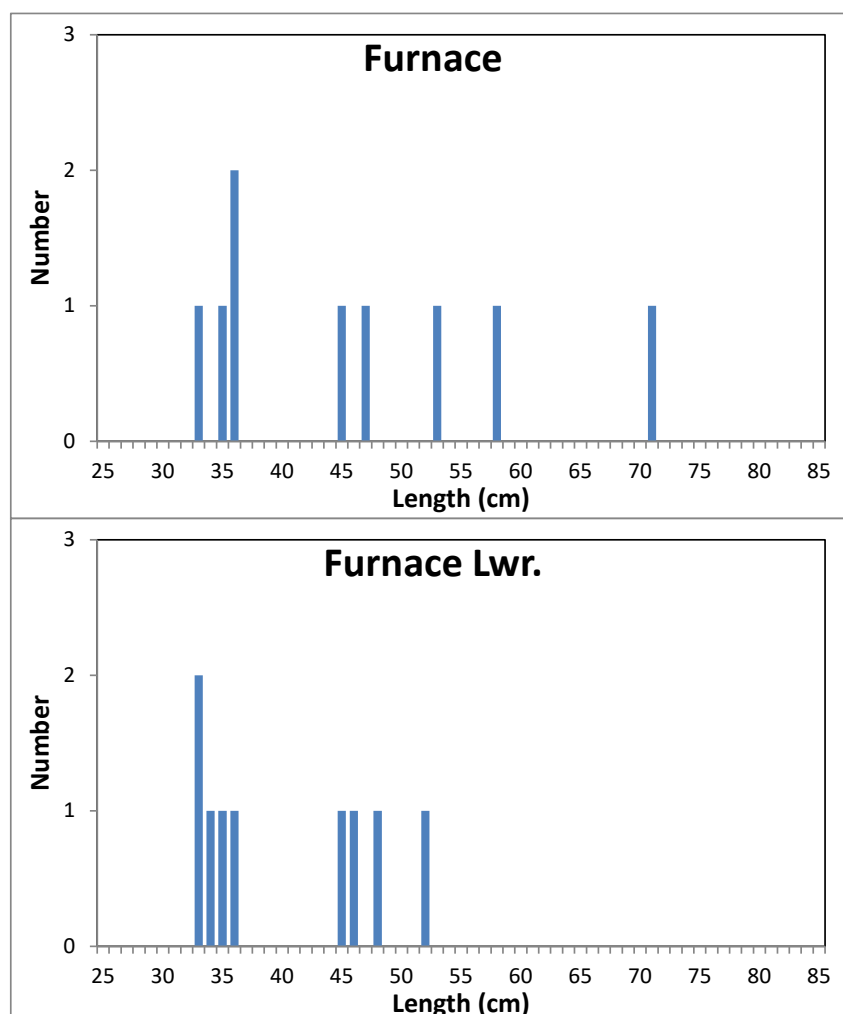


Figure 2-43. Length–frequency of yellow eels captured at L. Furnace and L. Furnace Lower, 2017.

5.6.2 Waterford Estuary

The Waterford Estuary comprises the estuarine habitat of the Barrow, Suir and the Nore rivers. An area of approximately 70 km² was fished over the three week long survey (15 days) comprising five Zones of intensive fishing (Figure 5.38). A combination of baited pot and fykenets were used, the baited pots were used during the full and new moon phases where the tides are stronger with the fykenets used in the slacker tides.

5.6.2.1 2017 Survey

The baited pots (Weeks 1 and 3) caught a total of 6285 eels (276.64 kg) giving a cpue of 34.92. Of these, 2362 eels were measured. The length of eels caught in baited pots ranged in length from 15.5 to 76.0 cm and in weight from 0.007 to 0.857 kg (Figure 5.39, Table 5.3). The fykenet fishing in Week 2 yielded smaller numbers. In total 378 eels were caught (49.84 kg) giving a cpue of 5.04. Of these 377 eels were measured. The length of the fykenet caught eels ranged from 23.0 to 66.5 cm and their weights ranged from 0.017 to 0.578 kg (Figure 5.39, Table 5.3). The baited pot method captured smaller

eels than the fykenet method. The smallest eel captured in pots was 15.5 cm while the smallest noted in fykenet catches was 23.0 cm. Baited pots captured greater numbers of eels overall as they attracted eels in to the area towards the nets.

In 2017, 120 eels were sacrificed from the study area. The sample was collected across all Zones, approximately 20 from each Zone (with 40 retained from Zone 1). These eels are being kept to examine the otolith microchemistry of the eels in the estuary.

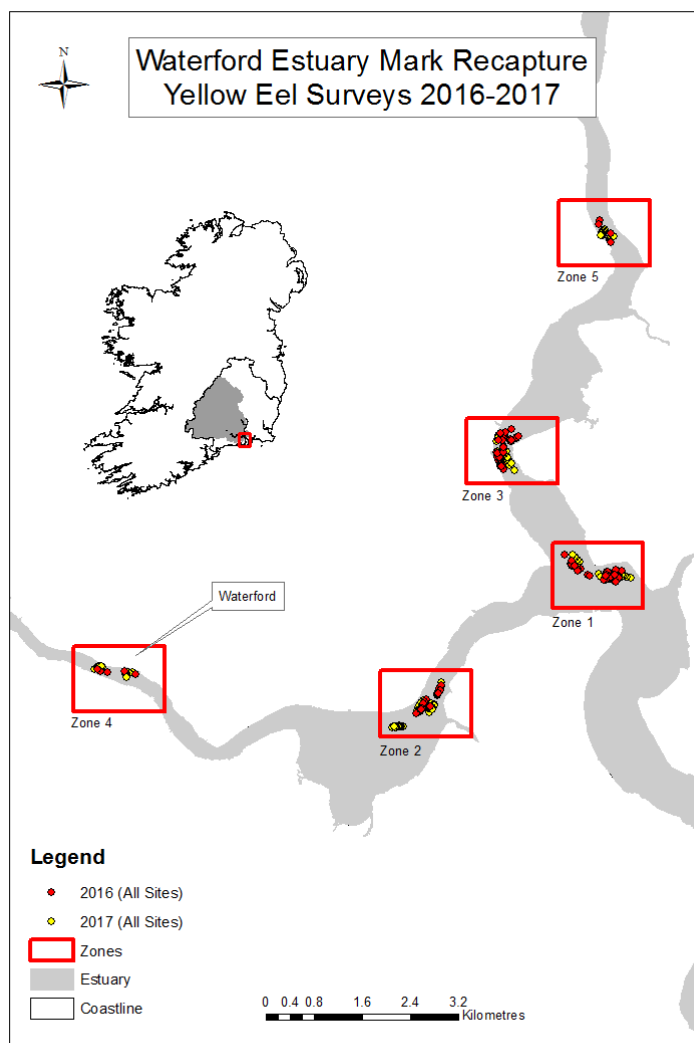


Figure 2-44. Locations of fykenets and pots sampled on Waterford Estuary, 2016 and 2017. (Inset: Map of Ireland with Barrow and Suir catchments (shaded) and South Eastern River Basin District (outlined)), red squares denotes study zones.

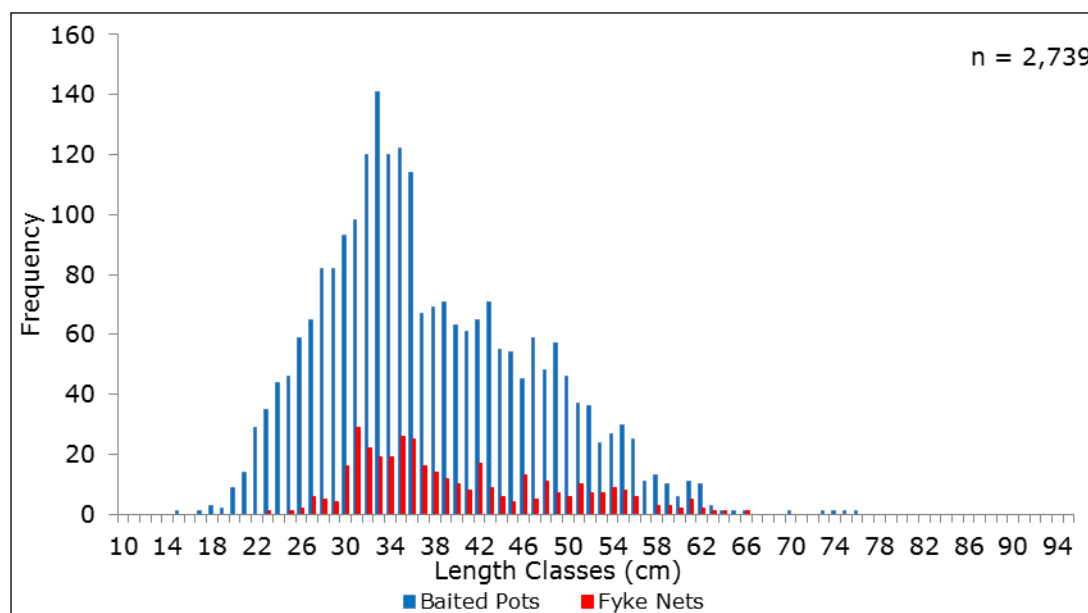


Figure 2-45. Length–frequency of yellow eels captured on the Waterford Estuary, 2017 (separating total catch using baited pots and fykenets).

5.6.3 Munster Blackwater Estuary

The Munster Blackwater joins the sea in Youghal on the south coast of Ireland. The estuarine habitat has an approximate area of 1298 ha. Five chains of pots were set on each night of the survey (Figure 5.40). Each chain had five pots, giving a total of 25 pots set per night. On 11 out of 14 of the nights fished, two chains of fykenets (in chains of three) were also fished in combination with the pots. Catches along the estuary were generally quite low across all three weeks of the survey period. A total of 330 eels were caught, using pots giving a cpue of 1.04. A total of 197 was recorded using fykenets giving a cpue of 2.98. This gives a total of 540 eels over the sampling period yielding a total weight of 47.5 kg (of which all 540 were measured). The same survey in 2016 caught 521 eels with a cpue of 1.39 and a weight of 99.9 kg.

The difference in catch between the two fishing methods can most likely be attributed to the difference in the effort, the site characteristics in which the nets were set and net location in week 3 was targeted in the lower zones to capture eels for the acoustic study. The length–frequencies for the catch are presented in Figure 5.41. It can be noted that the two fishing methods were quite similar in the size range of eels which they captured. In 2017, the eels ranged in length from 15.3 to 79.7 cm and in weight from 0.008 to 0.668 kg. Larger eels captured during the study were initially retained to be surgically implanted with acoustic tags as part of an ongoing investigation into eel movement in the estuary.

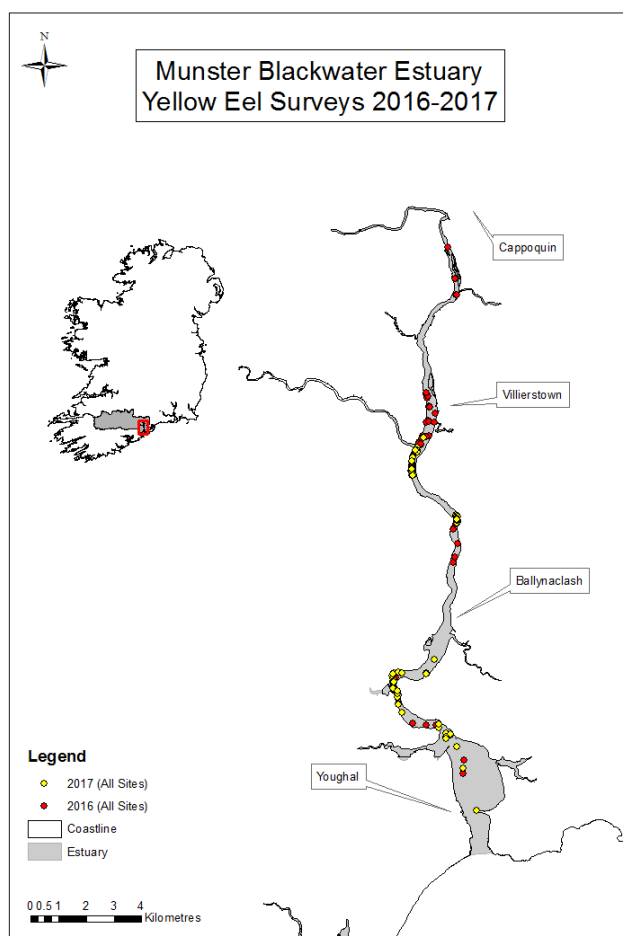


Figure 2-46. Sampling locations on Munster Blackwater Estuary, 2016 and 2017. (Inset: Map of Ireland with Munster Blackwater catchment (shaded) and South Western River Basin District (outlined)), red square denotes study area.

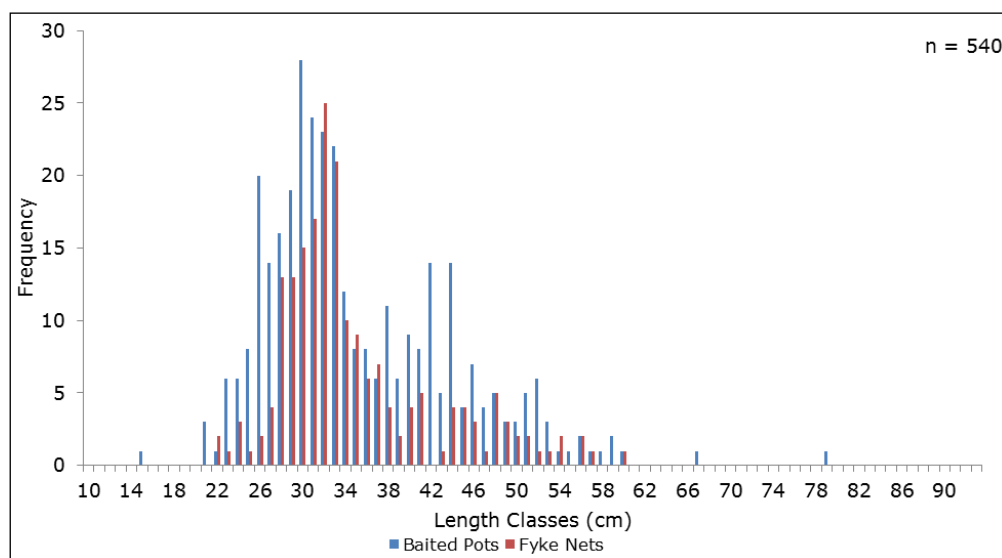


Figure 2-47. Length–frequency of yellow eels captured on the Munster Blackwater Estuary, 2017 (separating total catch using pots and fykenets).

Table 2-14. Catch detail from yellow eel lake and transitional water surveys, 2017.

Site	Dates	No. Eels	Nets*Nights	cpue	Mean Length (cm)	Min. Length (cm)	Max. Length (cm)	Mean Weight (kg)	Min. Weight (kg)	Max. Weight (kg)
Upper L. Corrib	July	1882	200	7.91	53.3	30.7	83.2	0.284	0.050	1.104
	August	511	160	3.19	53.1	31.9	81.4	0.281	0.052	1.079
	September	66	40	1.65	56.4	35.3	65.9	0.339	0.052	0.634
Lower L. Corrib	June	144	160	0.90	47.9	33.5	61.8	0.2001	0.054	0.519
	August	364	160	2.28	49.7	32.4	70.3	0.2227	0.059	0.584
L. Conn	June	442	160	2.76	48.5	34.0	93.7	0.215	0.067	1.139
	August	424	160	2.65	45.4	30.6	79.9	0.170	0.052	1.127
L. Ramor	May	157	40	3.93	52.1	34.4	73.5	0.239	0.061	0.681
	June	235	40	5.88	52.9	27.5	73.7	0.252	0.051	0.698
	July	216	40	5.40	50.9	33.2	74.8	0.229	0.062	0.747
	August	332	80	4.15	55.1	36.9	83.8	0.29	0.078	1.188
L. Muckno	May	83	40	2.08	48.7	31.9	72.9	0.213	0.054	0.834
	June	219	40	5.48	48.7	29.2	80.1	0.234	0.045	1.102
	July	191	40	4.78	47.1	28.8	88.1	0.205	0.039	1.673
	August	124	40	3.10	48.3	29.4	77.4	0.215	0.037	0.845
	September	86	40	2.15	45.0	26.5	73.4	15.410	0.026	0.729
Lough Cullin	August	146	80	1.83	46.0	31.0	66.0	0.181	0.048	0.577

Site	Dates	No. Eels	Nets*Nights	cpue	Mean Length (cm)	Min. Length (cm)	Max. Length (cm)	Mean Weight (kg)	Min. Weight (kg)	Max. Weight (kg)
M. Blackwater Clondulane Weir	June	698	90	7.76	43.3	25.6	86.6	0.183	0.029	1.442
Waterford Estuary	Wk 1 (Baited Pots)	1108	80	13.85	37.7	15.5	66.5	0.112	0.007	0.671
	Week 2 (FykeNets & Unbaited Pots)	471	95	4.96	40.8	21	67	0.133	0.015	0.578
	Week 3 (Baited Pots)	5177	100	51.77	38.2	18.9	76	0.099	0.009	0.857
Munster Blackwater Estuary	Pots Only	343	330	1.04	35.7	15.3	79.7	0.090	0.008	0.668
	Fykes Only	197	66	2.98	35.3	22.4	60.4	0.084	0.017	0.451
L. Feeagh	July	40	60	0.67	43.4	31.3	59.9	0.153	0.055	0.200
L. Furnace Upper	July	9	60	0.45	40.7	33.1	52.9	0.112	0.055	0.200
L. Furnace Lower	July	9	20	0.15	46.4	33.9	71.1	0.203	0.050	0.615

Table 2-15. Biological data from yellow eel lake surveys, 2017.

Location	Year	Total Eels	No. Females	No. Males	No. Immatu re	% Female	% Male	% Immatu re	% Prevalence <i>A. crassus</i>	Mean Intensity <i>A. crassus</i>	Preferential Diet from Stomach Contents
L. Ramor	2017	80	80	0	0	100	0	0	73	5.48	<i>Asellus</i> sp.
L. Muckno	2017	100	96	0	4	96	0	4	79	5.43	<i>Chironomid</i> sp.
L. Cullin	2017	49	42	7	0	86	0	14	73	6.25	<i>Asellus</i> sp. ,Gammarus sp. & fish remains
Clondulane Weir	2017	15	13	1	1	86	7	7	56	7.56	<i>Asellus</i> sp.

5.7 Electric-fishing river yellow eel surveys

5.7.1 Background

Under the National Eel Management Plan 2009, IFI has been tasked with a number of monitoring objectives. These include establishing baseline datasets to track changes in the eel population over time; monitoring the impact of fishery closure on yellow eel stocks; determining the prevalence of parasites and the current quality of the eel stocks.

The Eel Monitoring Programme (EMP) has engaged in catchment electric-fishing for eels since 2013, using a semi quantitative bankside method and a quantitative 3-pass depletion fishing methods (Figure 5.42). In 2013 and 2014, the Fane and Kells Blackwater catchments were electric-fished. Both lacustrine dominated catchments, demonstrated that the majority of the eels captured were on the inflows and outflows of the catchment lake (i.e. Lough Muckno and Lough Ramor respectively). From 2015, the focus moved to riverine catchments (i.e. those without a lake in the system) in order to assess the distribution of eel compared with lacustrine catchments. From 2015 to 2017, five riverine catchments have been surveyed for eels (Table 5.5).

Table 2-16. Catchments electric-fished by EMP, 2015–2017.

Year	Catchment	Subcatchment
2015	Munster Blackwater	Bride
2016	Barrow	Greese
2017	Barrow	Tully
2017	Barrow	Aughnavaud
2017	Barrow	Pollmonty



Figure 2-48. Bankside electric-fishing survey (Photo: K. Kelly).

5.7.2 Tully River

In 2017, the Tully catchment was fished along with two smaller subcatchments the Aughnavaud and the Pollmonty Rivers, located lower in the Barrow system (below the high water mark; Figure 5.43). A fykenets study of the Barrow canal near the Tully catchment was also surveyed in 2017.

The Tully catchment is approximately 20 850 ha (208.5 km²) in area and flows southwest from Kildare town to just north of Athy, where it joins the main channel of the Barrow and flows southwards to towards Waterford. The subcatchment is made up of the Tully, Ballysaw, Kildoon/Finnery and Mullaghmoynne Rivers. The main channel flows southwest and drains into the Barrow main channel near Levinstown. A total of 14 sites were bankside fished on the Tully, with a subset of three of these sites being fished using the 3-pass depletion method. There are no lakes in the system and no eels were retained from the electric-fishing. Figure 5.43 shows the locations of the sites fished on the Tully catchment (red points) as part of the overall investigation into eel distribution carried out on the River Barrow Catchment in 2017.

After the intensive electric-fishing on the Tully catchment, no eels were captured in either electric-fishing method (Figure 5.43). No major barriers were found and information gained from local fishermen, farmers and landowners in the area, suggested that numbers of adult eels and elvers had been plentiful in the past but had declined drastically in recent years.

5.7.3 Aughnavaud & Pollmonty Rivers

The Aughnavaud and Pollmonty Rivers join the main channel of the Barrow near St Mullins, around the high water mark (HWM) of the catchment. The Aughnavaud is approximately 6440 ha (64.4 km²) in area and the Pollmonty is a further 4825 ha (48.25 km²). Two sites were bankside fished in the Aughnavaud and three were bankside fished on the Pollmonty River. One site on each subcatchment was also fished using a 3-pass depletion method. There are no lakes in these systems and no eels were retained from the electric-fishing. Figure 5.43 shows the locations of the sites fished on the Aughnavaud (green points) and Pollmonty (blue points) as part of the overall investigation into eel distribution carried out on the River Barrow Catchment in 2017.

Small numbers of eels were captured on the Aughnavaud and Pollmonty Rivers. Using the bankside method, one eel was caught on the Pollmonty and five were located on the Aughnavaud (Figure 5.43a). The depletion method (carried out just one week later) gained a similar result, one on the Pollmonty and five on the Aughnavaud (Figure 5.43b). The eels captured using the two fishing methods ranged in length from 14.6 to 34.3 cm. The length–frequency for this catch is shown in Figure 5.44.

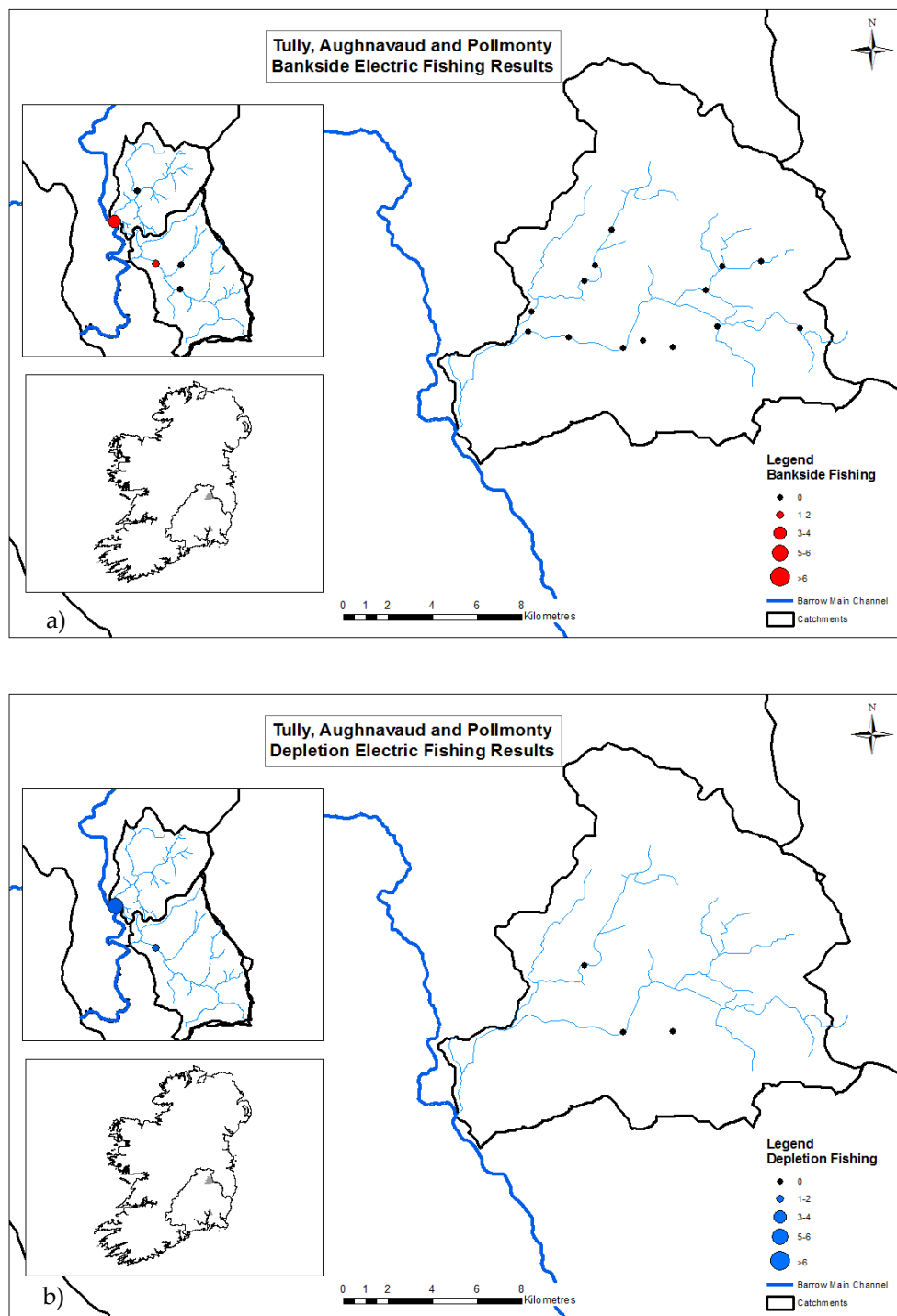


Figure 2-49. Results of a) semi-quantitative (Bankside) electric-fishing and b) quantitative (Depletion) electric-fishing sites sampled on Tully, Aughnavaud and Pollmonty catchments, 2017. (Inset(s): Map of Ireland with Tully, Aughnavaud and Pollmonty catchments (shaded) and South Eastern River Basin District (outlined).

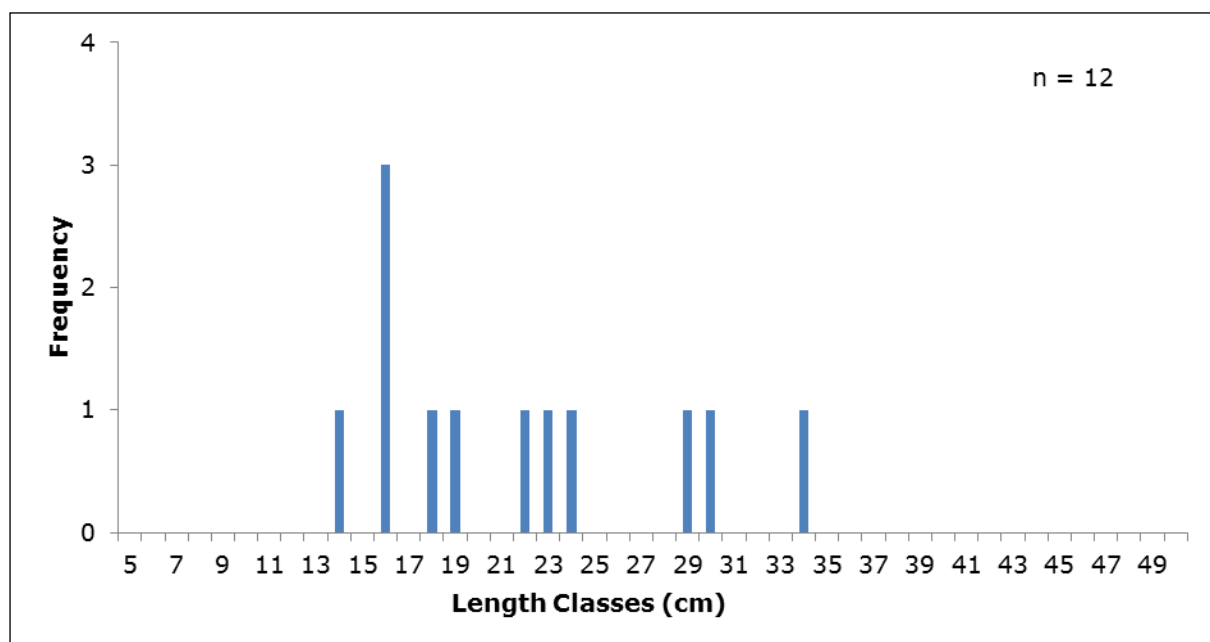


Figure 2-50. Length–frequency of yellow eels captured on the Aughnavaud and Pollmonty Rivers, 2017 (graph depicts pooled results from bankside and depletion methods).

5.8 Summary: yellow eel, 2017

Of the lakes sampled in 2017 the lowest cpue was in Lower Lough Corrib where 580 eels were caught in 320 net nights giving a cpue of 0.90. The highest cpue was in Upper lough Corrib where 1882 eels were caught in 200 net nights giving a cpue of 7.91. The majority of these eels were caught in one bay in the lake coinciding with a new moon, however the majority of the eels were classified as yellow eels and not pre-silver or silver eels. A repeat survey of Munster Blackwater estuary resulted in similar results for the two years with 521 eels recorded in 2016 and 540 eels in 2017. A repeat survey in Waterford estuary resulted in 6988 eels in 2016 and 6756 eels in 2017.

Fyke surveys in freshwater resulted in different results with a good number of eels present above Clondulane Weir on the Munster Blackwater River in contrast to the limited numbers in the estuary. In the Barrow small numbers of eels were found in Barrow canal at Levitstown in contrast to the large numbers found in Waterford Harbour downstream.

The electric-fishing carried out this year focused on the Tully catchment in the middle section of the catchment and the Pollmounty and Aughavaud subcatchments which are found at the high-water mark. Following an intensive survey of the Tully subcatchment no eels were recorded in the subcatchment, with only one individual being recorded in the Pollmounty and five eels in the Aughavaud. This result builds on the evidence of recent years of reduced eel distribution in the subcatchments of the River Barrow.

5.9 Water Framework Directive yellow eel

5.9.1 Introduction

In December 2000, the European Union introduced the Water Framework Directive (WFD) (2000/60/EC) as part of a standard approach for all countries to manage their water resources and to protect aquatic ecosystems. The fundamental objectives of the

WFD are to protect and maintain the status of waters that are already of good or high quality, to prevent any further deterioration and to restore all waters that are impaired so that they achieve at least good status by 2015.

A key step in the WFD process is for EU Member States to assess the health of their surface waters through national monitoring programmes. Monitoring of all biological elements including fish is the main tool used to classify the status (high, good, moderate, poor and bad) of each waterbody. The responsibility for monitoring fish has been assigned to Inland Fisheries Ireland. A national fish stock surveillance monitoring programme has been initiated at specified locations in a 3 year rolling cycle.

5.9.2 WFD sampling programme methods

5.9.2.1 Lakes

Lakes are surveyed between June and September. Standard multimesh monofilament survey gillnets were used to sample the fish population. Surface floating nets, “Dutch” fykenets and benthic braided single panel (62.5 mm mesh knot to knot) gillnets were used to supplement the gillnetting effort. Survey locations were randomly selected using a grid placed over the map of the lake and portable GPS instruments were used to mark the precise location of each net. All nets were set between 3 and 6 pm, fished overnight and lifted between 10.00 am and 12.00 midday in order to ensure that the activity peaks of each fish species were included.

5.9.2.2 Rivers

Electric fishing is the method of choice for WFD surveillance monitoring of fish in rivers to obtain a representative sample of the fish assemblage at each sampling site. The standard methodology includes fish sampling, hydrochemistry sampling, and a physical habitat survey.

Various electrofishing methods appropriate to the habitat type were used (Depletion wading and non-wading, Single pass wading and non-wading, Separate sides, non-wading); a new ten-minute electrofishing sampling method was introduced in 2015 on surveys in the River Barrow catchment (Delanty *et al.*, 2017) and developed further by Matson *et al.* (2017). In 2016 ten sites were surveyed using a ten-minute boat electrofishing method as part of a study to examine the potential for using this method in future in deeper rivers, other sites were surveyed using depletion electric fishing using either handsets or boats.

A macrophyte survey was also carried out at selected sites. Surveys were carried out between July and early October (to facilitate the capture of 0+ salmonids) when stream and river flows were moderate to low. All habitats, in wadeable and deeper sections, were sampled (i.e. riffle, glide, pool). The WFD river surveys have supplied vital information on juvenile eels (<30 cm) rarely encountered by lake fykenet surveys.

5.9.2.3 Transitional waters

A multimethod approach is used for sampling the transitional waters. Beach seining using a 30 m fine-mesh net is used to capture fish in littoral areas. Beam trawling is used for specified distances (100–200 m) in open water areas adjacent to beach seining locations. Fykenets were set overnight in selected areas adjacent to beach seining locations.

5.9.3 2016 Results

5.9.3.1 Lakes

A total of 19 lakes (spanning 13 catchments), were sampled with eels present in 18 lakes sampled (94% of sites; Figure 5.45). A total of 266 eels were caught during lake surveys. A mean cpue of 0.98 was found across all lake sites. While the highest cpue value for eels was found in MacNea Upper (Erne, cpue = 3.67) the lowest were noted in Lough Lene (Boyne, cpue = 0.11) and Ross Lake (Corrib, cpue = 0.11) (SSCE, 2018). No eels were captured in Lough Tay (Ovoca). The eels ranged in length from 25.3 to 77.6 cm (SSCE, 2018).

Lough Tay has shown decreases in eel captures from the 2009 surveys, resulting in no captures in the 2012, 2015 and 2016 surveys, (Kelly *et al.*, 2016). Lough Tay is located in the Ovoca catchment approximately 50 kms from the high water mark at an altitude of 250 m. There are a number of lakes present downstream (Lough Dan and the Upper and Lower lakes in Glendalough). With no major obstacles to the eels getting into this lake the lack of captures maybe due to the decrease in the distribution of eels within catchments as recruitment declines results in eels no longer pushed up into the margins or the extremities of a catchment to survive.

5.9.3.2 Rivers

A total of 193 river sites (across 21 catchments) were covered in the 2016 surveys (Figure 5.45). In 2016, fishing methodology changed depending on the site, a breakdown of how many sites were fished with the seven different methods is available in Table 6-7. All discussions on the results of the surveys does not include boom boats as eels are not assessed using this method. The WFD river sites had a 28% eel presence rate, with 43 sites recording eels (74% wading and 25% non-wading methodologies). A total of 86 eels were caught, ranging from 7 to 72.3 cm (SSCE, 2018). Densities ranged from 0.00006 to 0.1206 eels per m² in the Maigue River (Castleroberts Br_A) and Mayne River (Snugborough_A), respectively.

Table 2-17. WFD methodology and number of sites 2016.

Method	No sites
Timed wading	91
Timed nonwading	16
Boom Boats	39
Depletion wading	23
Depletion nonwading	7
Single pass nonwading	15
Separate sides nonwading	2

5.9.3.3 Transitional waters

A total of 395 eels were captured in the transitional water surveys across nine of the eleven locations, covering all seven of the catchments surveyed (Figure 5.45). They ranged in length from 21 to 78 cm. Cpue values for transitional water sites ranged from 0.56 (Drongawn Lough) to 6.94 (Gill Lough) (SSCE, 2018). No eels were captured in Barrow Suir, Nore Estuary zone and Suir Estuary Lower. Fifty-nine eels were caught

in beach-seines in the Barrow Estuary, Barrow Nore Estuary and in Lough Gill ranging in length from 4 to 29 cm.

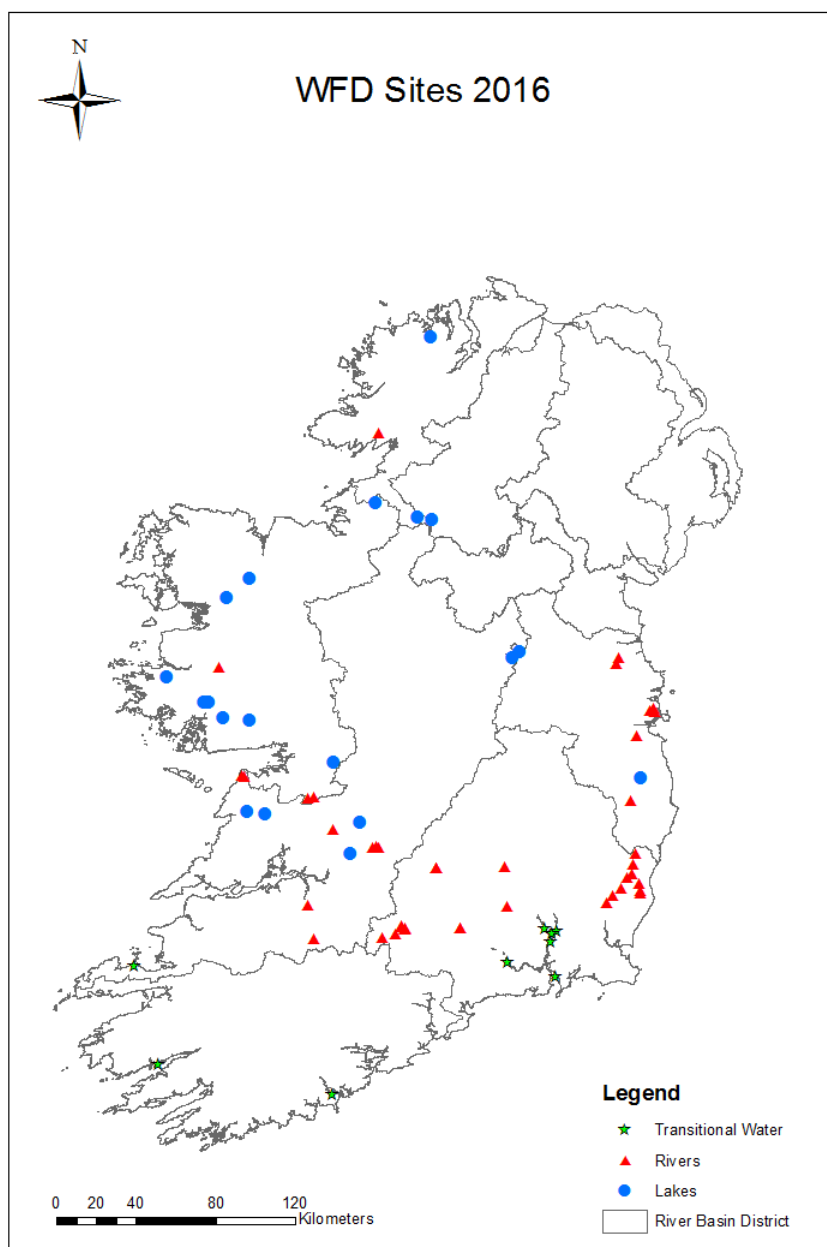


Figure 2-51. WFD locations surveyed in 2016.

5.10 Silver eel escapement surveys 2018

In Ireland escapement and mortality is calculated for two ESB catchments by the National University of Ireland Galway (Shannon, Erne), for the Burrishoole system by the Marine Institute and for the Fane and Barrow systems by Inland Fisheries Ireland. The Fane is the only east coast catchment currently being monitored for silver eels and the Barrow in the southeast (Figure 5.46).

The locations identified in the 2009 National Management Plan that have been excluded from the current programme (Table 5.7) are the Waterville site where it was proposed to use a resistivity fish counter to determine silver eel escapement. This will be re-evaluated once there is clear evidence of this technology being suitable for silver eel. The other site excluded from the programme is Lough Mask. This site was fished in 2010 and it was found to be difficult due to the geology of the region. With the suspension of the Galway Fishery on the outflow of the Corrib catchment any further work on Lough Mask has also been postponed with the redistribution of resources to the east coast.

Table 2-18. The locations where silver eel escapement will be assessed.

Catchment	Priority	2015	2016	2017	Method
Erne	High	√	√	√	Coghill net / Mark-recapture
Shannon	High	√	√	√	Coghill net / Mark-recapture
Burrishoole	High	√	√	√	Trap
Fane	High	√	√	√	Coghill net / Mark-recapture
Barrow	High	√	√	√	Coghill net / Mark-recapture
Boyne				√	Trial Site/River Fyke

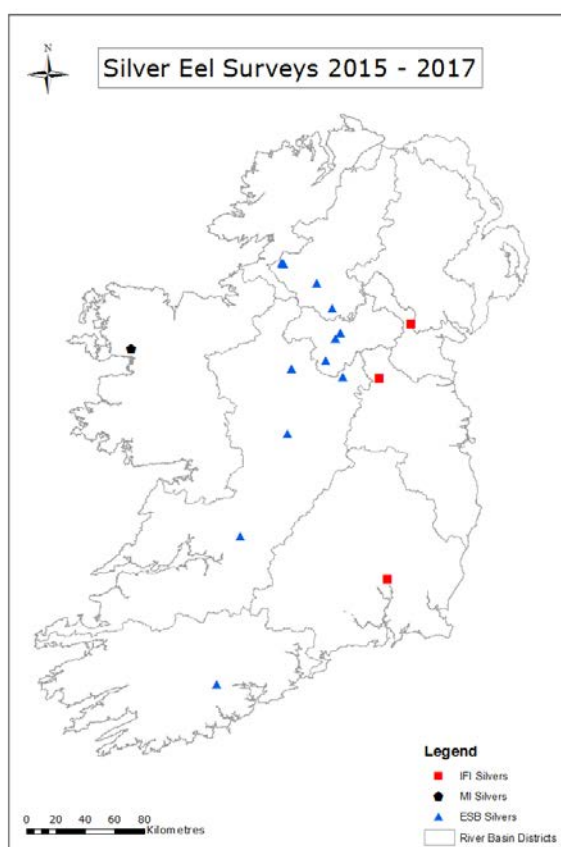


Figure 2-52. Silver eel monitoring locations, 2015–2017.

5.10.1 Shannon

The Shannon, Ireland's largest river, and its lake ecosystems include some of the country's best eel habitats. It is one of the better-known river systems in Europe in respect to eel population studies, due to long-term fishery records, ongoing research and monitoring of the trap and transport programme (e.g. MacNamara and McCarthy, 2013). National University of Ireland (NUIG) monitored the silver eel fishing activity and conducted scientific research, which formed the basis for calculation of production and escapement rates of the river system. The eel research workers from the National University of Ireland (NUIG) monitored silver eel fishing activity at conservation fishing sites and they conducted research at Killaloe Eel Weir, which formed the basis for calculation of production and escapement rates of the river system.

5.10.1.1 Catch

The annual monitoring of the Shannon silver eel populations and T&T was undertaken by NUI Galway researchers in conjunction with ESB Fishery Conservation staff. Conservation fishing on the River Shannon involved three contracted crews. These were located at Athlone (two crews fishing near the Athlone Yacht Club and near the Jolly Mariner Marina) and at the Killaloe eel fishing weir (Figure 5-47). The Athlone crews fished from 01/09/17 to 15/12/17. Fishing at Killaloe, a nationally important silver eel monitoring index site, extended from 25/09/17 to 13/02/18. All catches, except for some used in mark-recapture studies at Killaloe, contributed to the silver eel trap and transport (T&T) programme. The relative contributions of the three crews are indicated in Figure 5.48. As is usual, the Killaloe weir (62%) was the most important silver eel source, followed by the Jolly Mariner crew (30%) and the least productive Athlone Yacht Club crew (8%). The total quantity transported and released below Parteen weir was 16.737 t.

The total T&T catch in the River Shannon was 16 737 kg, 10 393 kg at Killaloe representing 62% of the total catch and 6341 kg at Athlone (Figure 5-3). As in previous years, the variation in daily catches at the Killaloe eel weir have been monitored by NUIG in relation to lunar cycle, discharge and other environmental factors. In Figure 5.49 some of these results are summarised, with particular reference to discharge patterns. During this season an added complication in terms of prediction of downstream migration route selection by eels was the occurrence of significant spillage at Ardnacrusha Dam in addition to spillage occurring at the more usual location via Parteen weir.

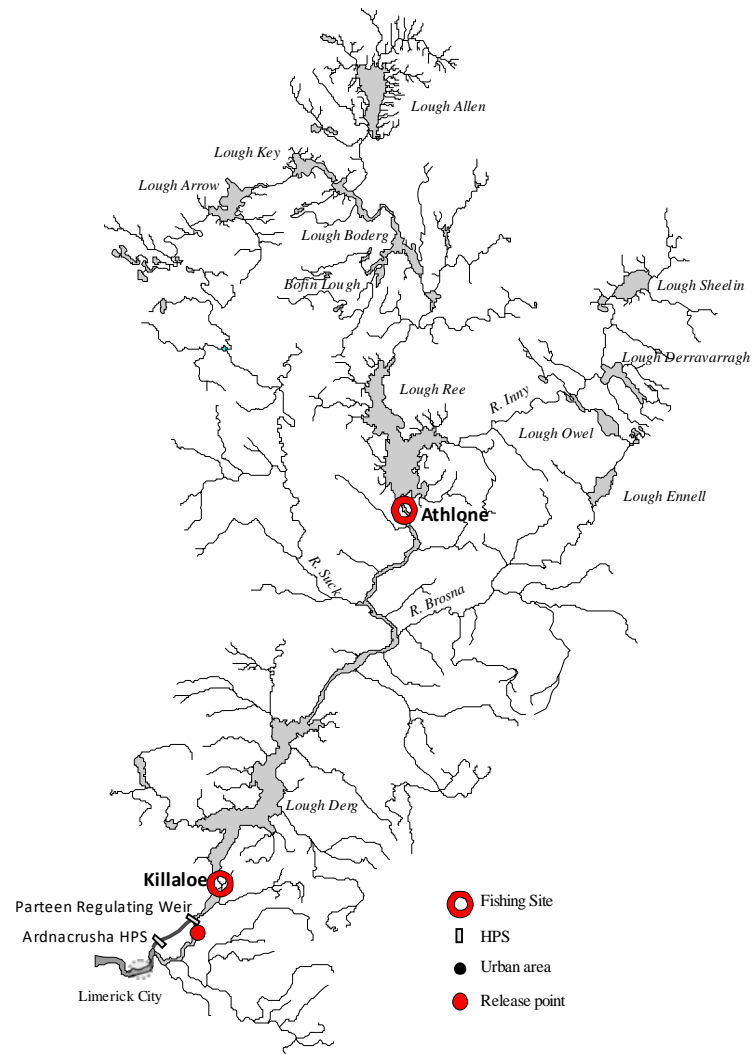


Figure 2-53. The River Shannon catchment area with fishing sites and silver eel release point indicated.

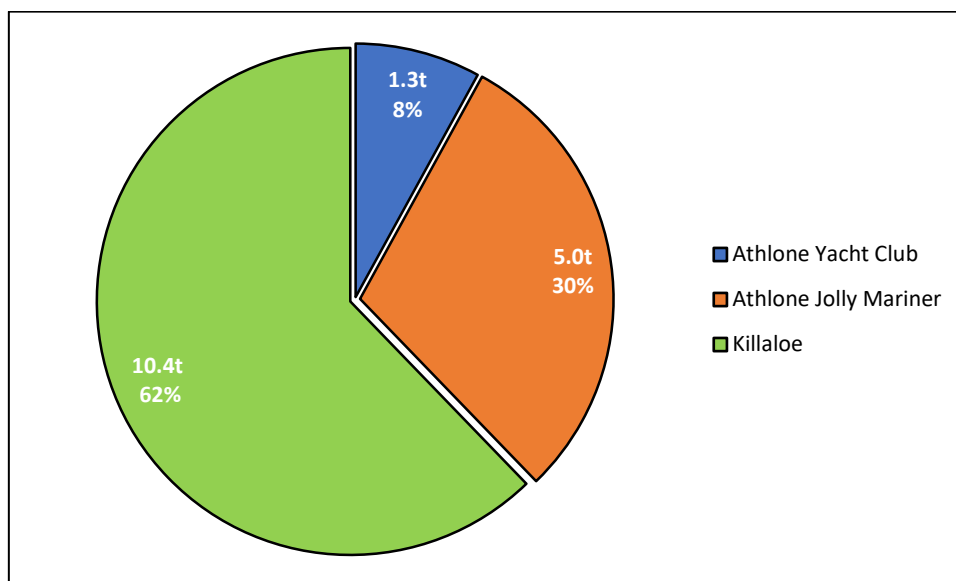


Figure 2-54. The relative quantities of silver eels contributed by fishing crews to the River Shannon T&T during the 2017/2018 season.

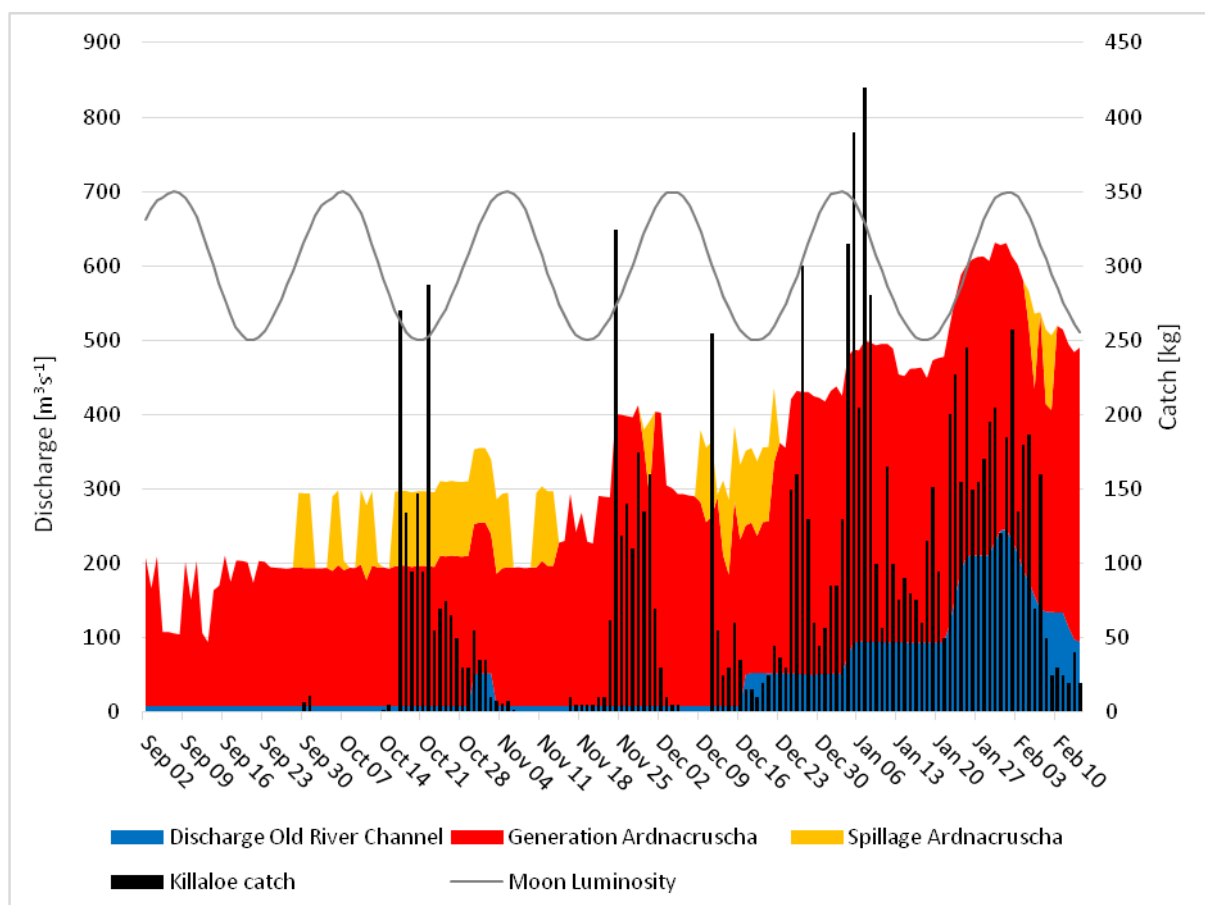


Figure 2-55. The seasonal variation in daily catches at the Killaloe eel weir during the 2017/2018 fishing season together with variation in discharge via Ardnacruscha (generation and spillage quantities) and as spillage to the Old River Shannon channel.

5.10.1.2 Production and escapement

A summary of the results of an analysis of the River Shannon silver eel production and spawner escapement biomass for the 2017/2018 season is presented in Figure 5-50. As usual the estimation of production involved records of daily catches at Killaloe weir, which were used with results of floy-tagging / mark-recapture experiments. These data are used to estimate quantities of eels approaching the weir and those not caught which proceed downstream. In the 2017/2018 season a series of five tagging experiments were undertaken which involved release of 653 tagged eels and an overall recapture rate of 38.6%. This figure was used for eel weir efficiency in calculation of silver eel production, which was estimated (Figure 5-50) to have been 34.139 t. This low production level, which was comparable to the previous year, suggests that a collapse of the Shannon eel stock may be occurring though further years of monitoring would be needed to confirm such a trend. The reduced production level has implications for the T&T conservation work. In the 2017/2018 season the T&T represented 49% of production and was well above the EMP target of 30%. The higher than previously recorded efficiency recorded at Killaloe confirms the importance of this monitoring and eel conservation facility.

Contrary to expectations earlier in the season when spillage at Ardnacrusha was initially occurring, route selection to the old river channel represented almost 20% of the eels going downstream from Killaloe (Figure 5-50). Dam mortalities were estimated at 2.948 t. This is a precautionary overestimate as some eels would have taken advantage of the Ardnacrusha spillway route though we cannot state definitively what quantities may have been involved. Ardnacrusha spillage occurred mostly in early season or when eel numbers were not at their peak. So its impact, whether positive due to spillway migration, or negative, due to reduction in Parteen spillage and in diversion of eels to the old river channel, may not have been as adverse as it might have been under different discharge regimes. Escapement, estimated as 31.191 t, was 91.4% of production.

5.10.1.3 Length

A sample of silver eels (n=107) were examined by NUIG at the Athlone site on 03/11/2017 (Figure 5.51). No major differences in size frequency appear to have taken place over last three years. A sample (n=201) of silver eels was examined by NUIG at Killaloe on 29/11/2017 (Figure 5.52). These included both males (14.4%) and females (85.6%). The mean female size was 662 mm. Another Killaloe sample (n=255) was examined by NUIG on 11/01/2018. This contained few males (1.96%) and the predominant female (98.04%) had a mean size of 677 mm. Because of limitations in sampling frequency it is difficult to interpret some of the differences between the Athlone and Killaloe silver eel size frequencies on the basis of this seasons results and a more systematic analysis of variation in population structure is therefore being initiated.

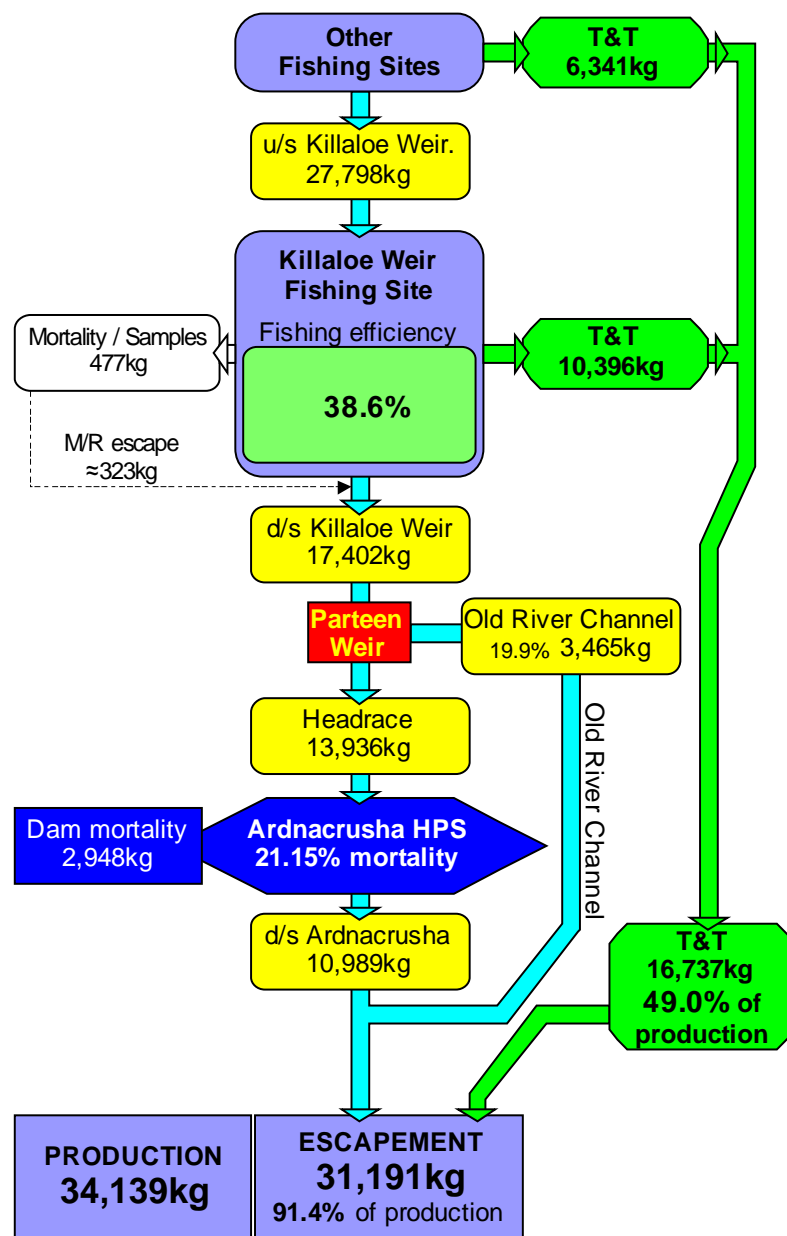


Figure 2-56. A summary of the results of the 2017/2018 analysis of silver eel production and spawner biomass escapement from the River Shannon.

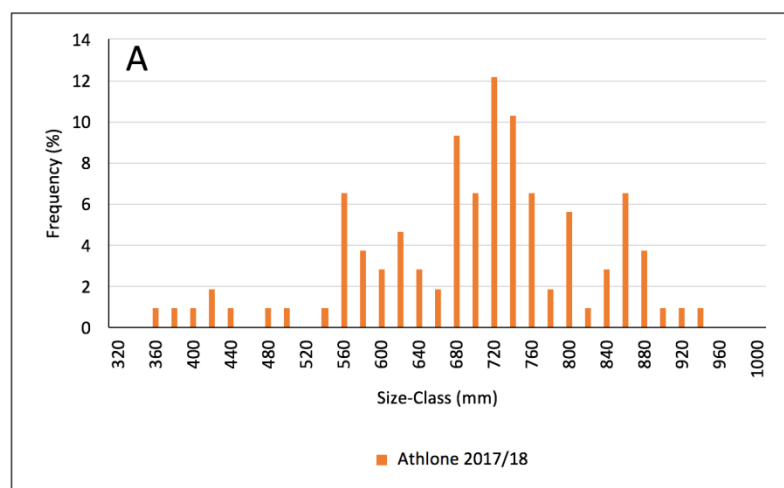


Figure 2-57. The size frequency of silver eels examined at Athlone in November 2017.

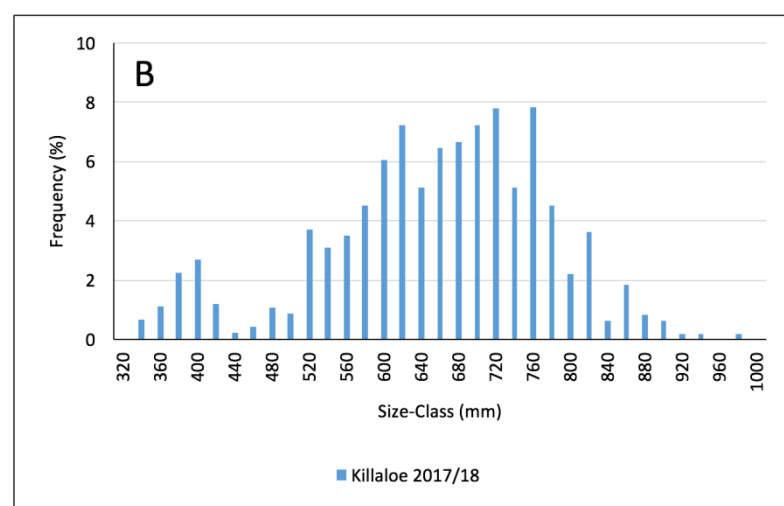


Figure 2-58. The size frequency of silver eels examined at Killaloe weir in November 2017.

5.10.2 Burrishoole

The only total silver eel production and escapement data available in Ireland is for the Burrishoole catchment in the Western RBD, a relatively small catchment (0.3% of the national wetted area), in the west of Ireland. The Burrishoole consists of rivers and lakes with relatively acid, oligotrophic, waters (Figure 5.53). The catchment has not been commercially fished for yellow eels, has not been stocked and there are no hydro-power turbines.

The eels have been intensively studied since the mid-1950s; total silver eel escapement from freshwater was counted since 1970 (Poole *et al.*, 1990; Sandlund *et al.*, 2017; Poole, data unpublished); and an intensive baseline survey was undertaken in 1987–1988 (Poole, 1994). The detailed nature of the Burrishoole data makes it suitable for model calibration and validation (e.g. Dekker *et al.*, 2006; Walker *et al.*, 2011).

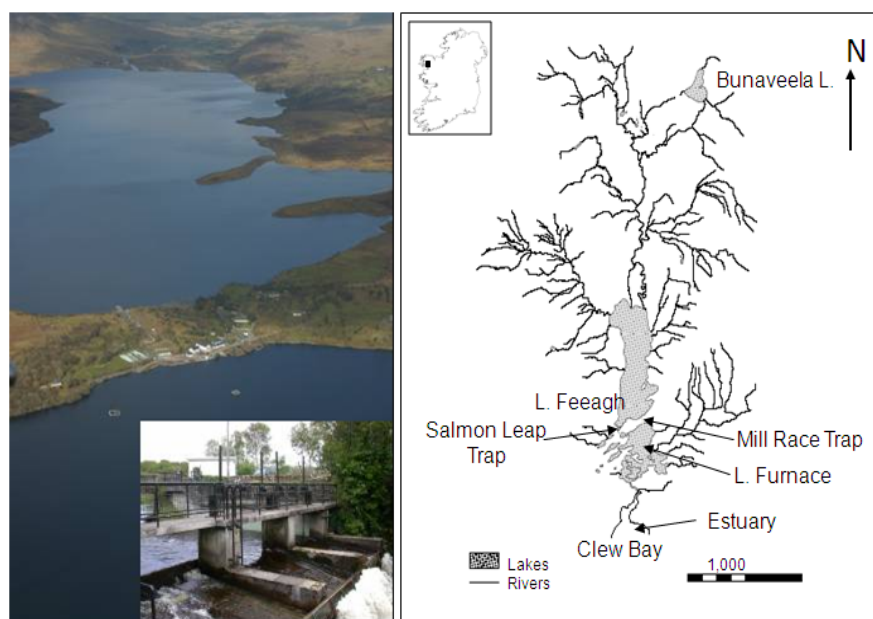


Figure 2-59. An aerial view of the Burrishoole catchment, looking north over the tidal Lough Furnace, in the foreground, and the freshwater Lough Feeagh: inset shows the silver eel downstream trap at the "Salmon Leap". A map of the Burrishoole catchment showing the locations of the silver eel traps at the lower end of the freshwater catchment.

5.10.2.1 Catch

The total run amounted to 2208 eels, lower than recorded in 2016. As in other years, the largest proportion of the total catch (83%) was made in the Salmon Leap trap.

The silver eel season in 2017 was characterised by the lack of any major floods or storm events. The eels migrated on small floods and flow rates were easy to manage.

In 2017, the timing of the run was 15% migrating in August, 31% in September and 40% in October (Table 5.8). 90% of the run was completed by the end of October. Figure 5-54 shows the daily counts of silver eels.

Table 2-19. Timing and numbers of the 2017/2018 silver eel run.

	Salmon Leap	Mill Race	Total	%
May	2	0	2	0.1
June	0	0	0	0.0
July	90	1	91	4.1
August	252	75	327	14.8
September	603	81	684	31.0
October	713	171	884	40.0
November	153	40	193	8.7
December	21	2	23	1.0
Jan. 2016	2	0	2	0.1
February	1	0	1	0.0
March	1	0	1	0.0
April	2	0	2	0.1
Total	1840	370	2210	

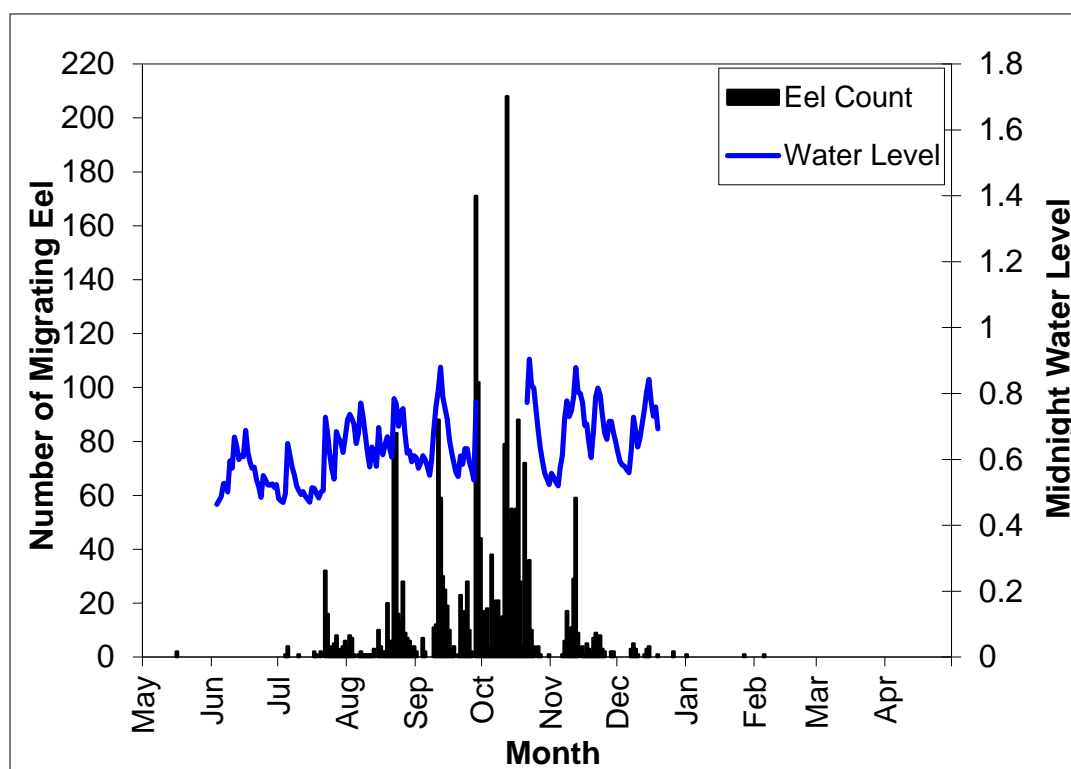


Figure 2-60. Daily counts of downstream migrating silver eel and mid-night water levels (m).

5.10.2.2 Length, weight and sex

Sampling of individual eels ($n = 481$) gave an average length of 44.4 cm (range: 30.6–91.2 cm) and an average weight of 177 g and the proportion of male eels was 35.1%. The length frequency is presented in Figure 5-55 along with those for 2015 and 2016 for comparison. The lack of eels above 46/47 cm was notable. Figure 5-56 shows the time-series of total counts and the mean weights since 1971.

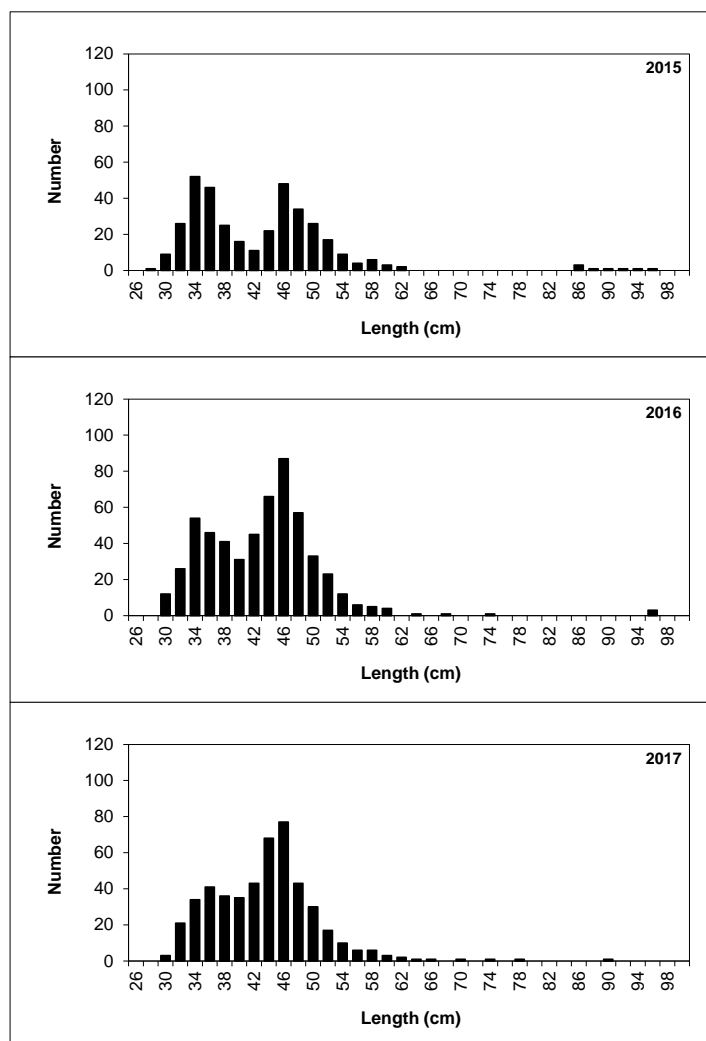


Figure 2-61. Length frequency of subsamples of silver eels trapped in the downstream traps, 2015 (n=365), 2016 (n=554) and 2017 (n=481). Note change of y-axis scales.

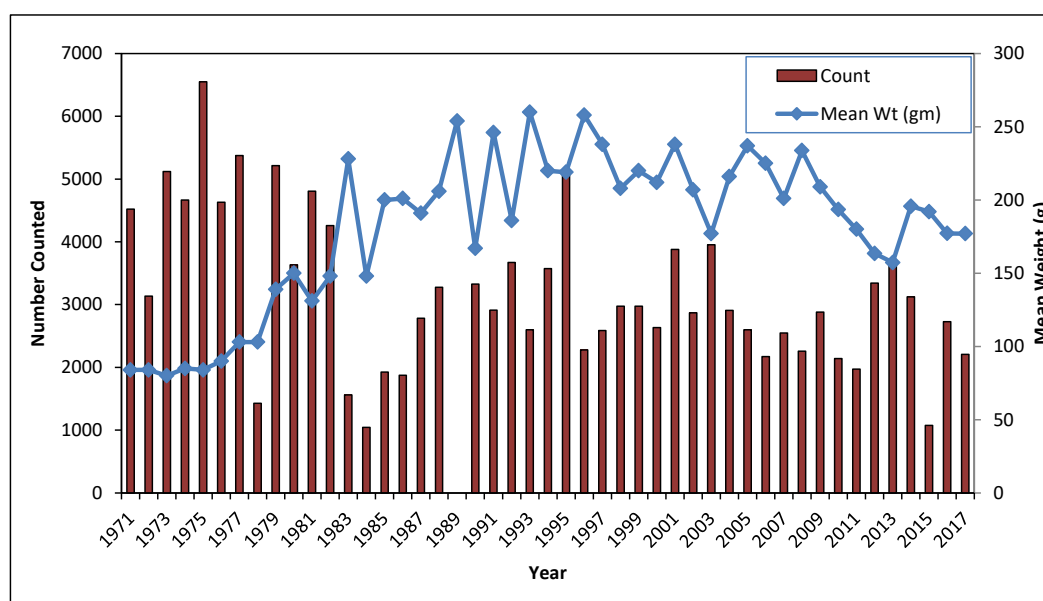


Figure 2-62. Annual number and mean weight of silver eels trapped in the Burrishoole downstream traps.

5.10.3 Erne Transboundary

The River Erne, a transboundary system, is the second largest river system in Ireland, with an extensive lake habitat. The River Erne conservation fishery and trap and transport (T&T) programme was monitored by researchers from the National University of Ireland (NUI) who also undertook mark-recapture experiments at Roscor Bridge following the methods of McCarthy *et al.* (2014).

5.10.3.1 Catch

The conservation fishing on the River Erne was undertaken at six sites. The locations of these and of the release point below the Cathaleen's Fall hydropower dam are indicated in Figure 5-57. The fishing sites included ones located in the upper, middle and lower sections of the river catchment area. The fishing season began on 01/09/17 and extended to 06/12/17. However, on scientific advice ESB extended authorization for fishing at the two lowermost sites (Ferry Gap and Roscor Bridge) until 20/12/17.

The total catches from the six fishing sites was 43.6 t and the relative proportions of this derived from each fishing site is indicated in Figure 5-58. The quantities varied from 3.6 t (Roscor Bridge) to 11.6 t (Ferry Gap). The daily variation in eel catches at the Ferry Gap is presented in Figure 5-59. The lunar periodicity noted at other sites was less obvious. This was also true of the effects of discharge. However, the site is a complex one with a variety of different netting systems and is influenced by a range of environmental factors that are not important in simpler river fishing sites.

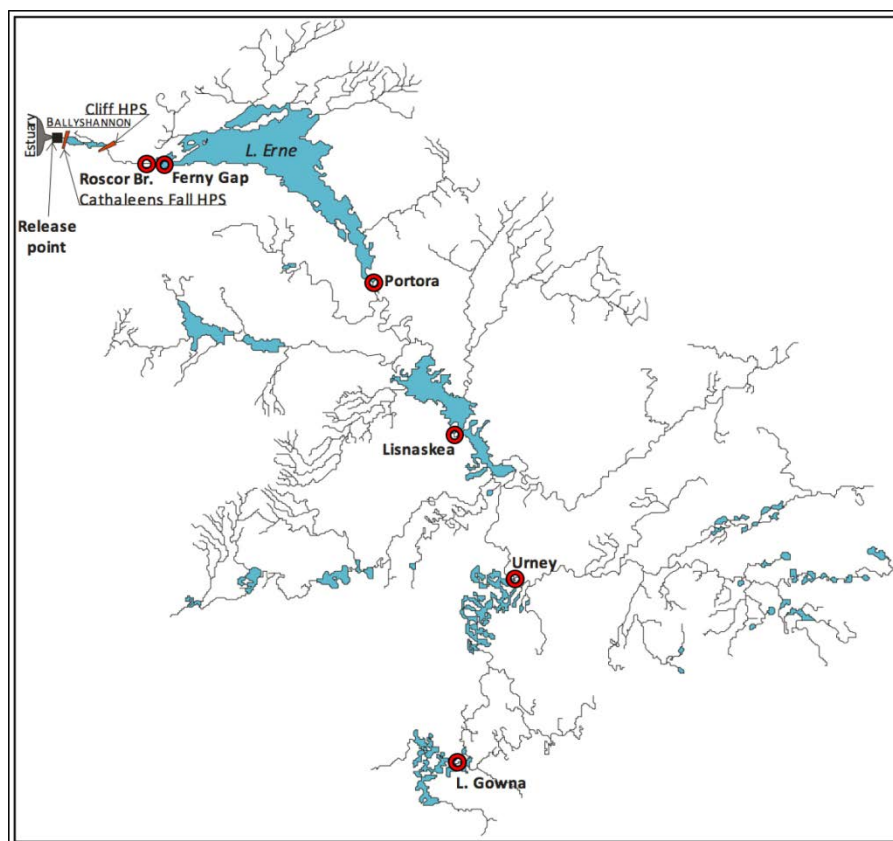


Figure 2-63. Map of River Erne catchment with conservation fishing sites, release point and hydropower dams indicated.

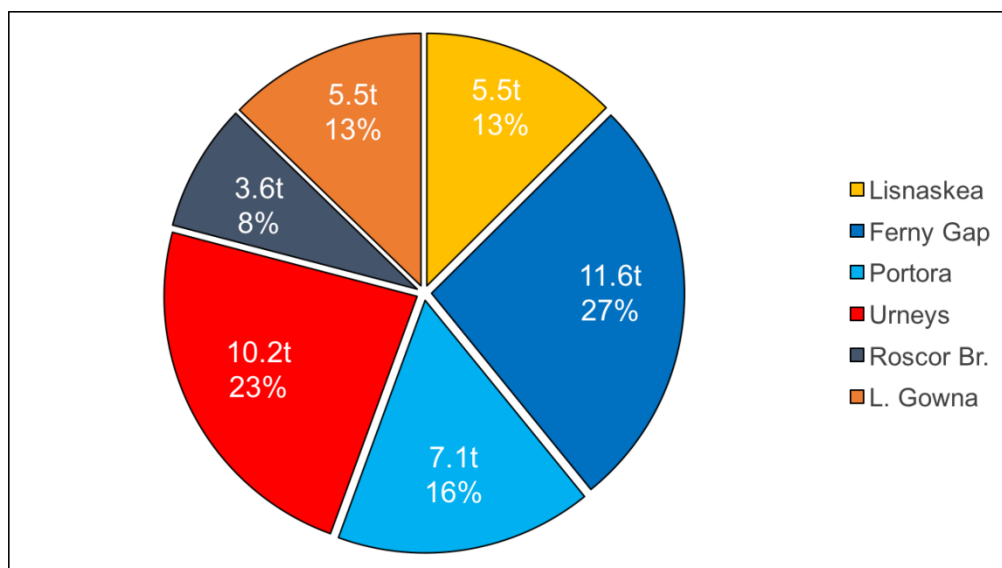


Figure 2-64. Proportions of the River Erne trap and transport catch obtained by each fishing crew in the 2017/2018 season.

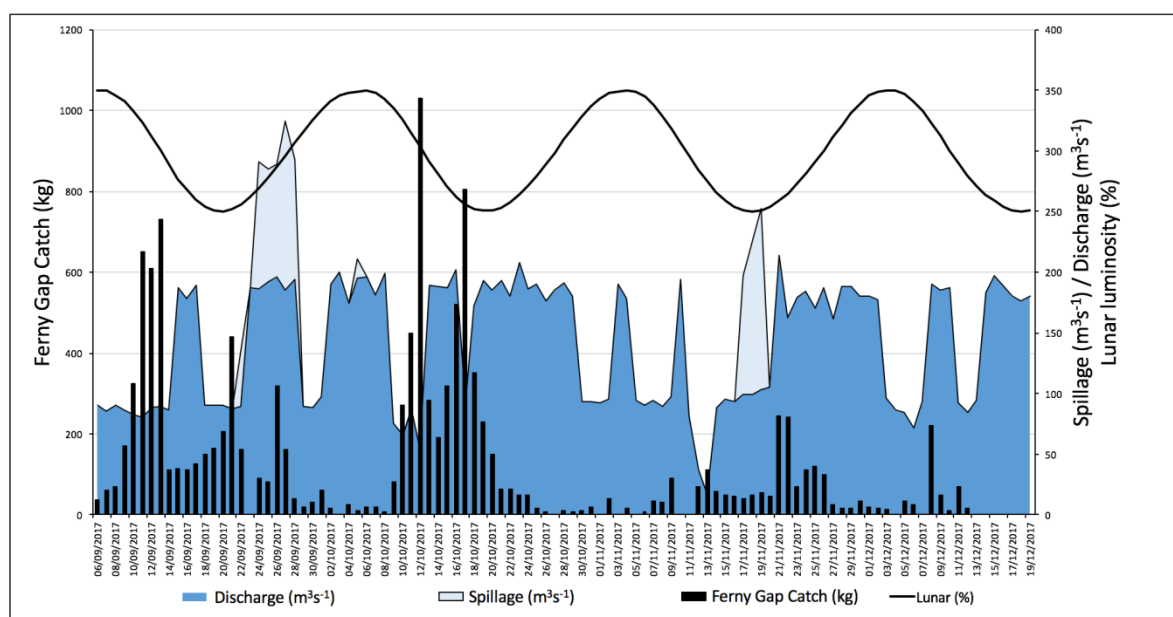


Figure 2-65. Variation in daily catches at the Ferny Gap fishing site, in relation to lunar cycle and discharge during the 2017/2018 season (the threshold discharge of 130 m³s⁻¹ used in population analyses is indicated by a black line).

5.10.3.2 Production and escapement

Quantification of eel spawner biomass escapement and production has previously relied on Lower R Erne catch data estimates of fishing site efficiency. Fishing at Roscor Bridge was delayed in the early part of the 2017 eel season and the crew declined to facilitate scientific monitoring and tagging at the site. In the absence of catch data, one option for assessment of compliance with EMP targets is a method based on modelling. The Roscor Bridge difficulties lead to development of a model, using catch data from a nearby (Figure 5-60) extensive fishing site (Ferny Gap) and environmental variables to predict daily catches at Roscor Bridge. The type of model chosen was a Generalized Additive Model (GAM) which can incorporate non-linear relationships and offer an

objective way to predict eel abundance or biomass. GAMs require no a priori information on the functional relationship between the response variable (Roscor Bridge catch) and the explanatory variables. Data from 2011 to 2017 were included in the model, with two-thirds of the data used to fit the model while the remaining one-third was used to evaluate the accuracy of model predictions. Final fitted model performance was evaluated by predicting Roscor Bridge catch at each of the datapoints in the test dataset, given the catch at the Ferny Gap and the environmental factors at that point. Predicted catch and observed catch values were highly correlated (Pearson's $r = 0.88$, $p < 0.001$), and 91% of observed daily catches fell within the range of predicted catch ($\pm 95\%$ C.I.). Based on this result it was decided to use the River Erne GAM to predict catch for the entire season 2017/2018 at Roscor Bridge. The model was used to make daily predictions of catch and when summed for the entire season this amounted to 4.248 t. The incomplete season catch recorded at Roscor Bridge in the 2017/2018 season was 3.553 t, all of which was included in the T&T releases. The River Erne GAM predicted a cumulative catch of 3.687 t for this incomplete fishing period.

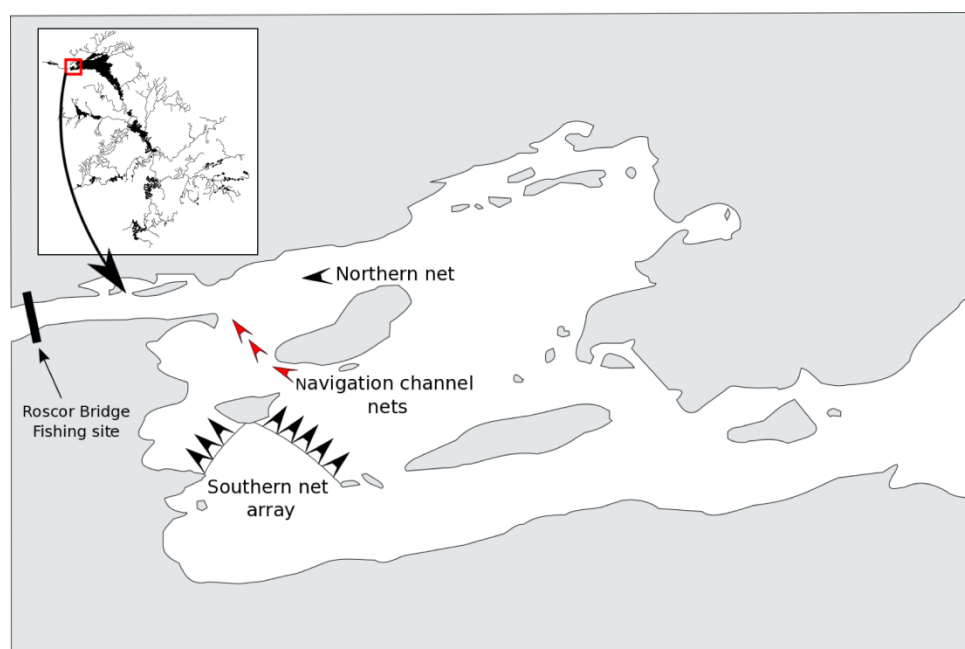


Figure 2-66. Map of the Ferny Gap with location of net arrays marked.

Daily GAM predicted catches were used, together with information gained in previous years on Roscor Bridge fishing efficiency (low discharge efficiency = 9.78% and high discharge efficiency = 18.43%) to calculate the biomass of eels migrating to the fishing site and downstream to the dams. The threshold discharge of $130 \text{ m}^3\text{s}^{-1}$ was used in distinguishing between high and low discharge levels at Roscor Bridge. Silver eel production (68.81 t) was estimated by combining the estimated biomass approaching Roscor Bridge (28.894 t) with the upstream T&T (39.916 t). The cumulative full season biomass approaching the dams was 24.646 t. Hydropower mortalities, assigned on a nightly basis, were estimated using results of telemetry undertaken in previous years (detailed in previous Country Reports). The combined mortalities estimated for the two dams was 10.073 t in the 2017/2018 season. The total T&T biomass was 43.469, which was 63.17% of production. Spawner escapement biomass was estimated to have been 58.042 t, which was 84.35% of production. The summary details for the River Erne are presented in Figure 5-61.

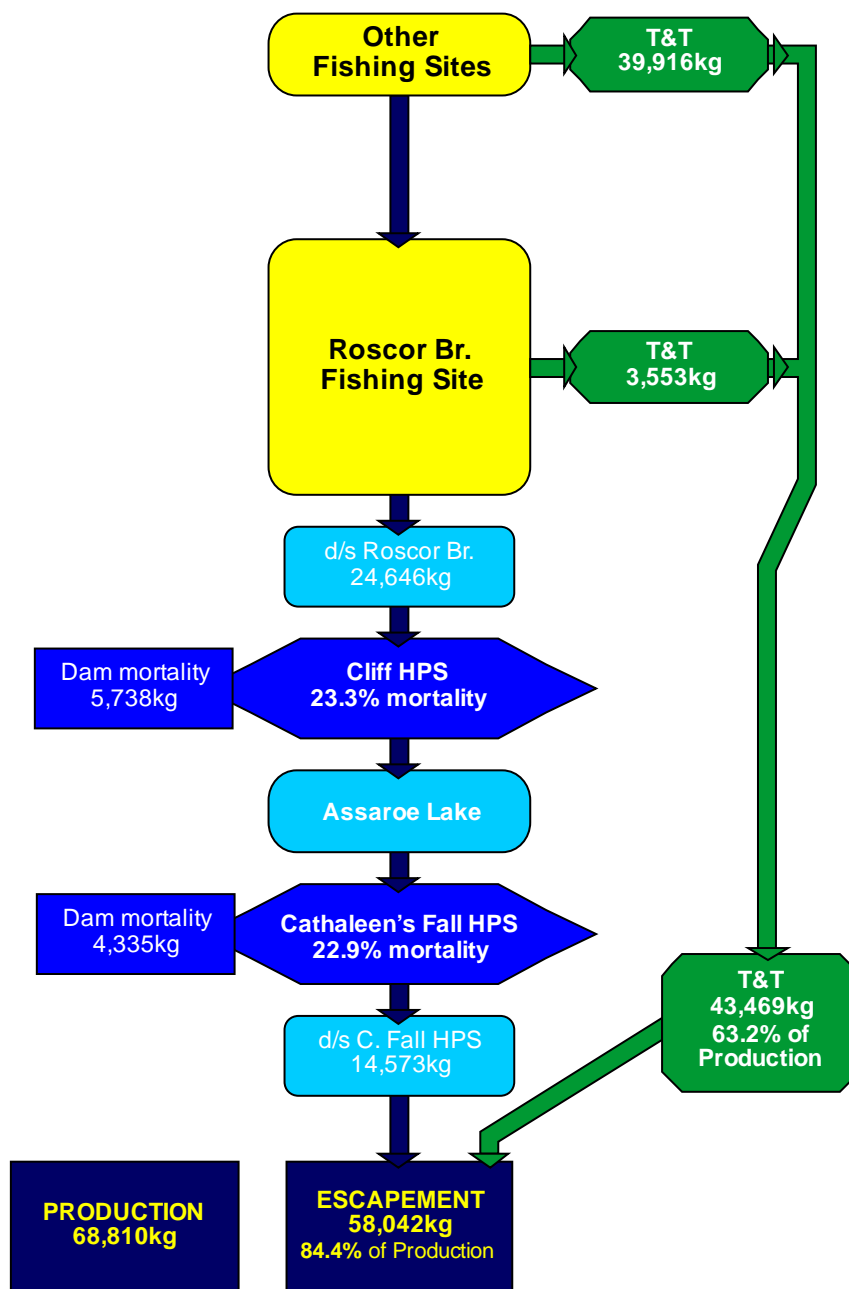


Figure 2-67. A summary of the analysis of silver eel production and escapement in the River Erne during the 2017/2018 eel migration season.

5.10.3.3 Length and weight

The eel population structure at Ferny Gap has been shown in previous years to vary between nets and between months. In the 2017/2018 a sample ($n=105$) was examined from the navigation nets and the results are presented as a size frequency distribution in Figure 5-62. The eels were mainly females (92.38%), which varied from 454 mm to 1015 mm. The mean female size was 737.67 mm.

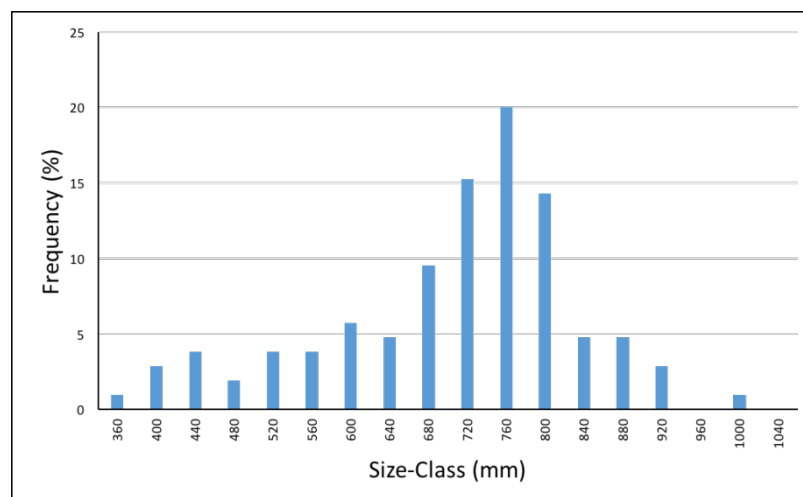


Figure 2-68. Relative size–frequency distribution of eels from Ferny Gap fishing site 14/12/17 (n=105).

5.10.4 Clarebane River (Fane)

The Fane is a relatively small catchment with the silver eel fishery located in the upper reaches of the system approximately 28 km from the coast. The Fane has a riverine wetted area of 84 ha and a lacustrine wetted area of 553 ha. A research silver eel fishery was carried out on the Clarebane River on the outflow of Lough Muckno in the Fane catchment from 2011 to the present (Figures 5-63 and 5-64). The site was the location of a commercial fishery until 2008.

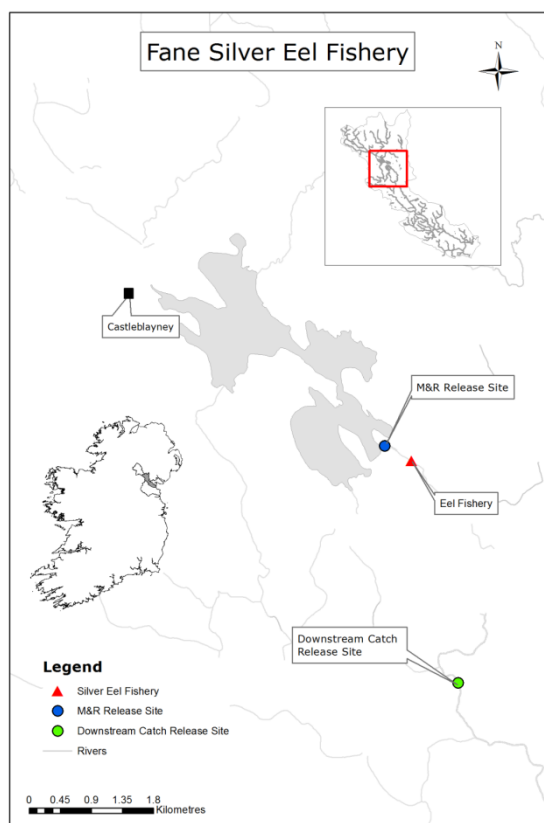


Figure 2-69. Location of Silver eel fishery on the Clarebane River (Fane).



Figure 2-70. Coghill net fishing for silver eels in the Clarebane River, 2013 (Photo: C. O'Leary).

5.10.4.1 Silver eel catch

The Fane silver eel fishery depends on water levels in the river in order for the nets to be set. As the fishing site is located downstream of Lough Muckno and a water abstraction site there is a delay due to the lake absorbing rainfall before a rise in river water levels is observed in the Clarebane River. Silver eel catches at the Fane Fishery were varied in 2017 with a total catch of 770 kg and 20 nights fished. The catches, numbers

of nights fished and numbers of eels captured from 2011 to 2017 are presented in Table 5-9. In 2017, increasing rainfall levels on a first quarter moon (Figure 5-20), early in the silver eel season led to large catches in September. Forty percent of total catch was captured over two nights (28th and 29th September). The catches then tapered off for the rest of the season coinciding with water levels that never rose above 1 m for the season. In total 20 nights were fished across September, October and December respectively. No fishing was carried out in November due to very low water levels and no eels were caught in the December fishing.

Table 2-20. Fane Silver eel catch record 2011–2017.

Year	Days fished	Catch (kg)	No eels
2011	13	268	1433
2012	21	448	1965
2013	19	1151	3097
2014	25	797	2542
2015	23	730	1810
2016	9	76	206
2017	20	770	2376

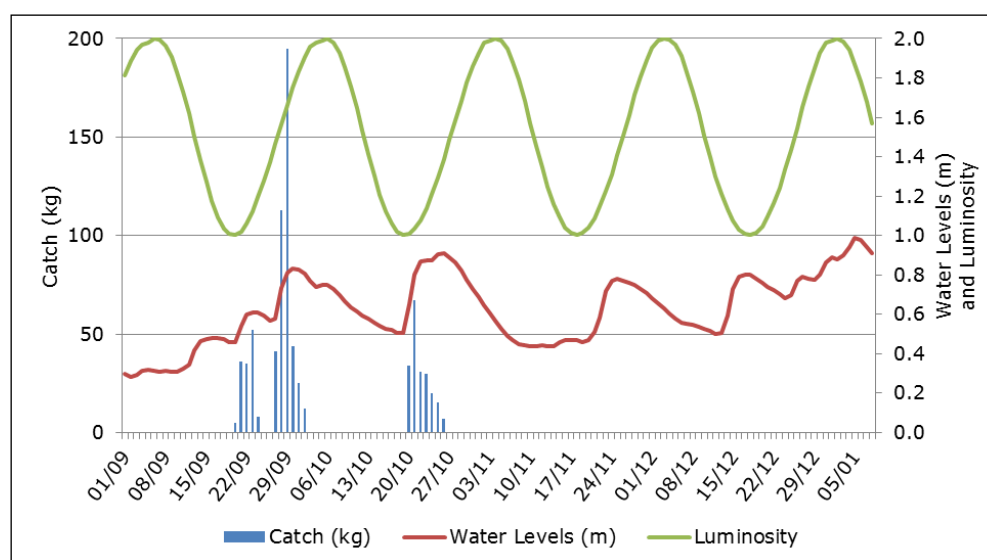


Figure 2-71. Water levels, moon phase and catch (kg) for the Fane fishery 2017 silver eel season.

5.10.4.2 Mark-recapture

A series of mark–recapture studies are undertaken at the site to determine the efficiency of the fishery (Table 5-10). Each year a number of eels tagged at the fishery and released upstream, when conditions are right this study can be repeated twice and three times when the silver eels are migrating. Due to the dry conditions for 2016 no MR studies were undertaken and the pattern of the silver eel run in 2017 resulted in only one eel being recaptured.

Table 2-21. Mark–recapture study 2012–2017.

YEAR	NO. TAGGED	RECAPTURED	RECAPTURED WITHIN YEAR	OVERALL RECAPTURE RATE %	WITHIN YEAR RECAPTURE RATE %
2012	469	94	36	20	8
2013	273	92	60	34	22
2014	320	93	87	29	27
2015	252	103	101	41	40
2017	124	1	1		
Average rate	30.91				

5.10.4.3 Eel biology

In 2017, morphometric measurements were taken on 427 eels in 2017. The processed eels had an average length was 51.9 cm (ranging from 30.9 to 94.7 cm). The average weight per eel was 0.3316 kg (ranging from 0.0140 to 1.7510 kg), (Table 5-11). The length frequency for the processed eels is shown in Figure 5-66. There were no silver eels retained during the 2017 fishing on the Fane catchment, therefore there are no results attributed to eel biological quality or parasite infections.

Table 2-22. Length and weight data for processed silver eels from the Fane catchment, 2011–2017.

Year	No. Eels	Mean Length (cm)	Min. Length (cm)	Max. Length (cm)	Mean Weight (kg)	Min. Weight (kg)	Max. Weight (kg)	Total Weight (kg)
2011	1433	43.8	30.4	91.7	0.187	0.044	1.709	268
2012	1541	47.1	31.4	96.0	0.251	0.050	2.090	387
2013	1165	49.2	30.8	96.6	0.289	0.030	1.952	337
2014	1334	50.4	30.4	95.0	0.292	0.045	1.721	389
2015	1622	54.0	31.2	96.6	0.370	0.030	2.045	599
2017	427	51.9	30.9	94.7	0.332	0.014	1.751	142

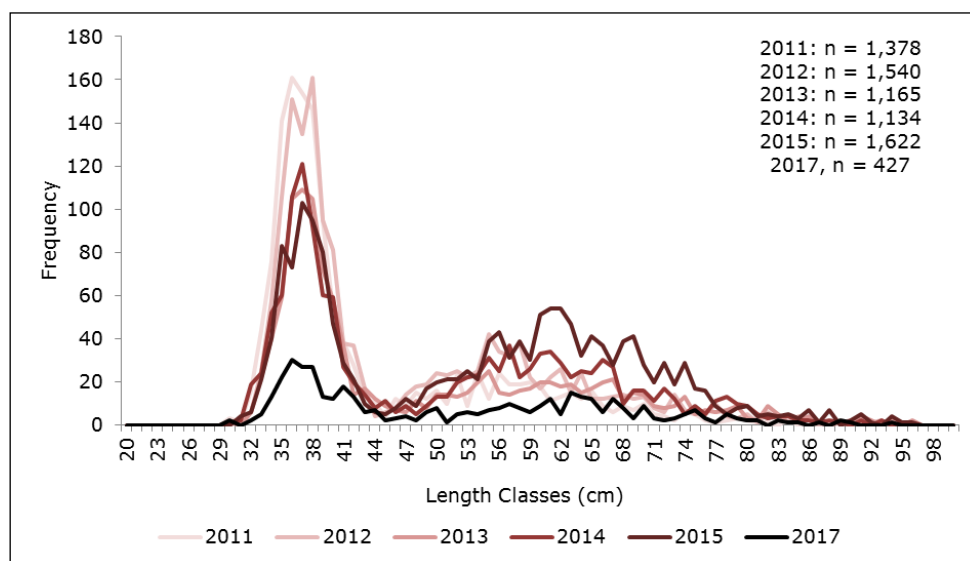


Figure 2-72. Length frequency for silver eels caught on Clarebane River (Fane Catchment), 2011–2017.

5.10.5 River Barrow

The Barrow catchment is a large riverine catchment located on the east coast of Ireland in the South Eastern River Basin District (SERBD). The SERBD is 60% calcareous bed-rock which makes it a productive habitat for eels. There has historically been a commercial fishery on the River Barrow and the presence of historical catch will aid in the assessment of the current silver eel escapement levels from the river. There are also historical research data on the River Barrow from the Fisheries Research Centre which are available to Inland Fisheries Ireland. The assessment of the silver eel stocks from a river dominated catchment will help highlight any difference in production and escapement of eels compared with catchments with large lake/lacustrine wetted areas. The Barrow is the first riverine dominated silver eel index catchment assessed to date.

Four nets were fished from openings on the Ballyteiglea Lock gates of the canal section of the River Barrow during the silver eel season (Figures 5-67 and 5.68). The location fished is upstream of the town of Graiguenamanagh; approximately 5 km upstream from the tidal limit (estuary) in the River Barrow. The location of the Ballyteiglea Lock fishing site means that over 99% of the River Barrow freshwater wetted area is above the fishing site. Due to the size of the River Barrow, it is currently not possible to fish the entire freshwater channel, however through a mark recapture study it is hoped to assess the efficiency rate of the fishing site and estimate what proportion of the run is bypassing the nets.

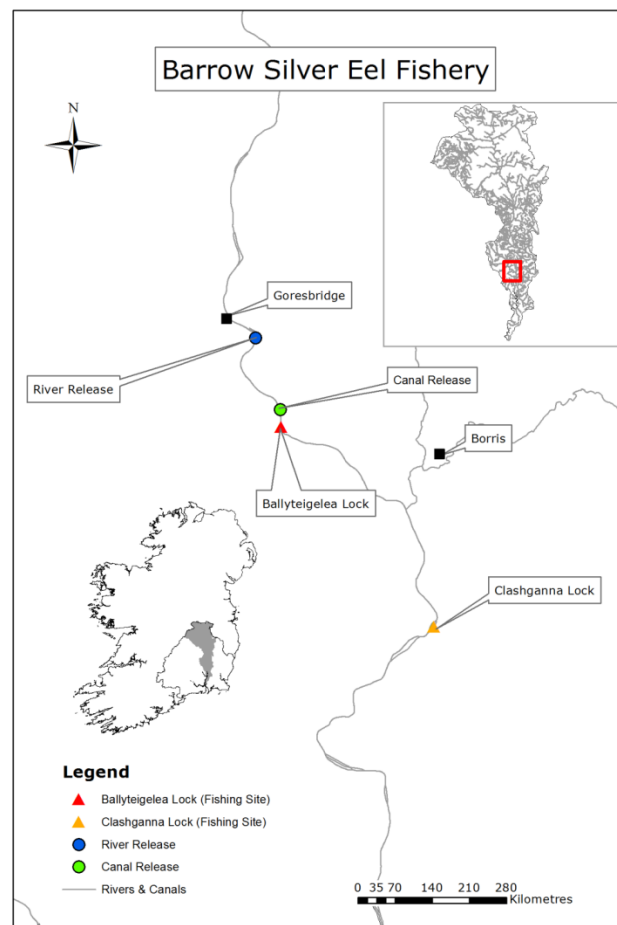


Figure 2-73. Map of silver eel fishing and release locations within the Barrow Catchment, 2016 (In-sets: Map of Ireland with Barrow catchment (shaded) and South Eastern River Basin District (out-lined) and detail of Barrow Catchment rivers)).



Figure 2-74. Ballyteiglelea Lock - location of research silver eel fishery on Barrow canal (Photo: C. O'Leary).

5.10.5.1 Eel catch

The Barrow silver eel fishery performed much as the Fane fishery in 2017 (Table 5-12). Increasing rainfall levels on the first quarter (Figure 5-69), early in the silver eel season led to large catches over two nights September (155 kg and 57% of the overall catch). In total 24 nights were fished with a total weight of 273 kg and morphometric measurements were taken on 351 eels. Catches then tapered off for the rest of the season coinciding with decreasing water levels (Figure 5-69).

Table 2-23. Silver eel catch record for Barrow 2014–2017.

Year	No. Days Fished	Catch (kg)	No of Eels
2014	22	174	1223
202015	20	128	687
2016	25	193	880
2017	24	273	1388

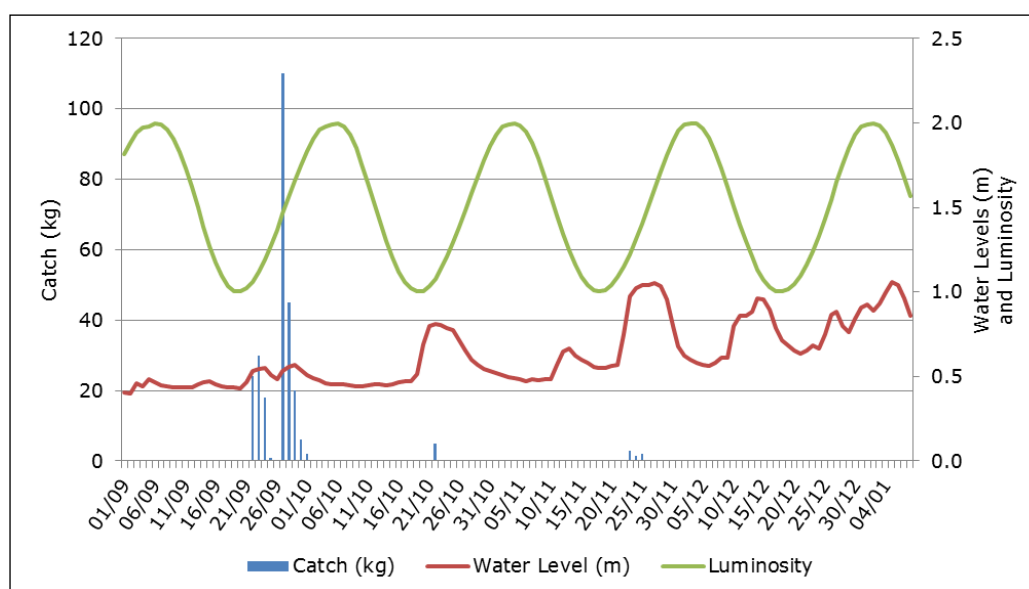


Figure 2-75. Water levels (m), Luminosity and Catch (kg) for the Barrow fishery 2017 silver eel season.

5.10.5.2 Mark-recapture

A series of mark-recapture studies are undertaken at the Barrow fishery to determine the efficiency of the site (Table 5-13). There are two locations for the study, one is Ballyellin lock, located upstream of the fishing site. The eels released at this site have two options for migrating downstream via the main channel or the canal, the second location is within the canal just upstream of the fishing site. Due to the unusual silver eel migration pattern for 2016 and 2017 only one MR session was undertaken in these years.

Table 2-24. Mark-recapture Preliminary Results for Barrow Fishery, 2015–2017.

Location	Year	Month	No. Tagged	No. Recaptured	% Recapture	Average rate
Ballyellin Lock	2014	October	202	7	3	11
Ballyellin Lock	2015	October	60	16	27	
Ballyellin Lock	2015	November	167	4	2	
Ballyteiglea Lock	2015	November	50	21	42	34
Ballyteiglea Lock	2016	November	48	21	44	
Ballyteiglea Lock	2017	September	51	8	16	

5.10.5.3 Eel biology

Morphometric measurements were taken on 351 eels in 2017. The processed eels had an average length was 45.5 cm (ranging from 26.2 to 81.8 cm). The average weight per eel was 0.2032 kg (ranging from 0.0250 to 1.078 kg), (Table 5-14). The length frequency for the processed eels is shown in Figure 5-70. During the silver eel season at the Barrow fishery, a total of 83 were retained in order to assess biological quality and were dissected in the laboratory. Of these, 67% were female and 33% were male (Figure 5-71 and Table 5-15).

The prevalence of the swimbladder parasite *Anguillicola crassus* was 69.8%, with a mean infection intensity of 5.67 worms per eel (Figure 5-72). In total, 329 parasites were recorded among the 83 retained eel samples. Swimbladder tissue health was assessed using the Swimbladder Degenerative Index (SDI) and the Length-Ratio Index (LRI). Both reported only slight/ moderate damage to the swimbladder tissue of the eels within the sample (Figures 5-73 and 5-74).

Table 2-25. Length and weight data for silver eels from the Barrow catchment, 2014–2017.

Year	No. Eels	Mean Length (cm)	Min. Length (cm)	Max. Length (cm)	Mean Weight (kg)	Min. Weight (kg)	Max. Weight (kg)	Total Weight (kg)
2014	811	41.4	27.6	76.2	0.140	0.033	0.742	114
2015	730	41.8	31.5	77.4	0.149	0.050	0.873	109
2016	681	45.2	32.0	77.8	0.195	0.052	0.860	133
2017	351	45.5	26.2	81.8	0.203	0.025	1.078	71

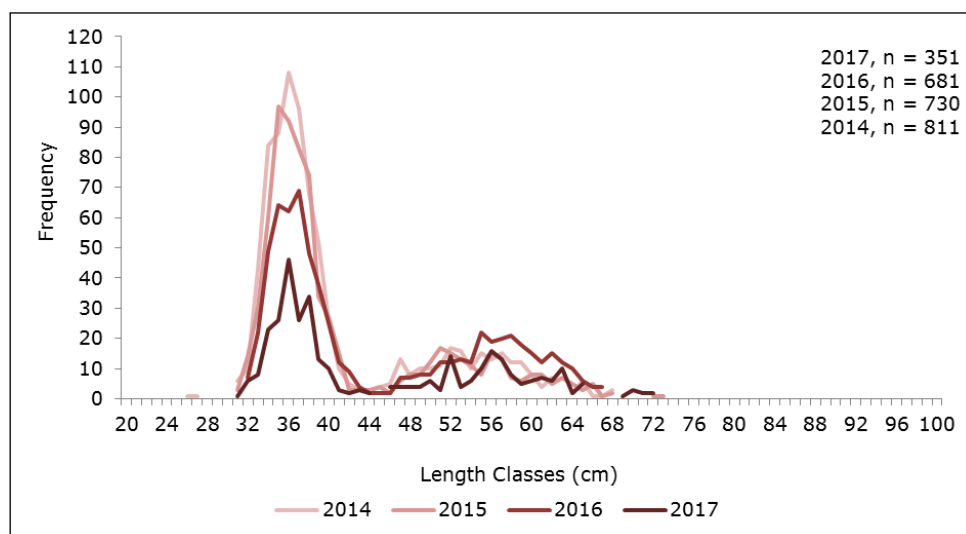


Figure 2-76. Length frequency for silver eels caught on Barrow fishery, 2014–2017.

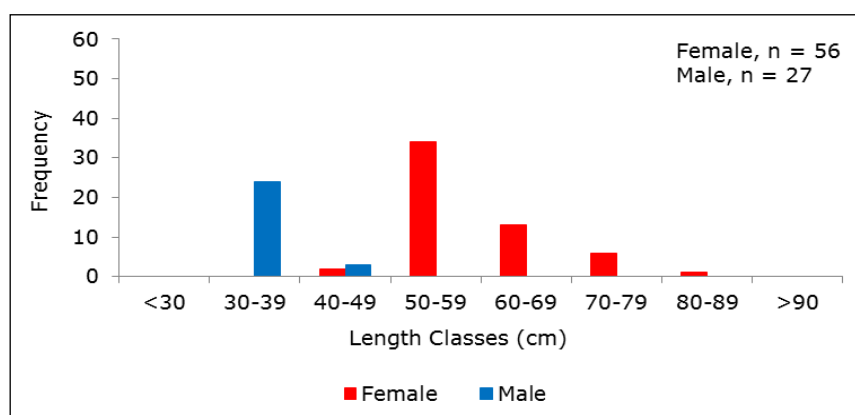


Figure 2-77. Sex distribution of sacrificed eels at Barrow silver eel fishery, 2017.

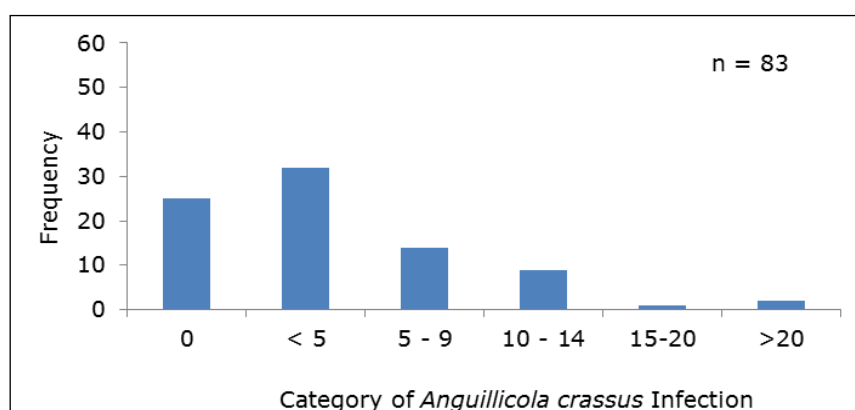


Figure 2-78. *Anguillicola crassus* infection intensity for sacrificed silver eels collected from Barrow fishery, 2017.

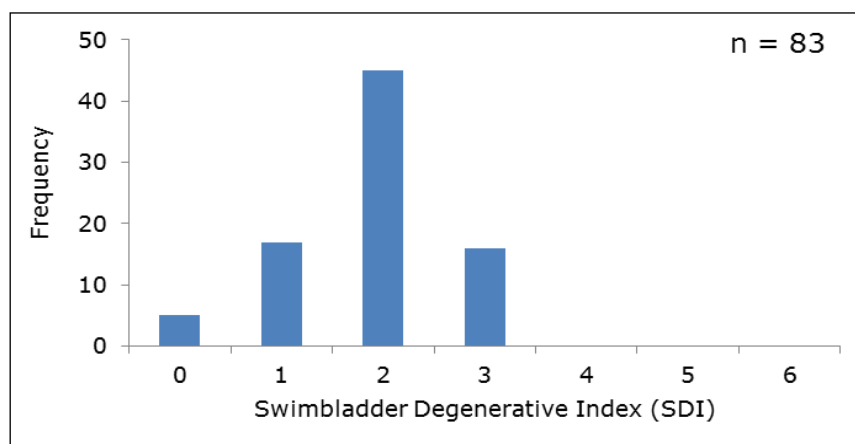


Figure 2-79. Swimbladder Degenerative Index (SDI) results for swimbladder health among sacrificed eels collected from Barrow fishery, 2017.

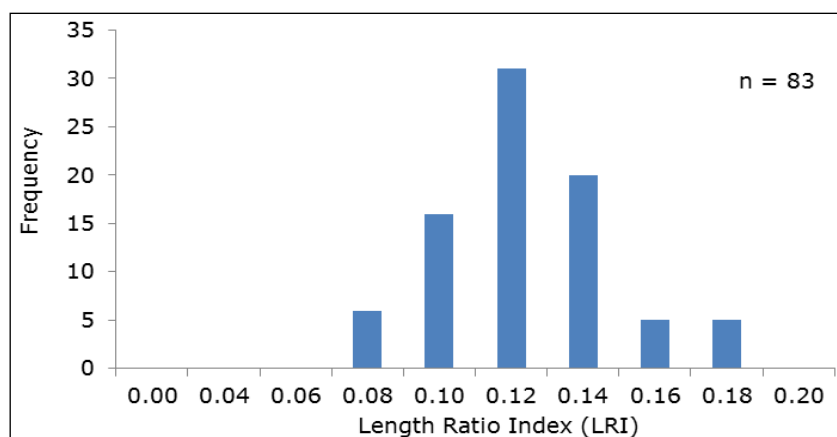


Figure 2-80. Length-Ratio Index (LRI) results for swimbladder health among sacrificed eels collected from Barrow fishery, 2017.

Table 2-26. Biological data for silver eels from Barrow catchment, 2014–2017.

Year	No. Eels	No. Females	No. Males	% Female	% Male	% Prevalence <i>A. crassus</i>	Mean Intensity <i>A. crassus</i>	Count <i>A. crassus</i>
2014	51	20	31	39	61	73	6.11	226
2015	55	19	36	35	65	56	5.16	160
2016	109	41	62	40	60	67	4.20	290
2017	83	56	27	68	33	69	5.67	329

5.10.6 Boyne

The Boyne catchment is a large catchment located on the east coast of Ireland in the Eastern River Basin District (SERBD). There has historically been a commercial fishery on the River Boyne and the presence of historical catch will aid in the assessment of the current silver eel escapement levels from the river. The fishing site selected on the Boyne was located at Floods Bridge on the main channel of the Kells Blackwater River (Figure 5-75). The location fished is 5 km downstream of Lough Ramor and upstream

of the town of Kells; approximately 50 km upstream from the tidal limit (estuary) in the River Boyne. A large river fykenet was fished during the 2017 silver eel season.

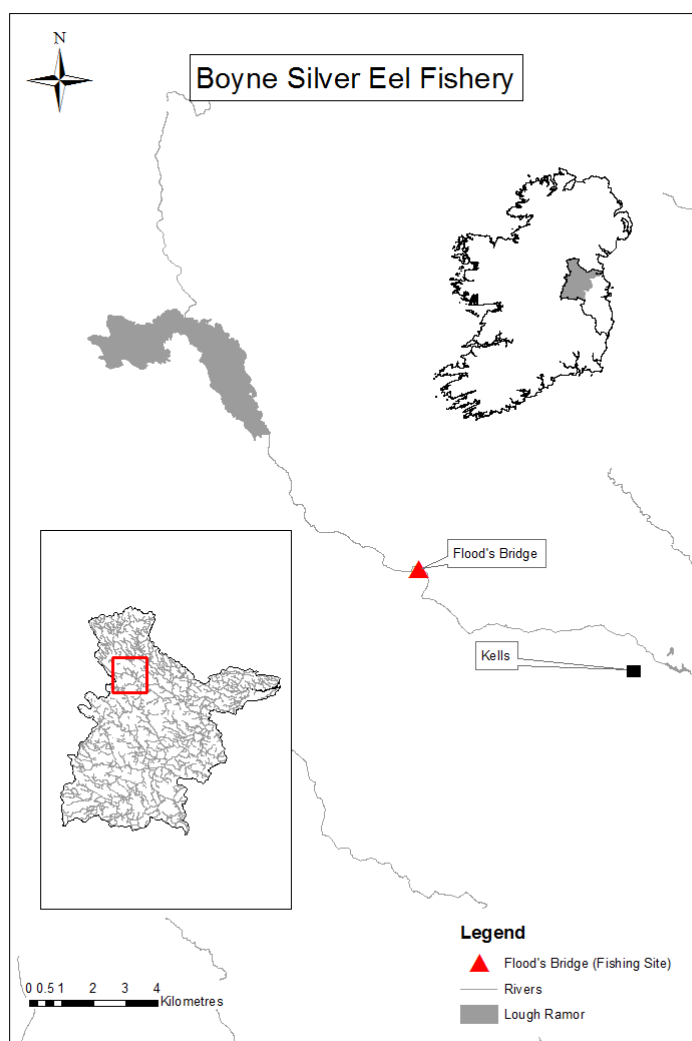


Figure 2-81. Map of silver eel fishing location within the Boyne Catchment, 2017 (Insets: Map of Ireland with Boyne catchment (shaded) and Eastern River Basin District (outlined) and detail of Boyne Catchment rivers).

5.10.6.1 Silver eel catch

The Boyne silver eel were low in 2017 with a total catch of 91 kg. Catches in the winged fykenet were limited despite fishing carried out during increased flow conditions and around the new moon. High rainfall levels on the first quarter (Figure 5-76), early in the silver eel season led to the largest catches in September (115 eels captured). A further 20 eels were caught in October and just eight in November. No eels were captured in December but a further 14 were caught in January 2018. In total, 157 eels were captured and measured during the silver eel season. As on the Fane catchment, the catches then tapered off for the rest of the season coinciding with decreasing water levels. In total 22 nights were fished.

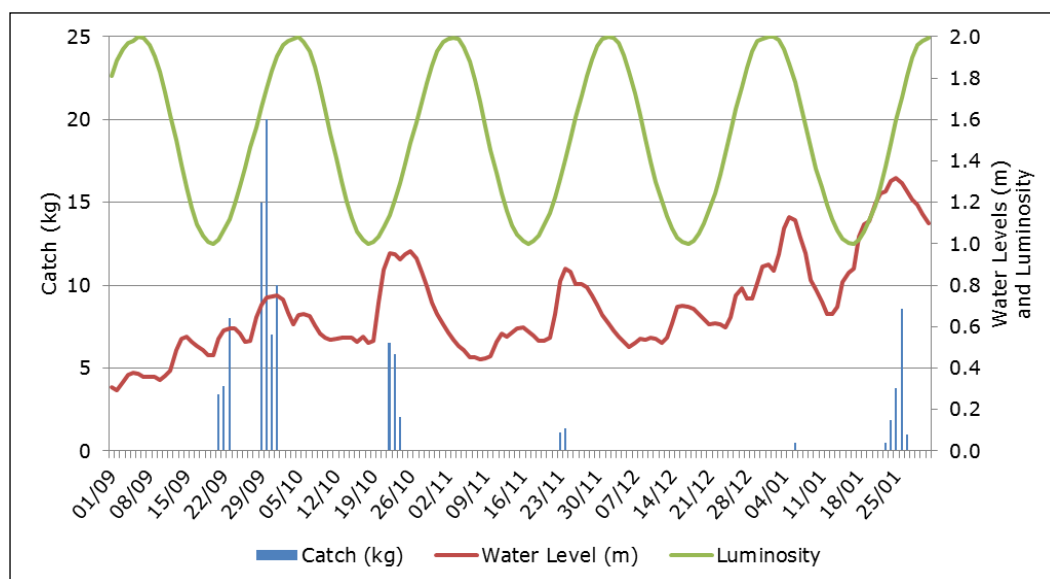


Figure 2-82. Water levels (m), Luminosity and Catch (kg) for the Boyne fishery 2017 silver eel season.

5.10.6.2 Eel biology

Morphometric measurements were taken on 157 eels in 2017/ 2018 season. The processed eels had an average length was 64.5 cm (ranging from 31.4 to 93.0 cm). The average weight per eel was 0.5260 kg (ranging from 0.0620 to 1.4245 kg), (Table 5-16). The length frequency for the processed eels is shown in Figure 5-77. During the silver eel season, a total of 61 were retained in order to assess biological quality and were dissected in the laboratory. Of these, 54 (89%) were female (Figure 5-78).

The prevalence of the swimbladder parasite *Anguillicola crassus* was 84%, with a mean infection intensity of 9.82 worms per eel (Figure 5-79). In total, 501 parasites were recorded among the 61 retained eel samples. Many of the infected eel had large intensity infections, with eight eels having infections in excess of 20 parasites; maximum infection was 77 parasites in one eel (Table 5-17). Swimbladder tissue health was assessed using the Swimbladder Degenerative Index (SDI) and the Length-Ratio Index (LRI). Despite the high intensity infections in many eels, both indices reported only slight/moderate damage to the swimbladder tissue of the eels within the sample (Figures 5-80 and 5-81).

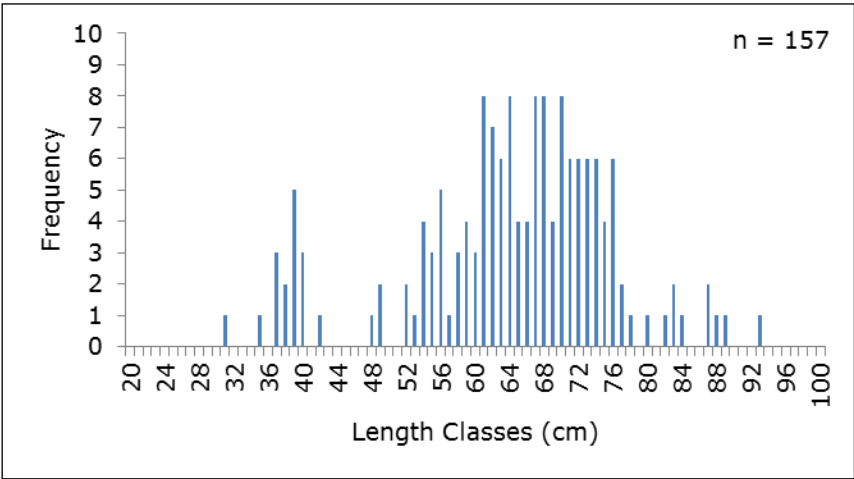


Figure 2-83. Length frequency of silver eels captured at the Boyne fishery, 2017.

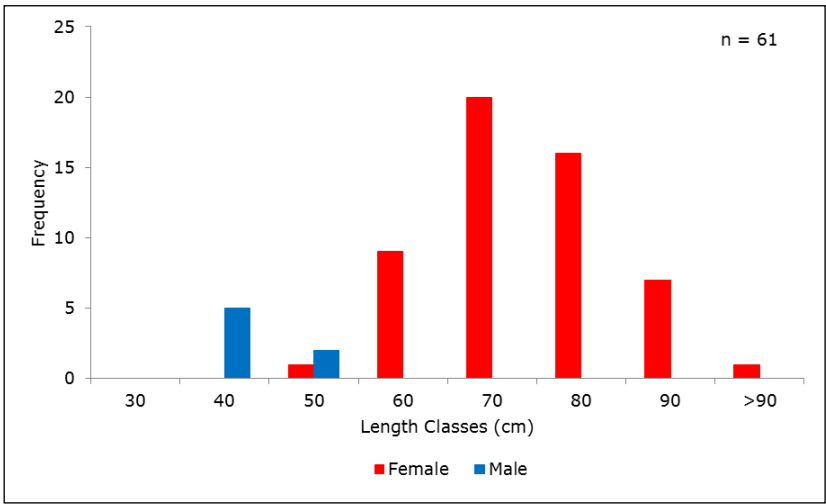


Figure 2-84. Sex distribution of sacrificed eels at Boyne silver eel fishery, 2017.

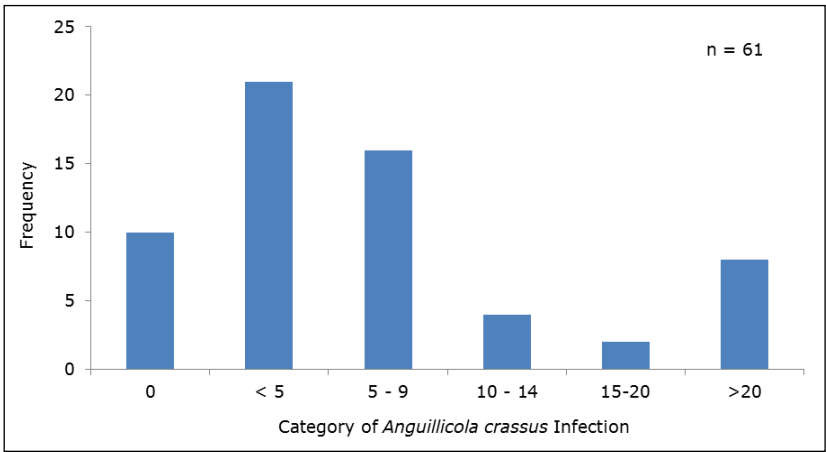


Figure 2-85. *Anguillicola crassus* infection intensity for sacrificed silver eels collected from Boyne fishery, 2017.

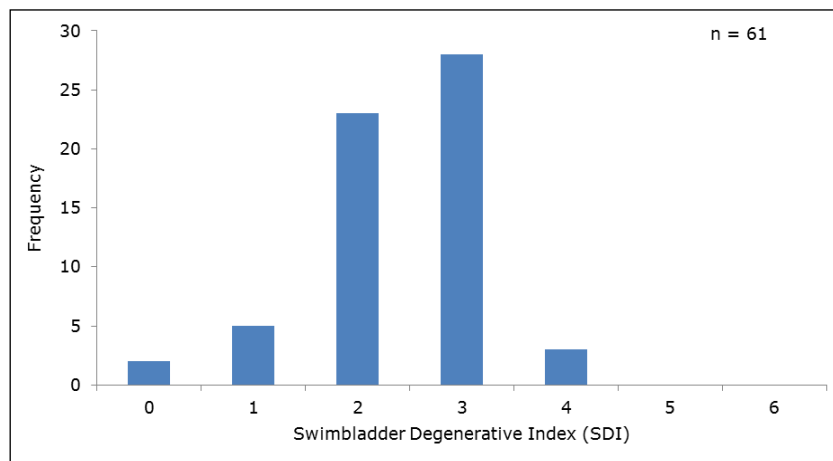


Figure 2-86. Swimbladder Degenerative Index (SDI) results for swimbladder health among sacrificed eels collected from Boyne fishery, 2017.

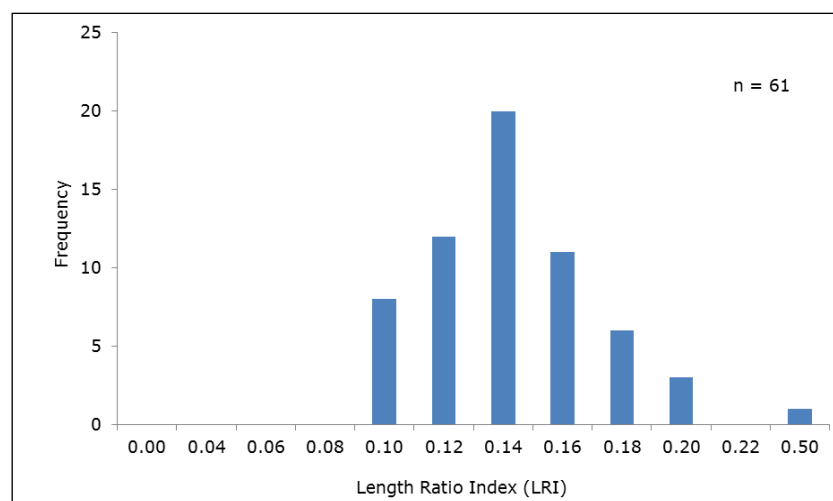


Figure 2-87. Length-Ratio Index (LRI) results for swimbladder health among sacrificed eels collected from Boyne fishery, 2017.

Table 2-27. Length and weight data for silver eels from the Boyne catchment, 2017.

Year	No. Eels	Mean Length (cm)	Min. Length (cm)	Max. Length (cm)	Mean Weight (kg)	Min. Weight (kg)	Max. Weight (kg)	Total Weight (kg)
2017	157	64.5	31.4	93.0	0.521	0.062	1.425	82

Table 2-28. Biological data for silver eels from Boyne catchment, 2017.

Year	No. Eels	No. Females	No. Males	% Female	% Male	% Prevalence <i>A. crassus</i>	Mean Intensity <i>A. crassus</i>	Count <i>A. crassus</i>
2017	61	54	7	89	11	84	9.82	501

5.11 Biological parameters

These are covered in previous report sections.

5.12 Parasites and pathogens

These are covered in previous report sections.

5.13 Contaminants

No new data available.

5.14 Predators

No new data available.

6 New information

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

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.

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1 Stock status summary

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

In Italy five habitat typologies have been identified relevant to eel, and the relative wetted areas and eel stocks have been assessed in each region (EMU): two typologies are freshwater habitats (lakes and rivers) and three are transitional waters (lagoons, managed lagoons and private *valli*). Data presented in the tables submitted for the ICES Data Call 2018 and in the Progress report 2018 for art.9 Reg. 1100/2007, have been aggregated as requested.

Table 1 shows data aggregated for each EMU and remaining Regions without EMPs.

	Wetted area	B ₀	B _{best}	B _{curr}	B _{curr} /B ₀	ΣF	ΣH	ΣA
	ha	kg		lifetime-1				
EMU_Emil	31045	458236	114057	83359	18%	0.33	0.02	0.35
EMU_Frio	16185	293033	72982	71479	24%	0.10	0.00	0.10
EMU_Lazi	6895	71054	31097	14129	20%	0.42	0.15	0.56
EMU_Lomb	17336	65561	11761	6673	10%	0.00	1.01	1.02
EMU_Pugl	12121	399772	124085	110137	28%	0.05	0.00	0.05
EMU_Sard	9250	210386	89376	28077	13%	1.00	0.01	1.01
EMU_Tosc	5521	75404	31563	4706	6%	2.01	0.02	2.03
EMU_Umbr	1115	3569	639	0	0%	0.01	Inf	Inf
EMU_Vene	94666	1773133	441267	388711	22%	0.11	0.04	0.15
Abru	602	1928	473	406	21%	0.01	0.12	0.13
Basi	724	2318	714	557	24%	0.01	0.21	0.22
Cala	494	1580	486	389	25%	0.03	0.15	0.18
Camp	1924	14339	6021	5553	39%	0.01	0.04	0.04
Ligu	526	1684	714	628	37%	0.02	0.07	0.09
Marc	1099	3516	862	623	18%	0.02	0.27	0.29
Moli	282	903	277	206	23%	0.01	0.25	0.26
Piem	4610	15632	2801	575	4%	0.01	1.37	1.37
Sici	1000	7871	3341	2936	37%	0.02	0.05	0.07
Tren	2111	7195	1288	105	1%	0.01	1.77	1.77
Vall	338	1082	194	0	0%	0.01	Inf	Inf
TOTAL	207845	3408195	933999	719250	21%	0.33	0.11	0.43

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

Eel (*Anguilla anguilla* L.) exploitation in Italy has a long-standing tradition, and is still important, despite a progressive and increased loss of interest towards this species. Fisheries still concern all continental stages, i.e. glass eel, yellow and migratory silver eel. The most distinctive exploitation pattern for eel in Italy has been in the past coastal lagoon fishery, that yielded most of yellow and silver eel extensive culture and fishery production (Ciccotti, 1997; Ciccotti *et al.*, 2000; Ciccotti, 2005; Ciccotti, 2014, Aalto *et al.*, 2016). Quite important was also eel intensive aquaculture, that played a major role within the national and European context up to some years ago and that has strongly reduced today (Ciccotti *et al.*, 2000; Ciccotti and Fontenelle, 2001; Ciccotti, 2014).

Eel is still present in lagoons and inland waters in all the regions, but its density, local stocks characteristics and growth vary widely depending on the type of environment (lagoons, rivers, lakes), hence production patterns are also very diverse.

Lagoons cover around 1420 km², 610 of which are currently exploited. Of the exploited area, about 300 km² are located in the upper Adriatic and 120 in the Po delta, the rest being scattered in Puglia, Campania, Lazio, Toscana, Sicilia and Sardegna (Ardizzone *et al.*, 1988; Ciccotti, 2014; Cataudella *et al.*, 2014; Aalto *et al.*, 2016). In the upper Adriatic

lagoons, the typical form of management was the *vallicoltura* that slightly differed from other lagoon management and fisheries, because of relying on fry stocking and active hydraulic management (Ciccotti, 2014; Cataudella *et al.*, 2014).

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. Most of the eel catches were in the past from the great Alpine lakes in the northern regions, but the eel also was an important target species for professional fisheries in some volcanic lakes of Central Italy. In lakes, fisheries were enhanced by eel restocking, because accessibility to lakes was reduced also in pristine times owing to the structure of river-lakes systems and secondarily to the presence of dams, most of which were implemented after the Second World War.

Recreational eel fisheries were common in some specific regions in relation to local traditions, and are still present, where allowed, with a patchy pattern.

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

Italy has established, since 2009, its Data Collection Framework for Eel, as foreseen by the Regulation 199/2008, and therefore eel has been included in the DCF Italian National Programme. The Eel Fisheries Data Collection (under Reg. 199/2008, DCF) is at present definitively in place, now as National Data Collection Program 2017–2019 (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 2017 are derived from the Eel Fisheries DCF, presented at the national level or environmental typology (such as inland or coastal waters), and/or disaggregated by Region (EMU) as well.

The management framework for DCF is the same that has been set up for the Eel Management Plan under Regulation 1100/2007. In the eleven Regions that preferred to delegate eel management to the central government (Directorate-General for Sea Fishing and Aquaculture of the Ministry of Agricultural, Food and Forestry Policy) where commercial eel fishing has been stopped completely since the year 2009, no data collection is carried out (Figure 2). In the remaining nine regions -EMUs, where eel fisheries are still ongoing, eel fishery data, both commercial and recreational, are collected with a standard methodology, as foreseen by the Italian National Plan for the Data Collection Framework (Figure 2).

The period 2010–2018 has been important in Italy as regards eel management. Following the submission of the Italian Eel Management Plan (IT-EMP), with the latest amendment submitted to the European Community September 30, 2010, the Plan was finally adopted in July 2011 (PNG Italia, 2010). With it, Italy has set the instrument to participate in the process recovery of the eel stock, as required by Regulation 1100/2007. Notwithstanding an initial delay, then, Italy has recovered the lag in the application of the Eel Management Plan because since 2009 at different levels in Italy the process of implementation of the IT-EMP was already in place. The work concerning the IT-EMP has been coordinated within a National Working Group that involved Administrations, Technicians and Scientists. During 2013 and 2014, the work of the National Working Group has been finalized to the gathering of data for the evaluation of the parameters required to assess progress achieved through the implementation of the National EMP. This was foreseen by Article 9 of Regulation 1100/2007, for the second report in 2015 (PNG Italia, 2015), following the first Report of 2012, to which Italy also complied with other Reports in 2013 and 2014 (PNG Italia, 2012, 2013, 2014). During the 2017 several working groups and technical tables, which have involved Administrations, Technicians, and Scientists, have been carrying out to finalize the data collection of the necessary information for the evaluation of the parameters required to draft the third report provided for 2018 as foreseen by Art. 9 of Regulation 1100/2007.

Italy, as extensively explained in the IT-EMP and as discussed during the consultation meetings organized by the EC - DG Mare, has followed the approach of using for the assessment process a database progressively implemented during the years. Compared to 2008, when the work for the compilation of the IT-EMP was initiated, a series of tools and activities have been put in place between 2009 and 2018 that have resulted in a database much more detailed and reliable.

The management framework described above has influenced the setting up of the Eel National Management Plan (IT-EMP) foreseen in Regulation 1100/2007. The IT-EMP has taken into account the complexity of the situation in the country, and is, therefore, a combined plan: it provides a national framework covering coastal waters and those administrative regions, which preferred to delegate eel management to the central government (eleven regions in all). For these eleven Regions, a total closure of all eel fishing has been applied, both commercial and recreational, and the transposition of this indication into Regional regulations is nearly completed. The remaining nine regions have drawn up their own Regional Eel Management Plans, which were prepared on a coordinated basis and using a standard calculation method for defining targets, whereas the intervention measures and implementation aspects were defined according to regional regulations and local choices. Italy has in fact decided to avail itself of the opportunity provided in Article 2 of the regulation, which stipulates that *'if appropriate justification is provided, a Member State may designate the whole of its national territory or an existing regional administrative unit as one eel river basin'* and, for the reasons highlighted above, therefore has proposed the regional administrations as Eel Management Units, point accepted by the Commission.



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

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

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

A distinctive feature of the IT-EMP, which reflects on management at the national level, concerns the reforming of the regulation for glass eel fishing. Up to 2008, professional glass eel fisheries were regulated by the Ministero delle Politiche Agricole Alimentari e Forestali by a national legislation (DM March 22, 1991; D.M August 7 1996) that did

not contain specific indications for the eel, *Anguilla anguilla*, because generally targeting juvenile fish of all euryhaline species caught for aquaculture purposes. Glass eel fisheries did occur in many river mouths, and in many channel mouths as well. Most of the glass eel yield was from the Central and Southern Tyrrhenian area (Western Mediterranean Sea). The main sites of glass eel catches were the estuaries of rivers such as the Arno and Ombrone in Toscana, the Tiber and the Garigliano in Lazio, and the Volturno and Sele in the Campania region. Occasionally fry fishers from other regions, who reached those sites with trucks equipped with oxygenated tanks to collect mullet, sea bass, sea bream and eel fry, frequented those sites usually used by local fishers. Local fishers were usually single or cooperative fishers that are were equipped with boats and structures to store the product alive. Fishing instruments vary depending on the characteristics of the site.

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

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

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

such as commercial and recreational fishing for eels. For the moment, only five regions (Piemonte, Valle d'Aosta, Liguria, Marche and Sicilia) have implemented such forbiddance with explicit rules, the other six regions are still providing.

In the last two years, the responsibility for the management framework of glass eel fishing/restocking, and all eel related measures have encountered a complication related to the fact that for due to a decree of the Government for a spending review, in most regions the number of provinces has been reduced. In most cases by the abolition of some provinces or by fusion of some. Therefore, competences for fisheries in many cases has fallen back to Regions. This has created some confusion, and a difficulty in managing operations and as a consequence getting data for the year 2017/2018.

2.2 Significant changes since last report

During this year, several coordination meetings have been held among MIPAAF (Ministero delle Politiche Agricole Alimentari e Forestali) and the representatives of Regions, technicians, and scientists. Purpose of the meetings was: updating the current state of the implemented measures provided for Regulation 1100/2007; setting up a coordination framework for the new EU MAP Regulation; carry out a shared quality-check of eel landings and fishing effort data of the last three years (2015, 2016, 2017), for the evaluation of the parameters required to assess progress achieved by Article 9 of Regulation 1100/2007; provide guidelines for the monitoring of all eel life stages in order to harmonize the survey methods as required by the new EUMAP Regulation.

These activities have ensured a greater coordination and agreement between the Ministry and the Regions, and therefore greater access to the data required for the eel scheduled assessment for 2018 (Art. 9 Reg. 1100/2007). Indeed, 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. Datasets have then been checked with Responsible Managers of the Fishery Offices (or other Responsible Units) from the Regions (Administrations of the EMUs) and from the Italian Ministero delle Politiche Alimentari e Forestali (MIPAAF), within a Panel coordinated by the Ministry. Results have been submitted and shared for acknowledgement with the same Managers, and agreed by all before preparing the Report and its Annexes.

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

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

3 Impacts on the stock

In the present report, data on eel stock and fisheries are reported for Italy relative to the year 2017, based on the data and assessments collected at the National level to assess progress achieved through the implementation of the National EMP, and based on the National Report relative to the Data Collection Framework 2017–2019, modules "Work Package 2 - Campionamento biologico - Task 2.3a Anguilla Work Package 3 – Pesca Ricreativa - Task 3.1 Anguilla", also relative to the year 2017.

Data have been aggregated for EMUs as request and for habitat typology (freshwater or transitional waters, for Italy). It is worthy of notice that within the DCF Program, the data are available for habitat type (river, lake, lagoon and managed lagoon) and for fishing gear. Such level of detail is usable at Technical National Report relative to the Data Collection Framework, modules “ Work Package 2 - Biological sampling - Task 2.3a *Anguilla*, Work Package 3 - Recreational Fishing - Task 3.1 *Anguilla*” DCF 2017–2019.

3.1 Fisheries

Total fishing capacity for eel in Italy have been difficult to assess. Theoretically, it would coincide with the whole amount of fishers licensed for fishing in inland waters (river and lakes) and coastal lagoons, both commercial and recreational, even if in the practice fishers really interested and involved in eel fishing are only a part of the whole universe of fishers. To these, all authorized glass eel fishers in coastal and inland waters must be added (see glass eel new legislation in Section 2.1.pp 8).

For the eel commercial fishing capacity relative to the nine MUs where eel fisheries are present, fishing being prohibited in the remaining eleven Regions where no EMP is in place, the best estimates are from census returns (the first carried out in 2007 and then a revision in 2011) of the total number of fishermen involved in eel fishing.

Overall, 1140 operators are involved in eel fishing, in the nine regions all typologies included. These fishers are licensed fishers as well as employees in the managed lagoons, and they do not target only eel, but other freshwater or euryhaline fish as well. In most cases, eel importance in catches is quite low. An assessment of eel importance among catches has been performed in 2010, on all the fishers operating in rivers lakes and lagoons, and it revealed that for about 77% of the fishers, eel represents at most 15% of total catch. For 23% of the fishers, eel is less than 1% of total catch.

For recreational fisheries, potential fishing capacity coincides with all licensed fishers in all of the national territory, all regions included (315 251 in number). The effective number of recreational anglers involved in eel fishing is obviously much lower. The estimate of the total amount of eel recreational anglers is obtained within the DCF programme, on the basis of the information provided by the two main recreational fishermen’s organizations (FIPSAS and ARCI Pesca) in Italy that account for most of inland waters recreational fisheries. The effective number of eel recreational fishers estimated for 2017 amounts to 3327.

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

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

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

The same methodology (interviews to a sample of fishers) is used to assess data for recreational anglers. Annual mean cpue for 2017 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”.

3.1.1 Glass eel fisheries

In Table 3.1.1 glass eel catches in kg for the season 2017/2018 are reported, as inferred by the fishers declarations, separated for coastal waters (estuaries, “T” code) under the Central Administration, and inland waters (rivers up of the tidal limit, “F” code), under regional administrations.

Table 3.1.1. Glass eel catches (eel <12 cm) - kg -, season 2017/2018.

YEAR	VALUE (KG)	EMUS (CODE DCF PROGRAM)	CODE (ICES DATA CALL)	GLASS EELS	HABITAT TYPOLOGY
2017	00.00	EMU_TOS	IT_Tosc	G	T
2017	00.00	EMU_TOS	IT_Tosc	G	F
2017	00.00	EMU_LAZ	IT_Lazi	G	T
2017	145.80	EMU_LAZ	IT_Lazi	G	F

The glass eel regulation foresees that glass eel fisheries can continue on a local scale, provided that 60% is used for restocking in national inland waters open to the sea, and provided that fishers compile specific and detailed logbooks of catches and sales. This system, together with reinforced controls by the Carabinieri Forestali Corp, 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. Up to 2010, the new regulation was not in force, its definite approval achieved in 2011, therefore no licences were issued in 2010 and there were no catches, nor information on quantities used for restocking. From 2011, the new regulation being in force, fishing has started again and catches are declared to the Ministry on a weekly basis.

With regard to the destination of glass eel catches and to the proportion retained for restocking, on the basis of the forms returned to administrations, it has been possible to document the destination of glass eel only in a generic way. Glass eel destination from national fisheries seems documented, while import data apparently escape registration. In some EMUs, there are still quantities whose origin and destination are only generically declared. The unavailability or scarcity of glass eels on the domestic market has resulted in the fact that some Regions used eels of size greater than 12 cm (10–30 g), and in some cases (EMU Friuli Venezia Giulia) also of larger size (40 g) to make restocking in public waters, as foreseen by the Regional Management Plans. The source of this restocking seed is aquaculture or imported (France). This highlights the need to pay attention to health and quality when dealing with restocking of eel of size exceeding 12 cm.

Only for some sites in some regions (Toscana, Lazio), it is possible to document where exactly restocking were performed, as most provinces and regions have not provided documentation that allows to document exact destination. Probably, in some regions in the northeast, part of the captures were released in lagoons and other basins, or in

valli, where fishery has ceased, to allow silvering growth for release, while a share has been possibly been designated to aquaculture facilities.

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

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

3.1.2 Yellow eel fisheries

Annual catches of yellow eel for commercial and recreational fisheries for the year 2017 accounted for 90 870 kg, as evaluated under the DCF programme. Data are reported by EMU (nine regions, in the remaining eleven, catch is zero) in Tables 3.1.2.1–3.1.2.2.

Table 3.1.2.1. Yellow eel commercial catches for 2017.

Year	Value (kg)	EMUs (DCF Program)	Code (ICES Data Call)	Yellow eels	Habitat typology
2017	480.00	EMU_EMR	IT_Emil	Y	F
2017	75.00	EMU_FVR	IT_Frio	Y	F
2017	4760.00	EMU_LAZ	IT_Lazi	Y	F
2017	59.55	EMU_LOM	IT_Lomb	Y	F
2017	1105.00	EMU_SAR	IT_Sard	Y	F
2017	13778.40	EMU_TOS	IT_Tosc	Y	F
2017	1050.00	EMU_UMB	IT_Umbr	Y	F
2017	4350.00	EMU_VEN	IT_Vene	Y	F
2017	8192.81	EMU_EMR	IT_Emil	Y	T
2017	2520.00	EMU_FVG	IT_Frio	Y	T
2017	2662.00	EMU_LAZ	IT_Lazi	Y	T
2017	5378.07	EMU_PUG	IT_Pugl	Y	T
2017	8744.18	EMU_SAR	IT_Sard	Y	T
2017	10980.00	EMU_VEN	IT_Vene	Y	T
Total	64 135.01				

Table 3.1.2.2. Yellow eel recreational catches for 2017.

Year	Value (kg)	Code (ICES Data Call)	Yellow eels	Habitat typology
2017	24.00	IT_Cala	Y	F
2017	5638.00	IT_Emil	Y	F
2017	5340.00	IT_Lazi	Y	F
2017	4710.00	IT_Lomb	Y	F
2017	22.00	IT_Piem	Y	F
2017	38.00	IT_Sici	Y	F
2017	2998.00	IT_Tosc	Y	F
2017	2003.00	IT_Umbr	Y	F
2017	5962.00	IT_Vene	Y	F
Total	26 735.00			

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

3.1.3 Silver eel fisheries

Annual catches of silver eel for commercial and recreational fisheries in the year 2017 accounted for 114 725 kg, as evaluated under the DCF programme. Data are reported by EMU (nine regions, in the remaining eleven, catch is zero) in Tables 3.1.3.1–3.1.3.2.

Table 3.1.3.1. Silver eel commercial catches for 2016.

Year	Value (kg)	EMUs (DCF Program)	Code (ICES Data Call)	Silver eels	Habitat typology
2017	12.00	EMU_EMR	IT_Emil	S	F
2017	125.00	EMU_FVR	IT_Frio	S	F
2017	4910.00	EMU_LAZ	IT_Lazi	S	F
2017	337.45	EMU_LOM	IT_Lomb	S	F
2017	3607.50	EMU_SAR	IT_Sard	S	F
2017	2543.33	EMU_UMB	IT_Umbr	S	F
2017	3185.00	EMU_VEN	IT_Vene	S	F
2017	9694.47	EMU_EMR	IT_Emil	S	T
2017	1075.00	EMU_FVR	IT_Frio	S	T
2017	880.00	EMU_LAZ	IT_Lazi	S	T
2017	5428.10	EMU_PUG	IT_Pugl	S	T
2017	42193.45	EMU_SAR	IT_Sard	S	T
2017	22938.40	EMU_TOS	IT_Tosc	S	T
2017	3270.00	EMU_VEN	IT_Vene	S	T
Total	100 199.70				

Table 3.1.3.2. Silver eel recreational catches for 2016.

Year	Value (kg)	Code (ICES Data Call)	Silver eels	Habitat typology
2017	8036.00	IT_Emil	S	F
2017	150.00	IT_Frio	S	F
2017	1578.00	IT_Lazi	S	F
2017	990.00	IT_Camp	S	F
2017	3.00	IT_Lomb	S	F
2017	1501.00	IT_Tosc	S	F
2017	2267.00	IT_Vene	S	F
Total	14 525.00			

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

3.2 Restocking

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

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

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

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

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

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

3.3 Aquaculture

Data are not available for 2017 yet. Table 3.3.1 shows total aquaculture production in Italy since 2009. Information requested in this section is collected under the DCF (Task "Aquaculture") and used for SIPAM databases and for EuroStat (Regulations 788/96 and 762/2008 on the submission by Member States of Statistics on Aquaculture production).

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

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

3.4 Entrainment

Anthropogenic and environmental impacts are taken into account in the Italian stock assessment only for EMUs where stocking practices have been carried out in rivers over dams. The model used allows to consider anthropogenic mortalities, expressed in terms of silver eels survival during the downstream migration, by considering the number of dams with hydroelectric turbines and their correspondent probability of survival to each plant ($\varsigma = 0,682$; ICES, 2011). Further information are available in “Italian progress report under Art.9 of Regulation (CE) n°1100/2007–2018”, Rapporto Italiano Del Piano Nazionale Di Gestione (Png) dell’Anguilla europea Art.9 Reg. (Ce) N° 1100/2007 Anno 2018.

3.5 Habitat quantity and quality

No available data.

3.6 Others

No available data.

4 National stock assessment

4.1 Description of method

As illustrated above, Italy has a mixed Eel Management Plan that includes a National EMP and nine Regional EMPs. The former deals only with coastal waters, and hence only with glass eel fisheries, while the RMPs deal with inland waters of the nine regions

where eel stock is exploited. The stock assessment for eel was, however, carried out for all the 20 Italian Regions, i.e. including also the other eleven regions where no recovery plans for the eel were foreseen.

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

Biomass and mortalities are estimated using a deterministic model based on most recent scientific knowledge of 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.* (2006a) 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 ($\zeta=0,682$; ICES, 2011).

On the basis of the escapement pristine data, B_0 , (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 it simulates the system dynamics in potential conditions (i.e. absence of anthropogenic pressures: fishery, hydropower, restocking; and in pristine wetted area) to obtain an annual estimate of the potential silver eel biomass (B_{best}), and with all anthropogenic pressures to obtain the annual estimate of current silver eel biomass (B_{curr}).

Lifetime mortalities values (i.e. glass eel fishery; habitat loss; restocking; yellow and silver eel fishery; hydropower) are calculated by comparing abundances of silver eel escapement obtained with different anthropogenic pressures scenarios for each year simulated. We assessed several scenarios from potential condition to current ones (i.e. all anthropogenic pressures turned on and current wetted area) by using the following formula: $-\ln(N1/N0)$; where $N1$ and $N0$ are the abundances in two different conditions. Lifetime natural mortality is obtained as $-\ln(\text{Settlement best/potential escapement})$, both in abundances.

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

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

In 2017, a total of 516 individuals (yellow and silver eel) were sampled in order to assess stage composition (reconfirm yellow or silver stage), length and weight. Samplings were carried out by taking a random batch of eels from a single fisher cumulated catch of the day or of the week. Sample processing foresees different procedures depending on data to be obtained from the samples. Usually, length and weight are measured directly on anaesthetized eel, and digital pictures for subsequent specific morphometric measurements are obtained. For 2017, samples were released because no other observations were due.

Table 4.4.1. Silver eel and yellow eel biological samplings carried out in each EMU for DCF 2018, year 2017.

SILVER EEL				Length (cm)			Weight (g)		
EMU	Habitat	Site	N	mean \pm s.d.	min	max	mean \pm s.d.	min	max
FVG	LGN	Grado Marano	30	68.91 \pm 6.35	56.53	80.63	637.55 \pm 196.39	334.60	1099.63
LOM	LAK	Iseo	6	41.29 \pm 3.86	37.87	48.87	149.93 \pm 41.45	122.13	233.3
VEN	RIV	Sile	30	66.59 \pm 11.87	49.02	89.02	613.32 \pm 334.81	244.6	1212.7
TOS	MLG	Orbetello	30	42.96 \pm 6.07	33.53	56.03	152.37 \pm 67.14	72.36	318.03
EMR	MLG	Comacchio	30	82.85 \pm 8.21	50.04	94.98	1285.76 \pm 322.23	246.96	1975.03
UMB	LAK	Trasimeno	30	53.85 \pm 11.91	35.02	76.96	349.49 \pm 221.71	86.53	734.88
LAZ	LAK	Bolsena	30	53.05 \pm 15.42	34.54	80.04	358.17 \pm 328.13	67.11	1088.89
PUG	LGN	Lesina	30	51.62 \pm 14.40	31.04	79.04	315.48 \pm 256.00	60.97	860.02
SAR	MLG	Cabras	30	47.11 \pm 13.91	32.97	83.97	248.77 \pm 274.30	60.16	1105.54
"YELLOW EEL"				Length (cm)			Weight (g)		
EMU	LGN	Site	N	media \pm d.s.	min	max	media \pm d.s.	min	max
FVG	LAK	Grado Marano	30	55.74 \pm 6.62	46.5	67.5	312.05 \pm 116.87	152.06	529.26
LOM	RIV	Iseo	30	46.783 \pm 5.55	38.04	59.87	182.58 \pm 59.15	99.78	329
VEN	MLG	Sile	30	31.88 \pm 7.54	21.35	51.85	56.24 \pm 50.00	9.97	261.77
TOS	MLG	Orbetello	30	40.855 \pm 4.15	32.03	48.48	114.91 \pm 39.09	41.98	212.35
EMR	LAK	Comacchio	30	43.37 \pm 15.40	18.98	89.98	220.49 \pm 257.86	16.69	1320.03
UMB	LAK	Trasimeno	30	45.21 \pm 9.93	31.46	64.96	188.47 \pm 140.13	55.03	562.98
LAZ	LGN	Bolsena	30	40.69 \pm 8.38	24.49	62.99	139.03 \pm 102.22	19.62	436.88
PUG	MLG	Lesina	30	43.49 \pm 9.39	20.04	63.04	166.32 \pm 117.03	17.27	435.07
SAR		Cabras	30	36.61 \pm 9.44	22.97	59.47	100.78 \pm 96.46	20.28	383.89

4.1.2 Analysis

For 2017, no analysis of age and sex determination have been performed because not requested within DCF. Anyway, procedure and methods usually used for the evaluation are described below.

Age determination

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

Life stages

Maturation stage is determined by combining gonad development assessment, Pankhurst's (1982) ocular index (OI), which reflects changes in eye diameter during metamorphosis to the silver stage (Acou *et al.*, 2009) and Durif's silvering index (Durif *et al.*, 2005).

Sex determination

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

4.1.3 Reporting

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

Data 2017 has been used for the drafting of the "Progress Report under Regulation (EC) 1100/2007" Reference year 2017 June 8" to the DG MARE. Data are also provided for the additional information required in the Note Ref. Ares (2018) 1830726 -05/04/2018, in line with Article 11 of Regulation 1100/2007, as a separate ANNEX.

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

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

4.1.4 Data quality issues and how they are being addressed

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

The whole set of data used for the assessment for single EMUs has been prepared and checked by scientists, based on the whole and best available information from all possible sources. Results have been submitted and shared for acknowledgement with the Responsible Managers of the Fishery Offices (or other Responsible Units) from the Regions (Administrations of the EMUs) and from the Italian Ministero delle Politiche Alimentari e Forestali (MIPAAF) and agreed by all before preparing Reports and annexed tables.

Therefore, the approach proved to be valid, because the database is significantly expanded and improved, both from a qualitative and quantitative point of view. Consequently, the estimates obtained can be considered highly reliable.

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

4.2 Assessment results

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

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

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

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

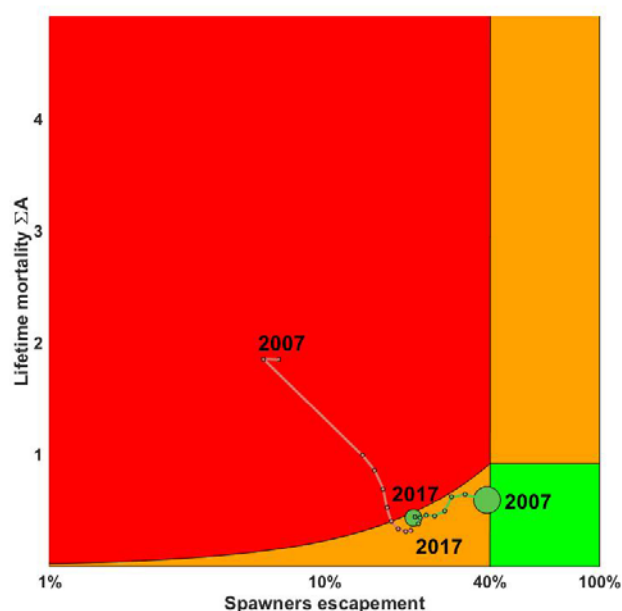


Figure 4.1. Precautionary diagram of potential spawner escapement trends of both EMUs (green) and regions without EMP (red) from 2007 to 2017.

5 Other data collection

5.1 Recruitment time-series

The Data Collection Framework for Eel, as foreseen by the Regulation 199/2008, has replaced the previous statistical system (ISTAT) in place up to 2004 for the marine compartment and to 2008 for inland fisheries. In this report, time-series for eel catches are presented only when available, joining data derived by the old official statistical system (ISTAT) and the new data from the Eel Fisheries Data Collection (under Reg. 199/2008). The data from the ISTAT system present some gaps such as uncertain estimates, possible overlaps with aquaculture production, no distinction between stages, no information on the fishing effort. Nevertheless, these time-series currently represent the only official source for eel for the period prior to 2009.

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

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

On the other hand, since 2011 in some regions recruitment monitoring have been progressively activated on a local basis (EMU Toscana, EMU Lazio, EMU Puglia) by the Regional Administrations, each following a specific methodology but based on a common approach. Most of these monitoring are active within specific programmes for Eel

Regional Plans implementation supported by the European Fisheries Funds as well as by funding at the local level (regional).

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

Table 5.1. Available time-series and/or monitoring of glass eel recruitment in Italy, and monitoring that have been activated within the Regional Eel Management Plans or other Eel specific projects.

EMU	Habitat	SITE	SAMPLING TYPE	UNIT	Time-scale	min	max
LAZ	F	Tevere	com. catch	kg	year	1974	2001
LAZ	F	Tevere	com. catch+sci. monit.	kg	daily	1990	2006
LAZ	F	Tevere	weekly monit.	Number	1 week/month	2013	2017?
LAZ	F	Marta	com. catch+sci. monit.	kg	daily	1999	2008
LAZ	F	Marta	weekly monit.	Number	1 week/month	2013	2017?
LAZ	T	Fogliano	weekly monit.	Number	1 week/month	2013	2017?
LAZ	T	Caprolace	weekly monit.	Number	1 week/month	2014	2017?
LAZ	T	Lungo_San Puoto	weekly monit.	Number	1 week/month	2014	2017?
LAZ	F	Garigliano	com. catch	kg	daily	1999	2002
PUG	T	Lesina	sci. monit.	Number	daily	2013	2017?
PUG	T	Varano	sci. monit.	Number	daily	2013	2017?
PUG	T	Torre Guaceto	sci. monit.	Number	daily	2014	2017?
PUG	F	Fiume Morelli	sci. monit.	Number	daily	2014	2017?

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

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

5.2 Yellow eel abundance surveys

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

The collection of these additional variables is aimed at gathering information related to descriptors such as: abundance of recruits; abundance of biomass (yellow eel), number or weight of silver eels. In relation to this need, in the three-year period 2017–2019 a pilot study has been planned for the development of the methodology of monitoring to be implemented in different aquatic systems: rivers and lagoons, characteristic respectively of the Tyrrhenian and Adriatic area. Aim of the first year of the pilot study

(2017), was to test monitoring protocols for all eel life stages, in order to extend standardized monitoring protocols in the different habitats considered, useful for providing comparable indicators in the long term and assess the effectiveness of stock recovery measures on European scale.

5.3 Silver eel escapement surveys

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

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

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

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

5.4 Biological parameters

See above chapter 4.4.1.

5.5 Parasites and pathogens

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

5.6 Contaminants

No relevant data here, because new data are not available and no routine monitoring has been implemented on a centralised basis.

Scattered information is available, because some lake fisheries have been closed since 2012. These concerned also eel (such as the Lago di Garda, Lombardia), in relation to fish contamination by dioxin or other contaminants. Contaminant data are not available here, even if carried out by local Health Agencies because neither centralised nor regional implementation carried out on purpose for eel.

At the moment, there is an ongoing research project between CREA (Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria) and Tor Vergata University. The project foresees the study of eel quality by means of analysis of contaminants, in two coastal lagoons. Results will be available next year.

5.7 Predators

No relevant data here, because new data are not available and no routine monitoring has been implemented on a centralised basis.

However, ichthyophagous birds have a strong impact in the area of the lagoon of Venice and in all the North Adriatic area, mainly in relation to fish predation in the valli, and represent one of the main causes of product loss (Ciccotti, 2014; Cataudella *et al.*, 2014).

Predation by ichthyophagous birds represents the main factor limiting fish productions in Italian coastal lagoons or in the North Adriatic extensive aquaculture situations (valli). The specific impact on eel cannot be quantified; it depends on a number of factors that vary among lagoons. On the other hand, the presence of other waterbirds represents a main attraction in these same sites, in relation to the different usages of lagoons (tourism, conservation, hunting).

Another predator of eel found in some rivers and estuaries, and that has enormously prevailed recently, is *Silurus glanis*. Its presence is ascertained in the Tiber River (Lazio) and in the river Po lower course (Emilia Romagna), as well as in many other rivers in Italy, but its impact on eel local stocks cannot currently be quantified.

6 New information

None.

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

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.

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Reporting Period: This report was completed in September 2018, and contains data up to 2017 and some provisional data for 2018.

1 Stock status summary

There are no data to provide good and reliable stock indicators for eel in Latvia. Eel fisheries in coastal waters of Latvia fell down to value less than 0.1 t per year. Only the part of freshwaters are accessible for eel, monitoring results are demonstrating low or no natural recruitment of eel. Eel fisheries in inland waters of Latvia depend from eel restocking carried out since 1990, i.e. in previous USSR times. In the frame of eel recovery since 2011 glass eel restocking is carried out again in waterbodies without man-made obstacles.

The total amount of waters in Latvia, where eel have been found historically in pristine or nearly pristine conditions, is unknown. According to rough estimates it could be 114 thousand ha and historic silver eel biomass (B_0) accordingly about 2 596 00 kg.

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

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

An average landing of eel in Latvia's coastal waters were 0.12 kg/ha before year 1980 and only 0.01 at present. The highest landing (0,7 kg/ha) was observed in 1938.

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

According to rough estimates currently 27.9% of silver eel biomass escapes from Latvian waters.

No data on mortality rates.

Rough estimates from fisheries data of silver eel biomass.

Habitat	Area (ha)	B_0	B_{CURR}	B_{BEST}	$B_{CURR}/B_0(\%)$
Rivers	8718	26000	1000	4000	25
Lakes	15507	54000	1500	6000	25
Coastal ¹	89800	179600	898	2160	42
Total	114025	259600	3398	12160	28

¹One nautical mile along the shoreline.

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

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

Basic principles of fisheries regulation are:

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

There are several main management actions provided to increase the silver eel escape-ment in Latvia:

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

All together more than 3.7 million glass eel were restocked in 2011, 2012, 2014 and 2017 in the rivers and lakes of Latvia. In 2018 restocking of glass eel was continued (715 400 glass eel restocked).

- mitigation of fisheries impact;

This management measure was not planned for EMP in the period for 2009–2013. Due to low and negligible impact on eel stock, fisheries were severely decreased and regulated by other reasons (not eel problems) in early 2000s. However, looking forward, after realisation of planned restocking of glass eel some technical regulation measures enforced, increased size limit from 40 to 50 cm, decreasing of bag limit for anglers from 5 to 3 individuals per angling occasion (bag limit). Recreational fishermen equates to anglers for catching eel.

Some research activities related to eel management carried out:

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

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

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

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

- monitoring effectiveness of glass eel restocking;

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

- study of eel quality;

Study results are published in:

Rudovica V., Bartkevics V. 2015. Chemical elements in the muscle tissues of European eel (*Anguilla anguilla*) from selected lakes in Latvia. Environ. Monit. Assess. 187: 608. DOI 10.1007/s10661-015-4832-8.

Zacs D., Rjabova J., Fernandes A., Bartkevics V. 2016. Brominated, chlorinated and mixed brominated/chlorinated persistent organic pollutants in European eels (*Anguilla anguilla*) 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 waterbodies 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

None.

3 Impacts on the stock

3.1 Fisheries

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

Effort and eel bycatch in coastal fisheries.

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

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

There are only three lakes in Latvian EMU waters where eel occur in catches. In one of these, Lake Liepājas (overall eel catch ~50 kg per year), it is planned to ban eel fishing starting from 2019. More substantial eel fishing is going on in inland lakes inaccessible for eel migration, restocked by glass eel in 1980–1990.

Eel catches in lakes of Latvia.

	2012	2013	2014	2015	2016	2017
Catches in Latvian EMU lakes (kg)	287	381	315	320	270	403
Catches in eel growing lakes outside EMU (kg)	5581	4037	3890	4766	3749	7646

3.1.1 Glass eel fisheries

There is no glass eel fisheries in Latvia.

3.1.2 Yellow eel fisheries

All eel fisheries carried out in EMU waters are mixed type, there are no specialized fisheries targeting on of life stages of eel.

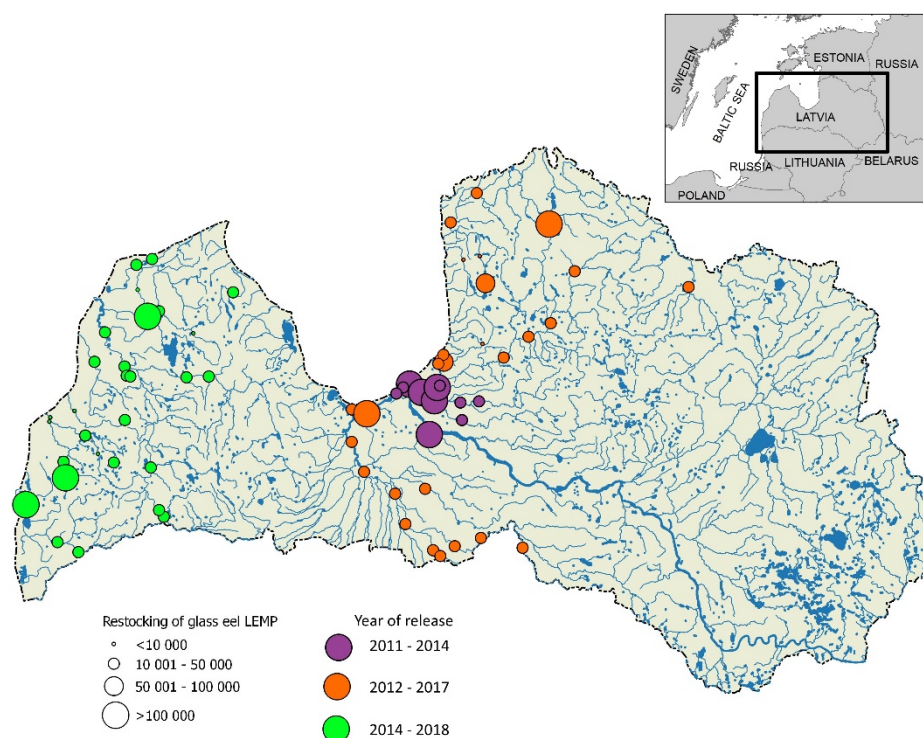
3.1.3 Silver eel fisheries

No specialized silver eel fisheries in the waterbodies of EMU, catches are mixed. In coastal waters catches are less than 0.2 t per year.

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 most part of these are caught in eel growing lakes outside EMU where they have been restocked in Soviet times. New survey of anglers is started in 2018 and estimates for the latest years will be available in 2019–2020.

Historical data on self-sustainable fishery (without rights to sell the fish) in coastal waters is available. The landing of eels on an effort unit in these fisheries is very small. At the present landings has dropped to 9 kg per year were eels were caught as bycatch.

3.2 Restocking



Restocking of glass eel in frame of EMP_Latvia.

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

Year	Lakes	Rivers	Total
2009	0	0	0
2010	0	0	0
2011	303 800	0	303 800
2012	740 300	289 700	1 030 000
2013	0	0	0
2014	805 000	581 200	1 386 200
2015	0	0	0
2016	0	0	0
2017	740 300	289 700	1 030 000
Total	2 589 400	1 160 600	3 750 000

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

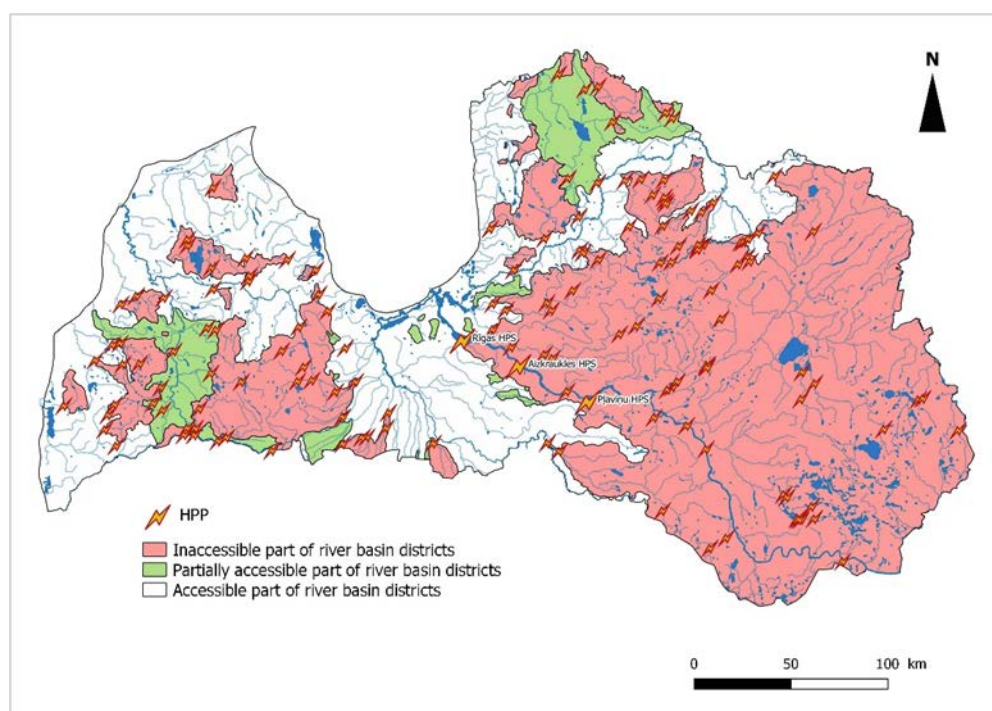
3.3 Aquaculture

20 000 glass eel in 2017 were given to institute BIOR fish farm “Tome” to ongrow them for release in the Ķekaviņa River and Lake Riebezera with no man-made obstacles. Same amount was taken for ongrowing this year.

3.4 Entrainment

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

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



Distribution of hydropower plants in the rivers of Latvia.

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

3.5 Habitat quantity and quality

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 in river lamprey fishery;
- at least moderate water quality;
- no fish winterkills.

Accessible inland and coastal water habitats for eel.

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

Significant changes in habitat area and quality since EMP Implementation in 2009 did not take place.

3.6 Others

No available data.

4 National stock assessment

4.1 Description of method

4.1.1 Data collection

The collection of biological data of eel in Latvia is rather complicated as the catch volumes are very small. In the fishery, eels are not sorted 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 assessed using the results of biological analyses. 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 catches. Data from biological analyses in Lake Ķīšezers and the Gulf of Riga until 2011 indicate that all analysed eel were silver eel females at various silvering stages according to Durif *et al.* (2009).

Sampling of eels from commercial fishery is carried out by sampling of all caught 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, *Anguillicolla crassus* presence/absence in swimming bladder registered. Otoliths are collected for age reading that was started in 2017.

4.1.2 Analysis

Not analysed.

4.1.3 Reporting

Reported in annual country reports.

4.1.4 Data quality issues and how they are being addressed

4.2 Assessment results

No available data.

5 Other data collection

5.1 Recruitment time-series

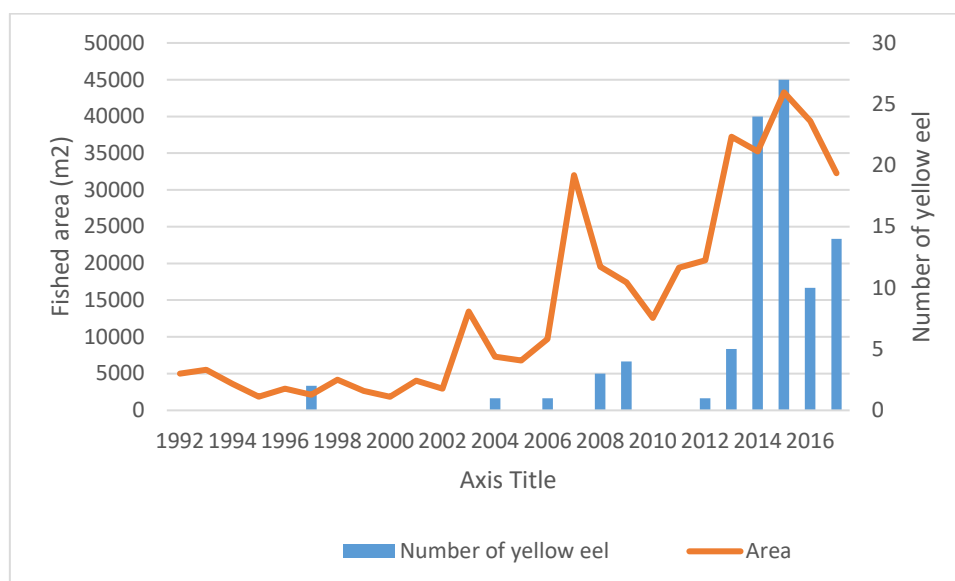
Latvia does not have historical data and no regular surveys on eel recruitment trends. Some research has been done on otolith microchemistry (Sr:Ca ratios) to discriminate restocked and naturally recruited European eels in Latvia. To evaluate the efficiency of the eel restocking program and reveal the migratory life histories of European eels in Latvian waters, a total of 75 individuals was 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 salt water and did not enter freshwater (SW, 0–7%) and eels that experienced both freshwater and salt water, referred to as inter-habitat-shifter (IHS, 60–85%). Restocked eels consisted of purely freshwater types (FW, 7–36.7%) without any exposure to salt water. 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 future as eel restocking increases.

5.2 Yellow eel abundance surveys

Yellow eel abundance in the rivers surveyed by electrofishing. Data on species, abundance and size/weight collected from 1992. Lakes restocked by glass eel also surveyed every year in the same transects.

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



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

Number of yellow eel in electrofishing.

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

5.3 Silver eel escapement surveys

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

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

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

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

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

5.4 Biological parameters

During year 2017, 147 eels were collected from commercial fisheries and monitoring in Latvia's EMU waterbodies. Length, weight, eye diameter, pectoral fin length, colour of the sides and sex data collected. Swimbladders examined for *Anguillicola* presence. Otoliths stored in collection and age reading started.

5.5 Parasites and pathogens

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

***Anguillicola crassus* in eel samples, LV_Latv coastal waters.**

Waterbody	Year	Life stage	Number of eel sampled	Eel with <i>Anguillicola</i>	
				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
Gulf of the Riga	2017	S/Y	43	5	11.6

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

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

5.6 Contaminants

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

5.7 Predators

Historical trends are available only on predator abundance. Northern pike *Esox lucius* (684 individuals) were collected with electrofishing from 2014 to 2017 to get stomach contents samples. No eel was found in the stomach samples of pikes, including the places where these two species coexist. This study is continued (Ivanovs, 2016).

Populations of cormorant and grey heron have tendency to increase in Latvia and according to the latest estimates there are up to 1500 pairs of breeding grey heron and 1000–2000 pairs of cormorant in Latvia. The results of the studies, carries out in Latvia, on the potential effects of cormorants on eel suggest that this is not relevant at present. Results from cormorant colonies indicated that the eel represents only 0.6% of the total fish found in the diet.

In Latvia, there are 210 to 230 breeding pairs of Osprey *Pandion haliaetus*. Studies showed that these birds are more depending on fish ponds. Eel represents only 0.2% in osprey diet (Kalvāns, Bajinskis, 2016).

There are no studies made on seal impact on eel stock in Latvia.

In research made on other diet composition in Latvia, 34 fish species where registered but eel was not found. Most important species where bearded stone loach *Barbatula barbatula* and bullhead *Cottus gobio* (Birzaks *et al.*, 1998).

Taking into account insignificant effect, no measures have been taken regarding to the control of predators.

It is probably that the small proportion of eel in predator diet was due to the low density of eel population in Latvian inland waters. Currently, the situation is changing, their relative abundance has increased as a result of restocking. Therefore, it is possible that, as the eel number increases in rivers and lakes, the impact of predatory species on eel stocks in Latvia will also increase. In future important predators could be cormorants as their number is constantly growing. Further research is needed.

6 New information

None.

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

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.

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1 Stock status summary

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

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

EMU_code	Assessed Area (ha)	B ₀ (kg)	B _{curr} (kg)	B _{best} (kg)	B _{curr} /B ₀ (%)	ΣF	ΣH	ΣA
LT_Lith	116 854	87 000	0	8581	0	>100%	5,1%	>100%

Key:

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

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

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).

ΣF=mortality due to fishing, summed over the age groups in the stock (%).

ΣH=anthropogenic mortality excluding the fishery, summed over the age groups in the stock (%).

ΣA=all anthropogenic mortality summed over the age groups in the stock (%).

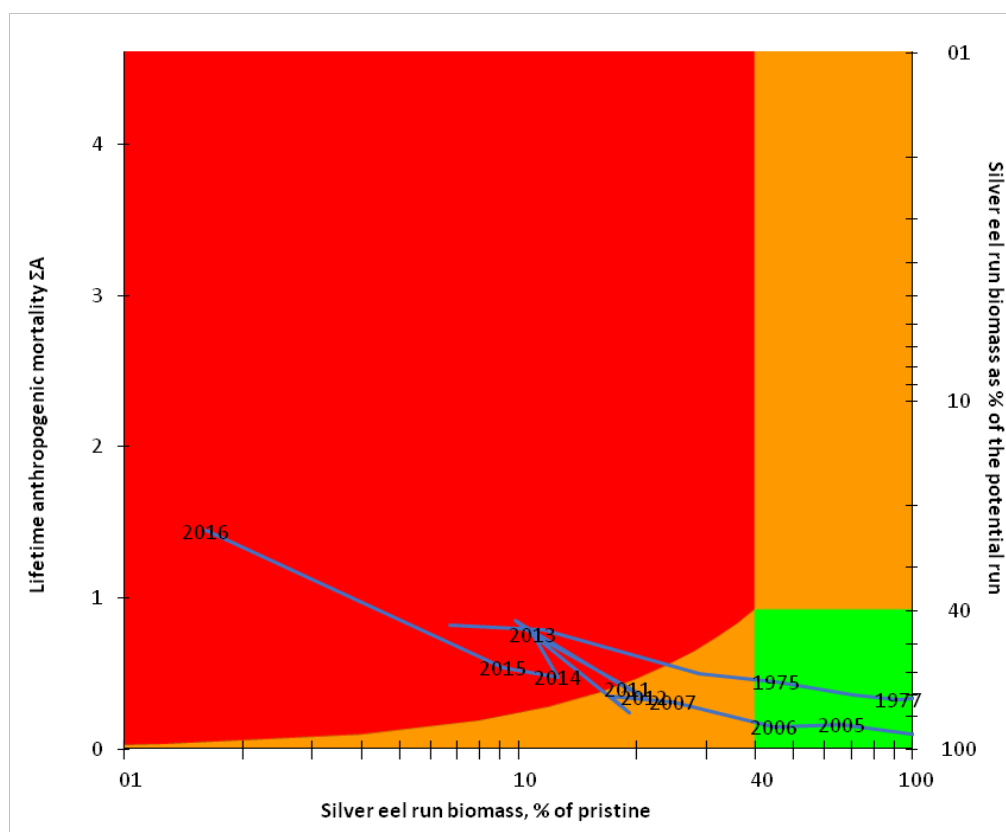


Figure 1.1. Precautionary Diagram for the Lithuanian eel stock in inland waters.

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

2.1.1 Eel stock in Lithuania

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

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

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

First stockings in Lithuanian inland waters were performed during 1928–1939 in Vilnius region (currently part of stocked lakes belongs to Belarus; Schiao *et al.*, 2006). Stocking of inland lakes resulted in later rise of specialized eel fishery in continental part of Lithuania. Commercial catches until the beginning of sixties were registered almost in waterbodies of Vilnius region where eels were stocked during 1928–1939, while in the rest part of the country specialized 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 all territory of Lithuania. It is evident, that inland stock and its abundance directly depends on stocking; natural eel stock in the Curonian lagoon and coastal waters of the Baltic Sea are in steep decline due to overall decline of the stock in all range of the species distribution.

2.1.2 EMU and EMP

ICES estimated eel stock to be outside safe biological limits and continuously (1999–2006) 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. EC announced in 2005 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 was done in 2007 ((EC) No 1100/2007). The Regulation obligates Member States to define the current state of their stocks, identify measures necessary for the recovery of stocks, implement these measures and assess the effectiveness of these actions.

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

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

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

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

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

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

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

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

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

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

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

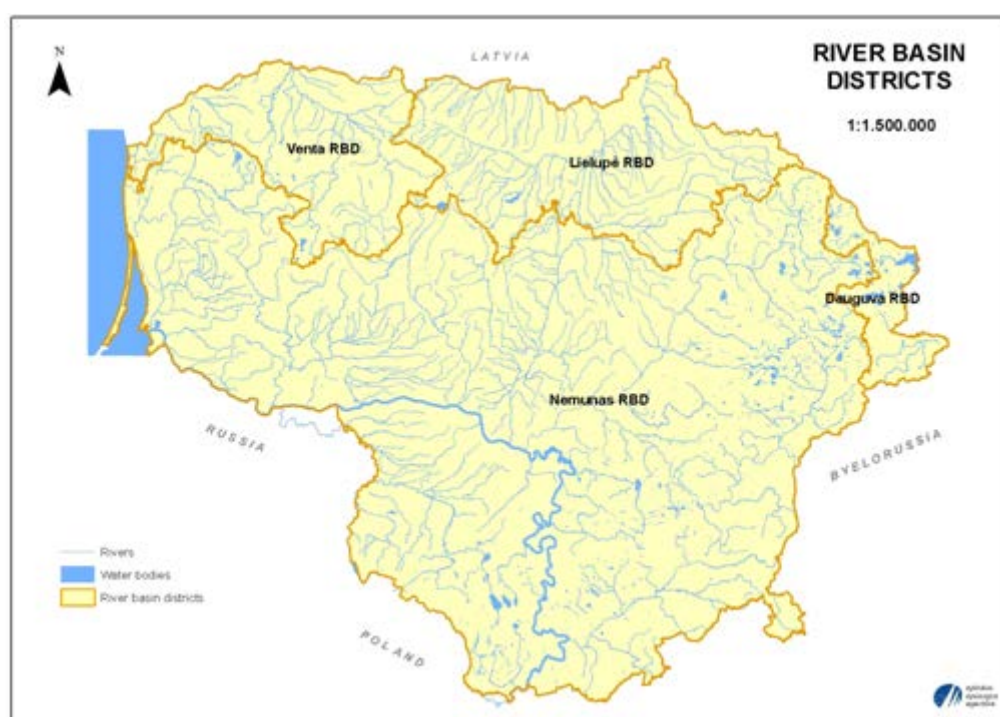


Figure 2.1. Lithuanian River Basin Districts.

2.1.3 Management authorities

Management authorities in the fisheries sector in Lithuania are:

The Ministry of Agriculture: makes and implements Lithuanian fisheries policy, conducts management of the fisheries sector, implements the fisheries policy according to the European Union regulations, implements measures related to conservation of fish stocks and controls fishery in maritime waters. The Ministry regulates commercial fishery and issues licences for fishing in maritime waters; owns, manages and uses a data system of fisheries in maritime waters (catches, fishery companies, economic and biological data, etc.).

The Ministry of Environment: Is responsible for fish stock conservation and control policy, conducts management of the fisheries sector in inland waterbodies. The Ministry regulates commercial and recreational fisheries in inland waterbodies and issues

licences (except for private fish ponds); manages and uses a data system of fisheries in inland waterbodies (catches, fishery companies, etc.).

The Ministry of Environment is responsible for the exploitation of fish stocks in inland waterbodies, including the Curonian Lagoon. The Ministry of Agriculture is responsible for the implementation of the fisheries policy in the context of European Union regulations.

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, including the eel, and their habitats and migratory routes are established and their implementation is area of responsibility of the Ministry of Environment, while the activities related to improving the conditions of aquaculture, spawning and migration of protected fish species is area of responsibility of the Ministry of Agriculture. Fish stocking programmes to public waterbodies (including eel stocking) are approved by the Ministry of Agriculture and coordinated with the Ministry of Environment.

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; the fishery is restricted to two month per year, eel fishery in lakes is banned. In the Curonian lagoon number of fishing gears (fykenets) is reduced (eels are caught as minor bycatch). All companies operating in commercial fishery must have licences and fill in logbooks daily. Daily bag limit in recreational fishery is reduced. In the Baltic Sea fishery is not allowed to target eel, i.e. practically it is banned (see additional details related to fishery restrictions in chapter 2.1.5).

2.1.5 Management actions

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

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

In 2015, in Lithuanian inland waters commercial fishery was banned by Ministry of Environment, however, fishery for migrating eels, lake smelt, vendace and river lamprey is still allowed. However, specialized fishery for eels using fykenets and longlines

is actually banned and only fishery for migrating eels in rivers allowed from 1 of April until 1st of June.

Number of Lagoon fykenets 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 very hard to estimate illegal fishery for migrating eels in rivers, however, despite very high fines (290 euro per fish) it is still might take place and it might make some impact on the stock.

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

After EMP was approved by EC first stockings were performed in 2011 and until 2016 154 waterbodies (mostly lakes) were stocked with almost 3 million of young eels, i. e. 0.6 million annually on average during the period from 2011 to 2018. Due to unsuccessful public tender in 2017 stocking was not done, however, in 2018 1.5 million of glass eels it is purchased and will be stocked. According to the national EMP, eels in Lithuania should not be stocked to basins upstream hydropower.

2.2 Significant changes since last report

For the first time after the beginning of the implementation of the national EMP scientific-based assessment of eel stock and human impacts is done in Lithuania.

3 Impacts on the stock

3.1 Fisheries

3.1.1 Glass eel fisheries

There is no fishery for glass eels in Lithuania.

3.1.2 Yellow eel fisheries

According to eel fishery statistics during last two decades (1997–2017), eel landings marginally increased in the inland waters (most eels fished are silver eels, ca. $\frac{1}{4}$ yellow; Dainys, 2017) but at the same time, it was steep decline in the Curonian Lagoon. In the Curonian lagoon most eels fished 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 (Figure 3.1). In 2017 the landings were above two tonnes in the Lagoon. It is likely this increase was caused by rainy year and high water in rivers (comparing to the few recent years) and relatively larger number of eel migrated downstream from lakes to the Curonian Lagoon. 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 already (Figure 3.3), while fishery landings in the inland waters (stocked eels) seem to be more stable (Figure 3.2).

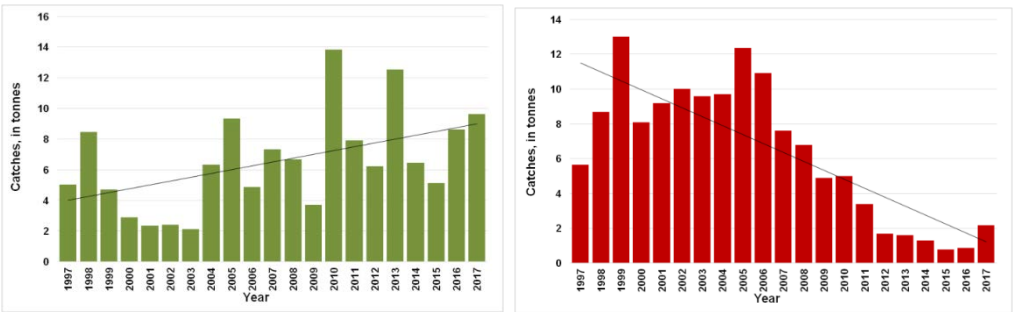


Figure 3.1. Eel catches in commercial fishery in the inland waterbodies (green colour) and the Curonian Lagoon (red colour).

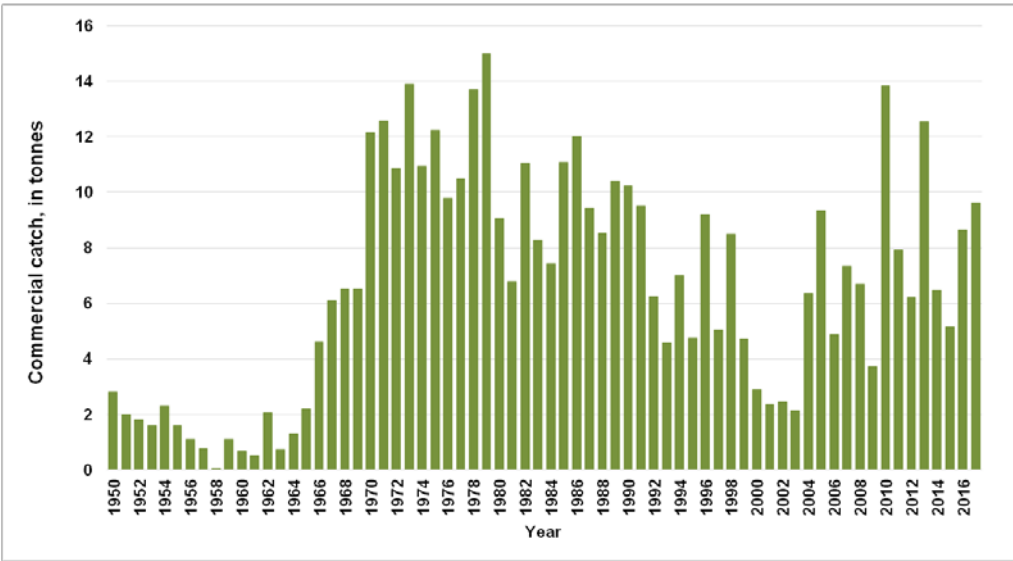


Figure 3.2. Time-trend in the reported catches from the inland fishery since 1950 (without the Curonian lagoon).

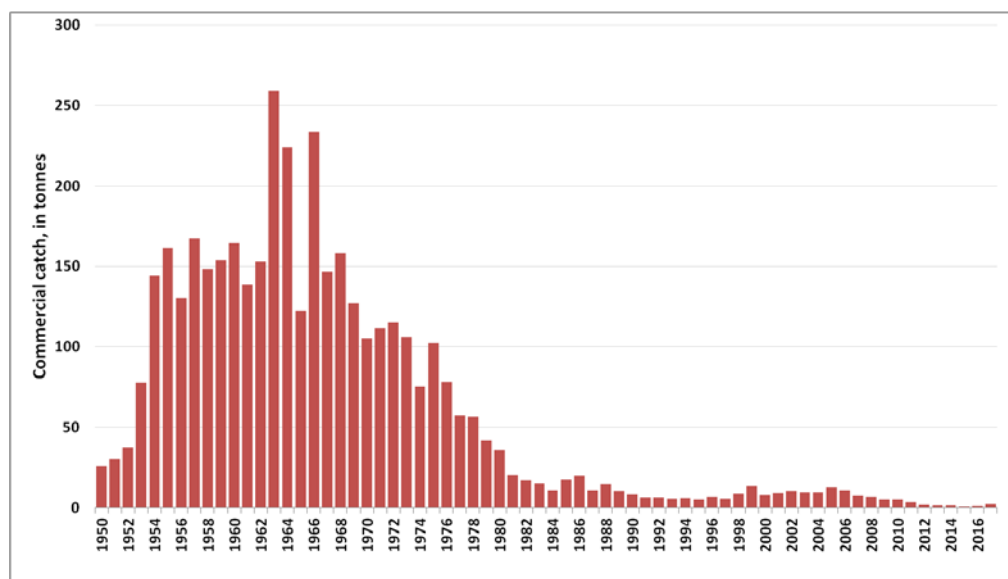


Figure 3.3. Time-trend in the reported catches from the Curonian lagoon fishery since 1950 (only Lithuanian part of the Lagoon, ca. ¼ of total area, without Russia).

3.1.3 Silver eel fisheries

Fishery for eels is mixed (yellow and silver) in Lithuania (see chapter above 3.1.2).

3.2 Restocking

Stocking of Lithuanian waters with glass eels started in the 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 eel originating in 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 small numbers. The last considerable stocking, prior to implementation of the Lithuanian Eel Management Plan, was undertaken in 2004 when 70.1 thousand eels were released into Lithuanian waterbodies.

After EMP was approved by EC first stockings were performed in 2011 and until 2016 154 waterbodies (mostly lakes) were stocked with almost 3 million of young eels, i.e. 0.6 million annually on average during the period from 2011 to 2018. Due to unsuccessful public tender in 2017 stocking was not done, however, in 2018 1.65 million of glass eels were purchased and stocked.

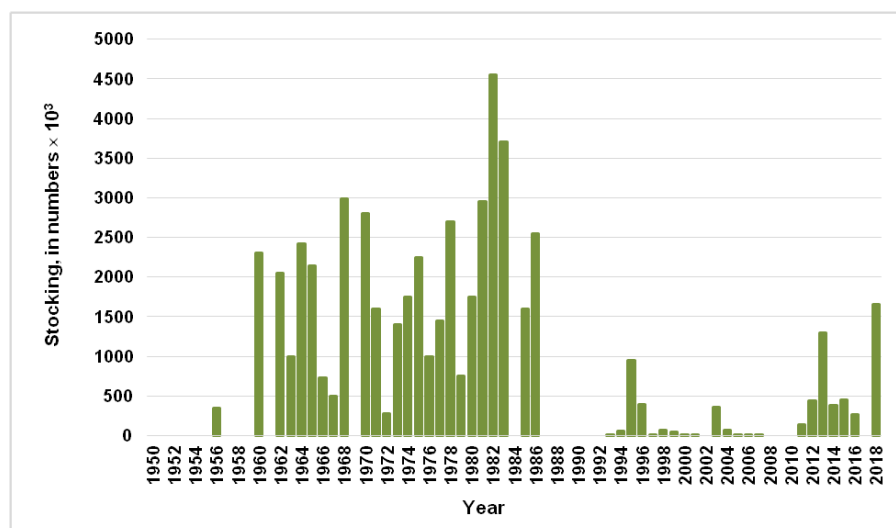


Figure 3.4 Stocking of inland waterbodies with glass eels in the period 1950 to 2018 (thousand individuals).

Table 3.1. Stocking of inland waterbodies with eels in Lithuania during 2011–2018*.

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

* Data from Fisheries Service under the Ministry of Agriculture of the Republic of Lithuania.

3.3 Aquaculture

In Lithuania, eels have been farmed by one company since 1998. In 2016, three companies have been farming eels and reported their production in recirculation systems (Table 3.2). However, in 2017 only one aquaculture company reported about production of farmed eels. According to recent EU legislation data are confidential (if only company reports their production).

Table 3.2. Eel production in aquaculture during 1998–2017.

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

* Since only one company produced eels in aquaculture in Lithuania, according to recent EU legislation data are confidential.

3.4 Entrainment

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.

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 Ocean for spawning, thus significant part of stocked eels had to pass HPP turbines during their downstream migrations (Figure 3.5). Eel stockings carried during 2011–2017 were performed in accordance with approach of the Lithuanian EMP: eels were stocked to waterbodies from which eel migration route to the sea is free or HPPs, if any, has fish pass.

Most of the eels were stocked to the waterbodies that are free from HPP impact, and eel migration routes to the Sea goes in free rivers or river sections. However, in some cases a HPP was built or reconstructed downstream the waterbody which was previously stocked with eels. Such situation occurred after the Ramučiai pond was stocked in 2012 (this pond was identified as without HPP downstream in the Lithuanian EMP). According to the data of the „Rivers, lakes and ponds cadastre of The Republic of Lithuania“ and “Small hydroenergetics” (Bilys *et al.*, 2017) Tūbausiai HPP was equipped with Kalpan turbine and started operating in 2012 (the same situation occurred in six other cases, see Table 6.1). In 2012, Plateliai Lake was stocked with the eels, although in Lithuanian EMP this lake was assigned to the waterbodies upstream of HPP (Gondingos HPP was built in 1961 and reconstructed in 2000). According to Lithuanian hydropower association (Bilys *et al.*, 2017), Plungė HPP was reconstructed in 2011 and one 37 kW turbine was installed. In other stocking cases eels were released to HPP-free waterbodies, or HPPs downstream stocked lake were equipped with fish pass. According to guidelines set in Lithuanian EMP, eel stocking in such waters is possible, however study by Dainys *et al.* (2018) demonstrated that only one third of all downstream migrating eels migrate through the fish pass, therefore more effective eel protection measures are needed to be implemented. According to the assessment of the HPP impacts in Lithuania (Ložys *et al.*, 2018), in 2017 5.1% of silver eels produced in Lithuanian inland waters were killed in HPP installations.

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

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

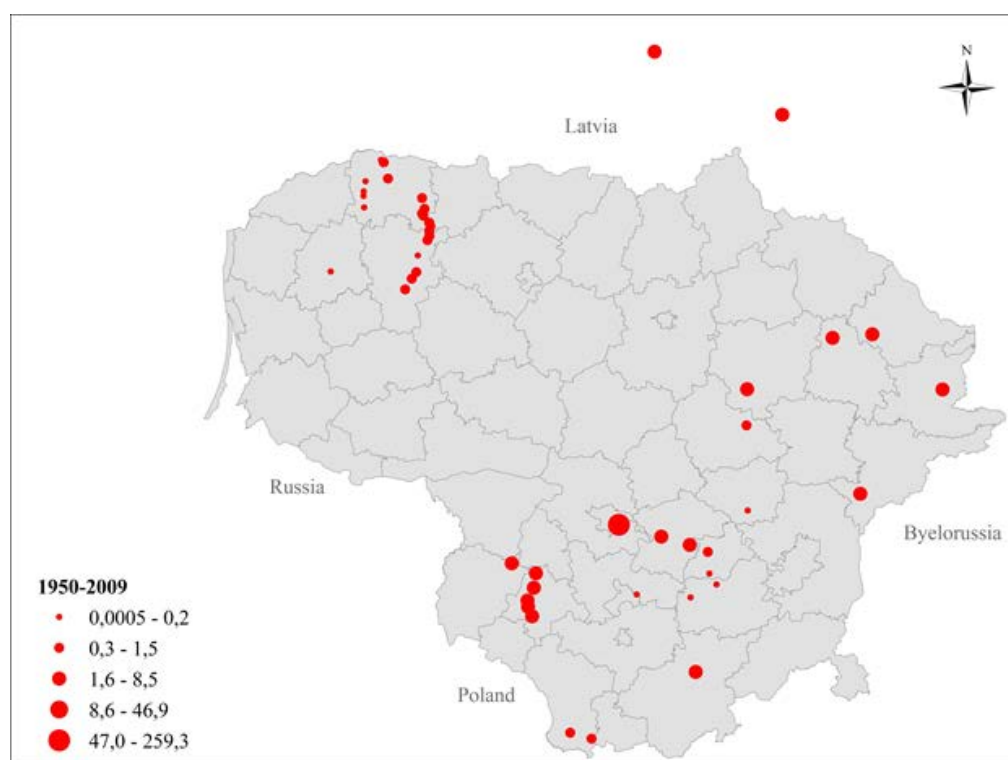


Figure 3.5. Spatial distribution of the HPPs having an eel stock upstream (stockings were carried during 1950–2009, before the implementation of the Lithuanian EMP). The size of the symbols in this figure is proportional to the number of eel (in millions) stocked upstream of each station.

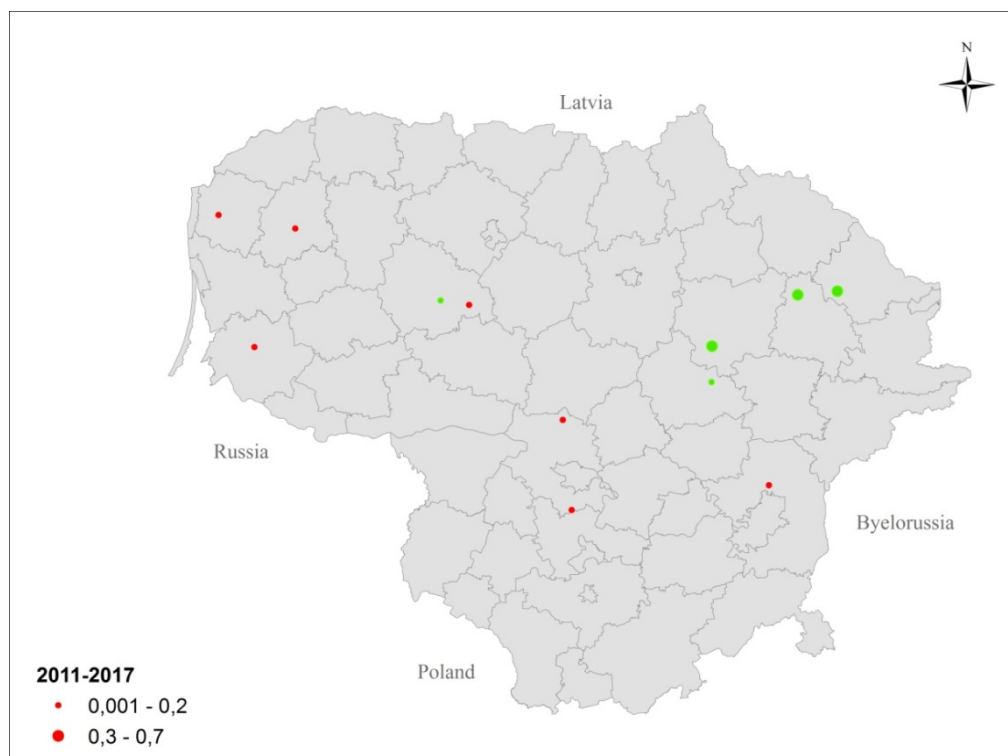


Figure 6.4. Spatial distribution of the HPPs having an eel stock upstream (stockings were carried during 2011–2017 after the implementation of the Lithuanian EMP). The size of the symbols in this figure is proportional to the number of eel (in millions) stocked upstream of each station, green colour indicates HPPs with installed fish pass.

3.5 Habitat quantity and quality

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

3.6 Others

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 eel 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 is cannot pretend that the results will be fully reliable in all detail. Production estimates for individual lakes in specific years will certainly be much less reliable than nation-wide estimates, or decadal averages, and so forth. Hence, the presentation of results will be restricted to nation-wide averages.

4.1.1 Data collection

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

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

A database of hydropower plants was made based on information available at the „Rivers, lakes and ponds cadastre of The Republic of Lithuania“, book issued by Lithuanian hydropower association “Hydropower in Lithuania” (2011) and “Small hydroenergetics” (Bilys *et al.*, 2017). In most cases detailed information on ownership, turbine types and capacity, location and year of construction or reconstruction was available. The mortality of eel passing a hydropower station depends on type and size of the turbine, thus mortality rate of eels passing different turbines was based on previous studies carried in Lithuania and neighbour countries (Dainys *et al.*, 2018; Larinier and Travade, 2002; Dêbowski *et al.*, 2016). If migrating eels had po pass 6 or more HPPs during their downstream migration it is assumed that mortality of these eels is 100% regardless of what turbine type is installed in each HPP.

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

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

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

4.1.2 Analysis

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

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

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

$$Silver_eel_run = Production - Catch$$

Passing hydropower generation stations reduces the silver eel run to:

$$Escapement = Silver_eel_run \times \exp^{-\Sigma H}$$

The hydropower-related mortality ΣH 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:

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

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 datasets (e.g. point-locations for release of recruits vs. lake-totals for fisheries).

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

accurate prediction of the real developments (continued upward or downward trends, extra actions, and autonomous developments).

4.1.3 Reporting

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

4.1.4 Data quality issues and how they are being addressed

During the implementation of the EMP and evaluation of the progress of eel stock restoration in Lithuania it was collected some new data for improvement of the estimations (and reduction of biases) of eel stock in the country. However, aiming to improve it further, it is needed to improve knowledge of mortalities in recreational fishery (detail study is needed) as it is still under discussion. It is also not well known about silver eel mortalities in the Curonian Lagoon fishery during their migration from lakes to the Sea. There is no detail studies on predation, despite it is not little 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 methodologies.

4.2 Assessment results

Overall predicted silver eel production was relatively low in 1950–1970, ranging between 0.05 and 15 t. Later silver eel production sharply increased and in 1998 reached its maximum of 280 t. However, since 2000 silver eel production start decreasing and in 2007–2017 it was on average 20.5 t per year. If stocking intensity will remain same as it was since beginning of EMP implementation (2011–2018), silver eel productions is expected to increase up to ca. 63 tons in 2030–2040 (Figure 4.1.).

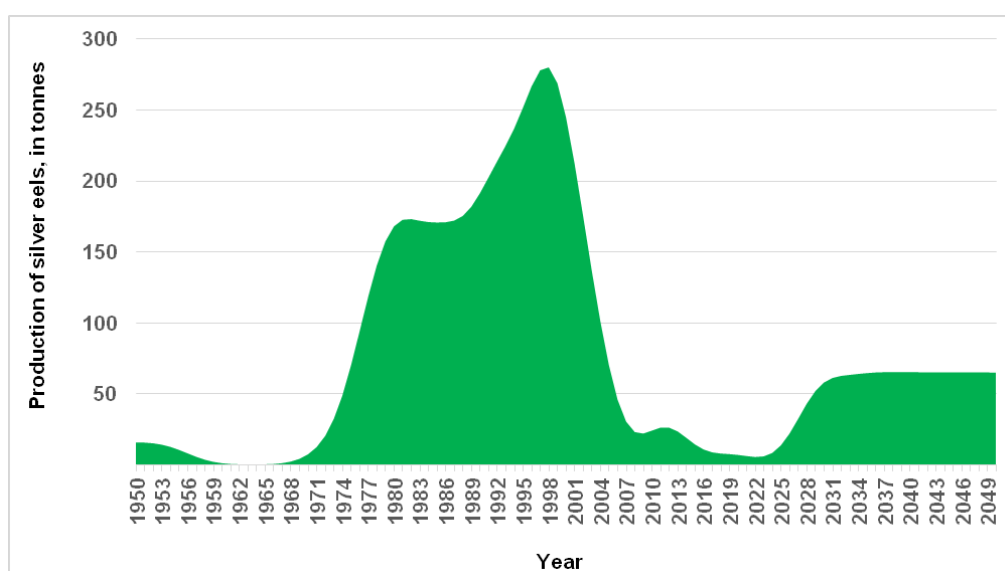


Figure 4.1. Production of silver eel by year: the estimated total production in inland waters before the impact of fishery and hydropower (1950–2050). For these results, a natural mortality rate of $M=0.10$ was assumed. Future forecast is made on the assumption that stocking will be carried at the same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

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

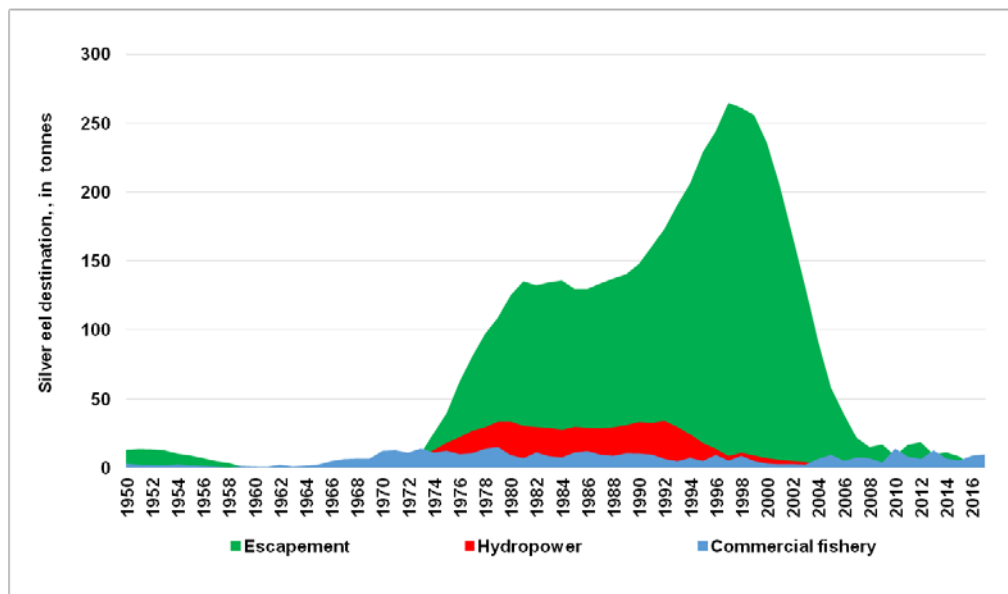


Figure 4.2 Time-trends in the destination of the silver eel produced in Lithuanian inland waters (1950–2017).

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

In some cases, negative hydropower mortalities were calculated (erroneously indicating that eels were produced by hydropower plants). This happens when the estimated eel production is below the reported eel catch e.g. stocking data are missing. This is clearly an unrealistic situation. In order to minimise under- or overestimation of eel mortalities, these “negative” data were omitted from further analysis.

Predicted escapement of silver eel ranged from 0 t (e.g. in 1961–1971) to 265 t (in 1997), on average 61% of the total production (range 0%–99%). The 2017 escapement is estimated at 0 t., while 2011–2017 annual average is ca. 9 tons (Figure 6.8).

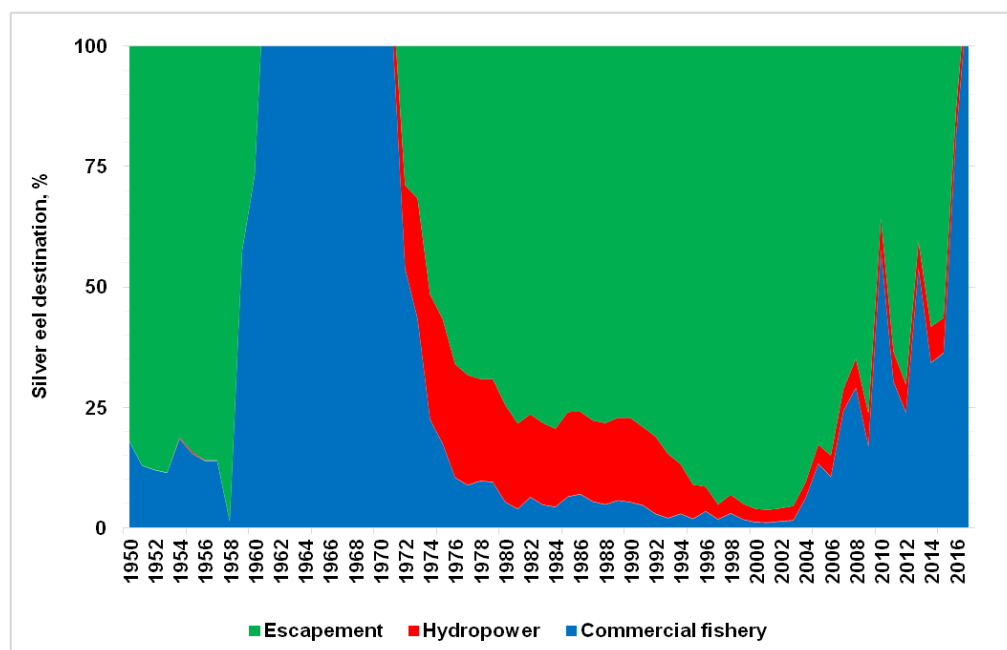


Figure 4.3. Time-trend in the estimated anthropogenic mortality and escapement, expressed in percentage impacts on the silver eel production in 1950–2017.

Table 4.1. Trends over time (2011–2017) in eel stock indicators (in kg and % or rate (table below)).

	B₀	B_{TARGET}	B_{BEST}	B_{CURRENT}	ΣF	ΣH	ΣA
2011	87 000	35 000	26 049	16 510	30,4%	6,2%	36,6%
2012	87 000	35 000	26 015	18 280	23,9%	5,8%	29,7%
2013	87 000	35 000	23 293	9 460	53,9%	5,5%	59,3%
2014	87 000	35 000	18 821	10 960	34,3%	7,5%	41,7%
2015	87 000	35 000	14 172	7 990	36,3%	7,3%	43,6%
2016	87 000	35 000	10 613	1 400	81,4%	5,4%	86,7%
2017	87 000	35 000	8 581	0	>100%	5,1%	>100%

	B₀	B_{TARGET}	B_{BEST}	B_{CURRENT}	ΣF	ΣH	ΣA
2011	87 000	35 000	26 049	16 510	0,36	0,06	0,46
2012	87 000	35 000	26 015	18 280	0,27	0,06	0,35
2013	87 000	35 000	23 293	9 460	0,77	0,06	0,90
2014	87 000	35 000	18 821	10 960	0,42	0,08	0,54
2015	87 000	35 000	14 172	7 990	0,45	0,08	0,57
2016	87 000	35 000	10 613	1 400	1,68	0,06	2,03
2017	87 000	35 000	8 581	0	-*	0,05	-*

*Observed mortality exceeds estimated biomass.

5 Other data collection

5.1 Recruitment time-series

Eels do not recruit to Lithuanian waters at glass eel stage. There is no assessment of yellow eel recruitment done in Lithuania.

5.2 Yellow eel abundance surveys

Yellow eel abundance surveys are not done in Lithuania (except one case mark–recapture study in 2014). Regular yellow eel sampling in some lakes is focused on collection of biological data.

5.3 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 EU Regulations by determining in the numbers of silver eels leaving inland waters to spawn. Barriers, especially hydropower installations, are considered to be one of the major threats for eels' downstream spawning migration. First attempt to evaluate silver eel migration success from Lithuanian inland waterbodies was carried in 2014. The results of this study are presented by Dainys *et al.* (2017).

A total of 63 silver eels were caught in four rivers in Eastern Lithuania during their spawning migrations using fykenets of 16–20 mm mesh size and tagged with Vemco acoustic tags in spring and autumn 2014. After implantation of acoustic tags eels were released back to three free-flowing and one dammed river. Eel migration was tracked using four Vemco VR2W receivers that were installed in the vicinity of the Kaunas HPP water intake to detect eels entering turbines and four receivers were installed just below the Kaunas HPP to detect those eels that had passed through. To detect eels that successfully migrated downstream, four receivers were installed on navigational buoys in the Nemunas Delta and four in the Klaipėda Strait (Figure 5.1).

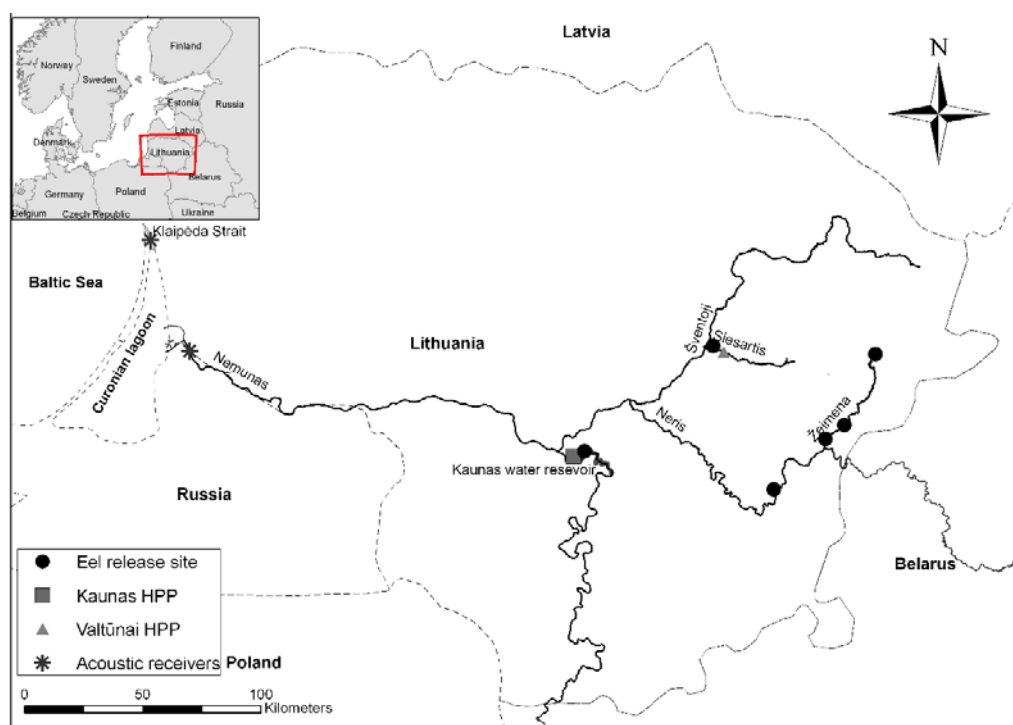


Figure 5.1. Eel release sites.

Eighteen out of the 38 silver eels released into free-flowing rivers of 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 five eels (16%) remains unknown.

The peak period of eels entering the Baltic Sea was observed during late fall: 18 eels (82%) were detected in the Klaipėda Strait during October–November while the remaining four eels were detected once each in June, July, December and January, respectively.

Overall migration success (including HPP effect) of all tagged and released eels in Lithuanian rivers and the Curonian Lagoon was 35%.

5.4 Biological parameters

All eels handled, recently are analysed with respect to size, weight, sex, stage, age, in some cases subsample for the prevalence and intensity of parasites. Fat is measured only occasionally.

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

5.5 Parasites and pathogens

Eel viruses and diseases are not monitored in Lithuania. No large-scale or long-term studies on eel parasites and pathogens were carried in Lithuania. Consistent sampling of eels from Lithuanian waters (waterbodies of different trophic level; eels of different age groups etc.) started in 2017 only, thus since then all eels analysed at the Nature research centre and/or Fisheries Service under the Ministry of Agriculture of the Republic of Lithuania are screened by the naked eye for *Anguillicola crassus*. Most of analysed eels were infected with *A. crassus*. Infection intensity was relatively low usually ranging between one and four nematodes (highest observed intensity was 23 parasites for one eel). Additionally, two other parasite species (*Diplostomum spathaceum* and *Pseudodactylogyrus* sp.) were found in analysed eels in 2017 (analysis was carried by Fisheries Service).

Parasitological analysis of eels stocked to three different lakes (in Vilnius district) was performed in 2014 as a case study.

Five different taxons of parasites were found as the result of parasitological analysis of collected samples in the Balsys Lake: ectoparasite belonging to *Dactylogyrus* genus and four species of endoparasites (Table 10). The dominant species was swimbladder parasite *Anguillicola crassus* (Nematoda); the parasite is invasive species originating in Asia. 14 (36.8 %) out of 38 studied eels were infected with the parasite. The average infestation rate for the infected eels was 3.7 (maximum 11). Pilecka-Rapacz and Kesminas (2006) in the Dringis Lake found 60.7 % of eels infected with *A. crassus*. Therefore, the status of eel population in the Balsys Lake is better; intensity of infestation is lower in the Balsys lake as well as intensity of infestation in the Dringis Lake was 3.9 (maximum 14).

Spearman test was used aiming to find a relation between infestation intensity with *A. crassus* and eel condition. Statistically significant relation between the condition factor and infestation intensity was not detected. Statistical analysis did not detect reliable relation between the condition factor and eel infection with other parasites.

Dactylogyrus sp. (Monogenea), was found on eel gills. 10.5 % of eels were infected by *Dactylogyrus* sp.; infestation intensity was on average 8.5 parasites per one eel (maximum twelve). *Camallanus lacustris* (Nematoda; Figure 5.2) was most often (in five eels; 13.2%) found among endoparasites in studied eel intestine. The infestation intensity was 5.8 parasites per one infected eel on average. Four (10.5%) of studied eels were infected with *Bothriocephalus claviceps* (Cestoda). Intensity of the infestation with the parasite was 1.5 per one infected eel. *Acanthocephalus lucii* (Acanthocephala) was found in the intestine of four (10.5%) out of 38 studied eels. Infestation intensity was six parasites per infected eel on average. No parasites were found in liver of studied eels.



Figure 5.2. Parasite *Camallanus lacustris* found in the intestine of eel from the Balsys Lake.

Table 5.1. Infestation of eels with parasites in the Balsys Lake in 2014.

Criteria of the infestation	Gills	Liver	Swimbladder	Intestine		
	<i>Dactylogyrus</i> sp.		<i>Anguillicola crassus</i>	<i>Camallanus lacustris</i>	<i>Bothriocephalus claviceps</i>	<i>Acanthocephalus lucii</i>
Number of infected eels	4	-	14	5	4	4
Proportion of the infected stock, %	10,5	-	36,8	13,2	10,5	10,5
Average intensity of infestation, in numbers	8,5	-	3,7	5,8	1,5	6

Five different taxons of parasites were found in eel samples collected in Karvys Lake: ectoparasite belonging to *Dactylogyrus* genus and four species of endoparasites (Table 5.2). The dominant parasite species found in Karvys lake population was swimbladder parasite *Anguillicola crassus* (Nematoda). Ten out of 32 (31.3 %) studied eels were infected with the parasite (Figure 5.3.). The average infestation rate for the infected eels was four (maximum seven). Pilecka-Rapacz and Kesminas (2006) in the Dringis Lake found 60.7% of eels infected with *A. crassus*. Therefore, the status of eel population in the Karvys Lake is better. However the intensity of infestation is slightly higher as the intensity of the infestation in the Dringis Lake was 3.9 (maximum 14).

Dactylogyrus sp. (Monogenea) was found on gills of five eels. The infestation intensity was 15.6%, infestation intensity was on average 5.2 parasites per one eel (maximum 12). *Camallanus lacustris* (Nematoda) was found in the intestine of three eels (9.4%). The infestation intensity was 7.7 parasites per one infected eel on average. Two (6.3%) of studied eels were infected with *Bothriocephalus claviceps* (Cestoda; Figure 5.4). Intensity of the infestation with the parasite was one per one infected eel. *Acanthocephalus lucii* (Acanthocephala) was found in the intestine of one out of 32 studied eels. Infestation intensity was five parasites per infected eel on average. No parasites were found in liver of studied eels.



Figure 5.3. Parasite *Anguillicola crassus* found in swimbladder of eel.

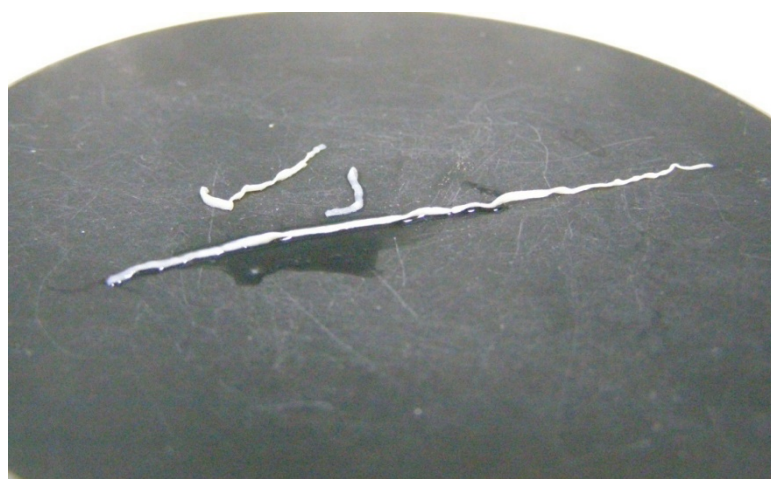


Figure 5.4. *Bothriocephalus claviceps* found in eel intestine.

Table 5.2. Infestation of eels with parasites in the Karvys Lake in 2014.

Criteria of the infestation	Gills	Liver	Swimbladder		Intestine	
	<i>Dactylogyrus</i> sp.		<i>Anguillicola crassus</i>	<i>Camallanus lacustris</i>	<i>Bothriocephalus claviceps</i>	<i>Acanthocephalus lucii</i>
Number of infected eels	5	-	10	3	2	1
Proportion of the infected stock, %	15,6	-	31,3	9,4	6,3	3,1
Average intensity of infestation, in numbers	5,2	-	4	7,7	1	5

Six different taxons of parasites were found in eels caught in Riešė Lake: ectoparasite belonging to *Dactylogyrus* and *Trichodina* genus and four species of endoparasites (Table 5.3). The dominant species found in Riešė lake population was swimbladder parasite *Anguillicola crassus* (Nematoda). Seven out of 30 (23.33 %) studied eels were infected with the parasite. The average infestation rate for the infected eels was 3.86 (maximum eight). Pilecka-Rapacz and Kesminas (2006) in the Dringis Lake found 60.7% of eels to be infected with *A. crassus*. Therefore, the status of eel population in the Riešė Lake, like in Balsys and Karvys lakes is better. The intensity of infestation is slightly lower in the Riešė Lake as the infestation in the Dringis Lake was 3.9 (maximum 14).



Figure 5.4 Parasite *Anguillicola crassus* found in the swimbladder of eel.

Spearman test was used aiming to find a relation between infestation intensity with *A. crassus* and eel condition. Statistically significant relation between the condition factor, infection and infestation intensity was not detected. Statistical analysis did not detect reliable relation between the condition factor, infection or infection intensity with other parasites as well.

Ectoparasites *Dactylogyrus* sp. (Monogenea) and *Trichodina* sp. (Ciliophora) were found on gills of some studied eels. *Dactylogyrus* sp. was found on gills of three eels (10%). The infestation intensity was 5.33 parasites per one infected eel on average (maximum seven). *Trichodina* sp. was found on gills of two eels (667%). The infestation intensity was 2.5 parasites per one infected eel on average (maximum three). Three eels (10%) were infected with *Bothriocephalus Claviceps* (Cestoda) in the intestine. The average intensity of the infestation was 2.33 per one infected eel. Three of studied eels (10%) were infected with *Camallanus lacustris* (Nematoda). The infestation intensity was 7.33 per one infected eel. *Acanthocephalus lucii* (Acanthocephala) was found in guts of three out of 30 studied eels (10%). The average infestation intensity was 5.33 per one infected eel. No parasites were found in liver of studied eels.

Table 5.3. Infestation of eels with parasites in the Riešė Lake in 2014.

Criteria of the infestation	Gills		Liver	Swimbladder		Intestine	
	<i>Trichodina</i> sp.	<i>Dactylogyrus</i> sp.	-	<i>Anguillicola</i> <i>crassus</i>	<i>Camallanus</i> <i>lacustris</i>	<i>Bothriocephalus</i> <i>claviceps</i>	<i>Acanthocephalus</i> <i>lucii</i>
Number of infected eels	2	3	-	7	3	3	3
Proportion of the infected stock, %	6,67	10	-	23,33	10	10	10
Average intensity of infestation, in numbers	2,5	5,33	-	3,86	7,33	2,33	5,33

5.6 Contaminants

No available data.

5.7 Predators

No available data.

6 New information

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.

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

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.

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1 Stock status summary

Table 29. Stock indicators and mortality rates for the period 2014–2016, derived from: Van de Wolfshaar *et al.*, 2018, assessed area from: Tien & Dekker (2004).

EMU_code	Assessed Area (ha)	B ₀ (T)	B _{curr} (T)	B _{best} (T)	B _{curr} /B ₀ (%)	ΣF	ΣH	ΣA
NL_Neth	378 700	10 400	1365	2647	51.6	0.54	0.12	0.66

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

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

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).

ΣF=mortality due to fishing, summed over the age groups in the stock (rate).

ΣH=anthropogenic mortality excluding the fishery, summed over the age groups in the stock (rate).

ΣA=all anthropogenic mortality summed over the age groups in the stock (rate).

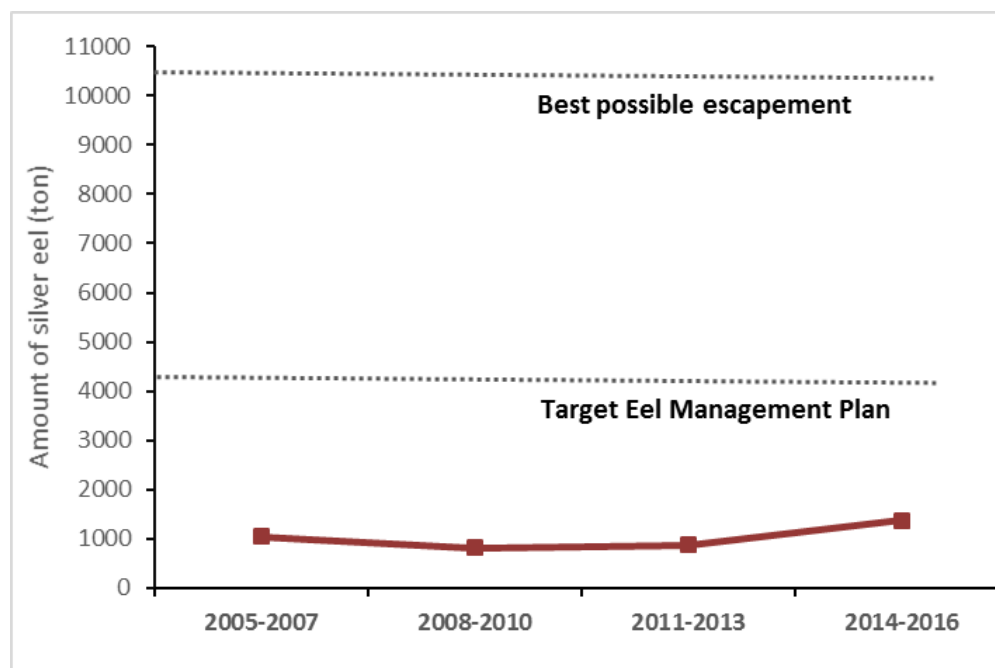


Figure 88. Estimated amount of silver eel that escapes to sea to spawn (red line); best possible escapement when only natural mortality occurs (upper dotted line); target of the Eel Management Plan (lower dotted line). The target of the Eel Management Plan is 40% of the best possible escapement.

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

2.1.1 Eel Management Units and Eel Management Plans

The Netherlands consists of one EMU coded 'NL_Neth' and there is one Eel Management Plan (EMP)¹ that was implemented in July 2009 and revised in 2011.

2.1.2 Management authorities

The Dutch Ministry of Agriculture, Nature and Food Quality (PO Box 20401, 2500 EK Den Haag, The Netherlands) is responsible for the conservation of stocks and for the management of all anthropogenic impacts, as well as for the delivery of the Eel Management Plan (EMP).

2.1.3 Fisheries

Fisheries on eel in the Netherlands is regulated by the Dutch Fisheries Act, while protection of eel is regulated under the Dutch Flora and Fauna Act. In summary, the following regulations apply: the minimum catch size is 28 cm, a number of fisheries is closed in the period 1 September–30 November, all eel caught in 1 September–30 November have to be released (except in Friesland, where decentral management takes place), and since 2011 a number of areas is closed for fisheries due to pollution (dioxins, Figure 89)².

¹ <https://www.rijksoverheid.nl/documenten/rapporten/2009/11/27/aalbeheerplan>

² <http://www.sportvisserijnederland.nl/vispas/visserijwet-en-regels/binnenwater/paling.html>



Figure 89. Overview of the areas closed for eel and Chinese mitten crab fishery as of 1 April 2011 (Source: Ministry of Agriculture, Nature and Food Quality).

2.1.4 Management actions

The management measures taken in the Netherlands in the framework of the EMP are listed in Table 30.

Table 30. Overview of all the (un)foreseen measures described in the Dutch Eel Management Plan to be implement to reach the 40% escapement objective (source: Van de Wolfshaar *et al.*, 2018).

No	Foreseen Measure	Planned implementation	Realised implementation
1	Reduction of eel mortality at pumping stations and other water works.	2015–2027	2015-2027 ^a
2	Reduction of eel mortality at hydroelectric stations with at least 35%	2009	November 2011 ^b
3	The establishment of fishery-free zones in areas that are important for eel migration	2010	1 April 2011 ^c
4	Release of eel caught (a) at sea and (b) at inland waters by anglers	2009	1 October 2009
5	Ban on recreational fishery in coastal areas using professional gear	2011	1 January 2011 ^d
6	Annual closed season from 1 September to 1 December	2009	1 October 2009
7	Stop the issue of licences for eel snigglers by the minister of LNV in state owned waters	2009	1 May 2009
8	Restocking of glass eel and pre-grown eel from aquaculture	2009	Early 2010
9	Research into the artificial propagation of eel	ongoing	EU-project started
	Unforeseen Measure		
10	Closure eel fishery in contaminated (PCBs, dioxins) areas		1 April 2011 ^e

^a In agreement with the European Commission changes have been made to the original schedule of solving migration barriers.

^b Due to technical difficulties the maximum achievable reduction in mortality by adjusted turbine management is 24%.

^c The vast majority of the contaminated areas that were closed for commercial fisheries on 1/4/2011 are the main rivers. These rivers are the most important “high ways” for diadromous species like salmon and eel.

^d The use of fykes and longlines by recreational fishers has been banned in nearly all marine and inland waters. The use of gillnets, however, by recreational fishers is still allowed in a few marine waters.

^e On 1 January 2015 the area closed for eel fishery due to contaminants (PCBs, dioxins) was extended.

2.2 Significant changes since last report

There have not been significant changes in the status of the eel across The Netherlands since the Country Report of 2017 (Bos, 2018).

3 Impacts on the stock

Table 31. Overview of the assessed impacts per habitat type or for 'All' habitats where the assessment is applied across all relevant habitats. Barriers include habitat loss; indirect impacts are anthropogenic impacts on the ecosystem, but only indirectly on eel (e.g. eutrophication). A = assessed, MI = not assessed, minor, MA = not assessed major, AB = impact absent (Bierman *et al.*, 2012).

EMU code	Habitat	Fish com	Fish rec	Hydro & pumps	Barriers	Restocking	Predators	Indirect impacts
NL_Neth	Riv	A	A	A	A	MI/MA	MI/MA	MI/MA
	Lak	A	A	A	A	MI/MA	MI/MA	MI/MA
	Est	NP	NP	NP	NP	NP	NP	NP
	Lag	NP	NP	NP	NP	NP	NP	NP
	Coa	MI	A	AB	AB	AB	AB	MI
All								

Table 32. Loss of eel (kg) for each impact per developmental stage.). A = assessed, MI = not assessed, minor; MA = not assessed major; AB = impact absent. ¹All eel caught recreationally were assumed to be yellow eel (Bierman *et al.*, 2012).

EMU code	Stage	Fish com	Fish rec	Hydro & pumps	Barriers	Restocking	Predators	Indirect impacts
NL_Neth	Glass	AB	AB	MI/MA	MI/MA	MI	MI/MA	MI/MA
NL_Neth	Yel-low	A	A	MI/MA	MI/MA	AB	MI/MA	MI/MA
NL_Neth	Sil-ver	A	AB ¹	A	MI/MA	AB	MI/MA	MI/MA
NL_Neth	Sil-ver EQ							

¹All eel caught recreationally were assumed to be yellow eel.

3.1 Fisheries

3.1.1 General information

Eel fisheries in the Netherlands occur in coastal waters, estuaries, larger and smaller lakes, rivers, polders, etc. Management of eel stock and fisheries has been an integral part of the long tradition in manipulating water courses (polder construction, river straightening, ditches and canals, etc.). Governmental control of the fishery is restricted to on the one hand a set of general rules (gear restrictions, size restrictions, for course fish: closed seasons), and on the other hand site-specific licensing. Since 1/1/2010 there is a general registration of landings, whereas a general registration of fishing efforts has not yet been implemented. In recent years, licences in state-owned waters are obliged to participate in so-called Fish Stock Management Committees ['Visstand Beheer Commissies' VBC]³, in which commercial fisheries, sports fisheries and water managers are represented. The VBC is responsible for the development of a regional Fish Stock Management Plan. The Management Plans are currently not subject to general objectives or quality criteria. The future of VBC and their role in fish stock management is under debate.

³ <http://www.visstandbeheercommissie.nl/>

Until April 2011 the total Dutch freshwater fishery on eel involved approximately 200 companies, with an estimated total catch of nearly 442 tonnes of eel in 2010. However, on 1 April 2011, a large part of the fishery was closed due to high PCB-levels in the eel (Figure 89). This closure has affected about 50 fishing companies catching 170 tonnes of eel in 2010, roughly a third of the annual landings of inland waters in the Netherlands.

3.1.2 Spatial subdivision of the territory

The fishing areas in the Netherlands can be categorised into five groups:

- 1) The Wadden Sea; 53°N 5°E; 2,591 km². This is an estuarine-like area, shielded from the North Sea by a series of islands. The inflow of seawater at the western side mainly consists of the outflow of the river Rhine, which explains the estuarine character of the Wadden Sea. The fishery in the Wadden Sea is permitted to licence holders and assigns specific fishing sites to individual licensees. Fishing gears include fykenets and poundnets; the traditional use of eel pots is in rapid decline. The fishery in the Wadden Sea is obliged to apply standard EU fishing logbooks. Landings statistics are therefore available from 1995 onwards; 11 tons in 2017 (Table 33, **Error! Reference source not found.**). In 2009 there were 21 companies having a commercial licence for fishing eel, and the total number of fykenets was estimated at 400.
- 2) Lake IJsselmeer; 52°40'N 5°25'E; now 1820 km². Lake IJsselmeer is a shallow, eutrophic freshwater lake, which was reclaimed from the Wadden Sea in 1932 by a dike (Afsluitdijk), substituting the estuarine area known before as the Zuiderzee. The surface of the lake was reduced stepwise by land reclamation, from an original 3470 km² in 1932, to 1820 km² since 1967. In preparation for further land reclamation, a dam was built in 1976, dividing the lake into two compartments of 1200 and 620 km², respectively, but no further reclamation has actually taken place. In managing the fisheries, the two lake compartments have been treated as a single management unit. The discharge of the river IJssel into the larger compartment (at 52°35'N 5°50'E, average 7 km³ per annum, coming from the River Rhine) is sluiced through the Afsluitdijk into the Wadden Sea at low tide, by passive fall. Fishing gears include standard and summer fykenets, eel boxes and longlines; trawling was banned in 1970. Licensed fishermen are not spatially restricted within the lake, but the number of gears is controlled by a gear-tagging system. The registered landings at the auctions are assumed to cover some the actual total. There are, however, differences in estimated landings reported by the fisheries organisation (PO IJsselmeer), the Fish Board (PVIS) and catch registration system of the Ministry of Agriculture, Nature and Food quality (Ministerie van LNV).
- 3) Main rivers; 180 km² of water surface. The Rivers Rhine and Meuse flow from Germany and Belgium respectively, and in the Netherlands constitute a network of dividing and joining river branches. Traditional eel fisheries in the rivers have declined tremendously during the 20th century, but following water rehabilitation measures in the last decades, is now slowly increasing. The traditional fishery used stownets for silver eel, but fykenet fisheries for yellow and silver eel now dominates. Individual fishermen are licensed for specific river stretches, where they execute the sole fishing right. No registration of effort is required. In 2009 there were 28 fishing companies, using an estimated number of 318 fixed fykes, 2433 train fykes, 551 eel boxes, and

unknown quantities of other gears (electric dipnet, longlines, etc.). Since 1 April 2011, the eel fishery on the main rivers has been closed due to high levels of pollutants in eel.

- 4) Zeeland; 965 km². In the Southwest, the Rivers Rhine, Meuse and Scheldt (Belgium) discharge into the North Sea in a complicated network of river branches, lagoon-like waters and estuaries. Following a major storm catastrophe in 1953, most of these waters have been (partially) closed off from the North Sea, sometimes turning them into fresh waterbodies. Fishing is licensed to individual fishermen, mostly spatially restricted. Fishing gears are dominated by fykenets. Management is partially based on marine, partly on freshwater legislation. In 2009 there are 27 companies, using an estimated number of 174 fixed fykes, 233 train fykes, and unknown numbers of eel pots. This area has also been affected by the ban on eel and Chinese mitten crab fishery due to high pollution levels.
- 5) Remaining waters; inland 1340 km². This comprises 636 km² of lakes (average surface: 12.5 km²); 386 km² of canals (> 6 m wide, 27 590 km total length); 289 km² of ditches (<6 m wide, 144 605 km total length); and 28 km² of smaller rivers (all estimates based on areas less than 1 m above sea level, 55% of the total surface; see Tien and Dekker, 2004 for details). Traditional fisheries are based on fykenetting, and hook and line. Individual licences permit fisheries in spatially restricted areas, usually comprising a few lakes or canal sections, and the joining ditches. Only the spatial limitation is registered. Eight small companies operating scattered along the North Sea coast have been added to this category. In 2009 there were about 100 companies, using unknown quantities of gears of all types.

Table 33. Marine fisheries landings (kg per country) in the Netherlands from ICES areas 4.a, 4.b, 4.c, UNK, 7.a, 7.d and 8.b).

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	
bel						1539	750	980		40	50	
deu										15		
eng						64						
nld	35535	27725	24129	18395	21906	19488	34973	28205	17951	31153	18155	
											18205	
Grand Total	35535	27725	24129	18395	21906	21091	35723	29185	17951	31208		
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
bel								60				
deu												
eng				20								
nld	17414	9131	6909	3960	4971	3684	4338	5797	4241	4297	11177	11081
Grand Total	17414	9131	6909	3980	4971	3684	4338	5857	4241	4297	11177	11081

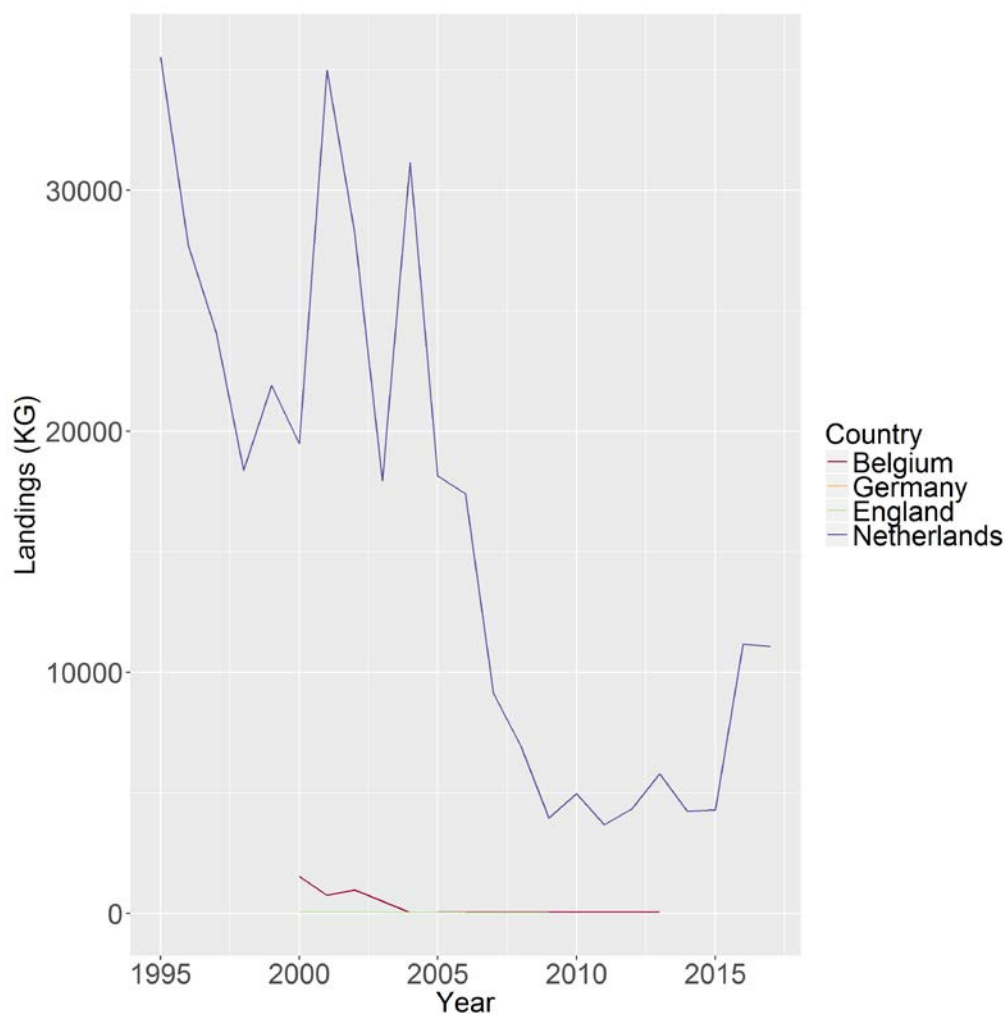


Figure 90. Marine fisheries landings (kg per country) in the Netherlands from ICES areas 4.a, 4.b, 4.c, UNK, 7.a, 7.d and 8.b)

The Water Framework Directive subdivides the Netherlands into four separate River Basin District (RBD), all of which extend beyond our borders. These are:

- 1) The River Ems (Eems), 53°20'N 7°10'E (=river mouth), shared with Germany. This RBD includes the northeastern Province Groningen, and the eastern part of Province Drenthe. Drainage area: 18 000 km², of which 2400 km² in the Netherlands.
- 2) The River Rhine (Rijn), 52°00'N 4°10'E, shared with Germany, Luxemburg, France, Switzerland, Austria, Liechtenstein. Drainage area: 185 000 km², of which 25 000 km² in the Netherlands, which is the major part of the country.
- 3) The River Meuse (Maas), 51°55'N 4°00'E, shared with Belgium, Luxemburg, France and Germany. Drainage area: 35 000 km², of which 8000 km² in the Netherlands.
- 4) The River Scheldt (Schelde), 51°30'N 3°25'E, shared with Belgium and France. Most of the southwestern Province Zeeland used to belong to this RBD, but water reclamation has changed the situation dramatically. Drainage area: 22 000 km², of which 1860 km² in the Netherlands.

Within the Netherlands, all rivers tend to intertwine and confluent. Rivers Rhine and Meuse have a complete anastomosis at several places, whereas a large part of the outflow of the River Meuse is now redirected through former outlets of the River Scheldt. Additionally, the coastal areas in front of the different RBDs constitute a confluent zone. Consequently, sharp boundaries between the RBDs cannot be made; neither on a practical nor on a juridical basis. This report will subdivide the national data on a pragmatic basis.

In this report, we will subdivide the national data on eel stock and fisheries by drainage area on a preliminary assumption that water surfaces and fishing companies are approximately equally distributed over the total surface, and thus, totals can be split up over RBDs proportionally to surface areas.

3.1.3 Fishing capacity

Capacity is defined as the potential fishery usage (i.e. number of licences issued). For marine waters and Lake IJsselmeer a register of ships is kept, but for the other waters no central registration of the ships being used is available. Registration of the number of gears owned or employed was lacking until recently.

For Lake IJsselmeer/Markermeer, an estimate of the number of gears actually used is available for the years 1970–1988 (Dekker, 1991). In the mid-1980s, the number of fykenets was capped, and reduced by 40% in 1989. In 1992 the number of eel boxes was counted, and capped. Subsequently, the caps have been lowered further in several steps, the latest being a buy-out in 2006. Since the number of companies has reduced at the same time, the nominal fishing effort per company has not reduced at the same rate, and underutilisation of the nominal effort probably still exists. The effort in the longline fishery is not restricted, other than by the number of licences.

The ministry (LNV-RVO) provides permits that give the right to fish with certain gears. The numbers of gears and rights differ per permit holder. Insight in the use of the permits is provided by the weekly catch reports that fishermen are obliged to hand in. When fishermen fish with a certain gear, they have to mark it with a label ('merkje'). Permits can also be reserved temporarily, e.g. when there is no vessel to fish with. In that case, there are no rights to fish (source: pers. com. RVO, Ministry of Agriculture, Nature and Food quality, 2017). In 2018, the total number of gears allowed was 1579 fixed fykes, 3193 train fykes (one fyke = two eel units), 7415 eel boxes and have not changed in the past few years.

3.1.4 Glass eel fisheries

There is no fishing on glass eel.

3.1.5 Yellow eel fisheries

3.1.5.1 Commercial

No reliable long-term time-series of yellow eel landing exist; total landings of yellow and silver eel combined have been reported.

Statistics from the auctions around Lake IJsselmeer were kept by the Ministry of LNV until 1994; since then by the Ministry of Agriculture, Nature and Fisheries (LNV).

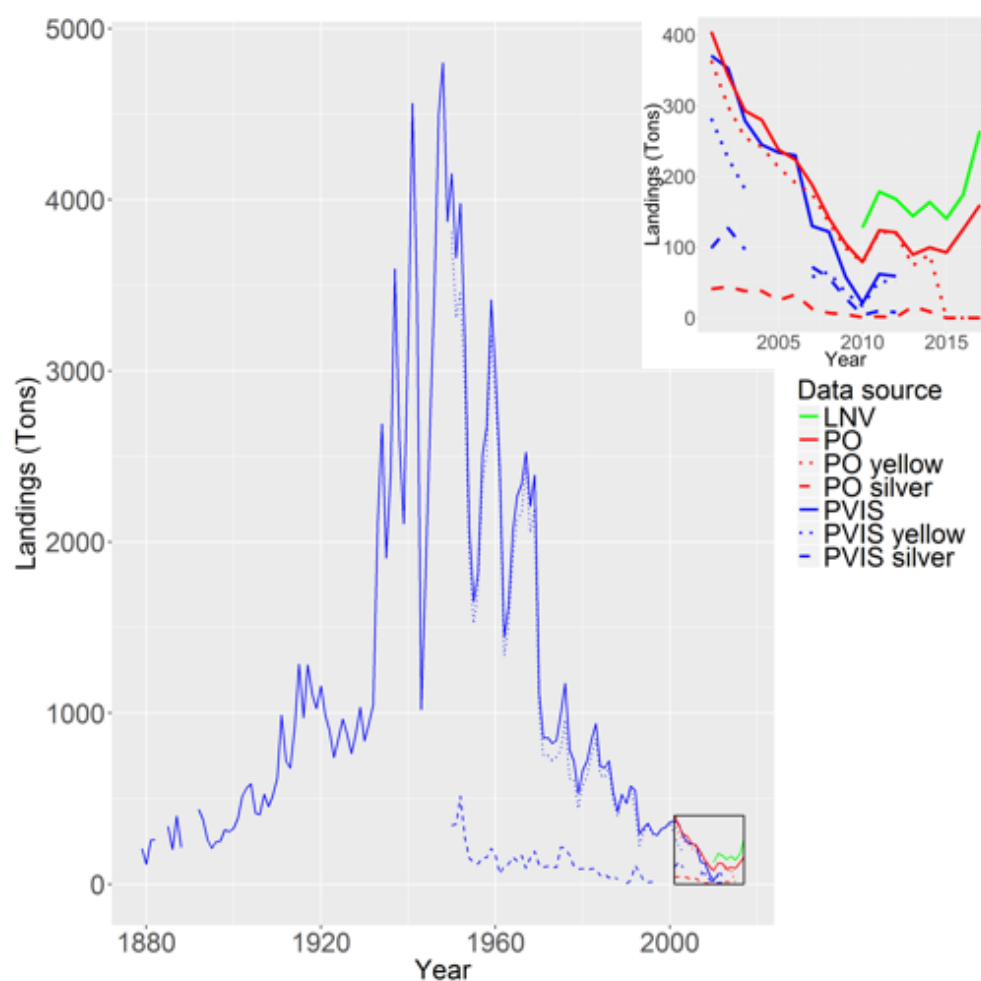


Figure 91). These statistics are broken down by species, month, harbour and main fishing gear. The quality of this information deteriorated considerably over the past decades, due to misclassification of gears, and the trading of eel from areas other than Lake IJsselmeer and Laker Markermeer at the IJsselmeer auctions. In the data from auctions around Lake IJsselmeer yellow and silver eel were reported separately, but data from recent decades (from early 1990s onwards) is unreliable: yellow eel from eel boxes and silver eel from all gears have been combined.

In addition, the fishers organisation (PO IJsselmeer) has kept records of the catches of their associated fish-

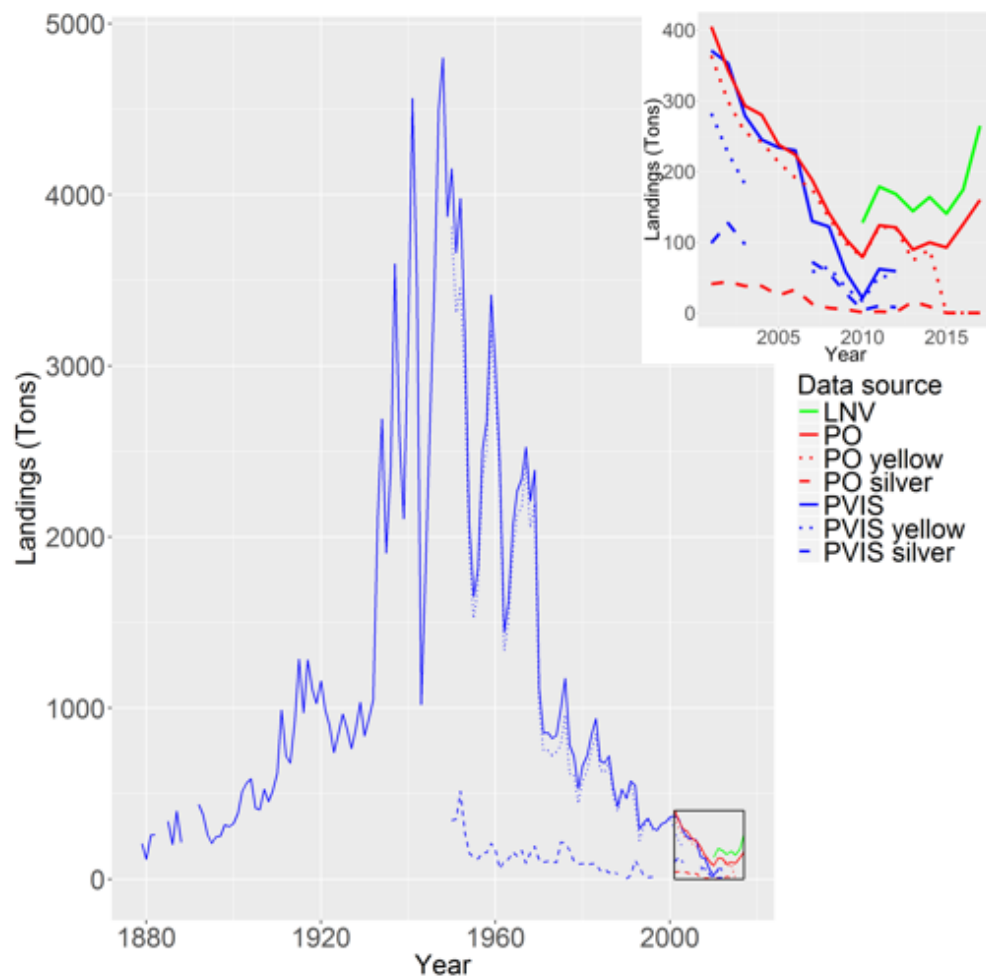


Figure 91).

An obligatory catch registration system was introduced in the Netherlands in January 2010 by the Ministry of Agriculture, Nature and Food quality (Ministry of LNV). Weekly catches of eel have been reported, but yellow eel and silver eel catches are combined in this program and no information on effort and gears have been reported. We regard these data from 2010 onwards as the best representative of the amount of eels actually caught and landed (Table 34).

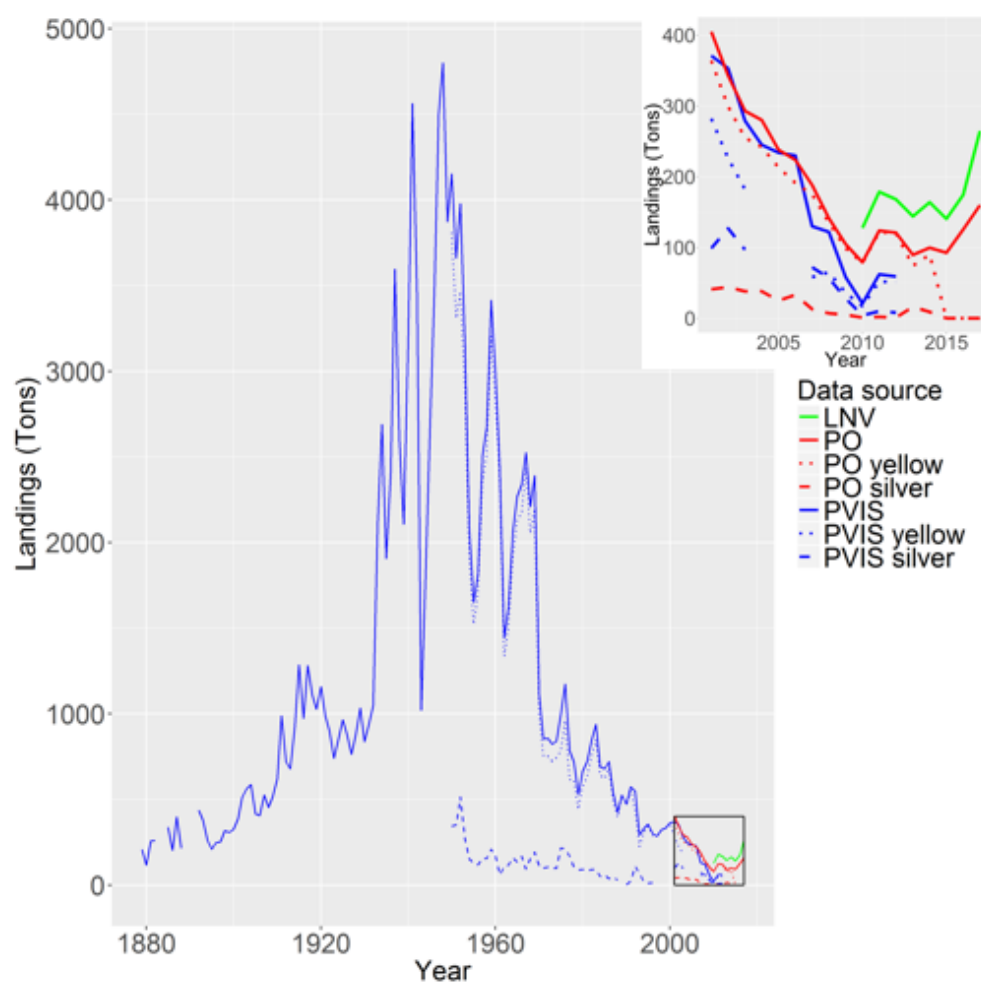


Figure 91. Time-series of landings of yellow eel, silver eel and yellow plus silver eel combined from Lake IJsselmeer/Markermeer at auctions. Source data: LNV, Productschap Vis and PO IJsselmeer.

Table 34. Total freshwater landings of yellow eel and silver eel combined in tons by year. Only landings recorded at the auctions are included; marine landings are reported in Table 33. Source: Ministry of Agriculture, Nature and Food quality (LNV).

Year	LNV
2010	442
2011	367
2012	350
2013	315
2014	317
2015	289
2016	303
2017	411

3.1.5.2 Recreational fishery

In 2009, an extensive Recreation Fisheries Program was started in the Netherlands. In December 2009, 50 000 households were approached during the screening survey to determine the number of recreational fishermen in the Netherlands (result 1.69 million recreational fishermen). In 2010, 2000 recreational fishermen were selected for a 12-month logbook programme (March 2010–February 2011). In this period in the Netherlands about 1 500 000 eels were caught by recreational fishermen, while about 500 000 eels were retained. (Van der Hammen and de Graaf, 2012). The program was repeated in 2012/2013 and in 2014/2015 (Van der Hammen and Van der Graaf, 2017).

In the period April 2014–March 2015, 2 156 000 eels were caught in freshwater of which 1 936 000 were released and 220 000 eels (30 tons) were retained. In marine waters, 440 000 eels were estimated to have been caught of which 247 000 were released and 193 000 were retained (40 tons) (Van der Hammen and de Graaf, 2017). In 2014, the 70 tons of landed eels (freshwaters + marine waters) made 1.77% of the total landings (Van der Hammen & de Graaf, 2017). The number of retained eels in inland waters decreased in 2014 compared to previous years while in marine waters this number fluctuates a bit more. The number of released eels increased in both inland and marine waters in 2014 compared to previous years.

Table 35. Recreational Fisheries: retained and released catches of eel (in numbers) in the Netherlands in inland and marine areas. Only estimated numbers from angling were available (Van der Hammen and de Graaf, 2013; 2015; 2017).

Year	Retained		Released		
	Inland	Marine	Inland		Marine
	Angling	Angling	Angling		Angling
2010	341,000	180,000	887,000		117,000
2012	313,000	91,000*	1,517,000		67,000*
2014	220,000	193,000	1,936,000		247,000

*data less accurate.

3.1.6 Silver eel fisheries

3.1.6.1 Commercial

Data on total landings of yellow and silver eel combined have been reported for IJsselmeer/Markermeer. Data from auctions around IJsselmeer did report yellow and silver eel separately, but information in recent years (early 1990s onwards) is unreliable: yellow eel from eel boxes and silver eel from all gears have been combined and labelled 'silver eel' (see van de Wolfshaar, 2018 for details). In addition, catches registered by the PO IJsselmeer from 2001 onwards do distinguish silver eel from other eel catches. However, some silver eel may still be reported among the catches of 'other eel'. Still, landings and catches of silver eel are included "as is" in the figure of yellow eel landings and catches (

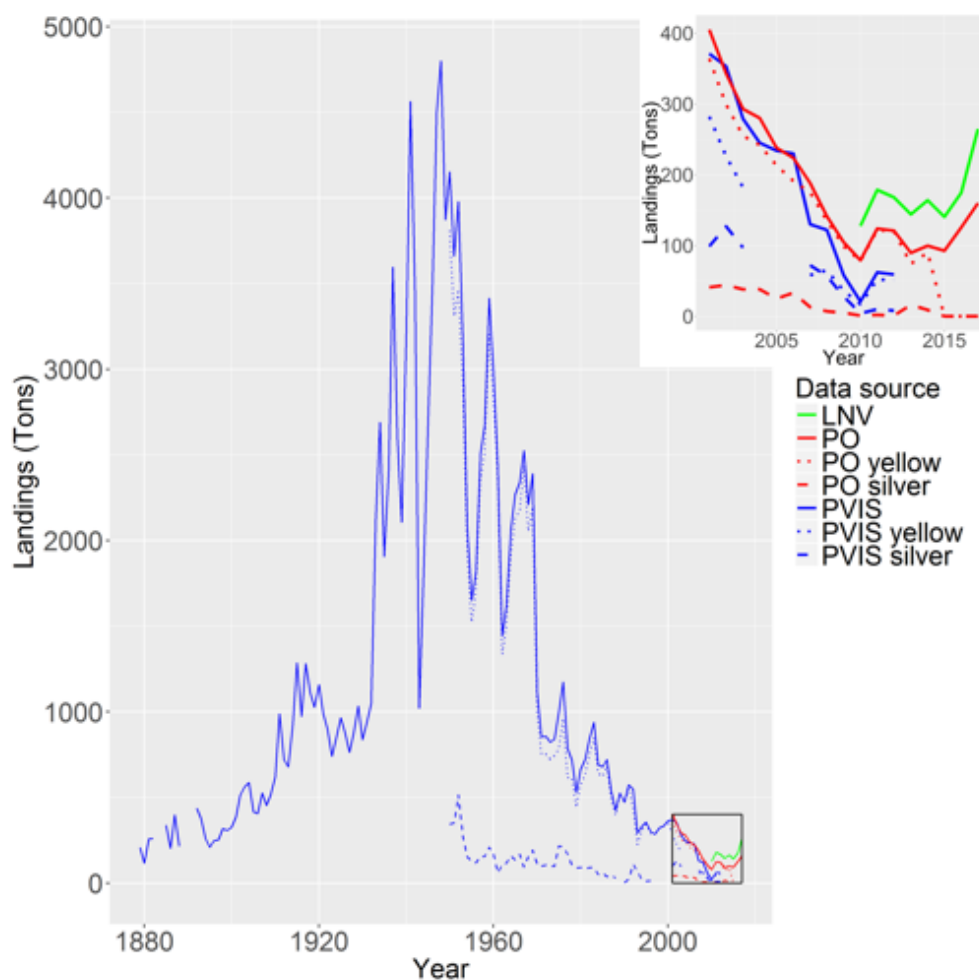


Figure 91). An obligatory catch registration system has been introduced in the Netherlands in January 2010 by the Ministry of Agriculture, Nature and Food quality (LNV). However, weekly catches of eel have been reported, but they consist of combined data for yellow eel and silver eel and no information on effort or gears have been reported.

3.1.6.2 Recreational

No data available, it is assumed that (migratory) silver eels are not feeding and will not be caught by anglers.

3.1.6.3 Marine fishery

The number of marine fishing vessels that have landed eel in the Netherlands consisted of 37 fishing vessels in 2017. Together, they landed 11 081 kg (11 tons, Table 33) of eel, which is similar to the landings of 2016 but more than twice as much compared to the years before. However, this number low compared to the landings of Lake IJssel (160 t for 2017).

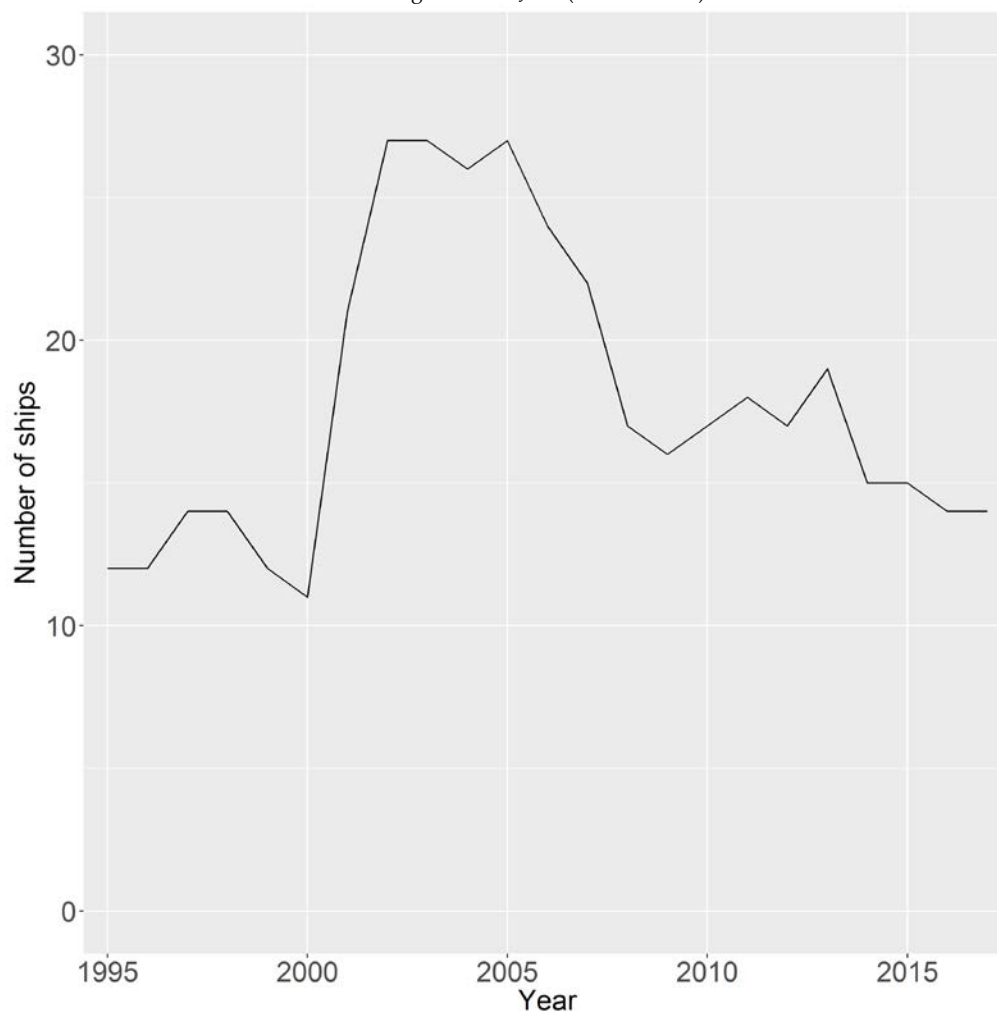


Figure 92 shows the number of vessels between 1995–2017 that 1) landed more than 1000 kg eel in total; 2) landed more than 10 kg on average; and 3) landed eel more than ten times eel in the Netherlands. This figure shows that the number of vessels that relatively often catch relatively large numbers of eel remained quite stable in the past decade.

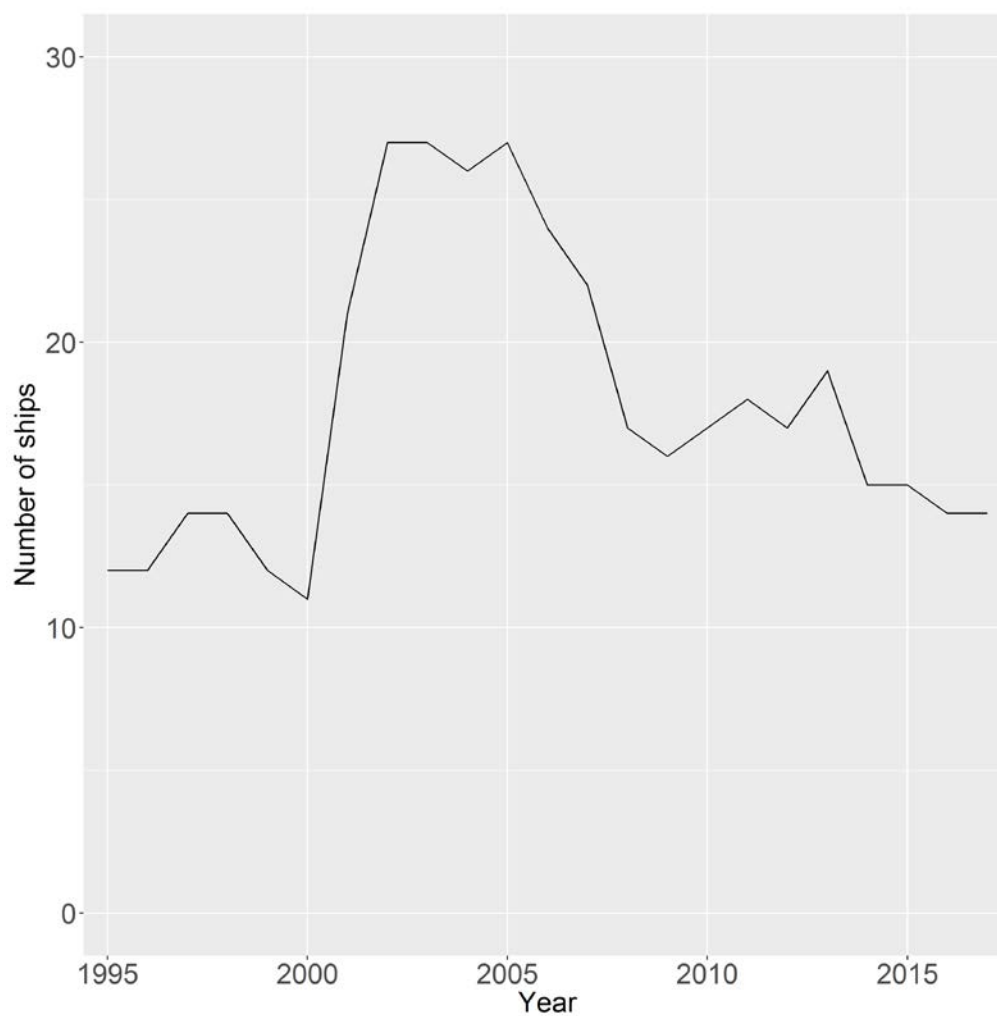


Figure 92. Number of vessels that, between 1995–2017 1) landed more than 1000 kg eel in total; and 2) landed more than 10 kg on average; and 3) landed eel more than ten times eel in the Netherlands from ICES areas 4.a, 4.b, 4.c, UNK, 7.a, 7.d and 8.b.

3.2 Restocking

3.2.1 Reconstructed time-series on stocking

No (historical) data available with regards to origin and whether or not stocked eels were quarantined, overall all stocked of glass eel (see

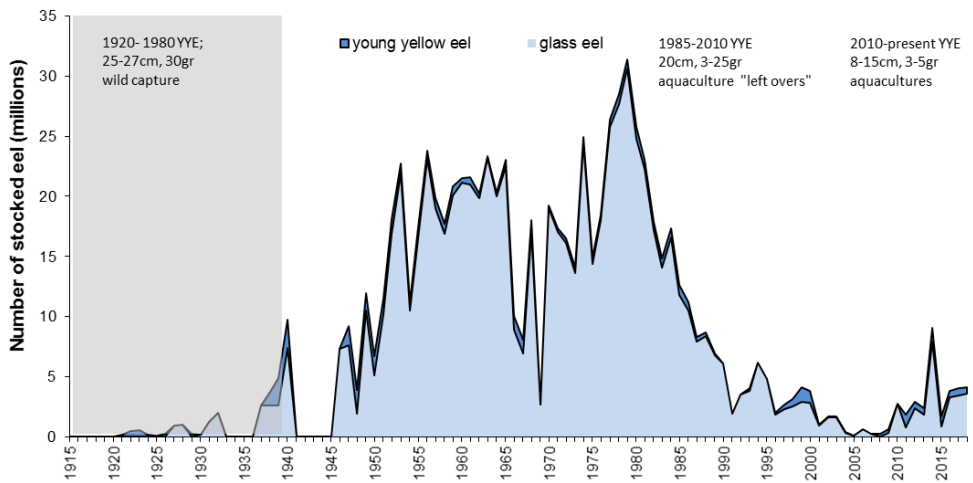


Figure 93) is sourced outside the Netherlands.

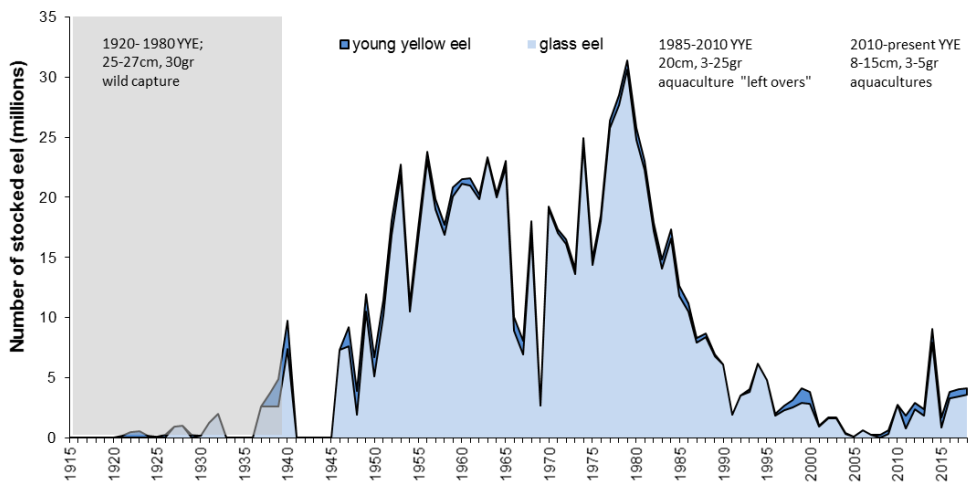


Figure 93. Overview of stocking of glass eel and young yellow eel in the Netherlands (1920–2017). Note that the average weight of stocked young yellow eel decreased from ~30 g to ~3 g between 1920 and 2010.

3.2.2 Amount stocked

The locations and numbers of eels stocked in 2018 in the Netherlands can be found in Table 36.

Table 36. Overview of glass eel and young yellow eel stocked in the Netherlands in 2018 (Source DUPAN).

	DATE	STOCKING LOCATION	ORIGIN	KG	N	N/KG
N	GLASS EEL					

1	23/03/2018	Friese boezem	France	480	1 517 000	3160
2	11/04/2018	Veerse Meer	France	175	658 000	3760
3	11/04/2018	Grevellingen	France	344	1 293 000	3759
4	11/04/2018	Zeeuws-Vlaanderen	France	29	109 000	3759
	TOTAL Glass eel			1028	3 577 000	
	YOUNG YELLOW EEL					
5	06/06/2018	Friese boezem	Glass eel from France (aquaculture in NL)	1442	517 000	359
	TOTAL young yellow eel			1442	517 000	
	TOTAL glass eel+yellow eel			2470	4 094 000	

3.3 Aquaculture

3.3.1 Seed supply

Table 37. Origin of glass eel used for aquaculture in the Netherlands since 2010. Numbers are rough estimates (Source DUPAN).

Year	France	Spain	England	Total (kg)
2010	4725	1890	135	6750
2011	5325	1350	100	6775
2012	5500	650	550	6700
2013	3400	250	1250	4900
2014	4400	500	300	5200
2015	5200		Few hundred*	5500
2016	5300	800	150	6250
2017	4690	900	300	5890
2018	5730	0	550	6280

*assuming 'a few hundred' to be 300 kg.

3.3.1.1 Production

The production of eels through aquaculture remains relatively stable over the past seven years (Figure 94).

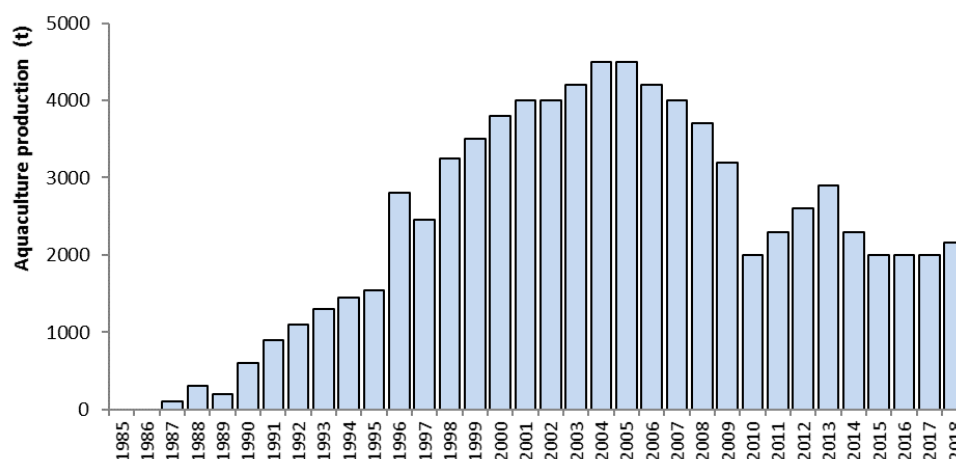


Figure 94. Trend in aquaculture production of yellow eel for consumption in the Netherlands. In 2018, the production was ~2155 t (rough estimate) (Source DUPAN).

3.4 Entrainment

A summary of the methods to estimate entrainment is given below, more information can be found in Van der Wolfshaar *et al.* (2018).

A conceptual model for silver eel migration was built, based on a hierarchy of waterbodies, which may provide a reasonable description of silver eel migration in The Netherlands. In this conceptual model, silver eels are split into three groups of starting origin, according to waterbody type. These three main waterbody types correspond to the three main hierarchy levels of waterbodies in The Netherlands:

- 1) 1st hierarchy (termed **'polder' waterbodies**): waterbodies which are below sea level and serviced by a large number of small pumping stations with often high levels of mortality during passage. In the model, each polder is serviced by a single pumping station (i.e. no multiple pumping stations in sequence). Pumping stations of coastal polders can pump water directly into the sea, in which case the silver eels that survive the passage of these sites are directly contributing to the silver eel 'escapement' out of the Netherlands. However, for most polders, pumping stations would discharge water into a waterbody of the 2nd hierarchy in our model ('boezem' waterbodies);
- 2) 2nd hierarchy (termed **'boezem' waterbodies**): waterbodies such as canals, small inland lakes (such as the Frysian lakes), but also smaller streams and rivers which are either connected directly to the sea or to large nationally managed waterbodies (the 3rd hierarchy of waterbody in the model; see below) via larger pumping stations and/or sluices;
- 3) 3rd hierarchy (termed **'national' waterbodies**): large nationally managed waterbodies such as sections of the main rivers and large lakes. Silver eels have been found to experience low levels of mortalities during passage of most of the barriers (because these are mainly discharge sluice complexes) in these large waterbodies. The exception are the passages of hydropower plants by eels that start their migration from upstream sections of the main rivers Rhine and Meuse. Both these sections hold a substantial biomass of silver eel (van de Wolfshaar *et al.*, 2018).

A key assumption in this model is that barriers within a hierarchical class, for example within polder waters, are never in sequence. Instead, sequential barrier mortality only

occurs when silver eels are transferred from one hierarchical class to another, for example from polder to boezem. This approach is thought to hold true in the majority of cases. However, there are some polder waters with two boezem layers, in which polder waters are pumped into an 'inner boezem' and subsequently pumped into an 'outer boezem' (which would be the second hierarchy in the model presented here).

Given the assessed mortality and transition rates, the percentage of silver eels (out of the total starting biomass) that is estimated to die during migration depends only on the proportional distribution of silver eel biomass over the different hierarchies of waterbodies. Instead, the biomass of silver eels that is estimated to die during migration will be dependent on the absolute biomass of all starting silver eel.

For the parameterisation of the barrier mortality model we use "net mortality rates" for barriers: the proportion of silver eels that ends up in front of that barrier multiplied by the proportion that dies during passage. If there is only one route available in passing a barrier, the mortality rate of this barrier can be multiplied by the number of silver eels that end up in front of the barrier. In our approach we consider blockage (i.e. silver eels that end up at barriers but are not passing), the same as mortality, since in both cases these silver eels do not contribute to the 'escapement' of silver eel to sea. In case an alternative route for migration through a pumping station or hydropower plant is available, such as a ship lock, sluice or fish pass, estimates of net mortality rates are typically lower than the proportion of silver eels that suffer mortality attempting to pass the pumping station or hydropower plant.

3.4.1 Mortality rates and transition from polder to boezem or the sea

Silver eel migrating from the polders to the boezem waters will encounter pumping stations. There are direct and indirect effects of pumping stations on silver eel migration. In the first place, pumping stations can cause damage and direct or delayed mortality in eel when passing through a pump. Second, a pumping station may function as a barrier for eel, both during upstream and downstream migration.

Pumping stations can roughly be divided into three groups: 1) water wheels, 2) Archimedes screws, and 3) pumps [centrifugal pumps (radial water flow); propeller-centrifugal pumps (radial/axial water flow), propeller pumps (axial water flow)]. Based on literature, mainly studies conducted in the Netherlands and Belgium, propeller pumps have the highest mortality (Table 38); these type of propeller pumps are the most common type used to regulate water levels.

For the 1st hierarchy 'polder waters', average densities per polder area and an overall estimate of mortality rate based on the national distribution of types of pumping stations and estimated mortality rates were used to provide an overall estimate of escapement from polders to sea, and to the 2nd hierarchy of boezem waters. From polder waters to boezem waters or to the sea: a best guess estimate of 35% mortality was used. Regionally, the starting biomass and mortality rates will be different from the average, but for the purpose of estimating a national mortality rate, this generic approach for the 1st hierarchy will largely level out.

Transition rates between the three hierarchies of waterbodies (and the sections of river upstream of the hydropower plants) are needed to complete the model. The majority of polders (except some coastal polders) are thought to have pumping stations that discharge water into the boezem rather than to the sea. We estimated (best guess) that 20% of the eel in polder waters is transferred directly from polder to sea, whereas the remainder (80%) is transferred to boezem waters where additional mortality due to barrier passage might occur.

Table 38. Calculation of the average pumping station mortality used to estimate silver eel mortality during migration.

Pump type	Proportion	Average mortality* (%)	Weighted Mortality (%)
Water wheel	0.002	0	0
Archimedes screw	0.27	12	3.2
Centrifugal pump	0.14	12	1.8
Propeller-centrifugal pump	0.05	9	0.4
Propeller pump	0.55	56	29.3
Pump Mortality (estimate used in Yellow Eel Model)			~35%

* Mortality is % dead + 0.5 % damaged.

3.4.2 Mortality rates from national waterbodies to sea, and hydropower stations

The mortality estimates for silver eel migrating from boezem to national waters are based on an inventory of the main migration barriers for silver eel migrating from the Netherlands (Winter *et al.*, 2013a and 2013b), which was updated for changes and input from water boards during 2013–2017 for this evaluation study.

Given the mortalities of barriers weighted by the amount of silver eel per barrier relative to the total amount of silver eel, the overall estimated mortality is 6% for passage to the sea and 14% for passage to national waters.

3.4.3 Mortality rates from national waterbodies to sea, and hydropower stations

The approach for barrier mortality estimation for national waters is also based on the inventory of Winter *et al.* (2013a, 2013b) and updated for the period 2013–2017 as described above for the barriers in boezem waters.

Given the mortalities of barriers weighted by the amount of silver eel per barrier relative to the total amount of silver eel, the overall estimated mortality from national waters to the sea (excluding hydropower stations) is 0.5%.

3.4.4 Migration mortality

Based on the distribution and mortality estimates reported above, the model scheme can be filled with a best guess mortality scenario Figure 95.

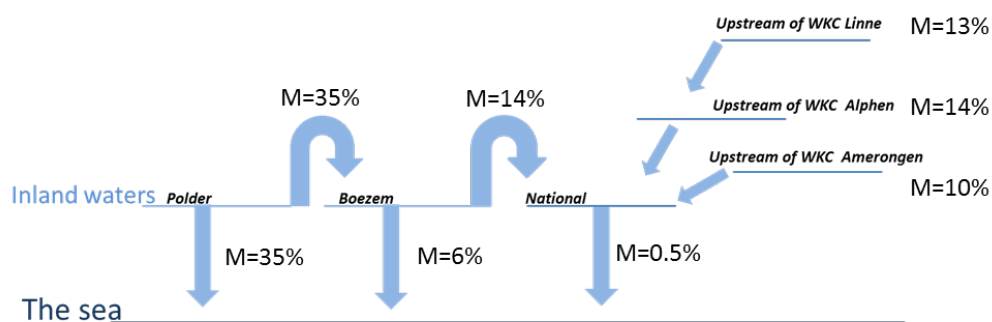


Figure 95. Migration mortality scheme, used to estimate overall migration mortality of silver eel. 'WKC' = hydropower station (Dutch: 'waterkrachtcentrale').

3.5 Habitat quantity and quality

General information on habitat quantity is mentioned in paragraph 0 and in Van de Wolfshaar *et al.* (2018). A summary of the impact of entrainment in the different habitats can be found in Table 31.

3.6 Others

3.6.1 Assisted migration of silver eel

Since 2011 several (pilot)projects have started at migration barriers (pumping stations) to assist the migration of silver eel (programme 'Paling Over De Dijk', PODD). In 2011 0.54 t of silver eel was caught and released again past barriers at four sites ('assisted migration'). In 2017, about 7.5 t was caught and released (Figure 96).

However, the mortality rate of silver eel passing the selected barriers has been assessed at moderate to low (Bierman *et al.*, 2012; Winter *et al.*, 2013a). Thus, the net amount of eels saved by the assisted migration is much lower than the amount caught and released. In 2013 the barriers for silver eel were prioritised (Winter *et al.*, 2013a) to improve the selection and efficiency of assisted migration initiatives. Applying location-specific mortality rates, the net amount of 'saved' eels in 2017 was almost 2 t (Figure 96). Rates of 50% mortality were used for unknown locations (Van der Wolfshaar *et al.*, 2018).

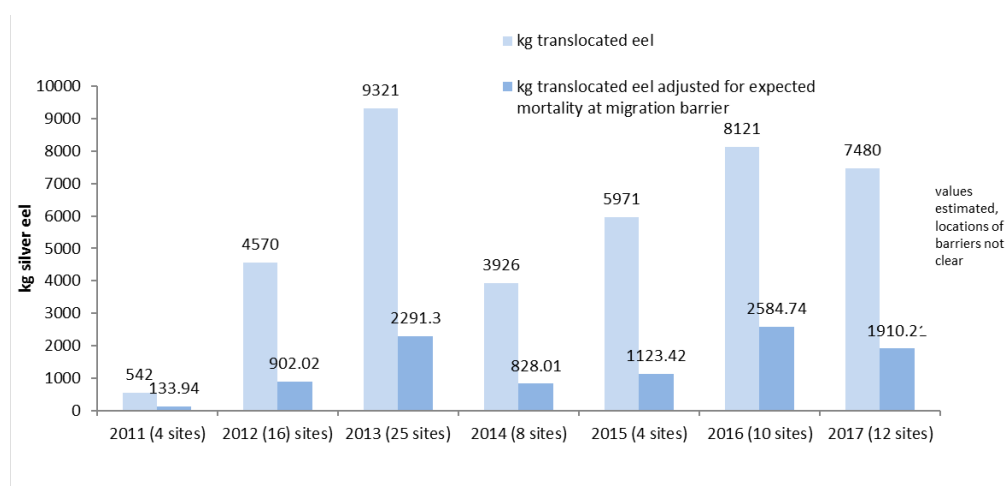


Figure 96. Overview of the "gross" and "net" amount of silver eel assisted over migration barriers in the Netherlands (2011–2017).

3.6.2 Illegal, unreported and unregulated (IUU) fishing

The task of adherence to rules and regulations pertaining to eel fishery is carried out by the Netherlands Food and Consumer Product Safety Authority (NVWA). Following indication of illegal eel fishing in 2012, they intensified their monitoring in 2013. In 2015 in total 202 fishing gears associated with illegal eel fishing were seized, this number decreased in 2016 to 80 and the number seized gear in 2017 was 24 (Table 39). The NVWA does not record weights of illegal catches.

Table 39. Overview of suspected causes of illegal fishing activities in the Netherlands (2017). Number of cases per cause per area. Weights of illegal catches are not known (Source: NVWA).

CAUSE	IJSSELMEER	MARKERMEER	ZUID-HOLLAND	NOORD-HOLLAND	FRIESLAND	ZEELAND	TOTAL
1. Fishing out of the season				1			1
2. Fishing without licence	4	1	1	1			7
3. Fishing using illegal gears	2	5		1	1	7	16
4. Retention of eel below size limit							
5. Illegal selling of catches							
6. Fishing in closed areas							
TOTAL							24

4 National stock assessment

4.1 Description of method

Methods are described in Van de Wolfshaar *et al.* (2018) and in Van der Sluis *et al.* (2016). The status of the Dutch eel population in the framework of the Dutch Eel Management Plan is assessed every three years. The latest report is Van de Wolfshaar *et al.* (2018).

4.1.1 Data collection

Glass eel monitoring				
Gear	Location	Frequency	Time	Period
liftnet (1x1m; mesh 1x1mm)	Den Oever	daily	8 hauls, one every hour between 22:00–5:00	~Mar–May
liftnet (1x1m; mesh 1x1mm)	eleven other locations along the coast	weekly	3 hauls at night-time	~Mar–May

Silver eel monitoring				
Gear	Location	Frequency	Time	Period
Fykes (5 sites)	Rhine, Den Oever, Kornwerderzand, Noordzeekanaal, Nieuwe waterweg	continuous	weekly	Sep–Nov
Fykes (4 sites)	Waal, IJssel, Meuse, Lek	every three years	weekly	Sep–Nov

Passive monitoring program: Main rivers and Lake IJsselmeer			
Gear	Location	Frequency	Period
Fykes (4) (stretched mesh 18–20 mm)	Veerse Meer, Haringvliet (North Sea)	continuous	Dec–Aug
Fykes (number depends on location. (stretched mesh 18–20 mm)	five locations in main rivers, estuaries and lakes: Rhine, Den Oever, Kornwerderzand, Noordzeekanaal, Nieuwe waterweg,	continuous	Mar–May
Fykes (number depends on location. (stretched mesh 18–20 mm)	Waal, IJssel, Meuse Lek	every three years	Mar–May

Due to closure of the eel fishery in polluted areas, this program, which started in the 1990s, has been interrupted. Almost two thirds of the sampling locations were located in the polluted areas and sampling ceased on 1 April 2011. Only the locations Veerse Meer and Haringvliet remained. An alternative program to study diadromous fish started in 2012.

Active monitoring program: Main rivers			
Gear	Location	Frequency	Period
Bottom trawl (channel; 3 m beam; 15 mm stretched mesh)	~35 waterbodies (rivers, lakes and estuaries)	10 min trawl, ~1000 m transect	spring and/or fall
Electrofishing (shore area)	35 waterbodies (rivers, lakes and estuaries)	20 min, 600 m transect	spring and/or fall

4.1.1.1 Sampling commercial catches

Area	Sampling frequency	No. of fishers sampled	Gear
Fryslan	Twice	2	Fykes
Hollands Noorderkwartier	Twice	2	Fykes
Rijnland	Twice	1	Fykes
Veluwe Randmeren	Twice	1	Train fyke
Noorderzijlvest	Twice	1	Fykes
Brabantse Delta	Twice	1	Train fyke
Hunze en Aa's	Twice	1	Fykes
Zuiderzeeland	Twice	1	Fykes
Stichtse Rijnlanden	Once	1	Fykes
Lake IJsselmeer	Twice	1	Train fyke
Lake IJsselmeer	Once	2	Train fyke
Lake IJsselmeer	Twice	2	Large fyke
Lake IJsselmeer	Once	3	Large fyke
Lake IJsselmeer	Twice	2	Longlines
Lake IJsselmeer	Once	1	Longlines
Lake Markermeer	Twice	1	Large fyke
Parameter		Sample details	
No. eels for length–frequency		max. 150 eels per sample	
No. eels for biology (sex, life stage, parasites)		< 50 cm: four eels per 10 cm size class ≥ 50 cm: two eels per 10 cm size class	
Period		May–August	

4.1.2 Analysis

The national stock assessment methodology is described in Van de Wolfshaar *et al.* (2018).

4.1.2.1 Age and growth increment analysis

Since 2010, age readings have been obtained annually of ~300 otoliths, which were collected from eels in different areas of the Netherlands. From 2014 onwards, ~50 otoliths were obtained annually and sent to the Swedish University of Agricultural Sciences (SLU) in Sweden. The number of annuli were counted to determine the age of individuals (“crack and burn” method). Furthermore, distances between consecutive annuli were measured using image analysis software to determine growth increments.

4.1.2.2 Life stages

Life stages (yellow, silvering, silver) are visually determined based on colouration of body and fins and eye diameter. Criteria for life stages are at present not formally described.

4.1.2.3 Sex determinations

Sex is determined by macroscopic examination of the gonads.

4.1.3 Reporting

Van de Wolfshaar *et al.* (2018) report on the status of the eel population in the periods 2005–2007, 2008–2010, 2011–2013 and 2014–2016.

4.1.4 Data quality issues and how they are being addressed

A summary of the data quality issues is given below, for more details see van de Wolfshaar *et al.* (2018).

4.1.4.1 Pristine silver eel biomass (B_0)

The B_0 value for inland waters in the Netherlands is set at 10 400 t. However, the value has a wide range (6500–20 250 t, inland waters $B_0 = 10 400$ t, range 5200–16 200 t). In addition, this range has been subject to discussion. Initially the pristine silver eel biomass (B_0) in the Netherlands, was set at 10 000–15 000 t (Klein Breteler, 2008). In a review it was concluded that B_0 was between 6500–20 250 t (Eijsackers *et al.*, 2009). However, ICES (review of the national eel management plans, ICES, 2010) did not accept all arguments of Eijsackers *et al.* (2009) and set B_0 at 13 000 t. A second review of B_0 values for the Netherlands concluded that the method to calculate B_0 was fundamentally of good quality with respect to adhering to the guidelines set by the Eel Regulation (Rabbinge *et al.*, 2013).

4.1.4.2 Anthropogenic mortality (B_{best} , $B_{current}$ and LAM)

The estimates for lifetime anthropogenic mortality (LAM) is set by the values of B_{best} and $B_{current}$. These values are uncertain due to the following main assumptions that influence $B_{current}$:

- the efficiency of the electrofishing gear;
- distribution of eel over the surface of a waterbody in the static spatial population model;
- assumptions of F when estimating eel populations using the demographic population model for some of the larger lakes.

4.1.4.3 Unquantified sources of anthropogenic mortality

The estimated lifetime anthropogenic mortality is most likely an *underestimate* of the true anthropogenic mortality because some sources of mortality have not been quantified:

- poaching;
- yellow eel mortality in hydropower plants and pumping stations;
- impact of (human-induced) viruses, parasites and pollution.

4.2 Assessment results

Current biomass of escaping silver eel ($B_{current}$)

Between 2005–2007 and 2008–2013, there was a modest decrease in the biomass of escaping silver eel while between 2008–2013 and 2014–2016 there was a modest increase ($B_{current}$, Table 40). Large differences between years in biomass were not expected as current silver eel escapement has largely been determined by processes (recruitment, anthropogenic mortality) that occurred in the previous 5–15 years. Furthermore, an increase in glass eel recruitment will, at the earliest, result in an increase of silver eel after 5–15 years, and glass eel recruitment has not significantly increased after the implementation of the EMP in 2009. Moreover, the total silver eel biomass depends not only on the status of the Dutch part of the eel stock, but also on the stock status in the other Member States.

Current best possible biomass (B_{best})

The current best possible biomass decreases between 2005–2007 and 2008–2013, while between 2008–2013 and 2014–2016 there was a modest increase (B_{best} , Table 40).

Lifetime Anthropogenic Mortality (LAM)

A reduction in Lifetime Anthropogenic Mortality (LAM) can be achieved by reducing fishing mortality and barrier mortality. A reduction in anthropogenic mortality is therefore the direct result of the measures taken by a Member State. In the Netherlands, the implementation of the EMP has resulted in a reduction in LAM between 2005 and 2016 from 81% to 48%. In each three year period, a reduction was achieved (Table 40). This reduction was mainly the result of a decrease in fishery mortality, both commercial and recreational: retained catches (landings) of both commercial and recreational fishery strongly decreased between 2005–2007 and 2014–2016.

Table 40. Stock indicators used to evaluate the impact of the EMP on the biomass of escaping silver eel (horizontal axis modified precautionary diagram) and anthropogenic mortality (vertical axis modified precautionary diagram).

Stock Indicator	2005–2007	2008–2010	2011–2013	2014–2016
B_0^*	10 400 t	10 400 t	10 400 t	10 400 t
$B_{current}$	1049 t	816 t	867 t	1365 t
B_{best}	5619 t	2445 t	2123 t	2547 t
% escaping Silver Eel ($100 * B_{current} / B_0$)	10%	8%	8%	13%
LAM	81%	67%	59%	48%

* Excluding coastal waters (2600 t).

5 Other data collection

5.1 Recruitment time-series

5.1.1 Fishery-independent

Recruitment of glass eel in Dutch waters is monitored at 12 other sites along the coast (

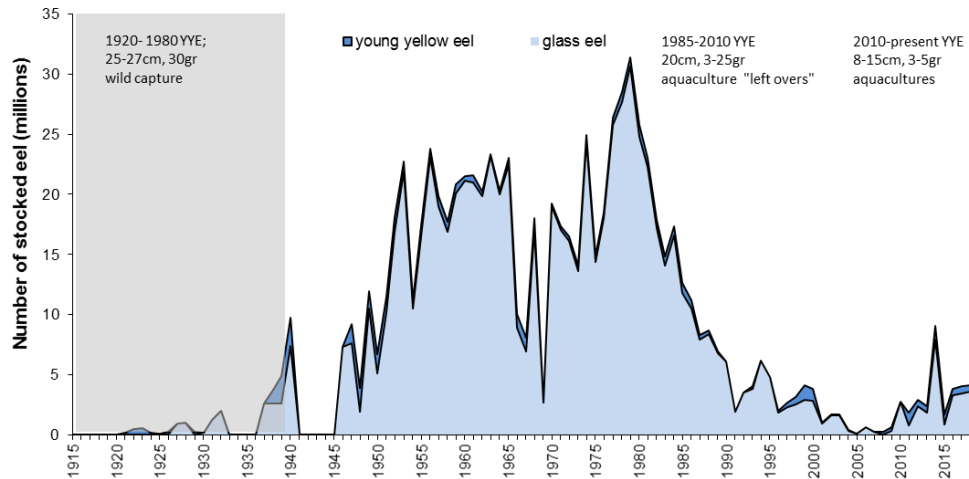


Figure 93; see Dekker (2002) for a full description). In Den Oever (

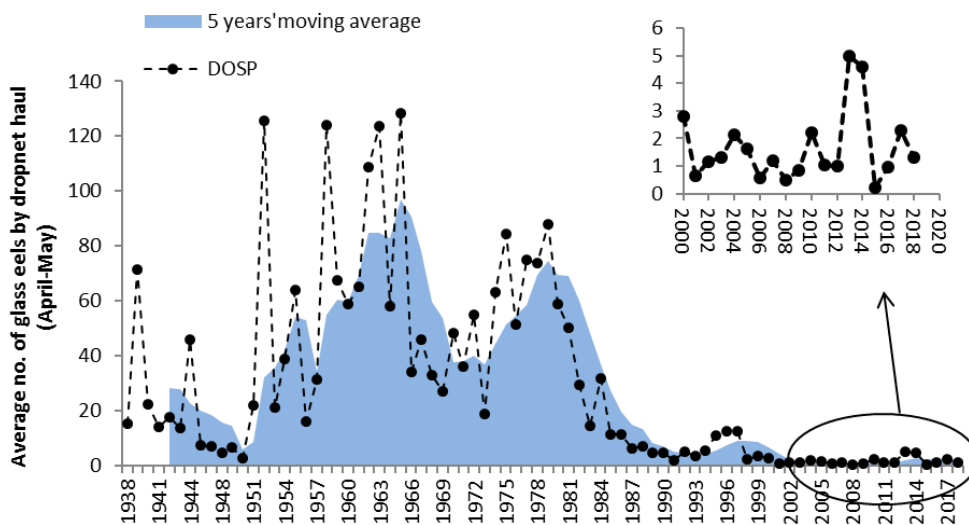


Figure 98, Table 41) recruitment significantly increased in 2013–2014 and was at the highest level since the mid-1990s. However, overall the recruitment levels were still low compared to the reference period (1960–1979) and in 2015 recruitment level reached a historic low. After a slight increase in 2016, in the past three

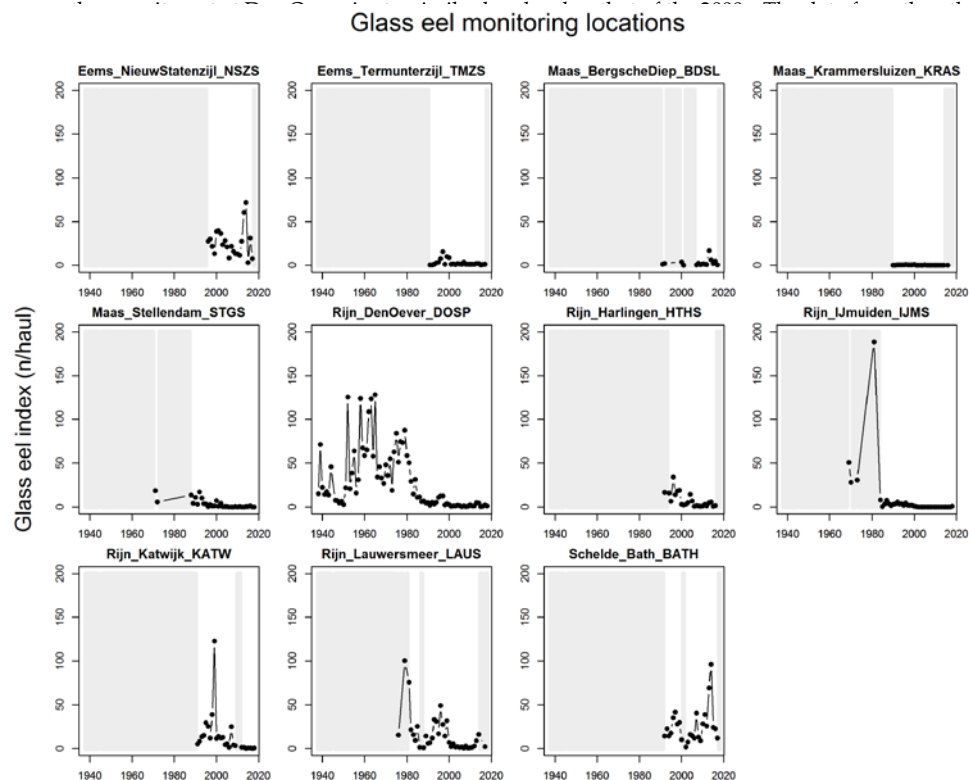


Figure 99) confirmed the overall trend of Den Oever, though individual series may deviate (e.g. recruitment at location IJmuiden was relatively high this year). Glass eel data are presented as the average number of glass eels per haul in the months April and May, between 18:00-8:00 and only years with >5 hauls are included (details in Griffioen *et al.*, 2017).



Figure 97. Locations of glass eel monitoring in the Netherlands.

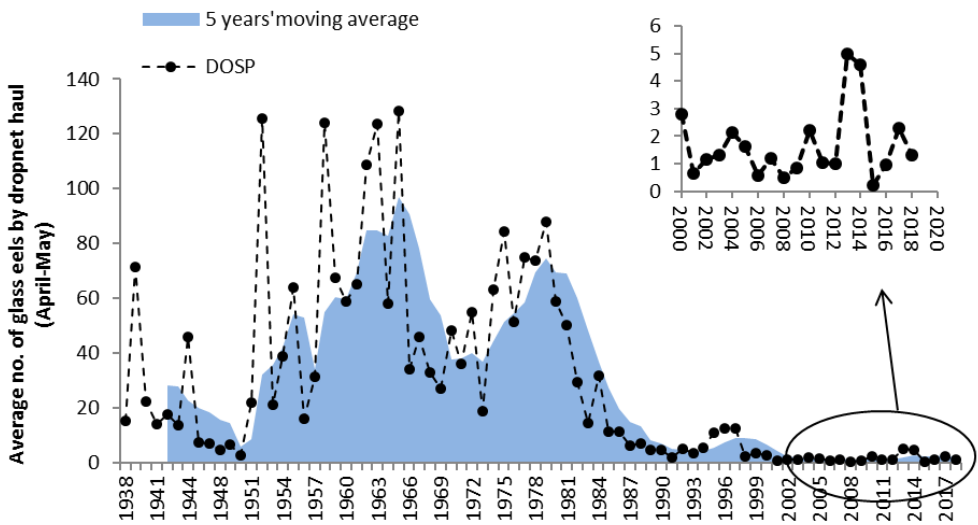


Figure 98. Trend indices (mean number per haul in April and May) of glass eel recruitment at Den Oever (1938–2018).

Table 41. Average number of glass eel caught per lift net haul at the sluices in Den Oever in the period April–May.

Decade	1930	1940	1950	1960	1970	1980	1990	2000	2010
Year									
0		22.4	2.7	58.9	48.1	59.0	4.9	2.8	2.2
1		14.3	21.9	65.2	36.1	50.4	1.8	0.6	1.1
2		17.5	125.6	108.9	55.0	29.4	5.2	1.2	1.0
3		13.7	21.1	123.7	18.8	14.7	3.5	1.3	4.9
4		46.1	38.8	58.1	63.0	31.6	5.4	2.1	4.6

5	NA	64.1	128.3	84.3	11.2	11.1	1.6	0.2
6	7.5	16.1	34.0	51.4	11.4	12.5	0.6	1.0
7	7.2	31.3	45.8	75.0	6.2	12.6	1.2	2.3
8	15.3	4.8	124.0	32.9	73.6	7.0	2.5	1.3
9	71.5	6.6	67.6	27.1	87.7	4.8	3.7	0.9

Table 42. Average number of glass eel caught by dropnet hauls after sunset, before sunrise in the period April–May at 12 sites in the Netherlands (1979–2018). If five or less hauls were carried out, data are not presented. Data are visualised in

Glass eel monitoring locations

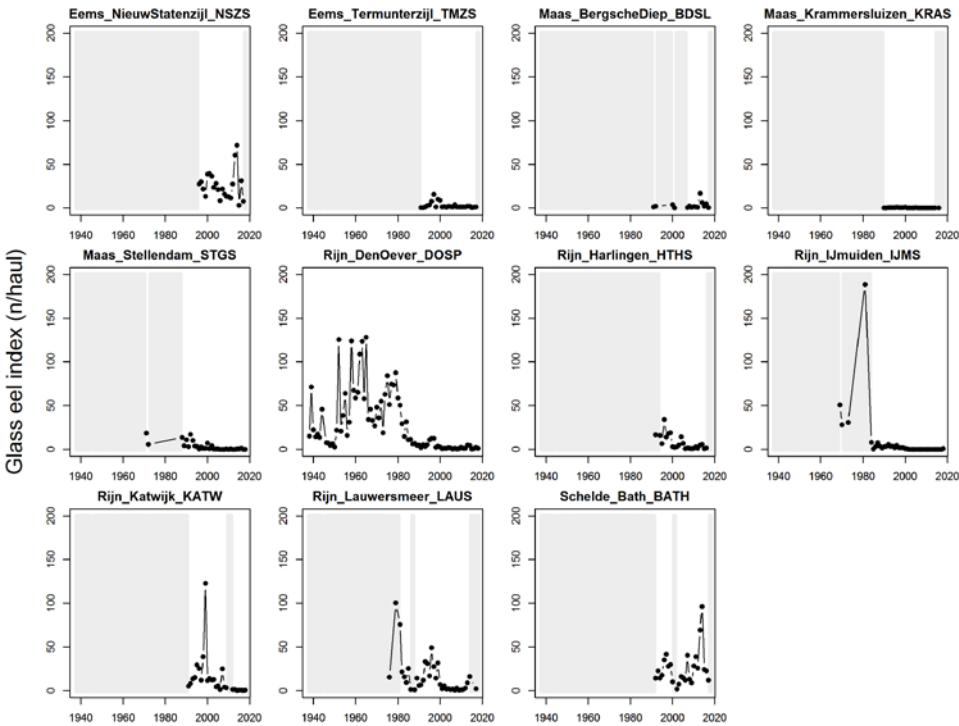


Figure 99.

YEAR	Schelde_Bath_BATH	Maas_BergscheDiep_BDSL	Maas_Krammersluizen_KRAS	Maas_Stellendam_STGS	Rijn_DenOever_DOSP	Rijn_Harlingen_HTHS	Rijn_IJmuiden_IJMS	Rijn_Katwijk_KATW	Rijn_Lauwersmeer_LAUS	Eems_NieuwStatenzijl_NSZS	Eems_Termunterzijl_TMZS
1979					87.7		222.3		100.4		
1980					59.0						
1981					50.4		188.7		75.9		
1982					29.4				21.6		
1983					14.7				15.8		
1984					31.6		8.1		9.5		
1985					11.2		0.6		25.2		
1986					11.4		3.3		1.3		
1987					6.2		7.7				
1988				13.8	7.0		4.0		1.0		
1989				4.4	4.8		1.5		14.3		
1990			0.3	10.9	4.9		3.2		6.0		
1991		1.3	0.2	3.1	1.8		3.6	5.1	6.6		0.5
1992	14.5	2.2	0.4	16.9	5.2	16.7	5.8	8.1	12.1		0.6
1993	22.7		0.4	10.1	3.5		3.3	13.5	33.2		1.2
1994	14.2		0.5	4.0	5.4	16.0	4.0	15.1	31.0		2.8
1995	17.8		0.4	3.3	11.1	6.6	2.0	29.7	16.9		3.7
1996	35.3		0.7	0.5	12.5	34.2	4.5	25.3	49.4	27.5	7.7
1997	41.6		0.6	2.8	12.6	14.0	1.8	12.3	27.8	30.0	15.6
1998	28.2		0.6	1.0	2.5	18.3	2.0	38.8	14.4	21.8	1.4
1999	29.7		0.5	1.2	3.7	19.1	1.9	122.7	31.7	13.5	10.1
2000	10.2	3.8	1.0	7.1	2.8	2.9	0.7	11.6	7.2	38.8	8.7
2001		0.1	0.1	1.0	0.6	2.3	0.5	14.1	2.4	39.7	1.1
2002	1.9		0.2	4.2	1.2	3.2	0.1	12.3	5.5	36.4	1.6
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

YEAR	Schelde_Bath_BATH	Maas_BergscheDiep_BDSL	Maas_Krammersluizen_KRAS	Maas_Stellendam_STGS	Rijn_DenOever_DOSP	Rijn_Harlingen_HTHS	Rijn_Ijmuiden_IJMS	Rijn_Katwijk_KATW	Rijn_Lauwersmeer_LAUS	Eems_NieuwStatenzijl_NSZS	Eems_Termunterzijl_TMZS
2015	24.2	2.2		0.2	0.2	1.0	0.1	0.6		3.0	0.4
2016	22.8	4.7	0.0	1.0	1.0	1.5	0.0	0.7		31.1	0.8
2017	12.2	0.5		0.1	2.3		0.0	0.4	2.3	7.6	1.4
2018				0.2	1.3		0.7	0.8	1.2		

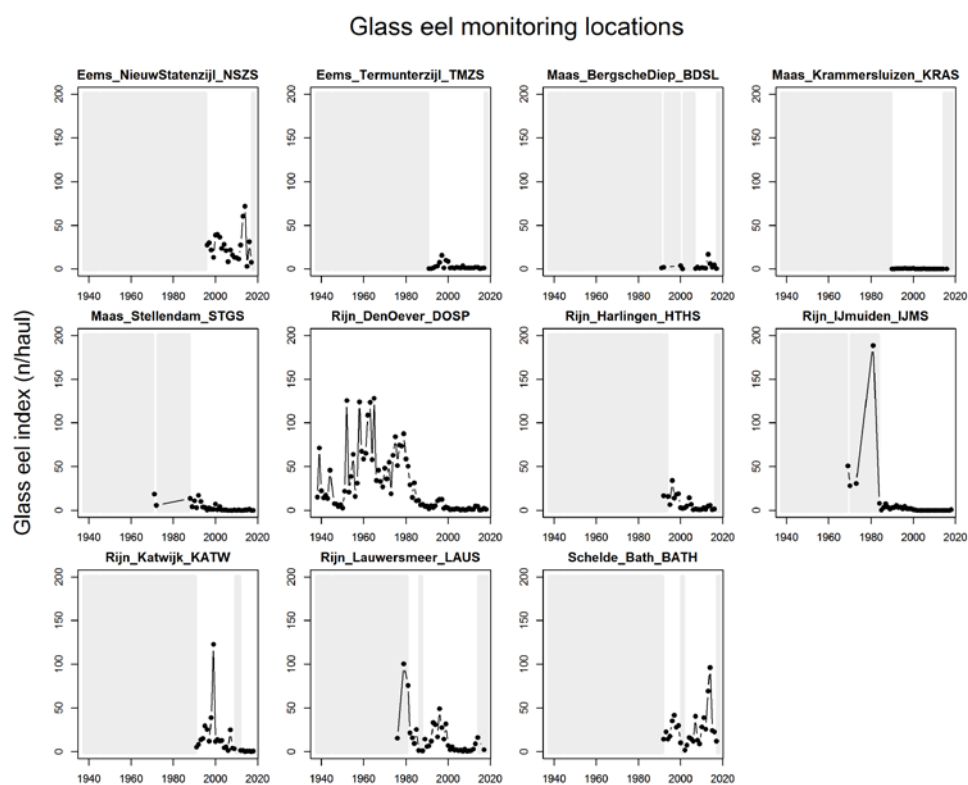


Figure 99. Time-series of the glass eel indices (data of Table 42). Grey = not sampled (data Wageningen Marine Research).

5.2 Yellow eel abundance surveys

No data available.

5.2.1 Recreational

No data available.

5.2.2 Fishery-independent

One of the few long time-series for eel is the fyke monitoring at NIOZ (Den Burg, Texel; van der Meer *et al.*, 2011) (Figure 100). This dataset shows a familiar pattern of a steep decline in abundance since the 1980s.

In the past almost all catches were yellow eel, based on their length. More recently, the catches also comprise silver eel (source: NIOZ). In 2016, 16 eel were caught within a period of 116 fyke days.

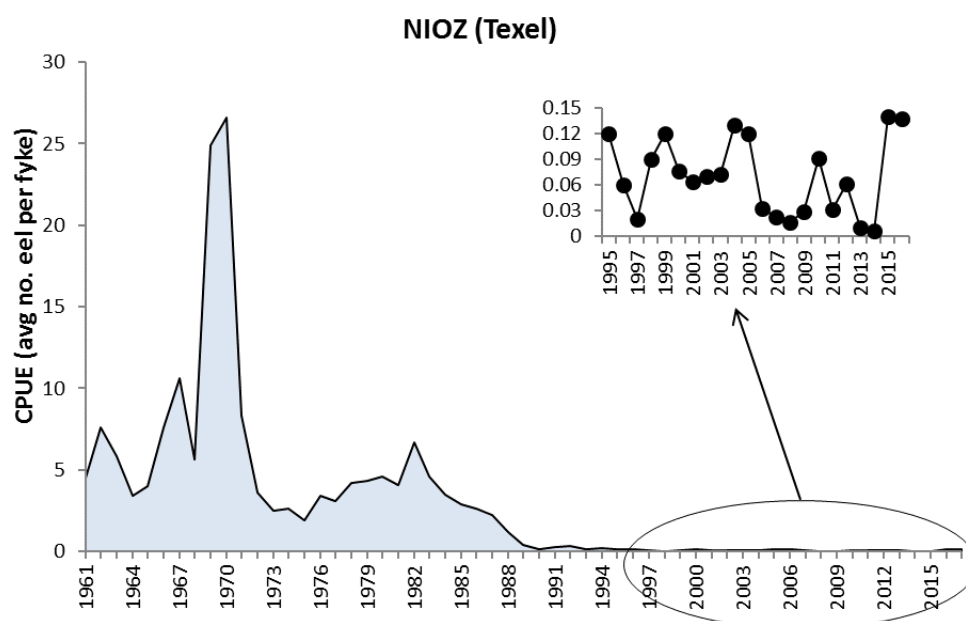


Figure 100. Time-series of the mean catch per fyke (numbers) of yellow eel at NIOZ 1960–2017 (data Van der Meer *et al.*, 2011 and NIOZ).

5.2.2.1 Lake IJsselmeer/Markermeer (active gear)

Figure 101 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.

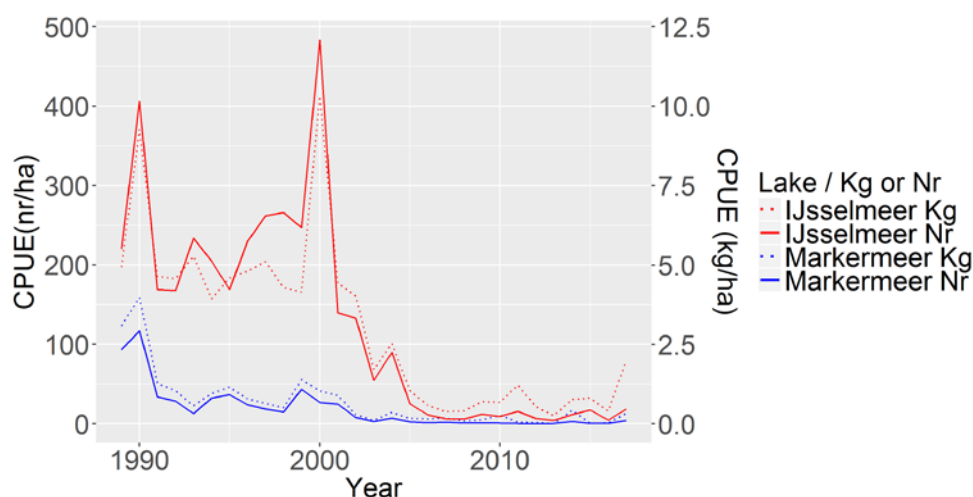
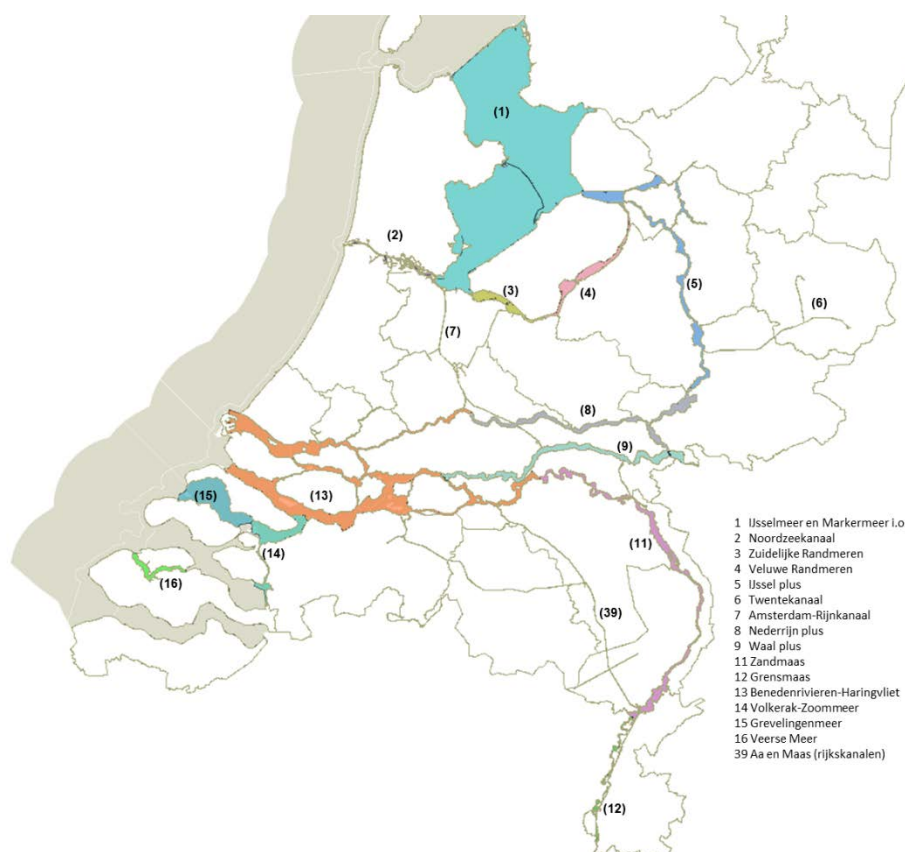


Figure 101. Cpue trends in Lake IJsselmeer stock surveys (N/ha and kg/ha), using the electrified trawl. Note: The northern and southern compartments (IJsselmeer and Markermeer resp.) have been separated by a dyke since 1976 (data: Wageningen Marine Research).

5.2.2.2 Main rivers (active gear)

A selection of data collected from 1999–2017 was made over five so-called “VBC-areas” (



). VBC areas were selected when annual monitoring data were collected for 12 years or more. Figure 103 shows the trends in cpue for the annual (yellow) eel surveys in these five VBC areas collected by electrofishing. Due to the large differences between cpues in the different VBC-areas, the selected VBC-areas were not combined in one graph. Cpues tend to fluctuate strongly over the past two decades with a notable decrease

during the latter part 2000s (except for VBC 12). From 2011 onwards, there seems to be an increasing in some VBC-areas although for some VBC-areas a notable increase did not occur until 2017.



Figure 102. Map of VBC areas in the Netherlands.

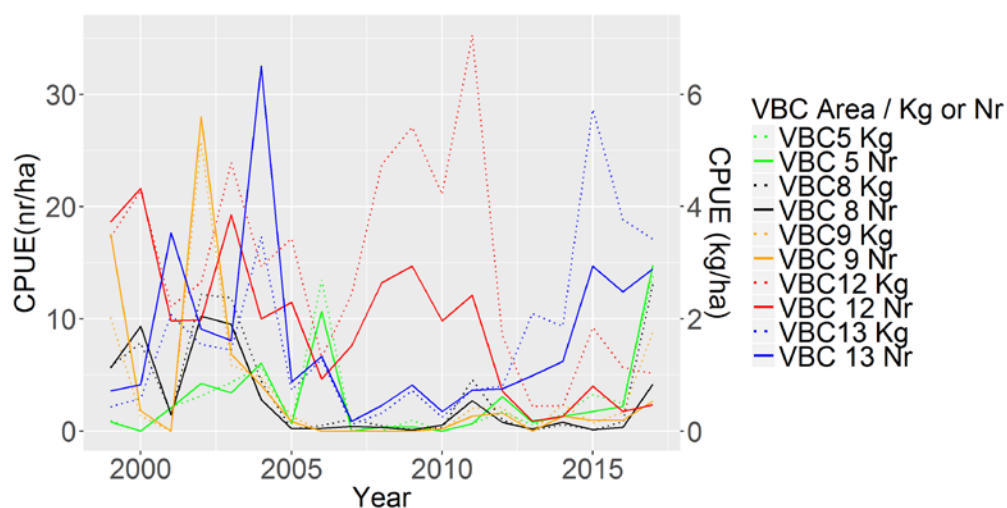


Figure 103. Cpue trends in five VBC areas (N/ha and kg/ha), sampled by electrofishing. (data: Wageningen Marine Research).

5.2.2.3 Main rivers (passive gear)

Data are collected for the main rivers, but is not yet available.

5.2.2.4 Coastal waters (active gear)

The number of eels caught in a coastal survey (Demersal young Fish Survey) is presented in Figure 104. Until the mid-1980s, considerable catches of eel were observed, after which a gradual decrease was observed. A more elaborate statistical analysis of the abundance and length composition of the eel stock in coastal waters is presented in Dekker (2009).

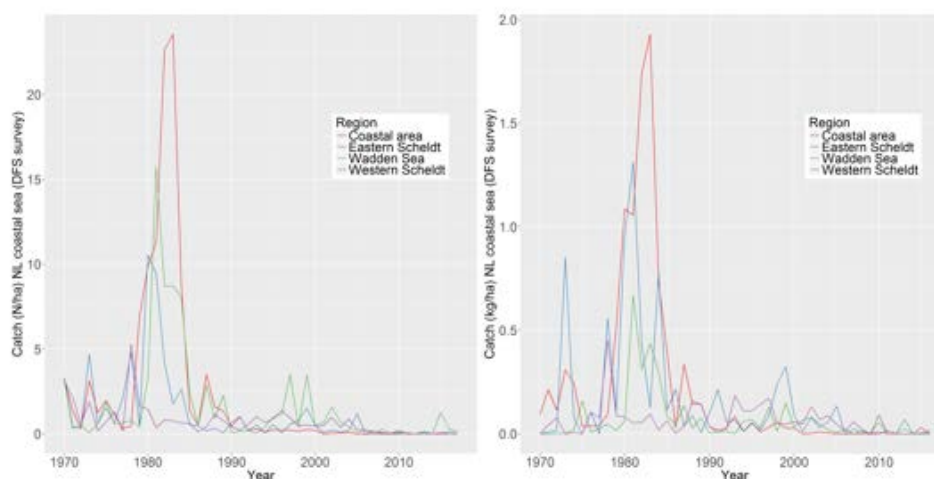


Figure 104. Trends in coastal survey catch 1970–2017. Left graph: n/ha; right graph: kg/ha. Most of the Wadden Sea belongs to RBD Rhine; Eastern Scheldt is mixed RBD Scheldt and Meuse; Western Scheldt belongs to RBD Scheldt (with an extra inflow from Meuse), the coastal area belongs to RBD Rhine (data: Wageningen Marine Research).

5.3 Silver eel escapement surveys

The Silver Eel Index has been implemented in the Netherlands since 2012. In cooperation with commercial fishermen the abundance of migrating silver eel is monitored on seven locations (main entry and exit points for migratory fish) during the months September–November. The programme and the results will be presented and discussed when sufficient data will become available, after at least five years. Due to irregular activities of participating fishermen in the research programme significant gaps in the dataseries already exist, especially for the locations at Den Oever and Kornwerderzand.

5.4 Biological parameters

See Van de Wolfshaar *et al.*, 2018.

5.5 Parasites and pathogens

The swimbladder nematode *Anguillicoloides crassus* was introduced from Southeast Asia in wild stocks of European eel in The Netherlands in the early 1980s. The market sampling for Lake IJsselmeer collects information on eels showing *Anguillicoloides crassus* infection based on inspection of the swimbladder by the naked eye. We scored an infection as ‘present’ when either we observed one or more *Anguillicoloides crassus* or a thickened swimbladder. As part of the extended market sampling program in 2009, data on *Anguillicoloides* infection rates have since also been collected in two other areas (Friesland and Rivers), and since 2011 the market sampling was conducted in most of the Netherlands.

Following the initial break-out in the late 1980s, infection rates in Lake IJsselmeer have been stable around 50%. Over the past years, infection rates appear to decrease for all areas, although numbers have increased in Friesland in 2017 (Table 43, Figure 105).

Table 43. Infection rates of eels (2010–2017) with *Anguillicoloides crassus*, in the Netherlands. Median infection rates of all sampled locations.

	FRYSLAN		LAKE IJSSELMEER		LAKE MARKERMEER		REST NL	
	N eels	N infected (% infected)	N eels	N infected (% infected)	N eels	N infected (% infected)	N eels	N infected (% infected)
2010	534	243(46%)	390	190(49%)	225	107(48%)	511	258(50%)
2011	107	40(37%)	293	127(43%)	104	35(34%)	583	231(40%)
2012	133	44(33%)	320	167(52%)	253	95(38%)	529	185(35%)
2013	17	8(47%)	14	7(50%)	93	40(43%)	283	106(37%)
2014	49	31(63%)	202	100(50%)	46	12(26%)	321	127(40%)
2015	61	24(39%)	267	110(41%)	nc	nc	297	112(38%)
2016	65	14(22%)	260	89(34%)	78	28(36%)	258	79(31%)
2017	74	34(46%)	170	33(19%)	172	45(26%)	291	74(25%)

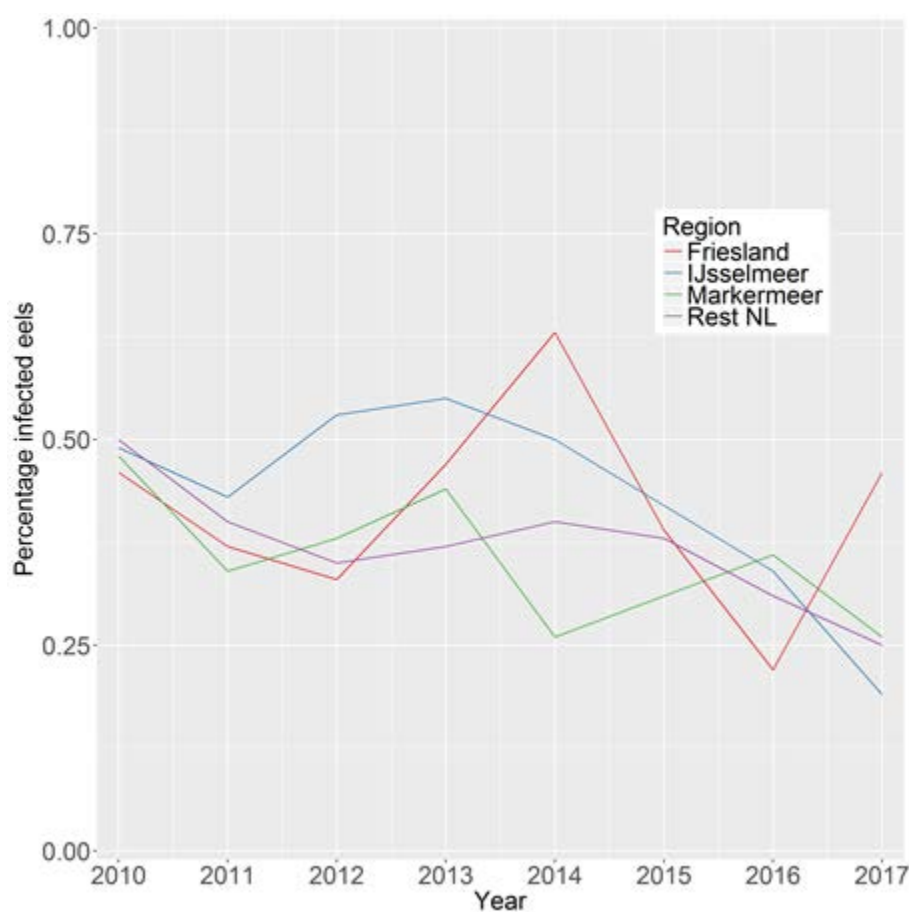


Figure 105. Percentage eels infected with *Anguillicoloides crassus* per region in the Netherlands.

5.6 Contaminants

In 2017, 16 locations were sampled to assess contaminant levels (sum-TEQ and sum Non-dioxin-like PCBs) in eel (Table 44). TEQ=Toxic Equivalent: sum of dioxins, furanes and dioxin-like PCBs. Eel samples of length class 30–40 cm consisted of about 25 individuals and eel samples of the predefined length class 53–75 cm consisted of approximately 15 individuals. Filets of the small eels were pooled (same mass per eel), for the large eels the mass of filet per eel used is determined by the size of the eel. In this way, the pooled sample is a proper representation of the eel composition in the Dutch waters (determined by monitoring the eel catch of fishermen).

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 (10 pg/g Sum TEQ and 300 ng/g Sum Non-dioxin-like PCBs⁴, plus 10% uncertainty) (Table 44). 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 106. Concentrations in 2017 were about similar to those in previous years for the River Rhine (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 are monitored from all locations nowadays.

⁴ Sum of 6 PCBs including PCB153. These are non-toxic indicator PCBs that can be measured easily.

Table 44. Sum-TEQ, sum Non-dioxin-like PCBs, and PCB-153 in eel (2017) (data: Wageningen Marine Research and RIKILT). PCB-153 is plotted in Figure 106. Values of Sum-TEQ above the regulatory limit of 11 pg/g ($10+10\%*10$) and of Sum-ndl-PCB above the regulatory limit of 330 ng/g ($300+10\%*300$) are indicated in grey.

Nr	Location	Size (cm)	Lipid level (%)	Sum-TEQ	Sum-ndl-PCB	PCB 153
1	2de Maasvlakte	>53	17.0	6.48	146	68.4
2	Drontermeer	>53	18.0	2.37	31	14
3	Haringvliet - West	>53	10.1	9.59	674	321
4	Hollands Diep	>53	20.0	23.1	1033	473
5	IJssel, Wijhe Deventer	30–40	4.4	4.46	160	68
	IJssel, Wijhe Deventer	>53	21.3	20.20	597	247
6	IJsselmeer Medemblik	>53	18.0	4.14	56	27
7	IJsselmeer, rand Ketelmeer	>53	19.3	10.50	344	154
8	Lek, Culemborg	30–40	3.6	4.48	215	93
	Lek, Culemborg	>53	20.8	20.9	830	352
9	Maas, Eijsden	>53	15.1	18.1	1040	434
10	Nieuwe Waterweg	>53	3.6	27.77	951	445
11	Noordzeekanaal, IJmuiden	>53	17.8	10.40	311	131
12	Overijsselsche Vecht, Ommen	>53	9.3	5.27	132	61
13	Rijn, Lobith	30–40	7.8	9.51	259	109
	Rijn, Lobith	>53	20.8	24.30	794	326
14	Sneekmeer	>53	16.2	2.03	35.9	17.2
15	Volkerak, Krammersluizen	>53	17.0	6.65	142	68.1
16	Volkerak, Steenbergen	>53	15.9	6.42	154	72.6

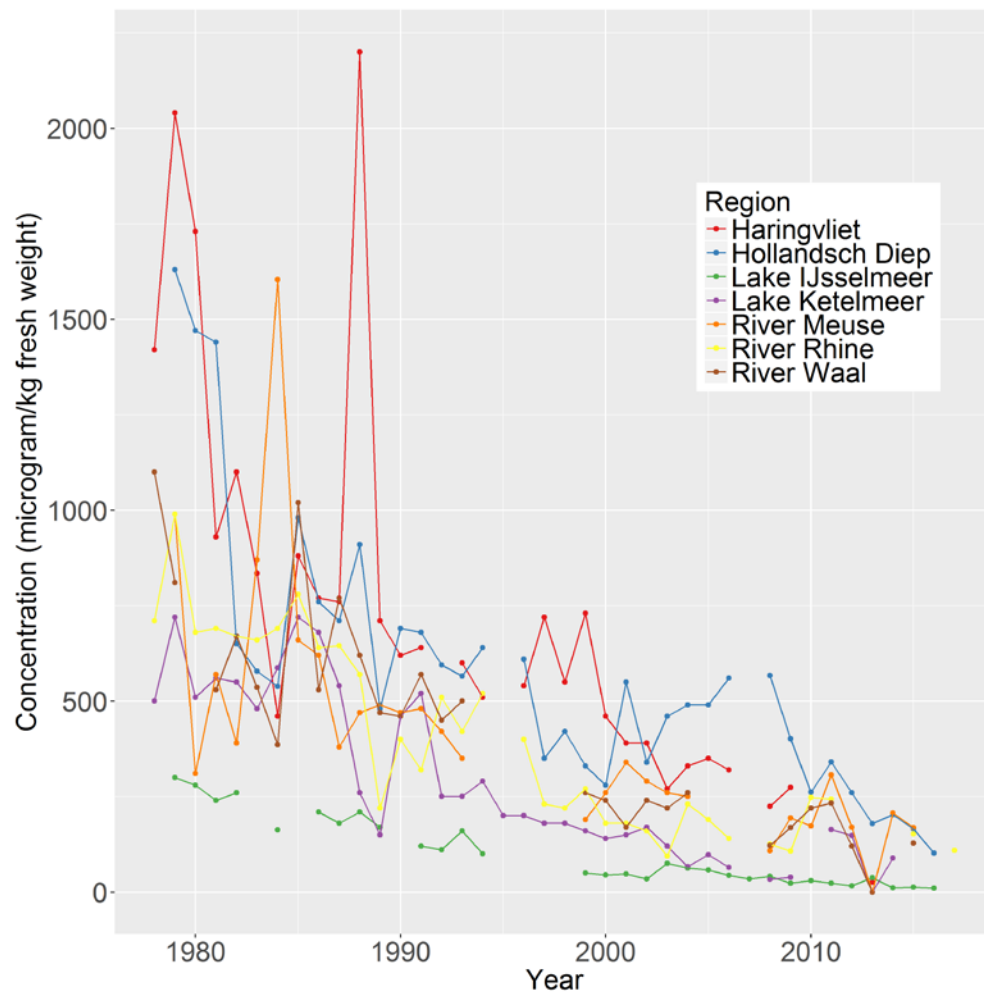
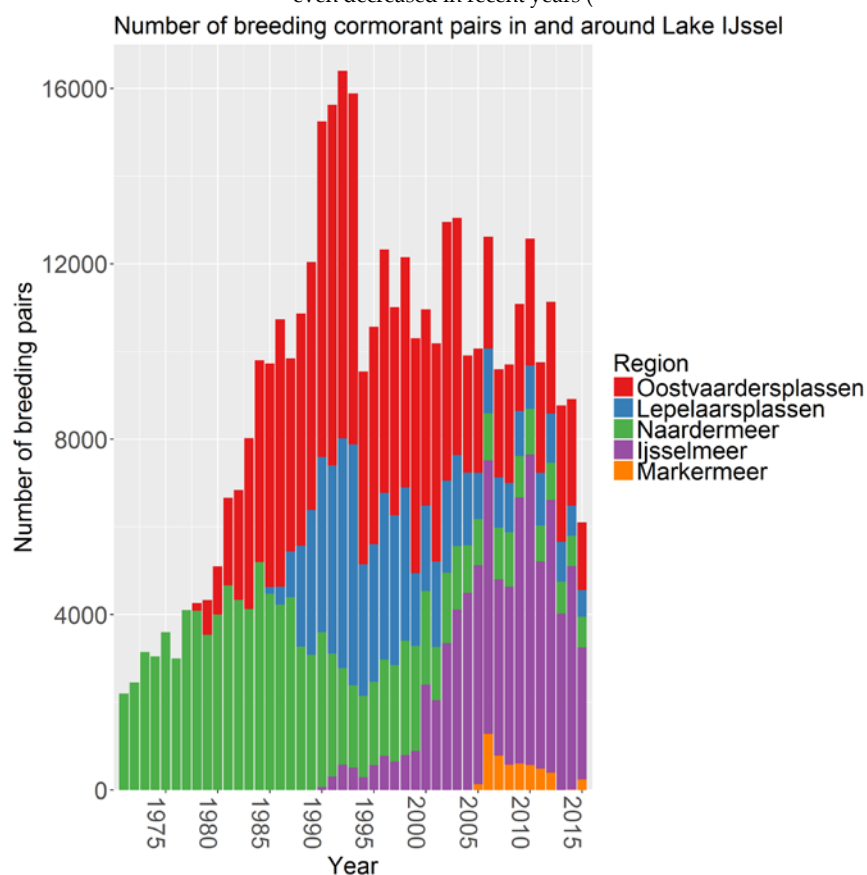


Figure 106. Trend in PBC-153 in 30–40 cm eel (1978–2017). Only data for one location for this size class are available for 2017 (River Rhine), see Table 44. Only consecutive years are connected with a line (data: Wageningen Marine Research and RIKILT).

5.7 Predators

Predation of eel by cormorants (*Phalacrocorax carbo*) is much disputed among eel fishermen and bird protectors. The number of cormorant breeding pairs increased rapidly until the early 1990s, then stabilised and even decreased in recent years (



, Figure 108). For Lake IJsselmeer, food consumption has been well quantified (van Rijn and van Eerden, 2001; van Rijn, 2004); eel constitutes a minor fraction of the diet of cormorants. In other waters, neither the abundance, nor the food consumption is accurately known.



Figure 107. Natura 2000 areas with cormorant breeding colonies adjacent to the IJsselmeer and Markermeer: (72) IJsselmeer (73) Markermeer and IJmeer (78) Oostvaardersplassen (79) Lepelaarsplassen (94) Naardermeer.

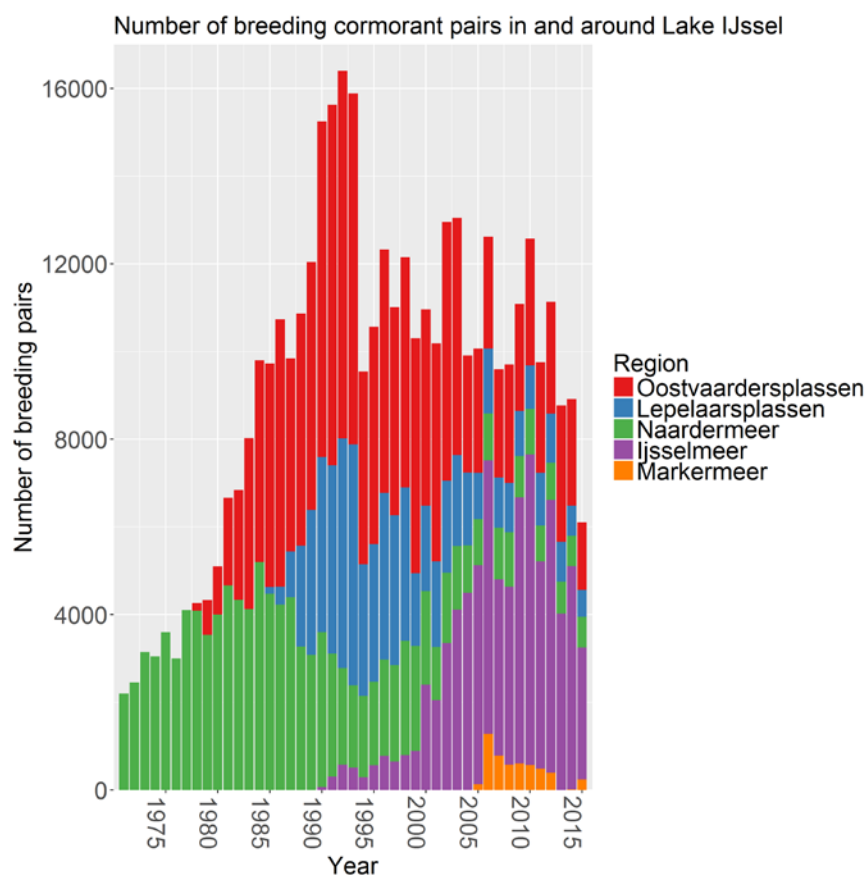


Figure 108. Trends in the number of breeding pairs of cormorants (*Phalacrocorax carbo*) in and around Lake IJsselmeer/Markermeer (Source: Netwerk Ecologische Monitoring, Sovon & CBS) (1980–2016).

6 New information

Two major improvements in terms of eel migration possibilities are planned in 2018.

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 the, several sluices will be permanently opened in autumn 2018. This will allow the return of brackish water and will restore the main route for migrating fish (especially salmonids). In addition, migrating (glass) eels might benefit from this opening as well.

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 freshwater from the IJsselmeer into the Wadden Sea and not the other way around. In addition, the current is much too strong for most species of migratory fish to swim against. As a solution, a “Fish Migration River” (an opening in the Afsluitdijk) will be constructed in 2018/2019 so that migratory fish can swim from fresh to salt water and vice versa. Especially glass eels might benefit from the tide current created by the Fish Migration River.

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

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.

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Reporting Period: This report was completed in September 2018, and contains data up to 2017 and some provisional data for 2018.

Acknowledgements: Knut Aanestad Bergesen, Norwegian Institute for Nature Research (NINA), Martin Ohldieck, Institute of Marine Research.

1 Stock status summary

Eel occurs in numerous watersheds and in marine coastal areas along the entire coastline. The abundance of eels is reduced towards the north. The length of the continental coastline is 25 148 km (including fjords and bays). Including islands, the total shoreline adds up to 83 281 km. Occurrence of eel is registered in 1788 lakes in 361 precipitation areas, but many areas and habitats have not been surveyed, so this is a minimum estimate (Thorstad *et al.*, 2010).

Eel fishing was banned in Norway on January 1st, 2010. Before this and since 1971, some fishers were involved in a monitoring program (Institute of Marine Research). They reported their catch and effort in logbooks. They recorded fishing gear, the number of days the traps were set out, and the number of small and large eels (the limit between the two was 200 g). This stopped in 2010. A similar program was started again in 2016 with only five fishers. In 2017 and 2018, 29 fishers participated. However, due to CITES export regulations⁵, the local market for selling eels is very limited (in 2017, about 7 tons were sold) and this creates an extra challenge for the fishers.

Traditionally, eel fishing mainly takes place along the coast in southern (Skagerrak coast) and southwestern Norway, in estuarine, brackish and saltwater areas around coastal islands, but also to some extent in freshwater. Some eel fishing also took place in Middle Norway before the ban. Eels have almost always been caught with fykenets. These are set on soft and muddy bottom, with preference of areas with seagrass beds (eelgrass *Zostera marina*). No distinction is made between yellow and silver eels, although the catch is mainly composed of yellow eels (Durif and Skiftesvik, 2016).

Glass eel fishing has always been prohibited in Norway. Catch in the sea is officially recorded by the Fisheries Directorate. There was no record of effort by the authorities (only the number of licences). There is a minimum legal size of 37 cm for silver eels and

⁵ In 2007, CITES listed the species in Appendix II (this came into force in March 2009) and requires exporting states to have an export permit which can only be issued if the export will not be detrimental to the survival of the species. Norway has not obtained such an export permit.

40 cm for yellow eels. All the fishers involved in the recent monitoring program must release eels under 300 g (approximately 50 cm in length).

Recreational fishing (prohibited since 2009) was quite important relative to commercial fishing (represented approximately 100 tons: average between 2000 and 2008). Recreational fishers along the south coast of Norway caught eel and sold them through fish-mongers. There was no limitation on fishing gear, and it was allowed to sell the catch up to 6250 Euros/year.

EMU_CODE	DESCRIPTION	ASSESSED AREA (HA)	B0 (KG)	BCURR (KG)	BBEST (KG)	ΣF	ΣH	ΣA
NO_Tot	Western Norway: from Stavanger to Austrheim	12 500	No data	17 400	18 600	0.014	ND	ND
NO_Tot	Southern and Eastern Norway: from Flekkefjord to Oslo	12 100	No data	259 200	262 400	0.014	ND	ND

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

The European eel is included in the Norwegian Red List since May 2006, categorized as critically endangered. The status of the eel was re-assessed in 2015 and moved to the VU (vulnerable category) under the reduction criterion (A1). This was due to the increase in all three Norwegian abundance indices at the time of the re-assessment. Indicators have been decreasing since.

In 2007, a working group was appointed to write a report on the status of eel in Norway and to draft a subsequent management plan. The report was completed in 2008⁶. The report concluded in two alternative management strategies: 1) that all eel fishing should be banned in Norway for a period of 15 years, or 2) that eel fishing catches be halved compared to the level of 2004–2007. Finally, it was decided that all recreational fishing for eel in freshwater and marine waters in Norway must be stopped from 1 July 2009 (not allowed to catch, land, or keep eel on board). The total quota for commercial fisheries in 2009 was 50 t, with cessation of fishing when this quota was reached. All commercial fisheries were stopped from 1 January 2010. However, since 2010 and onwards, fishers could apply to a 'scientific fishery' with an annual quota of 50 t, aiming at monitoring eel and collecting scientific catch data. This scientific fishery was supposed to be financed by the fishers being allowed to keep and sell the catch.

In 2016, the Directorate of Fisheries asked for a project plan to start a monitoring program involving fishers. The project that was finally adopted consists of three parts: 1) reporting of catch and landings of small (<300 g) and large eels, as well as soak time

⁶ Anonymous (2008) Forvaltning av ål i Norge: rapport med forslag til revidert forvaltning av ål i saltvann fra arbeidsgruppe nedsatt av Fiskeridirektøren. Bergen, 15.10.2008

and number of fykenets (for calculation of cpue); 2) mark-recapture program at three locations; 3) determination of age distribution. The project is carried out by the Institute of Marine Research (project leaders: Caroline Durif, Anne Berit Skiftesvik).

A few fish landing facilities in Norway have agreed to take in the eel catch for the local market.

There is no official assessment, since Norway is not part of the EU and thus not subjected to the EU regulation. However, Norway reports to the WGEEL three dataseries:

- Recruitment: late stage glass eels caught in a trap monitored by the NINA biological station in the river Imsa;
- Silver eel: downstream migrants in the river Imsa;
- Skagerrak beach-seine survey: yellow eels caught in a standardized beach-seine survey along the Skagerrak coast (Institute of Marine Research).

Since 2018 (this year), biomass indices (B_{current} and B_{best}) and fishing mortality is also given.

2.2 Significant changes since last report

We have calculated estimates for the biomass indicators (and available habitat) and fishing mortality for the coastal habitat in Norway.

3 Impacts on the stock

3.1 Fisheries

Landings for yellow eels are reported in the data spreadsheet.

3.1.1 Glass eel fisheries

There is no glass eel fishing.

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 km² is covered by freshwater. There are 144 river systems with a catchment area ≥ 200 km².

Eel 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 salt water but mostly in fjords and wind protected areas.

The analysis of telemetry data obtained on eleven 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 km² (Durif *et al.*, in preparation).

In Norway, the landscape is quickly elevated when leaving the coast. This limits the ascension of eels high up into the watersheds. That is, 63% of the eels were registered less than 10 km from the coastline. 50% of the lakes where eel is documented are located 50 meters above sea level.

Overall, the eel density and carrying capacity of habitats in fresh- and salt water in Norway is poorly known.

3.6 Others

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 fourfold after liming when compared with pre-liming levels.

4 National stock assessment

4.1 Description of method

Durif and Skiftesvik 2018 (in Norwegian) summarises the monitoring program started in 2017.

4.1.1 Data collection

The methods used to calculate the biomass indices will be available in early 2019 when we report to the Norwegian Fisheries Directorate.

4.1.2 Analysis

The methods used to calculate the biomass indices will be available in early 2019 when we report to the Norwegian Fisheries Directorate.

4.1.3 Reporting

The methods used to calculate the biomass indices will be available in early 2019 when we report to the Norwegian Fisheries Directorate.

4.1.4 Data quality issues and how they are being addressed

No available data.

4.2 Assessment results

The methods used to calculate the biomass indices will be available in early 2019 when we report to the Norwegian Fisheries Directorate.

5 Other data collection

5.1 Recruitment time-series

The only available time-series of elvers is from a trap at the mouth of the River Imsa in southwestern Norway (58°50' N, 5°58' E) (Figures 1 and 2, Table 1, 2 and 3). Staff at the Norwegian Institute for Nature Research (NINA) Research Station at Ims have been trapping and recording upstream migration of elvers annually since 1975. There is a wolf trap across the river at this site, collecting all downstream migrating fish as well. A few elvers may be able to migrate upstream at this site without being trapped, but probably not in large numbers. Larger elvers (>3 mm diameter) are counted, whereas smaller ones are measured in litres, with the assumption that there are 2000 elvers per litre. This assumption should have been checked. There should also have been a control check of the historical data, but still, the quality of the dataserie seems good. It should be noted that in Imsa, recruits migrating upstream are not true glass eel, but have already achieved a brown colour, and are here therefore termed elvers (true transparent glass eels do occur in Norway and were collected in 2014 for a population genetics study).



Figure 1. Map of Norway showing the location of the eel monitoring sites River Imsa and Skagerrak coast.

5.2 Yellow eel abundance surveys

5.2.1 Skagerrak beach-seine survey

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.

5.2.2 Scientific fishery

Otoliths have been randomly collected in several locations in Norway (18 locations).

The scientific fishery (around 30 fishers) started in July 2016 (see **Error! Reference source not found.**). Fishers reported their catch in weight and number of small and large eels, number of fykenets and as soak time.

5.3 Silver eel escapement surveys

No available data.

5.4 Biological parameters

Age and silvering stage available for around 1000 eels. Most of the data are from Imsa.

Silver stage is evaluated using Durif *et al.* (2005) wherever eye and fin measurements are available.

Diserud *et al.*, 2017.

5.5 Parasites and pathogens

Eel caught with fykenets were sampled in southern Norway (Flødevigen and Grimstad).

YEAR	NUMBER OF EELS WITHOUT ANGUILLICOLA	NUMBER OF EELS WITH ANGUILLICOLA	% OF EELS WITH ANGUILLICOLA
2016	101	22	18%
2017	86	20	19%
2018			
Freshwater	28	27	49%
Salt water	74	3	4%

5.6 Contaminants

No available data.

5.7 Predators

No available data.

6 New information

None.

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 HII prosjekt 81333. Rapport fra Havforskningen, Havforskningsinstituttet: 50.

¹ In 2007, CITES listed the species in Appendix II (this came into force in March 2009) and requires exporting states to have an export permit which can only be issued if the export will not be detrimental to the survival of the species. Norway has not obtained such an export permit.

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

Note to the reader the ICES data call on eel 2018 provides 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.

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Reporting Period: This report was completed in September 2018, and contains data up to 2017.

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1 Stock status summary

In Table 1 estimations on stock parameters are given.

Table 1. Summary of biomass and mortality indicators.

parameter	Oder EMU						2017
	2011	2012	2013	2014	2015	2016	
B ₀	1426	1426	1426	1426	1426	1426	1426
B _{goal}	570	570	570	570	570	570	570
B _{current}	87	75	60	51	71	52	41
ratioB _{current} /B _{goal}	0.15	0.13	0.11	0.09	0.12	0.09	0.07
B _{best}	150	150	150	150	150	150	150
sumF	1.07	0.94	1.40	1.15	1.12	1.17	1.23
sumH	0.51	0.51	0.51	0.51	0.51	0.51	0.51
sumA	1.58	1.46	1.91	1.66	1.63	1.69	1.74
parameter	Vistula EMU						2017
	2011	2012	2013	2014	2015	2016	
B ₀	1386	1386	1386	1386	1386	1386	1386
B _{goal}	555	555	555	555	555	555	555
B _{current}	59	46	38	24	25	23	18
ratioB _{current} /B _{goal}	0.11	0.08	0.07	0.04	0.04	0.04	0.03
B _{best}	125	125	125	125	125	125	125
sumF	1.55	1.74	1.62	1.46	1.23	1.39	1.21
sumH	0.80	0.80	0.80	0.80	0.80	0.80	0.80
sumA	2.35	2.54	2.42	2.26	2.03	2.19	2.00

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

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

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).

ΣF=mortality due to fishing, summed over the age groups in the stock (rate).

ΣH=anthropogenic mortality excluding the fishery, summed over the age groups in the stock (rate).

ΣA=all anthropogenic mortality summed over the age groups in the stock (rate).

2 Overview of the 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 km². 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 Trans-boundary 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.

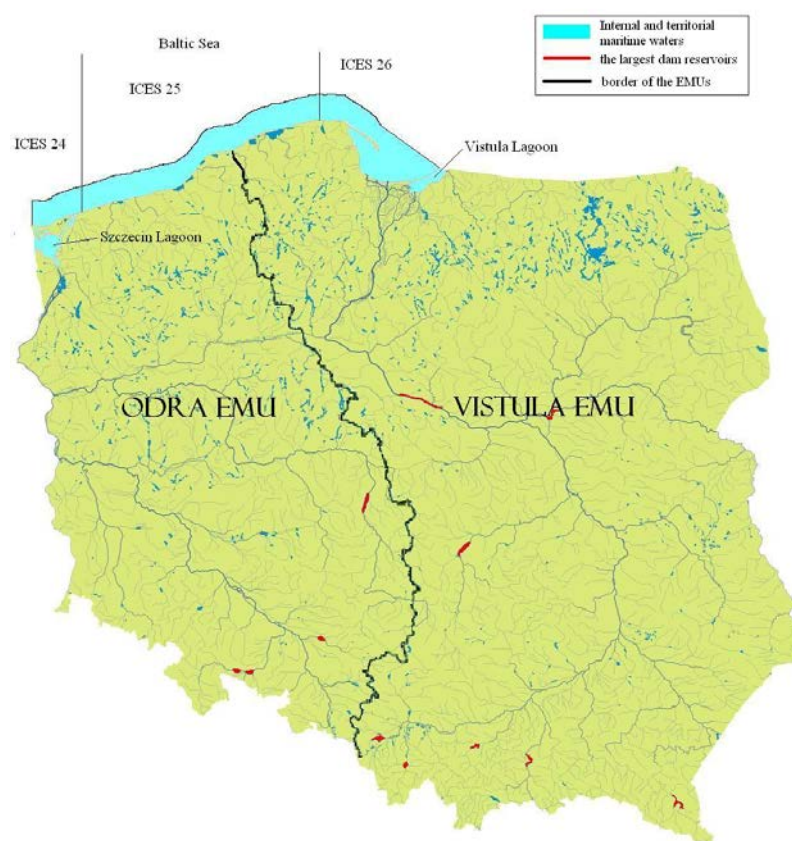


Figure 1. EMUs in Poland according to the Polish EMP.

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

Changes in the data and model fit in 2017 compared with previous fit were as follows:

- new recruitment indices provided by GLM estimates presented in the WGEEL Report in 2017 were used, and they differed only slightly from previous estimates;
- new data on catches, stocking, and the age structure of catches in 2015–2017 were included in the analysis;
- historical data on catches and stocking were updated for a few years;
- age data from ages older than 14 were combined into a plus group and included in the analysis for the six most recent years, previously the abundance of fish at age >14 was so low (practically zero), so it was omitted.

3 Impacts on the stock

3.1 Fisheries

3.1.1 Glass eel fisheries

Not relevant.

3.1.2 Yellow eel fisheries

No distinction has been made between yellow and silver eel in statistics. The data on inland catches were obtained by surveying selected fisheries facilities, then extrapolating the results for the entire river basin. These data are thus approximated. The data from the lagoons were drawn from official catch statistics (logbooks). These might also be incomplete because of poor statistics, the quality of which declined notably following 1990. Data are presented as total landings.

Table 3. Total landings of eel in entire basins and marine waters (1954–2017).

Decade Year	1950	1960	1970	1980	1990	2000	2010
0		733	847	1214	768	444	173
1		640	722	944	670	435	119
2		663	696	911	638	373	119
3		762	645	868	568	366	137
4	609	884	691	819	635	337	117
5	732	682	810	1022	642	220	102
6	656	804	761	921	629	184	138
7	616	906	868	887	526	181	172
8	635	943	910	943	544	160	
9	566	935	979	813	599	161	

Table 4. Estimation on 2016 recreational catch.

Retained (tons)					Released			
	Inland		Marine		Inland		Marine	
Year	Angling	Passive Gears	Angling	Passive gears	Angling	Passive gears	Angling	Passive gears
2015		NA	< 1 ton	NA	NA	NA	NA	NA

3.1.3 Silver eel fisheries

Data are presented as total landings (see above).

3.2 Restocking

Eel stocking was initiated in regions within current Polish borders as early as at the beginning of the 20th century, and it produced good results (Sakowicz, 1930). This was done mainly in rivers within the Vistula River basin and in the Vistula Lagoon. The stocking material of the day originated from the coasts of Great Britain (glass eel), although the Vistula Lagoon was also stocked with eel inhabiting the River Elbe (20–30 cm total length; Roehler, 1942). In the 1950s, great demand developed in Western Europe for live eel, and this fuelled efforts to stock all appropriate waters with this species. The restocking programme collapsed after the socio-economic changes of 1989 transformed the former state fisheries enterprises into private ones. The Stocking Fund, which had been a department of the central government budget office, was also discontinued at this time. Private fisheries enterprises leased waters in which stocking had once been performed, and the import of eel recommenced in the mid-1990s (Table 1). Because of economic concerns and the increasing price of glass eel, these were mostly fingerlings. Stocking did not recommence in either lagoon until 2005 as part of the stocking plan for Polish Marine Areas. The intensity of European eel stocking in inland and marine waters in 2011–2017 was determined using data obtained from the users of fisheries districts and from Inland Fisheries Institute database.

The mean share of enterprises stocking in the Vistula RBD was 63%, while in the Oder RBD it was 55%.

Table 5. Data on stocking quantities (mln. indiv.).

Decade	1980		1990		2000		2010	
Year	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel
0	51.8		10.2	0.4	3.1	1.4		1.3
1	60.0		1.7	0.0	0.7	0.8		2.7
2	63.2	0.1	13.8	0.1	0.0	0.8		1.7
3	25.1	1.1	9.7		0.5	0.6		3.5
4	47.6	0.2	13.1	0.1	2.3	0.8		2.3
5	36.3	0.1	23.7			0.7		3.6
6	50.2		2.8	1.0		0.9		1.5
7	56.9		5.1	2.2		1.4		1.8
8	16.7		2.5	0.8		1.5		
9	14.0	0.2	4.0	1.0		1.4		

3.3 Aquaculture

No data available.

3.4 Entrainment

On Polish rivers, there are tens of thousands of barriers of varying kinds. Their influence on eel migration is highly varied: practically every one of them to some degree makes it difficult for eel to move upstream; not all, however, constitute a hindrance for eel moving downstream. The barriers' influence depends on a range of factors, the main one of which is the purpose of the construction, and, in particular, whether water is used to produce electricity, for irrigation, in water supply, for ponds, etc. whether the water is used in its entirety, or whether it is possible for the eel to avoid machinery (turbines, pumps, etc.), which, in turn, depends on individual configurations of technology. The influence also depends on whether - if the eel can avoid the machinery - they are exposed to the risk of injury from falls, changes in pressure, etc. The worst, in this respect, are without doubt water-powered electricity generating facilities. In Poland there are around 600 of them, and their number has grown in recent years. Mortality among eel navigating the barrier of an electricity generating facility depends on the possibility for the eel of avoiding the turbines, on the size of the eel themselves, on the type and size of a given turbine, and the height of a given barrage. Mortality rises with the size of the eel; it is greater in Francis turbines than in Kaplan ones; and it is greater in smaller turbines. Smaller electricity generating facilities often have Francis turbines; however, it seems that eel have more chance of voiding a turbine in larger electricity generating facilities. It is also worth recalling that when passing through turbines eel are subject to much more serious injuries than, for example, salmon smelt. At the same time, it is only from 24% of the surfaces of lakes, which are the basic environment and site of natural eel production that eel can swim to the sea without encountering a water-powered generating station. From as much as 63% of those surfaces they have to deal with at least two power stations. Based on results A variable, often significant, part of the eel after release does not swim downstream, but quite the reverse swims upstream (up the facility's reservoir). This was observed both in spring and in fall experiments. On the Narew River (Zegrzyński Reservoir) in 2012, of 30 eel, 20 swam upstream, including nine that went as far as the reservoir backwater. Twelve of them (40% of all eel) did not pass the dam up to the end of the experiment, which is over a period of two and a half months. In 2013, the percentage of such eel was 32%. On the Słupia in Słupsk this was 18%, in Kondradowo 96%, in Krzynia 23%, on the Drawa in Kamienna 16%, and on the Radunia in Rutki 100%. Partly this may be a result of stress induced by capture, transport, marking, and release. At several places the eel are too big to get through the grates protecting the turbine inflows. Many eel, however, do not go near the inflow, but immediately swim upstream, several reaching the river above the reservoir. This phenomenon is described in the literature: barriers and reservoirs can prevent eel migration, sometimes forever. It is difficult to assess to what degree this is attributable to the eel natural impulse, and to what degree to the method employed in the research. Certainly, however, the limit on downstream movement placed on silver eel by barriers is not restricted to the injuries eel may suffer in passing through the turbines of a power station.

The Polish Eel Management Plan (PEMP) assumes an improvement in the conditions of downstream migration, and makes the success of the plan dependent on such improvement, and designates it as a fundamental course of action.

3.5 Habitat quantity and quality

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.

3.6 Others

Na.

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 recruitment indices estimated using GLM by WGEEL (ICES, 2017) and the coefficient of proportionality (R_{alfa}) was estimated in the model. Selection was estimated at ages 3–6, at others it was assumed at 1. Another parameter was Z_{ini} , which was total mortality used to estimate initial stock numbers (in 1960) from average recruitment at the beginning of the simulation period.

The model was fitted by minimizing the sum of squared residuals between observed and modelled catches and observed and modelled catch-at-age in those years in which age distribution was available. The residuals were determined from logged values. Details of the model were presented in the 2008 Polish eel management plan. The inverse of variance weighting was applied to weight terms of the total sum of squared residuals. Estimated fishing mortality and R_{alfa} were inversely correlated, and there was relatively little information in the data for selecting the most representative estimate of R_{alfa} . Thus, the model was run for series of R_{alfa} values, and as a representative for eel dynamics the R_{alfa} selected was that at which the minimized sum of squared residuals showed low changes, while the total mortality was relatively close to the mortality estimates from the catch curve. Otherwise, the minimizing procedure tended to select high R_{alfa} and produced unrealistically low fishing mortality.

Changes in the data and model fit in 2017 compared with previous fit were as follows:

- new recruitment indices provided by GLM estimates presented in the WGEEL Report in 2017 were used, and they differed only slightly from previous estimates;
- new data on catches, stocking, and the age structure of catches in 2015–2017 were included in the analysis;
- historical data on catches and stocking were updated for a few years;
- age data from ages older than 14 were combined into a plus group and included in the analysis for the six most recent years, previously the abundance of fish at age >14 was so low (practically zero), so it was omitted.

4.1.1 Data collection

During 2015–2016 the eel monitoring was conducted exclusively in marine and transitional waters, based on the requirements of Council Regulation (EC) No 199/2008. The monitoring 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 (log-books and official statistical questionnaires) biological variables – age, length, weight, sex, and life stage.
- abundance of recruits – catch data obtained on eel ladders set in Pomeranian rivers, data on stocking from statistical questionnaires and resellers.
- abundance of the standing stock – calculated by mathematical modelling, supplemented by data from scientific non selective fykenets set in lagoons and electrofishing in lakes.
- number of emigrating silver eels will be calculated by mathematical modelling.

The stock dynamics of eel for both EMUs is estimated using a version of CAGEAN model (Deriso *et al.*, 1985), described in the Polish Eel Management Plan. Data were delivered to WGEEL annually.

4.1.2 Analysis

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

4.2 Assessment results

Data are presented in Table 1.

5 Other data collection

5.1 Recruitment time-series

Not relevant.

5.2 Yellow eel abundance surveys

Routine electrofishing surveys are conducted every year in Pomeranian rivers to estimate abundance of salmon and sea 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 2017 results showed that electrofishing is not effective in lakes due to low eel abundance.

5.3 Silver eel escapement surveys

Tagging of 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 have 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.

5.4 Biological parameters

Data are collected according to EU – MAP requirements and includes standard analysis of length, age (from sectioned otoliths), and maturity stage (silvering index). During 2015–2017 more than 1600 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. For the first time, age data from inland waters were included.

In inland waters age groups ranging from four to 22 in the Oder EMU, and from four to 29 in the Vistula EMU were identified. The most abundant fish were from age groups 4–6 in the Oder EMU (33% of the total frequency) and from age groups 11–16 in the Vistula EMU (over 50% 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 3–7 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.

5.5 Parasites and pathogens

No new data are available. See 2017 CR for the latest results.

5.6 Contaminants

No new data are available. See 2015 CR for the latest results.

5.7 Predators

The cormorant daily food ration and annual food requirement in 2015–2017 were estimated assuming the following:

- the cormorant breeding population in Poland was approximately 30 000 pairs;
- the population of non-nesting cormorants accounted for 20% of the breeding population, or approximately 12 000 birds;
- adult cormorants consume approximately 400 g of fish daily;
- cormorants roost in Poland for 150 days;
- chicks are fed from May to July (90 days) and their dietary requirement is approximately 250 g indiv.;
- cormorant breeding success is 2.2 chicks/nest;
- weight share (%) of eel in the cormorant diet was 0.14%.

The estimate of the mean number of cormorants in Poland was based on data from the literature. In 2015–2017 the number of cormorants was approximately 130 000 individuals. Assuming that a cormorant individual consumes approximately 0.4 kg of fish per day, the cormorant population that migrates to Poland annually consumes approximately 576 000 tons of fish annually. The share of eels in the cormorant diet, which was estimated based on studies from 2012–2014, is 0.14%, which means that the great cormorant population of approximately 130 000 individuals consumes approximately 80 tons of eel in Poland annually. Considering the location of the largest colonies of this bird (in 2017, 50% of the cormorant population inhabited coastal waters, then approximately 40 tons of eels consumed by cormorants are from inland waters and approximately 40 tons are from coastal waters.

6 New information

None.

7 References

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

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.

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1 Stock status summary

In this section, the stock indicators are compiled. The pristine escapement estimates (Table 1.1) have been improved compared to the estimates reported presented in 2008 for the Portuguese EMP (PT_Port EMU).

Data presented in the tables submitted for the ICES Data Call 2018 have been used in the Progress report 2018 for the European Commission, in accordance with Article 9 of the Eel Regulation - Regulation (EC) N° 1100/2007.

Table 1.1. Stock indicators for the two Portuguese EMUs, PT_Port and ES_Minh according to the 2018 post-evaluation reports.

EMU_code	Assessed Area (ha)	B ₀ (kg)	B _{curr} (kg)	B _{best} (kg)	B _{curr} /B ₀ (%)	ΣF	ΣH	ΣA
PT_Port	135 487	1 364 571	698 826	1 026 094	51.21	0.38	0.00	0.38
ES_Minh	1823,69	36 474	4278	36 474	11.7	2.73	0.00	2.73

Key:

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

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

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).

ΣF=mortality due to fishing, summed over the age groups in the stock (rate).

ΣH=anthropogenic mortality excluding the fishery, summed over the age groups in the stock (rate).

ΣA=all anthropogenic mortality summed over the age groups in the stock (rate).

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

2.1.1 EMUs, EMPs

In compliance with Regulation EC 1100/2007, Portugal has considered **two EMUs** in accordance with Article 2 of the Eel Regulation: one that includes the entire territory (mainland), and the other that includes the International River Minho. Therefore, Portugal submitted **two EMPs**: one **national EMP** and a **transboundary EMP**, shared with Spain, for the River Minho.

The Portuguese Eel Management Plan was submitted in December 2008. This EMP was approved by the European Commission on the 5th April 2011, following the delivery of the last revised version on the 19th November 2010.

Despite the existence of five river basins extending beyond Portugal (Minho, Lima, Douro, Tagus, and Guadiana) (Figure 2.1a), and included in three different River Basin Districts (Figure 2.1b), it was agreed between both countries that the only Transboundary Eel Management Plan that should be considered was for River Minho, as it is the only international river where the river mouth is shared by both countries and there is a strong interest on the glass eel fishing. As coordination between the two countries was delayed, it was not possible to consider it in December 2008, when submitting the Portuguese Eel Management Plan.

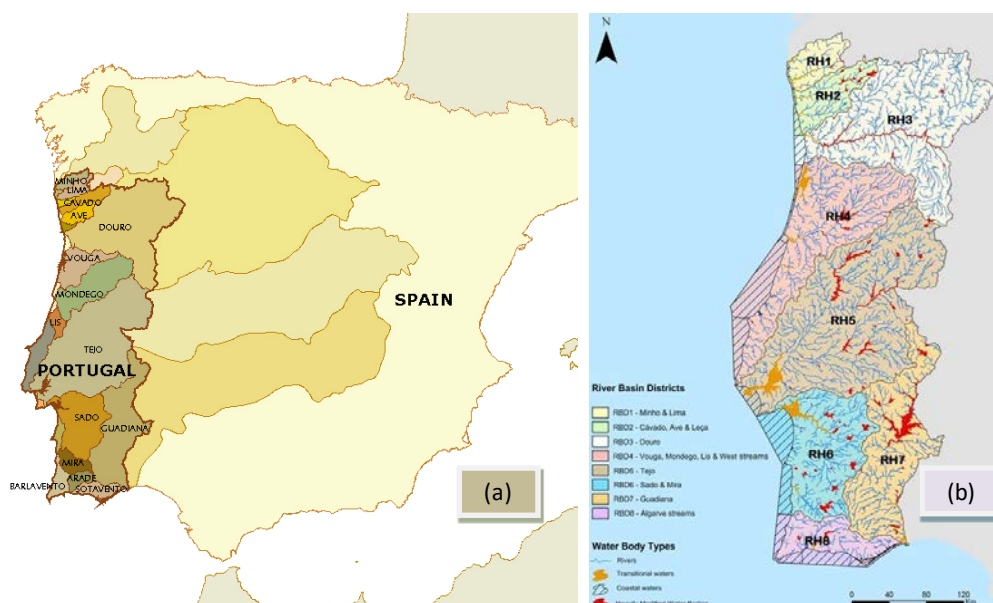


Figure 2.1. Map showing Portuguese River basins including the catchment area extending to Spain (a), and limits of the eight Portuguese River Basin Districts defined according to the Directive 2000/60/EC (b). RBD is labelled as RH in the map.

A first version of the Transboundary EMP, for River Minho, was sent to the European Commission in June 2011 followed by a revised version in November of the same year. The Transboundary EMP was approved by the European Commission on the 21st May 2012.

Because the EMP for the River Minho was not delivered in time, Portugal had to reduce the fisheries effort until the implementation of the EMP in that river. Hence, several

measures were taken to comply with the provisions of Article 4, number 4, i.e. to reduce fishing effort by at least 50% relative to the average effort deployed from 2004 to 2006. Those measures included reducing the number of fishing licences to fish glass eels, shrinking the authorized fishing zone for glass eels, shortening the fishing period, and banning the fishery for eels.

2.1.2 Management authorities

Eel fishery is managed by **DGRM** (General Directorate of Natural Resources, Maritime Safety and Services) with responsibility in coastal waters, and **ICNF** (Institute of Conservation of Nature and Forests) with responsibility in inland waters. These institutions are under two ministries: Ministry of Sea and Ministry of Agriculture, Forestry and Rural Development respectively. The exception is River Minho because as an international river having a common stretch bordering both countries, there is a Commission (**Standing Transboundary Commission of the River Minho**) that includes representatives from both countries setting specific rules that are applied to the fishery conducted in the international section of that river basin. Licences to fish in inland waters are issued by ICNF, whereas licences to fish in transitional and coastal waters are issued by DGRM. **Capitania do Porto de Caminha** issues licences for the Portuguese part of River Minho.

The management of waterbodies is the responsibility of **APA** (Portuguese Environment Agency) and 5 regional administration authorities for inland waters, which are under the Ministry of Environment. These authorities are responsible for the implementation of Water Framework Directive and therefore for obstacles in water basins.

Finally, ICNF is also the **National Authority for the CITES** convention, which implies they also have a role in the implementation of the EMPs.

2.1.3 Fishery regulations

Glass eel fishery is forbidden in all river basins since 2000 (*Decreto Regulamentar nº 7/2000*), except for the international River Minho where it is still permitted (*Decreto Lei nº 316, artº 55 of 26/11/81*).

Yellow eel fishery is ruled by eleven specific byelaws applied to eleven fishing areas in coastal waters (estuaries and coastal lagoons) and nine other byelaws that are applied to specific fishing areas called ZPPs (Zonas de Pesca Profissional / Professional Fishing Zones) (See Figure 2.2a), which are the only areas where professional eel fishery is allowed in inland waters. These laws set the rules for types and characteristics of fishing gears and in most cases, limit the maximum number of gears per fishing licence. Fishing effort is not recorded. In inland waters, professional fishery is ruled by Law 112/2017 (6 September, 2017) in the stretches represented in green, whereas in the sections represented in yellow it is ruled by the byelaws (Figure 2.2b).

Fisheries managed by DGRM have mandatory landing reports because eels are sold at fish auction, while in inland waters, there are no auctions. In 2012, in line with the implementation of the EMP, professional fishermen have become obliged to report catches annually to be able to renew their fishing licences. Minimum legal size is 22 cm in both areas of jurisdiction. The yellow fishery is permitted from January 1st until September 30th.

It is forbidden to catch **silver eels**, which implies it is mandatory to release them if they are caught. Besides, a closed season of three months (October, November and December) has been set to increase escapement of silver eels. This prohibition was first

set in 2010 for waters within the jurisdiction of DGRM, i.e. estuaries and coastal lagoons (*Portaria n° 928/2010, from 20 September*) and in 2012 for waters under the jurisdiction of ICNF, i.e. inland waters (*Portaria n° 180/2012, from 6th June*). In River Minho the yellow and silver eel fishery is forbidden since fishing season 2011–2012.

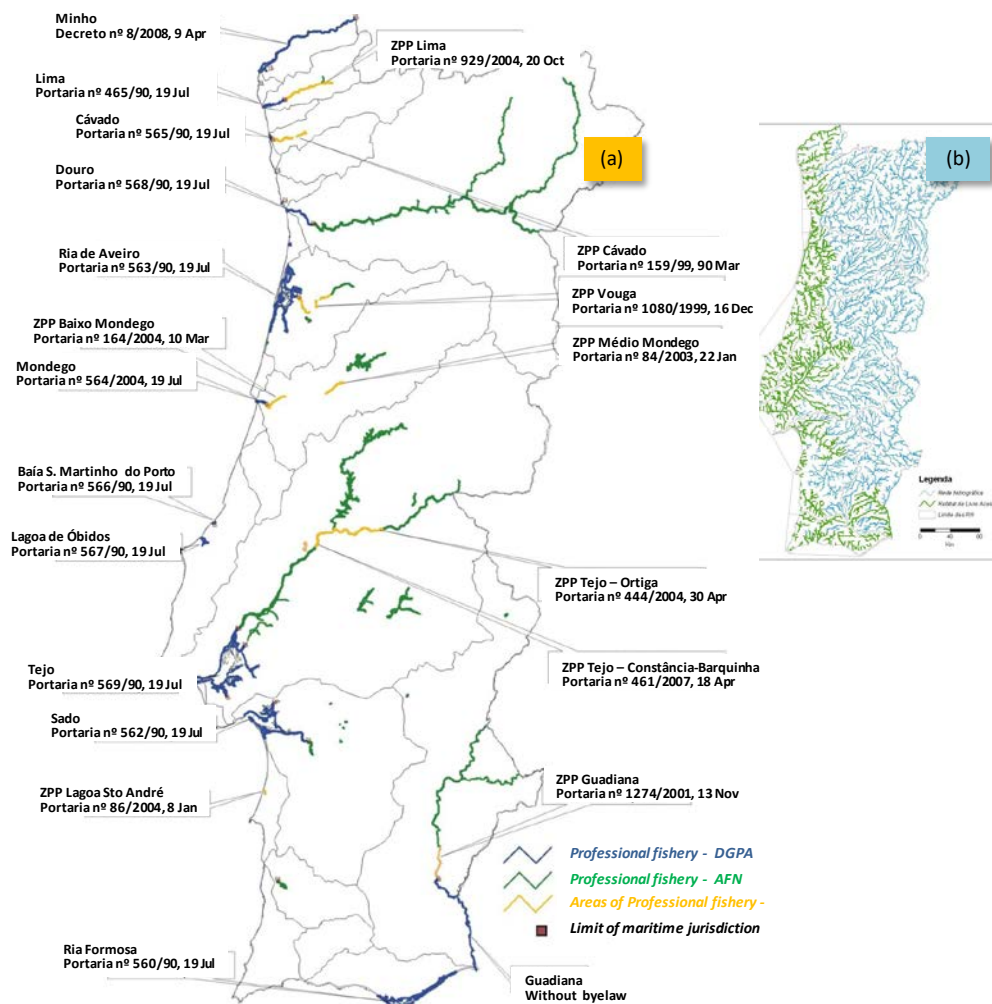


Figure 2.2. Map showing areas where professional fisheries can be conducted both in estuaries and coastal lagoons (jurisdiction of DGRM) and in inland waters (jurisdiction of ICNF) (a). The limit of maritime jurisdiction and the byelaws that rule the fisheries at each area are presented in the map (a). (Source: ICNF). The habitat that is accessible for the eel is also represented in green (b).

2.1.4 Management actions

The main objective of the Portuguese Eel Management Plan, which considered the entire country as one management unit, was to establish a series of measures to be applied at the national level that could contribute to reduce mortality and increase silver eel escapement as requested by Regulation 1100/2007. These measures can be classified into four categories:

- Fisheries restrictions;
- Mitigation of obstacles to upstream migration;
- Reinforcing police control on glass eel poaching;
- Data collection (Habitat/stock assessment).

An overview of the measures foreseen can be seen in Table 2.1. In general, all measures related to the fisheries have now been implemented. These measures focused on reducing the fishing capacity and effort but also on setting a ban on the fishery during the most intensive period of silver eel migration. Besides, to control the eel fishery in freshwater and reduce fishing effort, if needed, a special licence for the eel fishery was implemented in 2018, under the designation of species of relevant interest for the professional fishery.

Table 2.1. List of the management measures foreseen within the scope of the Portuguese EMP and state of implementation. 😊 - Fully implemented; 😞 - Partially implemented.

ACTION TYPE	ACTION	LIFE STAGE	PLANNED	OUTCOME
Com. Fish	Prohibit the eel fishery outside the professional fishing areas in freshwater jurisdiction	Y	After 2011	😊
	Set maximum number of fishing gears and licences per professional fishing area, in freshwater	Y	After 2011	😊
	Introduce obligation to report catches in freshwater to obtain a licence the following year	Y	After 2011	😊
	Introduce a specific annual licence for eel fishery in freshwater jurisdiction	Y	After 2011	😊
	Introduce closed fishing season (1st October to 31st December) in freshwater jurisdiction	S	After 2011	Portaria nº 180/2012 😊
	Introduce closed fishing season (1st October to 31st December) in marine jurisdiction	S	until 2012	Portaria nº 928/2010 😊
	Reduce the number of licences for marine water jurisdiction	Y	2009-	😊
Rec. Fish	Prohibit recreational eel fishery in marine (M) jurisdiction	Y/S	After 2011	Portaria nº 14/2014 😊
	Prohibit recreational eel fishery in freshwater (F) jurisdiction		After 2011	Portaria nº 108/2018 😊
Hydropower & Pumps	Mitigate the impact of existing obstacles (upstream migration)	G/Y	After 2011	😞
Restocking	0	na	Na	na
Other	Collect data and conduct studies on the stock (Recruitment/Production/Escapement)	All	Until 2012	DCF 2017–2019 😊
	Monitoring and control of glass eel poaching	G	2009	😊

The reinforcement of the actions to reduce the poaching was carried out when the Portuguese EMP was approved, occurring in the aquatic systems during the fishery but also in land when catches are being transported. Several actions have been undertaken by the authorities both in the marine jurisdiction (Maritime Police) and freshwater jurisdiction (SEPNA, a special unit from GNR, the National Republican Guard). These authorities have been making a huge effort to control the situation, however the nets seized are rapidly substituted by new ones. SEPNA has among other competences, the

obligation to monitor the illegal activities of fishing and can act on land. However, another special unit from GNR, the UCC acts close to the coast and has also been involved in these actions.

More recently, in 2017 and 2018, with the pressure on international illegal trade generated by the listing of *Anguilla anguilla* in CITES, the Portuguese Food and Economic Security Authority (ASAE) together with the CITES authority have been involved in joint actions that resulted in the seizure of glass eels at several Portuguese airports, on various occasions. Cooperation with the Spanish authorities, Europol and Interpol, have also been improved within the scope of the illegal trade on glass eels. The Sargasso operation, which ended in March 2018, resulted in the seizure of 600 kg of glass eels as well as all the material used for storage and transport. (Press release from ASAE in <http://www.asae.gov.pt/espaco-publico/noticias/comunicados-de-imprensa/asae-faz-a-maior-apreensao-de-meixao-de-sempre-em-portugal-e-desmantela-rede-de-trafico-de-meixao.aspx>).

The most difficult measures to implement are related to restoring longitudinal connectivity for fish migration and the collection of data on the stock because they both require high funding. In the first case, an extra difficulty is added because there are numerous obstacles and their impact has not been evaluated. As for the need to collect data on the stock (recruitment/production and escapement), vital to accomplish the objectives set by the Eel Regulation, it was finally started in 2017, under the EU MAP obligations.

The implementation of the Transboundary EMP for the River Minho has been more successful, mostly because it includes a smaller area and the measures were all focused on the fishing activity, which is easier to implement. The results can be consulted in Table 2.2.

Table 2.2. List of the management measures foreseen within the scope of the Transboundary Eel Management Plan for the River Minho and state of implementation. 😊 - Fully implemented.

ACTION TYPE	ACTION	LIFE STAGE	PLANNED	OUTCOME
Com Fish	Prohibit the eel fishery	Y/S	EMP	😊
	Reduce fishing effort	G	EMP	😊
	Introduce obligation to fill in logbooks	G	After approval	😊
Rec Fish	Prohibit the eel fishery in marine jurisdiction	Y/S	EMP	😊
Hydropower & Pumps	0	na	na	na
Restocking	0	na	na	na
Other	0	na	na	na

2.2 Significant changes since last report

The stock indicators have been provided for the first time both for the ICES data call 2018 and the 2018 EMPs Progress Reports.

The collection of information about the stock as well as biological sampling are being conducted since 2017, within the framework of DCF, following the Commission Implementing Decision (EU) 2016/1251 - Multiannual Programme for the collection,

management and use of data in the fisheries and aquaculture sectors for the period 2017–2019.

3 Impacts on the stock

3.1 Fisheries

3.1.1 Glass eel fisheries

The glass eel fishery is prohibited in all rivers of Portugal (*Decreto Regulamentar* nº 7/2000 of May 30), except for 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 fishery statistics from Minho are kept by the responsible local Authority – Capitania do Porto de Caminha. Total annual statistics have been recorded since 1974 (Figure 3.1).

Glass eel fishery in the River Minho was permitted between November and April for many years, but after the fishing season 2005/2006, mostly due to the eel population decline and the high fishing pressure, an agreement between the Portuguese and Spanish authorities, has been gradually reducing the fishing period. The fishing season is currently defined, to include four New Moons (the most profitable period). In the last fishing season (2017/2018) fishing occurred between the November and the February.

To reduce fishing pressure, it was decided by the Standing Transboundary Commission of the River Minho that starting on the fishing season 2010/2011 the maximum number of fishing licences for each country would be 200, and that the fishing zone for glass eels would decrease 25 km in the river length. In the same year a new change was introduced in the licensing process, as licences started to be issued to the owners of the boats and not to fishermen, implying that the drop to 126 licences in 2011 is a consequence of these changes rather than a real reduction in fishing pressure. The number of fishermen is however, generally the same, as there are two men per boat.

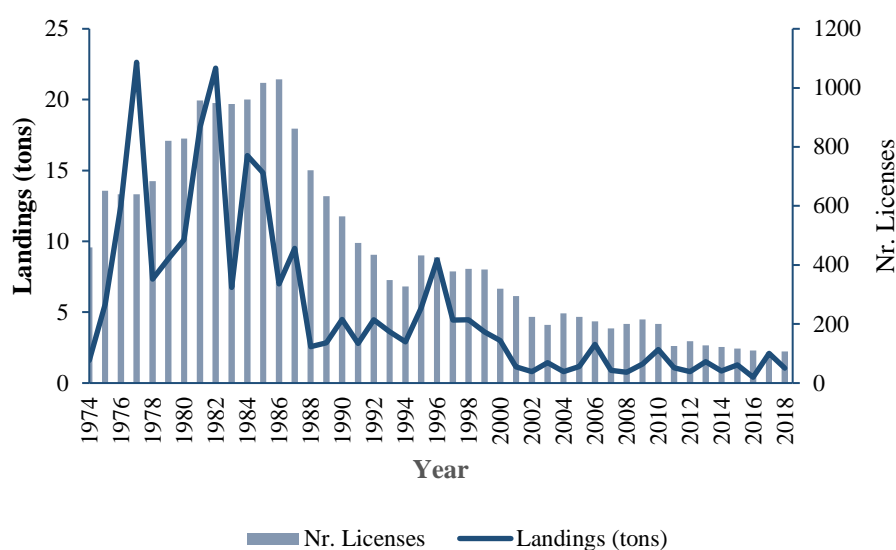


Figure 3.1. Glass eel recruitment and number of licences issued in the River Minho 1974 to 2018 (Source: Capitania do Porto de Caminha).

Following the implementation of the Transboundary EMP for the Minho, a change in reporting catches has been introduced since the fishing season 2011/2012. Fishermen who do not report catches of glass eels, are not issued a fishing licence the following year. In addition, fishermen are obliged to report their catches monthly to local authorities and to keep a logbook where they record the quantity of glass eels caught in each fishing session. If the difference between data registered in the logbooks and what is sold in the auction is higher than 250 g, licences will not be renewed. A quota of 3 kg of glass eels per fisherman per day was established from 2016 on.

3.1.2 Yellow eel fisheries

Fishing capacity in freshwater is not known, and under the present legislation it is not possible to estimate the number of fishermen and eel fishing gears they owe/use. Professional fishermen must obtain a licence issued by ICNF to fish in these waters and they are obliged to report their catches. The professional fishery is ruled by nine byelaws, which define the river sections where fishermen can fish, establish the number of fishermen for each fishing season and the rules for fishing (fishing gears and mesh size, size limit of the species, hour restrictions and species restriction).

The fishing licences issued by DGRM for local fishery in estuarine and coastal waters are linked to fishing boats. The same fishing boat can be 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 eleven specific byelaws that set the rules for eleven fishing areas. However, for certain areas and/or fishing gears there is no restriction on the number permitted for each licence. These different rules and the lack of record on the actual number of fishing gears fishermen use, contribute as extra difficulties to estimate fishing capacity.

The use of fykenets in the River Minho was banned by Decree 8/2008 (April 9th) and its application started on the fishing season 2008/2009. However, longlines are still permitted in the international part of the river (80 Km) and eels are caught as bycatch (maximum 10% allowed) of other fisheries.

Landings from coastal fisheries (estuaries and coastal lagoons) are shown in Table 3.2. There was a decline in catches after 2010, which continues today. However, it should be noted that a ban of three months (October, November and December), implemented in 2010 (Portaria nº 928/2010, from 20 September), might account for the decline observed. The changes in fishery regulations, derived from the implementation of the EMP, add as extra difficulties to evaluate the trend on the stock, based on landings.

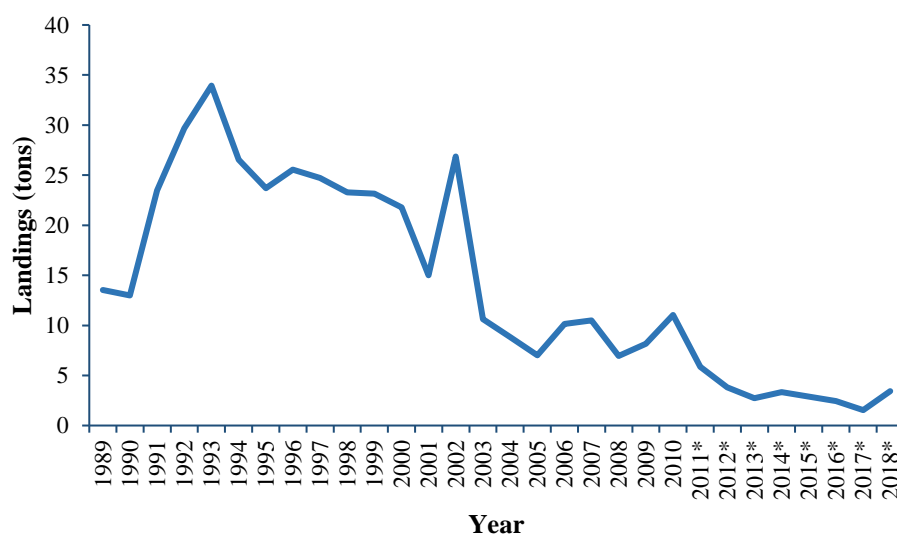


Figure 3.2. Annual landings of yellow eel fishery in coastal waters (estuaries and coastal lagoons), from 1989 to 2018. Data for 2018 are provisional (Source: DGRM). (*) An eel fishing ban was set between October and December, starting in 2011, to increase silver eel escapement.

Recreational fisheries have become forbidden for the eel. Following the measures established in the two EMPs, it is forbidden to catch eels by recreational fishery since 2010 in River Minho, since 2014 (Portaria nº 14/2014 from 23rd January) within the marine jurisdiction, i.e. in transitional waters and since April 2018 within the freshwater jurisdiction (Portaria nº 108 from 20th April).

3.1.3 Silver eel fisheries

It is forbidden to fish silver eels. With the implementation of the EMP, the eel fishery was closed during the most important period of spawning migration, i.e. from the 1st October to 31st December in both marine (Portaria nº 928/2010) and freshwater (Portaria nº 180/2012) jurisdictions. Besides, in the freshwater jurisdiction, if fishermen catch silver eels outside the ban period, they are obliged to return them to the water.

3.2 Restocking

There is no stocking of eels in Portugal.

3.3 Aquaculture

Aquaculture production of European eel is not significant in Portugal because there have been no units of eel aquaculture in Portugal. In brackish water systems, production of eels is a by-product in aquaculture systems directed towards extensive and semi-intensive sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus aurata*) farming. The production of eels in these systems is presented in Table 3.1.

Table 3.1. Aquaculture production of eels (tons) between 1997 and 2016 (Source: DGRM).

YEAR	PRODUCTION (TONS)
1997	16.2
1998	13.2
1999	3
2000	6
2001	6.5
2002	4.2
2003	4.7
2004	1.5
2005	1.4
2006	1.1
2007	0.5
2008	0.4
2009	1.1
2010	0.3
2011	0.6
2012	0.9
2013	1.4
2014	0.9
2015	0.9
2016	1.1

A new aquaculture unit for eel production has however, been installed in central Portugal (Figueira da Foz), but it is not yet producing. It is expected to produce 500 tons per year.

3.4 Entrainment

Anthropogenic impacts identified in the two Portuguese Eel Management Plans (PT EMU and PT Minho EMU) were mainly related to fisheries and obstacles to migration that have reduced available habitat to grow. Although turbine activity is usually a major mortality factor especially for silver eels, in Portugal there is no passage for eels in the hydroelectric dams, which implies there is no mortality associated with turbines. Besides, because these EMPs do not include stocking of upriver sections that are inaccessible for the eel, there is not a problem for silver eels escaping from continental waters to spawn. As for pumps or diversions, they may become a problem especially for glass eels that might easily be entrained by the pumps, but that impact has not been considered and is not being assessed.

3.5 Habitat quantity and quality

Habitat quality and quantity have been considered in the Portuguese EMP as measures to increase the quality and quantity of silver eels escaping to the sea. The improvement of water quality was a measure set in the Portuguese EMP to be achieved by the implementation of WFD. However, because there are many obstacles in the water courses, the quantity of habitat available for eels to grow, required a list of needs to be implemented in the short, medium and long run.

The quantity of habitat free of obstacles has also increased in River Mondego. A project entitled “Rehabilitation of habitats for diadromous fish in the River Mondego” funded by Programa Operacional Pesca 2007–2013 (PROMAR) (Reference 31-03-02-FEP-5), which aimed to remove obstacles allowed to install an eel pass in the first dam that was hampering the colonization of the watershed. The result was an effective increase of 30 km of river completely free of obstacles. The monitoring of the eel pass is under course.

In River Minho, the presence of the Frieira dam impedes eels from migrating upstream. As such, there is a high concentration of juvenile eels (elvers) just below this obstacle, which has driven the authorities to release these individuals in tributaries located below the dam to reduce mortality derived from high densities. In total there was a redistribution of 3.7 tonnes of eels between 2011 and 2017 (Table 3.2).

Table 3.2. Quantity of eels (kg) captured below the Frieira dam both in the salmonid ladder and the ramp. (Source: Estación de Frieira dam).

YEAR	Ramp	Ladder	Total
2011	187.52		187.52
2012	243.18		243.18
2013	98.86	658.45	757.31
2014	136.01	426.65	562.66
2015	103.75	652.3	756.05
2016	70.76	104.28	175.05
2017	82.7	915.44	998.145
TOTAL	922,78	2757,12	3679,915

An ongoing project (LIFE16 ENV/PT/000411) entitled “Conservation and management actions for migratory fish in the Vouga river basin” aims to improve habitat accessibility for migratory species. The European eel will also benefit from this project that will end in 2022 (1st August 2017 to 31st July 2022).

3.6 Others

Nothing to report.

4 National stock assessment

4.1 Description of method

4.1.1 Data collection

Surveys are currently done under the DCF (Period 2017–2019). A combination of methods including the commercial fishery and independent surveys are used as a proxy to estimate stock indicators. Wherever there is a fishery, it is monitored, but in the absence of a fishery, experimental fishing is carried out.

The river basin chosen to represent the PT_Port EMU was River Mondego (estuary and freshwater) to compare with data from the 1990s but because this EMU is the whole country and the production of eels is affected by the type of aquatic system, a coastal lagoon (Santo André Lagoon) was also included in the data collection to represent the

variety of aquatic systems (river + estuary + coastal lagoon). These surveys include experimental fishing for recruitment estimates (monthly from November to April) and surveys on yellow and silver eels in the Mondego River. Moreover, still within the framework of DFC biological sampling is also being conducted. A sample of eels is collected each year for length, weight, sex and age determination.

As for the other EMU, ES_Minh, the same surveys and biological sampling are being conducted under DCF. The yellow eel fishery is prohibited, which implies biological sampling is done by experimental fishing.

4.1.2 Analysis

Estimates of the silver eel biomass were improved compared to the estimated biomass provided in the Portuguese EMP presented in 2008, in which calculations were done by extrapolating data from watersheds of France. The biomass estimates herein presented are based on the densities of yellow eel surveys conducted in the Mondego River, using electric fishing. Additionally, sampling of yellow and silver eels that has been conducted between 2014 and 2016 within the framework of the Project “Rehabilitation of habitats for diadromous fish in the River Mondego” funded by PROMAR, provided data to determine the mean silvering age, the mean weight (yellow and silver eels), and the silvering rate. Data from scientific surveys conducted in 1988–1990 (Domingos, unpublished data) 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:

$$B_0 = [(YE \text{ densities } 1988) * (\text{silvering rate})] * \text{mean SE weight} * \text{wetted area}$$

$$B_{\text{current}} = [(YE \text{ densities } 2017) * (\text{silvering rate})] * \text{mean SE weight} * \text{wetted area}$$

$$B_{\text{best}} = B_{\text{current}} + \text{Anthropogenic mortality in Silver Eel Equivalents (SEE)}$$

The silvering rate and mean silver eel weight were obtained by conducting surveys in the river Mondego during the autumn period when silver eels can be distinguished morphologically. The silvering rate was estimated calculating the ratio between these individuals and the non-migrating ones (Durif *et al.*, 2009), being 2.8%, and the mean weight considered was 109 g.

The wetted area is the natural habitat of eel in the PT_Port EMU, which was considered unchanged since 1988, because all the anthropogenic obstacles present in 2017 already existed in 1988. Therefore, the pristine habitat (referred to the period 1988) in the EMU is the same as the current habitat and amounts to a total of 135 487 ha (see Table 1.1).

The anthropogenic mortality in SEE was calculated using the method proposed by the WGEEL and considering a five-year generation time, based on the age determined for silver eels from the Mondego. The catches of glass and yellow eel (silver eel fishery is forbidden), from five and three years ago, respectively, were used, and an 80% mortality in glass eel settlement and annual mortality of 0.138 were considered (Dekker, 2000); we assumed yellow eel average weight of 23.6 g and silver eel average weight of 109.0 g (Table 4.1).

Since glass eel catches are forbidden in the PT_Port EMU, the catches from the Minho river (fishery allowed) were used to estimate the illegal catches in the EMU by extrapolation. It was therefore considered that the main river basins (Lima, Cávado, Ave, Douro, Vouga, Mondego, Tejo, Sado, Mira, Guadiana) from the PT_Port EMU had the same amount of illegal fishing as the legal fishing that occurs in the Minho

River, and the total of illegal catches estimated by this method was considered to represent illegal catches of glass eel throughout the whole EMU.

Table 4.1. Data used to estimate the anthropogenic mortality in SEE for the PT_Port EMU.

Glass eel mean weight (g)	Yellow eel mean weight (g)	Silver eel mean weight (g)	Yellow eel mean age	Silver eel mean age	Glass eel settlement mortality	Eel natural mortality
0.28	23.6	109.0	3	5	80%	0.138

The only anthropogenic mortality considered was the mortality derived from the fisheries, which was estimated using the following expression:

$$\text{SumF} = -\ln (B_{\text{current}} / (B_{\text{current}} + k_g \text{ SEE})).$$

4.1.3 Reporting

The stock indicators are included in the 2018 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 recently obtained in the frame of the DCF (period 2017–2019), are regularly reported to the EC, is used/included in the ICES data call and contributed to estimate the indicators and to improve the stock assessment.

4.1.4 Data quality issues and how they are being addressed

The following quality issues must be addressed in a near future:

- Anthropogenic mortality indices are still missing in the EMU, namely glass eel illegal fishing.
- Coastal waters were considered to have the same eel densities as the fresh-water zone for the present estimated biomasses. DCF data from the Mondego estuary and Santo André coastal lagoon will be used to improve production estimates in estuaries and coastal lagoons all over the EMU.
- The silver eel biomass indicators represent the EMU total production and not the real silver eel escapement.

4.2 Assessment results

The assessment results are presented in chapter 1 and since those were the first stock indicators estimated since the delivery of the EMPs, it is not possible to report any changes over time.

5 Other data collection

Sampling of yellow and silver eels has been conducted between 2014 and 2016, within the framework of two Projects “Rehabilitation of habitats for diadromous fish in the River Mondego” and “Sustainable Management of the Eel Fisheries in Santo André Lagoon”, both funded by PROMAR. Biological aspects to be studied included sex ratio, age, *Anguillicola crassus* infection, and silvering rate. Ecological aspects include size distribution, abundance, influence of obstacles and escapement.

In the River Minho, the project “Migra Miño-Minho”, funded by INTERREG – POCTEP (2017–2020), aims to improve river connectivity for diadromous species including the eel.

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 fisheries from River Minho. There have been some changes in the number of licences throughout time (Figure.3.1), as well as in the extension of the fishing season.

There are no other recruitment series, but within the framework of DCF two new series are being started: one in the Minho River and the other in the Mondego River. The choice of this river system, aims to create the opportunity to compare present recruitment with data from 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. These data have contributed to improve the quality of estimates of production in coastal lagoons and rivers presented in the EMP. These surveys continue within the framework of DCF.

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 obtained for the Mondego River will be compared with new data from the SUDOANG project (SOE2/P5/E0617), funded by Interreg, in which acoustic transmitters will once again be used to measure real escapement aiming at calibrating a model for escapement in the SUDOE area.

5.4 Biological parameters

Biological parameters are being collected under DCF since 2017 according to the Commission Implementing Decision (EU) 2016/1251 of 12 July 2016 adopting a multiannual Union programme for the collection, management and use of data in the fisheries and aquaculture sectors for the period 2017–2019. River Mondego, 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 the other EMU.

In studies of eel age which have been conducted in Portugal, sagitta otoliths have been removed, cleaned with water, stored dry, and cleared in 70% alcohol (Vollestad, 1985) for ten minutes before being examined under a stereoscope microscope. The otoliths were read by more than one person (Gordo and Jorge, 1991), or by the same person who read them twice (Costa, 1989; Domingos, 2003; Lopes, 2013; Monteiro 2015). In the lack of agreement between both readings, a third reading was performed and if inconsistent, otoliths were excluded from analyses.

The same procedure is being followed for age reading. Silver stage is being identified according to Durif *et al.* (2009).

Stock assessment requires the collection of stock indicators to accomplish the goals set by the Eel Regulation (mortality and biomass indicators). A combination of methods including the commercial fishery and independent surveys are being used to estimate those indicators in both EMUs.

5.5 Parasites and 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 *Anguillicola crassus* is being carried out under DCF, but the results are not available yet. A summary of the infection analysed in previous years is presented below.

In a study conducted in 2008 in five brackish water systems (Aveiro Lagoon, Óbidos lagoon, Tagus estuary, Santo André Lagoon and Mira estuary), it was concluded that *A. crassus* was spread in all systems except in Óbidos Lagoon, which was probably related to the higher salinity observed in this lagoon, similarly to what happens in one sampling site (Barreiro) (Neto *et al.*, 2010) located in the lower part of the Tagus estuary. Prevalence values ranged from 0 to 100% and intensity values ranging from 0.4 to 5.8 (unpublished data). Within the DCF programme, the parasite was found in the swimbladder of seven among the 404 eels examined for the Óbidos Lagoon in 2009. The low prevalence found (1.73%) reinforces the idea that the infection rate is very low in areas with higher salinity, as it is the case in this lagoon. The presence of the parasite had already been reported for the River Minho (Antunes, 1999) and River Mondego (Domingos, 2003), which suggests the parasite is probably widespread in Portugal. In River Minho, the presence of the parasite was reported for the entire international section of the river and prevalence ranged between 23% and 100% (Braga, 2011). The map shows the locations where this parasite has been reported so far.

River Minho

Aveiro Lagoon

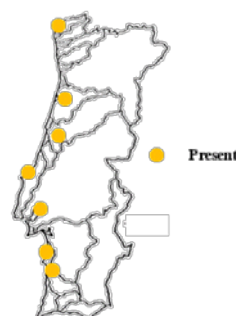
River Mondego

Óbidos Lagoon

River Tagus

Santo André Lagoon

River Mira



5.6 Contaminants

No new data are available for 2018, as there is no routine sampling for contaminant analysis in eel. 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.

5.7 Predators

Apart from the fish species Lusitanian toadfish (*Halobatrachus didactylus*) that can predate on eels (Costa *et al.*, 2008) and the European eel, which can display cannibalistic behaviour (Domingos *et al.*, 2006), the main predators of eels in Portuguese aquatic systems include the great cormorant, *Phalacrocorax carbo*, and the European otter, *Lutra lutra*. The eel is present in the diet of otters and cormorants throughout the year, but they become more important in spring and summer when the water level is lower (Trigo, 1994; Cerqueira, 2005; Dias, 2007). The impact of predation on the eel population is unknown but eels represented 25.4% of the diet of otters from Ria Formosa (Cerqueira, 2005), a shallow coastal lagoon, located in the south of the country, and 7% of the diet of cormorants from Minho estuary (Dias, 2007). The real impact of this predation on the eel stock in Portuguese waters is unknown, despite the increase in the population of the great cormorant and the European otter in recent years.

Data on eel predators are not being collected because this was not identified as a problem in the EMPs, but also because it is considered natural mortality. However, a recent study conducted in Santo André Lagoon in 2015 under the project “Sustainable Management of the Eel Fisheries in Santo André Lagoon” funded by PROMAR, concluded that the importance of the eel in the diet of the great cormorant was very reduced contrary to what has been reported by other authors elsewhere (e.g. Ovegård *et al.*, 2017).

6 New information

Some work has been devoted to analyse recruitment of glass eels to Portuguese coastal waters. (Startoudakis *et al.*, 2017; Correia *et al.*, in press). The difference found between the recruitment trend observed in the Minho river (Correia *et al.*, in press) and that reported by WGEEL for wider European geographical scales highlights the need to estimate recruitment indices with a higher geographic resolution to better support the assessment of the status of the European eel population.

A new glass eel recruitment series was established under DCF in the estuary of River Mondego, where data from the late 1980s existed. The sampling method used is the same as in the past (tela) to guarantee comparability among data. Moreover, still under DCF, glass eel recruitment is also being monitored in the River Minho.

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

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1 Stock status summary

1.1 Summary table

European eel has disappeared from the inner communities due to the construction of large dams, thus current indicators estimates are limited to Spanish coastal regions. Stock status indicators are compiled here as reported in the Spanish EMP post evaluation report (2018).

In that sense, and considering the tasks proposed in the 2015 Spanish EMP post evaluation report related to the 2nd phase, the pristine escapement estimations were improved compared to the above-mentioned report. Both Andalucía and Murcia regions improved the pristine biomass estimation by using recently collected field data and in the case of Murcia including freshwater (Segura River).

This made the overall pristine biomass to increase in almost 500 000 kg comparing to the 2015 estimate. However, B_{curr} decreased compared to previous exercise while B_{best} increased.

According to the estimations of the Spanish 2018 post evaluation report, European eel population status varies greatly among the different EMUs (Table 45), ranging from 0, in those inner regions where eel disappeared after the dam construction, to 55.2% of the target (Table 45). When the whole territory is considered, B_{curr} in Spain is 8.96% of the pristine one, and has thus slightly decreased in relation to 2015 post evaluation report (9.1%).

According to the estimations provided by the EMUs, the most important anthropogenic mortality is fishery. But non-fishery impacts, i.e. entrainment and mortality at water intakes, habitat quantity and quality decrease are underestimated because there is insufficient data for their estimation.

Table 45. Stock biomass and mortality indicators in the Spanish EMU according to the 2018 post-evaluation report.

EMU	A ₀ (ha)	A _{curr} (ha)	B ₀ (kg)	B _{curr} (kg)	B _{best} (kg)	B _{curr} / B ₀ (%)	ΣF	ΣH	ΣA
ES_Anda	126477	60767	6057545	128457	310599	2.1	0.885	-0.006	0.879
ES_Astu	3774	2591	63495	29466	81143	46.4	1.010	0.002	1.010
ES_Bale	4253	4253	330883	138586	138556	41.9	NP	ND	ND
ES_Basq	4050	3991	245040	127072	161787	51.9	0.242	ND	0.242
ES_Cant	1936	615	9680	1723	6579	17.8	1.465	-0.125	1.340
ES_Cast	1174	0	23488	0	0	0.0	NP	NP	NP
ES_Cata	9895	5567	364607	95415	196371	26.2	0.740	ND	0.740
ES_Gali	5535	4548	110700	12785	103785	11.5	2.087	0.054	2.141
ES_Inne	66868	0	2420205	0	0	0.0	NP	NP	NP
ES_Murc	13719	13500	26270	8095	54445	30.8	1.900	0.000	1.900
ES_Nava	272	231	5448	1134	ND	20.8	ND	ND	ND
ES_Vale	18217	6630	698026	385175	419444	55.2	0.088	0.003	0.091
TOTAL	10 355 387	102 693	10 355 387	927 906	1 472 739	8.96			

1.2 Precautionary diagram

The modified precautionary diagram (ICES, 2012) shows that the stock of the Spanish EMUs is in the three areas: safe (green), buffer (orange) and outside safe biological limits (red) (Figure 109). However, the EMUs have used different methodological approaches to calculate the indicators, so caution should be exercised in interpreting the differences between the different EMUs.

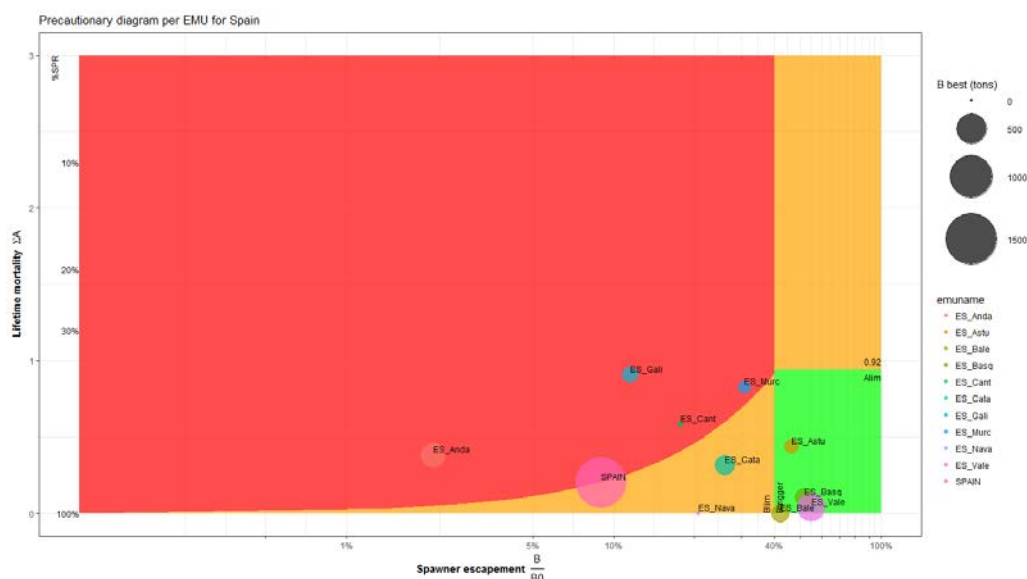


Figure 109. Stock status of the Spanish EMU (Spanish post evaluation report 2018) according to the modified Precautionary Diagram (ICES 2012). ES_Cast and ES_Inne not plotted because B_{best} is not available.

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

Spanish River Basin Districts (RBDs), charged of the design of the hydrological plan and the management of continental waters, were defined after the approval of the Royal Decree 125/2007 by which the territorial limits of the RBDs were fixed (Figure 110).

All the territory of the RBDs of Guadalquivir, Galicia Costa, Basque Country Inner basins, Catalonia Inner basins, Canary Islands basins, Balearic Islands basins and Atlantic and Mediterranean basins of Andalucía belongs to a single autonomous region (Figure 110) and are managed by the autonomous region they belong to. On the contrary, Segura, Júcar, Miño-Sil, Cantábrico, Duero, Tajo, Guadiana, Ebro and Guadalquivir RBDs extend over different autonomous regions and are managed by the Spanish Ministry of the Environment and Rural and Marine Affairs (MARM) through eight hydrographical confederations. Additionally, the Miño, Duero, Tajo and Guadiana RBDs are shared with Portugal, whereas the Ebro RBD is shared with France.

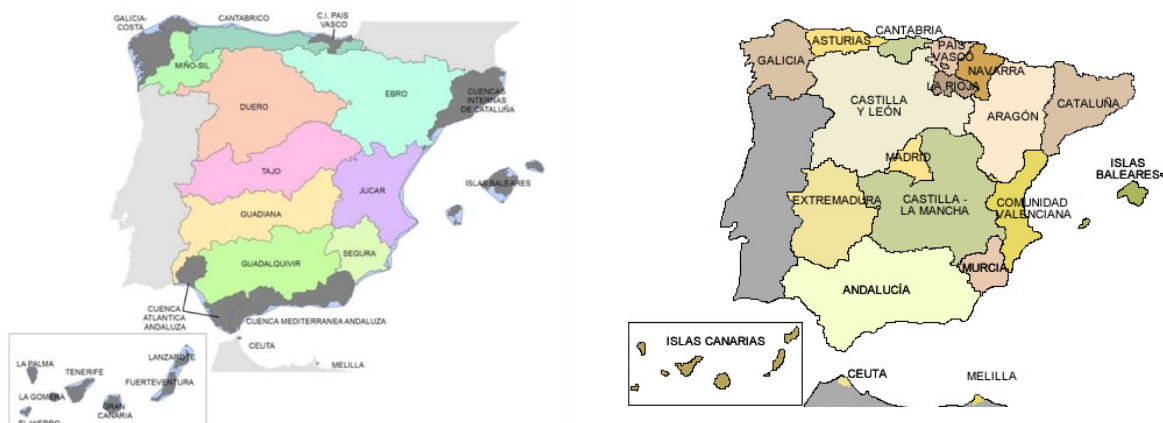


Figure 110. RDBs and Autonomous regions of Spain.

The Ministry of Environment, and Rural and Maritime Environment (MARM), responsible for fisheries and environmental issues, submitted the Spanish Eel Management Plan in December 2008. In May 2009 the clarifications and additional information required by the commission were submitted. Spanish EMP was revised in October 2009 by ICES, and the commission asked MARM to modify the Spanish EMP according to that evaluation. The revised version of the Spanish EMP was sent to the commission on June 2010 and was approved in October 2010. **Spain and Portugal made the Miño international River plan that was approved in May 2012** (all the plans are available at <http://www.magrama.gob.es/es/pesca/temas/planes-de-gestion-y-recuperacion-de-especies-pesqueras/planes-gestion-anguila-europea/>).

The Marine Secretary from MARM has coordinated the plan. *Anguilla anguilla* is a native species in Spain, whose population has undergone a significant decline in recent years as in the rest of Europe. The construction of large dams since the 1960s has led to its disappearance from most of the inland river basins of the Iberian Peninsula; the eel was historically widespread throughout the Iberian Peninsula, but it has lost over 80% of its original range, mainly due to river fragmentation by dams (Clavero and Hermoso, 2015; Figure 111).

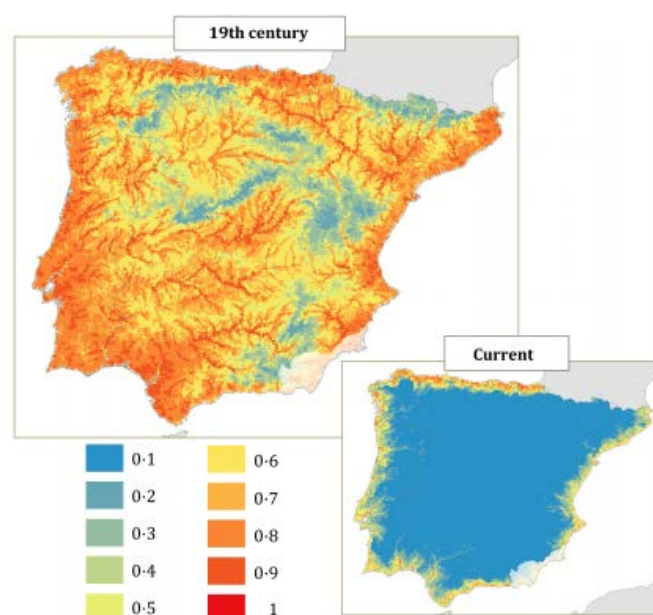


Figure 111. Probability of occurrence of the eel in the Iberian Peninsula in the 19th century and the present (Clavero and Hermoso, 2015).

Given Spain's national and regional structures, the Spanish management plan is based on a **National Eel Management Plan (EMP)** and **12 specific EMPs** (11 EMPs for the Autonomous Communities with eel populations that can complete their life cycle in these basins, and 1 EMP specific for the Ebro River Basin also with eel populations):

- 1) EMP of Galicia
- 2) EMP of Asturias
- 3) EMP of Cantabria
- 4) EMP of Basque Country
- 5) EMP of Navarra
- 6) EMP of Catalonia
- 7) EMP of the Ebro RBD (only Catalonia)
- 8) EMP of C. Valenciana
- 9) EMP of Castilla La Mancha, only for the eels in the upper part of the Jucar and in coordination with C. Valenciana
- 10) EMP of Murcia
- 11) EMP of Balearic Islands
- 12) EMP of Andalucía

The National EMP defines the structure and methodology, the monitoring and evaluation measures and the objectives at national level. It also contains a summary of the 12 specific EMPs. Each participating Autonomous Community, with exclusive competences on eel fisheries, has been defined as an **Eel Management Unit (EMU)** (Table 46) that shall undertake an Eel Management Plan, in accordance with Article 2(1) of Council Regulation (EC) 1100/2007.

Spanish rivers flow into both, the Mediterranean Sea and the Atlantic Ocean (Figure 112). The Atlantic rivers in the north part of Spain (also known as Cantábrico Rivers) are short with a high slope because the mountains are close to the sea. Among the five

large Spanish rivers, four born in the Spanish plateau and flow into the Atlantic Ocean (Duero, Tajo, Guadiana and Guadalquivir), only the Guadalquivir reaches the sea in Spain, the other three disemboque in Portugal. These rivers have a low slope. Besides, there is an important difference among the Atlantic rivers. The climate in the Cantabrian area is oceanic, thus there is not high variability of their flow during the rainy season and during summer water is not too low. On the opposite, the flow of Atlantic rivers born in the plateau but belonging to Mediterranean climate decrease as they go further south. Even if their pluvial regimen is Mediterranean, these rivers keep their flow quite constant due to the waters they receive from large tributaries born in the mountains.

The Mediterranean rivers have a low and irregular flow, with seasonal flooding and very dry summers. In fact, there are some water courses that remain dry most of the year, and only have water occasionally. Another difference between the Mediterranean and the Atlantic areas, is the presence of lagoons in the Mediterranean (Albuferas).



Figure 112. Main Spanish Rivers flowing to the Atlantic and the Mediterranean site (source educarex).

Table 46. EMU codes and their corresponding Ecoregion.

EMU	EMU code	Ecoregion
Basque Country	ES_Basq	South european Atlantic shelf
Navarra	ES_Nava	South european Atlantic shelf
Cantabria	ES_Cant	South european Atlantic shelf
Asturias	ES_Astu	South european Atlantic shelf
Galicia	ES_Gali	South european Atlantic shelf
Andalucia	ES_Anda	South European Atlantic shelf (Guadalquivir, Tinto, Odiel, Piedras, Guadalete, Barbate) Wester Mediterranean Sea(Almanzora, Andarax, Adra, Guadalfeo, Guaro, Guadalorce, Guadiaro, Guardarranque y Palmones)
Murcia	ES-Murc	Wester Mediterranean Sea
Castillas la Mancha	ES_Cast	Wester Mediterranean Sea
Valencia	ES_Vale	Wester Mediterranean Sea
Catalunya	ES_Cata	Wester Mediterranean Sea
Balearic Island	ES_Bale	Western Mediterranean Sea
Inner Bassins	ES_Inne	Western Mediterranean Sea

There is not stock assessment in Spain at a national level. Each autonomous region has assessed the stock for the management plan in a different way. The management plan of each autonomous region has its own objectives, methodology and structure.

In Spain, each autonomous government oversees the control, regulation and management of eel fishery and population. Thus, population assessment is made at the autonomous region level; that is, the methodology for data requirement and monitoring methods depend on the Autonomy. Almost all the autonomies compile eel fishery data, but each autonomous region has its own methodology to compile it.

2.2 Regulations

The autonomous regions oversee the management of the fishery in inner waters (including coastal waters). This causes great differences among the autonomous regions:

- The amplitude of the historical data series is variable among the autonomous regions, depending on the date in which the regulation of each autonomous region was issued.
- In some of the autonomous regions, the same regulation is applied to all the river basins while in others, each basin or even a zone within the same basin has its own regulation. Additionally, even in the same autonomous region, the fishery is regulated for some river basins but not in others.
- In some of the autonomous regions, fishermen are professional and must sell their catches to the fish market, while in others, they are non-professional. In this sense, the accuracy of the information related to catches and landings differs greatly among those autonomous regions.
- Each autonomous region has its own way of managing the stock; different fishing techniques are allowed.

- In many cases, the organizations that are involved in the management of the eel could differ within the same autonomous region depending on the eel development stages.

3 Impacts on the stock

3.1 Fisheries

For details about data gathering check Spanish Country report 2017 (ICES, 2017). Although some interannual variability can be observed in both glass eel and yellow and silver eel catches in Spain, they both have decreased during the last decades (Figure 113).

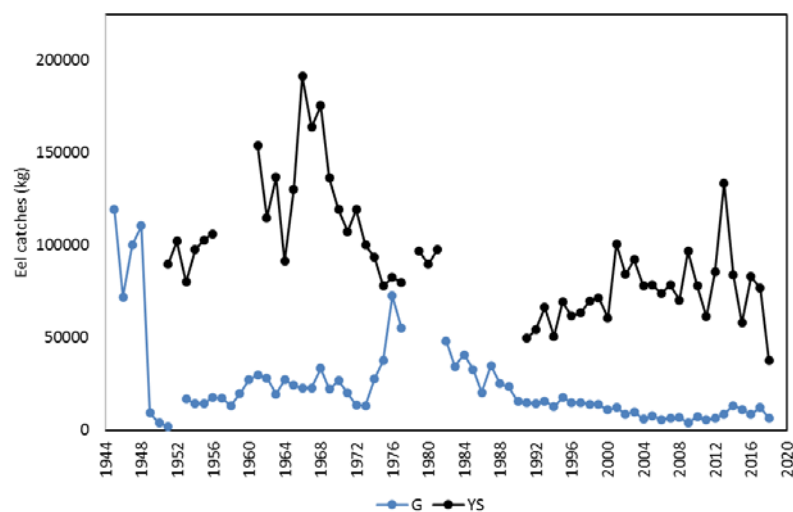


Figure 113. Glass (G) and yellow and silver eel (YS) catches in Spain since 1944.

3.1.1 Glass eel fisheries

Commercial glass eel fishery is very traditional in Spain. Although data for certain series are available since 1945 for the oldest series, data for some of the whole EMUs is only available since the 1970s.

Although some interannual variability can be observed, glass eel commercial catches in Spain have decreased since the late 1970s (Table 47).

Table 47. Commercial catches (kg) during the last decade fishing seasons. Updated and new data are shown in green.

Year	ES_Astu	ES_Cant	ES_Cata	ES_Mino	ES_Vale
2008	2379	24	1249	1333	164
2009	749	14	1597	1178	117
2010	2612	21	1667	2000	167
2011	2067	45	1527	1311	256
2012	1813	42	2160	1037	274
2013	3511	24	2584	813	223
2014	5820	521	3769	985	185
2015	4452	357	2658	1158	137
2016	3627	553	2085	360	42
2017	3717	325	5082	1212	566
2018	3340	NR	645	731	3

Recreational glass eel fishery takes place in the Basque Country and Cantabria (Table 48). 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. On the contrary, in Cantabria prohibited recreational fishery from 2014 on.

Table 48. Glass eel recreational catches (kg). Updated and new data are shown in green.

Year	ES_Basq	ES_Cant
2008	1205	358
2009	212	227
2010	614	207
2011	376	13
2012	1082	22
2013	1534	21
2014	2405	8
2015	2316	NP
2016	1731	NP
2017	1511	NP
2018	1725	NP

Only the number of glass eels for restocking inside Spain is known, the destination of the rest of the catch is unknown (Table 49).

Table 49. Destine of the cached glass eels (kg) per EMU in the last three years. NC: Not compiled. NR: not reported. Note that the fishery in the Basque Country (ES_Basq) is recreational. Updated and new data are shown in green.

Year	EMU_code	Catch (kg)	Stocking (kg)	Direct consumption (kg)	Aquaculture (kg)
2016	ES_Mino	360	NR	NR	NR
2016	ES_Astu	3627	0.0	NC	NC
2016	ES_Cant	553	0.0	NC	NC
2016	ES_Basq	1730.5	0	1730.5	0
2016	ES_Cata	2085	0	1365	720
2016	ES_Vale	44	2.7	NC	NC
2017	ES_Miño	1212	NR	NR	NR
2017	ES_Astu	3717	0.0	NC	NC
2017	ES_Cant	325	0.0	NC	NC
2017	ES_Basq	1511	0	1511	0
2017	ES_Cata	5082	NC	NC	NC
2017	ES_Vale	566	25	NC	NC
2018	ES_Miño	731	NR	NR	NR
2018	ES_Astu	3340	0	NC	NC
2018	ES_Cant	NR	0	NC	NC
2018	ES_Basq	1725	0	1725	0
2018	ES_Cata	645	NC	NC	NC
2018	ES_Vale	3	NC	NC	NC

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 (Table 50). Additionally, aggregated information exists for other EMUs (Table 51). The data sources are described in the 2017 Spanish Country report (ICES, 2017). The yellow eel catches decreased in Spain since 1950s, although the catches showed a historical peak in late sixties. The combined yellow and silver eel catches show great variability among regions, but in general, there is a decreasing trend in catches.

Table 50. Commercial yellow eel catches (kg) by EMU corresponding to Albufera (Valencia) and Mar Menor (Murcia) during the last decade fishing seasons. Updated and new data are shown in green.

Year	ES_Murc	ES_Vale
2008		2245
2009		4640
2010		2029
2011		1543
2012		1634
2013		1678
2014	13509	364
2015	5010	
2016	6329	1020
2017	7785	1134
2018	NP	346

Table 51. Yellow and silver eel catches (kg) by EMU during the last decade fishing seasons. Updated and new data are shown in green.

Year	ES_Andal	ES_Astu	ES_Bale	ES_Cata	ES_Gali	ES_Mino	ES_Murc	ES_Vale
2008		159	2138	NR	32766	447	20314	2953
2009		142	1993	NR	45730	NP	25631	3779
2010		1168	933	12016	28497	NP	22789	4940
2011		248	339	1900	31984	NP	18662	4071
2012		635	96	17600	36140	NP	19473	4232
2013		450	70	2017	46030	NP	24490	3220
2014		130	48	13519	38274	NP	33537	2778
2015	503	184	NP	10946	28304	NP	NP	1109
2016	3745	NP	NP	10056	32076	NP	NP	2849
2017	3100	NP	NP	13061	23016	NP	NP	1792
2018	4852	NP	NP	NR	26676	NP	NP	1024

Yellow and silver eel catches are separately reported from 2015 on. Yellow and silver eel fishing was prohibited from 2008 on in Miño river Basin and from 2016 on in Asturias.

3.1.3 Silver eel fisheries

Silver eel catches are reported since 1951 in Valencia and more recently in Murcia (Table 52).

Table 52. Silver eel catches (kg) by EMU corresponding to Albufera (Valencia) and Mar Menor (Murcia) during the last decade fishing seasons. Updated and new data are shown in green.

Year	ES_Murc	ES_Vale
2008		4910
2009		6942
2010		3688
2011		2497
2012		3822
2013		3598
2014	20028	2293
2015	13580	NR
2016	24244	4190
2017	19325	5618
2018	NR	4955

Valencia and the Balearic Islands allow yellow and silver eel recreational fishery, but no data are available.

3.2 Releases

Stocking is carried out in freshwater in Spain. Spanish EMUs use different life stages to stock (Table 9).

Table 53. Stocking kg in freshwater by EMU. G: Glass eel, GY: glass + yellow eel, Y: yellow eel, YS: Yellow and silver eel. Updated and new data are shown in green.

	G				GY			Y			YS		S	
Year	ES_Gali	ES_Cant	ES_Anda	ES_Cata	ES_Vale	ES_Vale	ES_Anda	ES_Astu	ES_Cata	ES_Nava	ES_Anda	ES_Cata	ES_Anda	ES_Cata
2008								4		101				
2009						388		3		102		380		388
2010						141				90				
2011		5	0	0	149		24	14	991	88		903		
2012		12	25	322	103				72				80	80
2013		13	256		78		8859							
2014	421		19		42		42		88		421			
2015			10			695					147			
2016			1			1055			381		690			
2017			169			1406			300		629			
2018			469	36		ND			165					

3.3 Aquaculture

Although there were different farms in Spain in the 1990s, nowadays there is only one remaining in Valencia (Figure 114, Figure 114. Aquaculture production in the Spanish EMUS since 1998.

Table 54, Table 55).

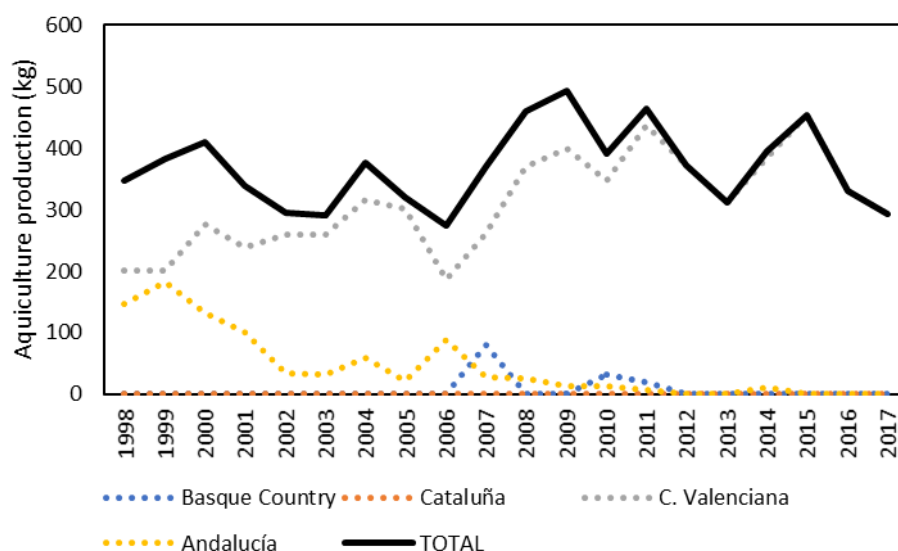


Figure 114. Aquaculture production in the Spanish EMUS since 1998.

Table 54. Freshwater aquaculture production of yellow eel (kg) by EMU.

Year	ES_Anda	ES_Basq	ES_Vale
1998	130000		100
1999	145000		90
2000	109000		80
2001	80000		70
2002			60
2003			50
2004	14000		40
2005			30
2006	70000		20
2007	11000	80000	10
2008	11000	65000	369730
2009		80000	
2010		31450	
2011		19190	4420
2013			81958
2014			5385
2015			81960
2016	0	0	0

2017	0	0	0
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Table 55. Open sea aquaculture production of yellow eel (kg) by EMU.

Year	Es_Anda	Es_Astu	Es_Cata	Es_Vale
1998	16700	0	700	200000
1999	37900	0	300	200000
2000	22500	0	3700	275400
2001	20900	0	0	238000
2002	34540	0	0	260320
2003	31370	0	0	260200
2004	46010	0	0	316650
2005	20430	0	0	300470
2006	19170	0	0	185630
2007	16700	0	0	261430
2008	14070	0	0	
2009	13380	0	0	399150
2010	12230	0	0	348000
2011	7180	0	0	437810
2012	860	0	0	371860
2013		0	0	311330
2014	12000	0	0	385430
2015	0	0	0	371970
2016	0	23	0	329880
2017	0	0	0	292300

3.4 Entrainment

Only Asturias and Galicia have estimated hydropower mortality (Table 56) which remains in the same order of magnitude throughout the series.

There is a theoretical study in the Basque Country that estimated mortality rates per turbine type from bibliography and silver eel population estimates (Díaz *et al.*, 2012; https://www6.euskadi.net/u810003/es/contenidos/informe_estudio/2013_recuperando_anguila/es_docu/adjuntos/4.OBJETIVOC.pdf). The cumulative mortality among eels passing through the turbines is between 51.9 and 81.0% in the Oria River. In another study in the Basque Country the impact of a hydropower station in the Silver eel from the Urola was determined (EKOLUR S.L.L., 2012). Preliminary results showed that less than 10% of silver eel passed through the bypass channel.

Table 56. Entrainment at water intakes mortality quantity SEE (kg) and rate in the Spanish EMUs according to the 2018 post evaluation report.

	pre-EMP		2011		2014		2017	
EMU	SEE	ΣH	SEE	ΣH	SEE	ΣH	SEE	ΣH
ES_Anda	ND	ND	ND	ND	ND	ND	ND	ND
ES_Astu	ND	ND	ND	ND	49	0.001	57	0.002
ES_Bale	0	0.000	0	0.000	0	0.000	0	0.000
ES_Basq	ND	ND	ND	ND	ND	ND	ND	ND
ES_Cant	ND	ND	ND	ND	ND	ND	ND	ND
ES_Cast	NP	NP	NP	NP	NP	NP	NP	NP
ES_Cata	ND	ND	ND	ND	ND	ND	ND	ND
ES_Gali	807	0.027	NC	NC	705	0.019	705	0.054
ES_Inne	0	0.000	0	0.000	0	0.000	0	0.000
ES_Murc	0	0.000	0	0.000	0	0.000	0	0.000
ES_Nava	ND	ND	ND	ND	ND	ND	ND	ND
ES_Vale	ND	ND	ND	ND	ND	ND	ND	ND

3.5 Habitat quantity and quality

Many obstacles have been removed and passes have been installed; however, available information does not allow estimating the available habitat increase in many of the EMUs (Table 57). Cataluña estimated the habitat increase due to elimination of obstacles and establishment of protected areas in SEE.

Table 57. Habitat quantity and quality increase mortality quantity SEE (kg) and rate in the Spanish EMUs according to the 2018 post evaluation report.

	pre-EMP		2011		2014		2017	
EMU	SEE	ΣH	SEE	ΣH	SEE	ΣH	SEE	ΣH
ES_Anda	ND	ND	ND	ND	ND	ND	ND	ND
ES_Astu	ND	ND	ND	ND	ND	ND	ND	ND
ES_Bale	NP	NP	NP	NP	NP	NP	NP	NP
ES_Basq	ND	ND	ND	ND	ND	ND	ND	ND
ES_Cant	ND	ND	ND	ND	ND	ND	ND	ND
ES_Cast	NP	NP	NP	NP	NP	NP	NP	NP
ES_Cata	ND	ND	ND	ND	ND	ND	1157	ND
ES_Gali	ND	ND	ND	ND	0	0	0	0
ES_Inne	ND	ND	ND	ND	ND	ND	ND	ND
ES_Murc	NP	NP	NP	NP	NP	NP	NP	NP
ES_Nava	ND	ND	ND	ND	ND	ND	ND	ND
ES_Vale	ND	ND	ND	ND	ND	ND	ND	ND

During 2015–2017 4800 kg of European eel were stocked in Spain. Valencia and Andalucía stocked 3160 kg and 1640 kg respectively. Most of them was glass/yellow eel (GY) stage from Valencia. Andalucía stocked both with glass (G) and yellow/silver eel (YS) stages. In addition, Cataluña stocked 680.8 kg yellow eel (Y) for the same period.

The biomass of restocked eels has been highly variable since the implementation of the management plan. In the first three years it reached its peak with eels restocked exclusively from and in Valencia. Stocked SEE biomass increased in 2018 comparing to that 2015 (Table 58).

Table 58. Biomass increase produced by Stocking quantity SEE (kg) and rate in the Spanish EMUs according to the 2018 post evaluation report.

	pre-EMP		2011		2014		2017	
EMU	SEE	ΣH	SEE	ΣH	SEE	ΣH	SEE	ΣH
ES_Anda	0	0.000	0	0.000	3	0.000	797	-0.006
ES_Astu	0	0.000	0	0.000	859	-0.031	0	0.000
ES_Bale	0	0.000	0	0.000	0	0.000	0	0.000
ES_Basq	0	0.000	0	0.000	0	0.000	0	0.000
ES_Cant	ND	ND	ND	ND	ND	ND	452	-0.125
ES_Cast	NP	NP	NP	NP	NP	NP	NP	NP
ES_Cata	ND	ND	ND	ND	ND	ND	2681	ND
ES_Gali	NP	NP	NP	NP	NP	NP	NP	NP
ES_Inne	NP	NP	NP	NP	NP	NP	NP	NP
ES_Murc	0	0.000	0	0.000	0	0.000	0	0.000
ES_Nava	NP	NP	NP	NP	NP	NP	NP	NP
ES_Vale	324	0.000	21142	0.000	108	0.000	1072	0.003

4 National stock assessment

4.1 Description of Method

4.1.1 Data collection

There is not stock assessment in Spain at a national level; each Spanish region assessed the stock for the management plan in a different way. It is the government of each region who oversees the control, regulation and management of eel fishery and population. Thus, population assessment is made at the region level, and the methodology data requirement and monitoring methods depend on the region.

AZTI carried out the first data compilation for eel in Spain for the WGEEL report (2006). Other compilations of data were carried out for the EMP and for the post evaluation of the EMP (2012, 2015 and 2018).

Thanks to the implementation of the European Union Multi-annual Plans (CE) from 2017 an improvement in the data compilation is foreseen.

4.1.2 Analysis

There is a great variability of the assessment of the current eel population in the post-evaluation report depending on the EMU. There are three different situations:

- 1) **Total lack of data in the EMU:** those EMUs have applied a reference area production value from scientific studies or from samplings in similar nearby habitats.
- 2) **EMUs with electrofishing surveys:** those EMUs have their own production values for certain areas and they have extrapolated these values to areas of similar habitats where no information was available.
- 3) **EMUs with fishery data and surveys:** those EMUs calculated Silver eel production based on these data.

As pristine production is concern, some EMUs have used reference values, and others have applied a conversion factor to their current production. To calculate the glass and silver eel equivalents, an average six-year generation time was considered based on the range of silvering ages observed in Spain (Fernández-Delgado *et al.*, 1989; Lobón-Cerviá *et al.*, 1995; Cardona *et al.*, 2002, PGA Murcia.). Thus, the catches of glass and yellow eel, from six and three years ago and current silver eel catches were used. Besides, 80% mortality in glass eel settlement (Briand, 2009) and annual mortality of 0.138 were considered (Dekker, 2000).

The Spanish EMP includes a series of calculations to define the pristine habitat and escapement. The exact definition of the pristine habitat was unknown and due to the lack of complete sets of data or harmonised methods to estimate escapement levels, a series of general criteria were assumed, based on the data available in each region and scientific literature (Table 59 and Table 60). These calculations were improved and reported in the 2012 post evaluation report being reviewed again for some EMUs in the 2015 report and the present report.

The criterion generally adopted for the definition of the **pristine habitat** was to consider the natural habitat of eel as the watercourses from the river mouth to a height of 800 m in basins with little slopes and to 600 m in those of greater slopes if there were no natural obstacles in levels below these heights. For the internal basins (without EMP in the 1st phase, see Section 2), data on surface water layer has been used with a series of technical criteria provided by the Hydrographic Confederations. The regions with EMP in the 1st phase have defined a more detailed estimate of their habitat, which may mean that the inland habitat area is underestimated compared with the coastal one. The **current habitat** was quantified as the previous one, but only considering the habitat before the first artificial impassable obstacle.

Some of the regions have improved their estimations in the 2015 post evaluation report and further in the present post evaluation report: they have obtained new current productivity values and they have calculated historic values applying a conversion factor.

Table 59. Approaches used by the Spanish regions to determine escaping silver eel pristine (B_0) and current biomass (B_{current}) in according to the 2018 post evaluation report.

Freshwater		
EMU	B_0	B_{curr}
ES_Andal	Area production rate (16.4 kg/ha) To obtain the pristine productivity the decrease in the recruitment index before the eighties (10%) has been applied to the B_{best}	Subtraction of fishing mortality to B_{best} and addition of stocking mortality
ES_Asturi	Area production rate (20kg /ha) (ICES, 2001) for "big" rivers Area production rate applied as conversion factor between "big/small" rivers	Extrapolation of the Silver eel productivity obtained each year in electrofishing surveys in each river basin
ES_Bale	NP	NP
ES_Basque	Area production rate (20kg/ha) (ICES, 2001)	Extrapolation of the Silver eel productivity obtained each year in electrofishing surveys. For those rivers with no sampling, extrapolation of area production rate obtained in electrofishing surveys to similar habitats.
ES_Cantab	Apply a conversion factor to B_{cur}	Extrapolation of the Silver eel productivity obtained each year in electrofishing surveys in each river basin
ES_Castile	Area production rate (20kg/ha) (ICES, 2001)	No current production, inaccessible habitat
ES_Catalu	Area production rate (20kg/ha) (ICES, 2001)	Extrapolation of the Silver eel productivity obtained in electrofishing surveys to areas of similar habitats within the same river. For rivers where no sampling has taken place the % population decrease since 2008 observed in similar rivers has been applied.
ES_Galici	Area production rate (20kg/ha) (ICES, 2001)	Extrapolation of the Silver eel productivity obtained in electrofishing surveys to areas of similar habitats where no information is available.
ES_Innere	Area production rate (20kg/ha) (ICES, 2001)	No current production, inaccessible habitat
ES_Navarre	Area production rate (20kg/ha) (ICES, 2001)	Extrapolation of the Silver eel productivity obtained in electrofishing surveys to areas of similar habitats where no information is available. .
ES_Vale	An average area production rate. Freshwater : 20 kg /ha (ICES, 2001) , lagoon: 77,8 kg/ha (EMP_ES_Bale, 2010), Transitional: 80 kg/ha (Rhone, French EMP)	Extrapolation of area production rate ((Rhone, French EMP)
ES-Murcia	Area production rate (20kg/ha) (ICES, 2001)	ND

Table 60. Approaches used by the Spanish regions to determine escaping silver eel pristine (B_0) and current biomass (B_{current}) in transitional waters and lagoons according to the 2018 post evaluation report.

EMU	Transitional	
	B_0	B_{curr}
ES_Andal	Area production rate (wetlands: 55.8 kg/ha) To obtain the pristine productivity the decrease in the recruitment index before the eighties (10%) has been applied to the B_{best}	Subtraction of fishing mortality to and addition of stocking mortality
ES_Asturi	Area production rate (14.3 kg /ha) (Expert criteria)	Extrapolation of area production rate (surveys)
ES_Bale	Area production rate: lagoons 77.8 kg/Ha. Obtained by the application of the decrease in the cpue (50%) before the 80ies to B_{curr}	Based on yield fishery data and surveys in Es Grau Lagoon (Cardona et al., 2002). For 2017 the decrease in the recruitment index since 2002 has been applied (60.4% decrease since 2002)
ES_Basque	Area production rate. A value of 82.7 kg/ha has been assumed, which corresponds to the highest production obtained in the downstream sampling points through the periodic sampling using electrofishing surveys.	Extrapolation of the productivity values obtained in the samplings points which are located closer to the transitional waters
ES_Cantab	ND	ND
ES_Castile	NP	NP
ES_Catalu	Area production rate (77,8 kg /ha) (EMP ES_Bale)	Extrapolation of area production rate (surveys); population decrease since 2008 where no sampling
ES_Galici	Surveys	Extrapolation of area production rate (surveys)
ES_Inne	NP	NP
ES_Navarre	NP	NP
ES_Vale	Lagoon: 77,8 kg/ha (EMP_ES_Bale, 2010), Transitional: 80 kg/ha (Rhône, French EMP)	Extrapolation of area production rate (Rhône)
ES_Murcia	Apply a conversion factor to B_{curr}	Based on fishery data and surveys (Martínez Baños, 2010)

4.1.3 Reporting

In Spain, each autonomous government oversees the control, regulation and management of eel fishery and population. Thus, population assessment is made at the autonomous region level, and the methodology data requirement and monitoring methods depend on the autonomy. Almost all the autonomies compile eel fishery data; but each autonomous region has its own methodology to compile data. AZTI carried out the first data compilation for eel in Spain for the WGEEL report (2006).

4.1.4 Data quality issues and how they are being addressed

The following quality issues have been detected in the 2018 post-evaluation report:

- Non-fishery anthropogenic mortality indices are still missing in many EMUs.
- Coastal and maritime waters have not been included in the pristine and current area, and therefore, in the biomass indicators.
- Some EMUs have used reference values from other EMUs to calculate the biomass indicators.
- Most of the estimations are based in rough extrapolations.

4.2 Assessment results

The Spanish EMP envisaged the improvement of the biomass and mortality indices in the EMP second phase starting in 2016. In the 2018 report, some pristine escapement estimations were improved compared to the previous report: Andalucía and Murcia (Table 61). The series of B_{curr} estimations was reviewed by Andalucía, Asturias, Cataluña and Navarra. Mortality estimates were also reviewed by Asturias retrospectively (Table 62). In this way B_{curr}/B_0 has also been re-estimated backwards for the previous reporting years.

Table 61. Pristine and current escapement and B_{curr}/B_0 relation evolution in the Spanish EMUs according to the 2018 post-evaluation report.

EMU	B_0 (Kg)	B_{curr} (kg)				B_{curr} / B_0 (%)				B_{best} (kg)			
		pre-EMP	2011	2014	2018	pre-EMP	2011	2014	2018	pre-EMP	2011	2014	2018
ES_Anda	6057545	100565	164841	137989	128457	1.7	2.7	2.3	2.1	310599	310599	310599	310599
ES_Astu	63495	ND	12584	28437	29466	ND	19.8	44.8	46.4	28063	59334	43886	81143
ES_Bale	330883	216540	220561	220561	138586	65.4	66.7	66.7	41.9	219470	222662	220871	138586
ES_Basq	245040	12215	129167	126866	127072	5	52.7	51.8	51.9	12215	238398	239334	161787
ES_Cant	9680	6433	1976	1259	1723	66.5	20.4	13.0	17.8	6433	28063	36575	6579
ES_Cast	23488	0	0	0	0	0.0	0.0	0.0	0.0	ND	0	0	0
ES_Cata	364607	78257	ND	ND	95415	46.3	ND	ND	26.2	357446	ND	ND	196371
ES_Gali	110700	15199	ND	24889	12785	13.7	ND	22.5	11.5	52697	ND	52021	103785
ES_Inne	2420205	0	0	0	0	0.0	0.0	0.0	0.0	ND	0	0	0
ES_Murc	26270	7031	3382	13510	8095	32.1	15.4	51.4	30.8	46890	32770	47387	54445
ES_Nava	5448	ND	1533	1935	1134	ND	43.1	35.5	20.8	ND	ND	ND	ND
ES_Vale	698026	385175	385175	385175	385175	55.2	55.2	55.2	55.2	408080	422688	406875	419444
TOTAL	10 355 387	821 415	919 218	940 622	927 906	7.9	8.9	9.1	9.0	1 441 893	1 314 514	1 357 548	1 472 739

Table 62. Mortality indicators evolution according in the Spanish EMUs according to the 2018 post-evaluation report.

	ΣF				ΣH				ΣA			
	pre-EMP	2011	2014	2018	pre-EMP	2011	2014	2018	pre-EMP	2011	2014	2018
ES_Anda	ND	ND	0.861	0.885	0.000	0.000	0.000	- 0.006	ND	ND	0.861	0.879
ES_Astu	1.557	1.551	0.460	1.010	ND	ND	0.031	0.002	1.557	1.551	0.465	1.010
ES_Bale	0.013	0.009	0.001	NP	ND	ND	ND	ND	0.013	0.009	0.001	ND
ES_Basq	ND	0.613	0.635	0.242	ND	ND	ND	ND	ND	0.613	0.635	0.242
ES_Cant	ND	ND	3.369	1.465	ND	ND	ND	- 0.125	ND	ND	3.369	1.340
ES_Cast	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
ES_Cata	1.230	ND	ND	0.740	ND	ND	ND	ND	1.230	ND	ND	0.740
ES_Gali	1.217	ND	0.718	2.087	0.027	ND	0.019	0.054	1.243	ND	0.737	2.141
ES_Inne	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
ES_Murc	1.898	2.271	1.255	1.900	0.000	0.000	0.000	0.003	1.898	2.271	1.255	1.900
ES_Nava	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ES_Vale	0.058	0.093	0.055	0.088	0.000	0.000	0.000	0.000	0.058	0.093	0.055	0.091

5 Other data collection

5.1 Recruitment time-series

All the data in this section are obtained from auctions or fishermen guilds. Highest landings of glass eel in Spain were obtained in late 1970s prior to the decline in early 1980s (Figure 112). There are four historical dataseries for glass eel catches in Spain which are updated yearly:

- San Juan de la Arena fish market in Asturias: It includes almost all the catches from the Nalón River. Until the 1970s only land fishing existed, then fishermen started to fish in boats, and the catches increased notably.
- The Albufera in C. Valenciana. In 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 dataseries, the Pujol, Perelló and Perellonet data will be considered for the historical dataseries of the Albufera.
- The Delta del Ebro lagoons in Catalonia. Data are obtained from the fish markets in the area. Since 1998, the administration from Catalonia compiles data for the fish markets corresponding to the Ebro river mouth, obtaining total catches in the Ebro. Additionally, since 1998 it compiles information from the rest of Catalanian Rivers also.
- The Miño. This RBD is shared with Portugal; but only data corresponding to Spain is reported here. The Miño River command compiles the Spanish catches data.

After a slight recovery in 2014, glass eel recruitment has shown a sustained decrease in the four Spanish series (Figure 115).

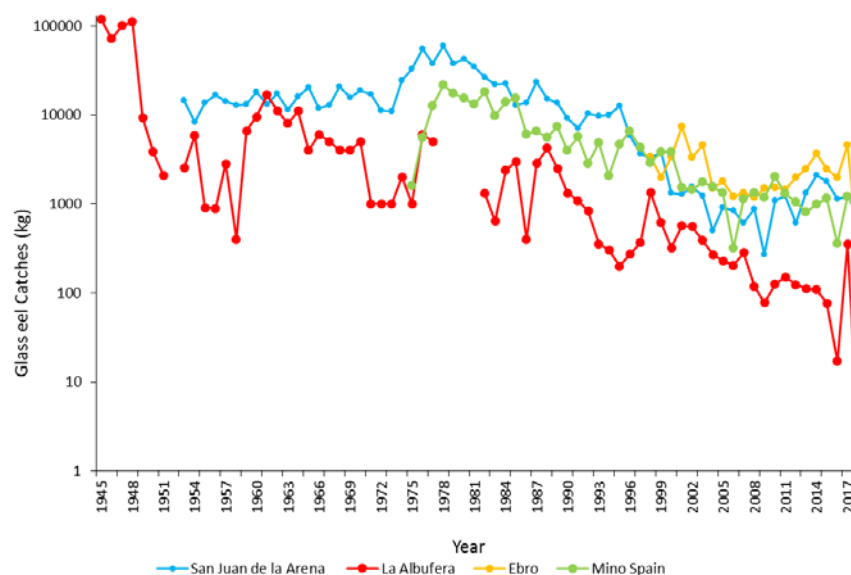


Figure 115. Evolution of the four Spanish recruitment series since 1945.

5.2 Yellow eel abundance surveys

Many autonomous regions make periodic multispecific electrofishing surveys but few of them have been exclusively directed to eel. There is not any agreed protocol for sampling, and there is not any compilation of this information at the national level. Some of the autonomous regions envisaged making eel specific surveys in their management plans.

Yellow eel recruitment in the Oria River is sampled in a yearly basis in a fish pass in the tidal limit.

5.3 Silver eel escapement surveys

The Basque management plan determines the spawning potential according to Durif *et al.* (2005) in one river per year. Results are available in the post-evaluation report. Additionally, in another study (EKOLUR S.L.L., 2012) silver eel migration period and related environmental variables were studied in the Urola River (Basque Country). The silver eel migrated between October and January, with a peak in November, and mainly during night and when there is high flow and turbidity. Valencia also started making silvering eel specific surveys in 2012.

Total density of eels and the size and number of male silver eels were quantified between 1990–2011 at 15 sites spread along four Rio Esva tributaries (Asturias, north-western Spain) (Iglesias and Lobón, 2012).

Some of the autonomous regions envisaged making silvering eel specific surveys in their management plans.

5.4 Biological parameters

Biological parameters are not sampled routinely in the autonomous regions, although the autonomous regions envisaged sampling them in their management plans.

There are no new data (see Spanish CR 2015). The information available until 2018 is shown in the electronic tables also.

5.5 Parasites and pathogens

There are no new data (see Spanish CR 2015).

5.6 Contaminants

There are no new data (see Spanish CR 2011).

5.7 Predators

There are no new data (see Spanish CR 2015). The available information does not allow estimating the impact of predators in the different Spanish EMUs.

6 New information

SUDOANG (<https://www.sudoang.eu/>) is an Interreg Sudoe project whose main objective is to provide tools and joint methods that support the conservation of the European eel and its habitat to managers in the Sudoe area. It is led by AZTI and the consortium includes Spanish, French and Portuguese scientists as partners and many regional and national eel management related managers participate in the project as associate partners. More specifically, the Eel Density Analysis model (EDA) will be implemented, which allows the prediction of yellow eel densities and silver eel escapement from electrofishing survey networks. Also, the project will quantify the impacts of hydropower facilities on downstream-migrating silver eels. In addition, #SUDOANG will produce recruitment estimates and will create a governance platform to support the proper management of the eel stock in the SUDOE area. All of this will be ready by the end of 2020, so the estimations of the stock indicators for the next post-evaluation report will be greatly improved.

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

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.

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Reporting Period: This report was completed in September 2018, and contains data up to 2017 and some provisional data for 2018.

Acknowledgments: Niklas B. Sjöberg from the Institute of Freshwater Research kindly added the results from our tagging (mark–recapture) studies in the Baltic Sea. Richard Fordham at Scandinavian Silver Eel AB kindly provided data on the aquaculture production and on restocking.

1 Stock status summary

The assessment made in 2015 was updated in spring 2018 and revised in late summer 2018 (Dekker *et al.*, 2018). Compared to the 2016 assessment, the 2018 update made no major changes in methodology, though some of the model parameters were changed slightly (notably: improved recruitment estimates and length–weight–relation, both for the inland stock). The revision corrected an error in the reported landings for inland waters (different lakes were reported as different areas within an unknown lake; the ‘unknown’ status made those data drop out). Below, we report on the revised assessment, as of November 1st 2018. For the Baltic coast (SE-east) assessment in 2018, indicators are reported more strictly than in 2015. Dekker (2015) reported B_{best} and $B_{current}$, considering the impacts of the Swedish fisheries only. Dekker *et al.* (2018) took all impacts throughout the eel’s life into account; that is: including the impacts in the yellow eel stage, often in other countries in the Baltic, and noting that those impacts remain unquantified for the Baltic as a whole, reported indicators as “not available” (the impact of the Swedish fishery was reported separately, as F_{SE}).

EMU_code	Assessed Area (ha)	B ₀ (t)	B _{curr} (t)	B _{best} (t)	B _{curr} /B ₀ (%)	ΣF	ΣH	ΣA
SE-West	NP	NA	NA	NA	NA	0.00	0.00	0.00
SE-Inland+	1 800 000	564	113	314	20.0	0.36	0.72	1.08
SE-Inland-	1 800 000	300	18	51	6.1	0.36	0.72	1.08
SE-East	NP	NA	3627	NA	NA	NA	NA	NA

Key:

EMU_code = Key: Inland+ includes the contribution of restocking in all indices, while Inland- does not.

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

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

B_{curr} = The amount of silver eel biomass that currently escapes to the sea to spawn (in the assessment year) (t).

B_{best} = The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock (t).

ΣF=mortality due to fishing, summed over the age groups in the stock (rate).

ΣH=anthropogenic mortality excluding the fishery, summed over the age groups in the stock (rate).

ΣA=all anthropogenic mortality summed over the age groups in the stock (rate).

1.1 Precautionary diagram

The precautionary diagram for eel in Sweden is provided in Figure SE. 1.

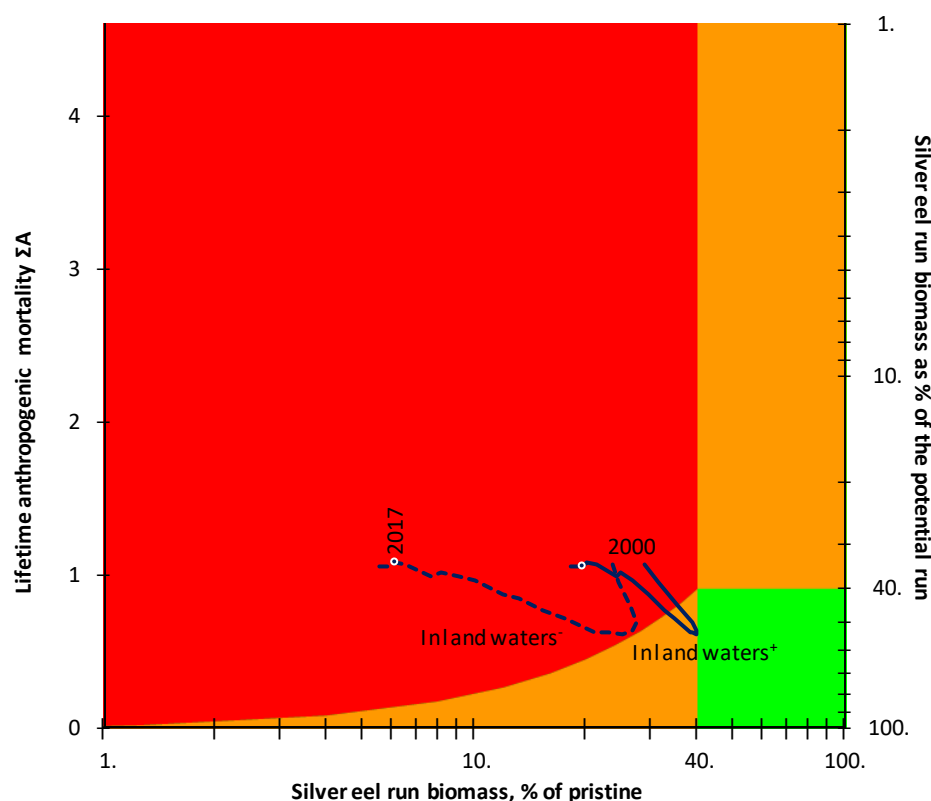


Figure SE.1. Precautionary Diagram for the Swedish eel stock in inland waters. For the west coast, and for the Baltic coast, no stock indicators are currently available. For inland waters, the true mortality is shown (not interpreting restocking as compensating for other mortalities), giving separate curves for the current biomass with or without the contribution from restocking, (%SSB+ resp. %SSB-).

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

2.1.1 EMUs, EMPs

Sweden has only one Eel Management Plan (EMP), covering the whole country including even the mountainous region in the north and northwest, where eels factually do not occur anymore. However, for different reasons, assessments are made for three separate regions, i.e. there are three Eel Management Units (EMU), namely the west coast (SE-West), Baltic (SE-East) and the Inland. 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, in the North Sea area, was closed in spring 2012. Öresund is the strait between Sweden and Denmark where most silver eels from the Baltic have to pass when leaving for the North Sea and the Atlantic Ocean. Öresund is defined as a part of the Baltic Sea in this report, and by all relevant eel advice and management authorities.

In the Baltic, there are two main types of eel fisheries. One is the traditional fishery with fixed traps (poundnets) along the “Eel Coast” in the southernmost county Scania, where silver eels are the target species. The other type of fishery also uses big poundnets, but targets several species including cod, perch, pike, flounder, etc. depending on the site and abundance of different species. Fykenets of different sizes are also used at several sites.

Finally, there is an eel fishery in a number (ca. 20) of inland lakes. The major part of eel landings come today from lakes Mälaren, Vänern and Hjälmaren. This fishery is also mainly maintained using poundnets and targets more species than eels. Pike-perch is one of the most important species in this context and has become the main species in many fisheries.

2.1.2 Management authorities

The fish stocks and the fisheries are managed by the governmental agency, Swedish Agency for Marine and Water Management, SwAM. Data and advice for management use are mainly given by the Department of Aquatic Resources at the Swedish University of Agricultural Sciences (SLU Aqua).

2.1.3 Regulations

The fishery for eels has been regulated in several different ways since 2007, e.g. a mandatory eel licence, an increased minimum legal size, effort restrictions in time and number of fishing gears, an upper limit in total catch per licence and a total closure of the eel fishery along the west coast in 2012.

At the EU Ministerial Council on December 11–13, 2017, a decision was taken on a moratorium for commercial fisheries on eel longer than 12 cm in all EU marine waters in the Northeast Atlantic, including the Baltic Sea. The moratorium should cover three consecutive months between September 1, 2018 and January 31, 2019. The SwAM subsequently decided in 2018 that the moratorium in Sweden should apply between November 1, 2018 and January 31, 2019.

2.1.4 Management actions

The Swedish EMP is an adaptive plan where a restricted fishery is one management action among others; the aim of the EMP is to reduce anthropogenic impacts to a level that will allow the stock to recover. Stocking is another one, where the target was to double the earlier amounts of slightly pre-grown elvers to about 2.5 million individuals stocked annually. An improved escapement of silver eels at hydropower plants is also a management measure in the EMP as well as an improved control of the fishery.

The stocking target was reached within a few years, except in 2015 when the EU-funds were emptied. In 2017 most eels aimed for restocking were destroyed due to an infection with Eel Virus European X (EVEX). Thus the national eel management plan suffered a great loss both in loss of restocking fish and economically. Trap and Transport (T&T) of silver eels from upstream to downstream sites in rivers has been implemented, but a few hydropower plants have also been reconstructed to allow a safe downstream migration of silver eels. Within this T&T-programme some 107 000 silver eels were safely transported downstream by road between 2010 and 2017. T&T will continue as one measure to decrease eel mortalities due to hydropower exploitation.

As mentioned, eel fishing has been reduced in Swedish coastal waters. In 2007, a licence requirement was introduced and was followed by additional restrictions. Since spring 2012, eel fishing south of Torekov (56°25') in the Kattegat (west coast) and further into the Baltic has been limited to the period May 1–September 14 or an individually determined period of 90 consecutive days. In the part of Kattegat just north of Öresund this determined period is restricted to 60 days only. All eel fishing along the west coast north of Torekov became prohibited. In freshwater eel fishing is allowed for licensed fishers during 120 individually determined days.

2.1.5 Local stock assessment

According to the Swedish Eel Management Plan, the whole Swedish national territory constitutes a single management unit. Several management actions, however, and most of the anthropogenic impacts, differ between geographical areas: inland waters and coastal areas are contrasted and west coast vs. Baltic coast (east and south). Anthropogenic impacts include barriers for immigrating recruits, restocking, yellow and silver eel fisheries, hydropower related mortality, Trap & Transport of young recruits and of maturing silver eels, etc.

The assessment in Dekker (2012; 2015) and Dekker *et al.* (2018) is broken down along geographical lines, also considering the differences in impacts, resulting in four blocks, with little interaction in between.

West Coast–natural recruitment and restocking, fishery on yellow eel (Figure SE.2).

The Swedish EMP presented an assessment, 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 had been closed as of 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 an adequate follow-up monitoring (no priority from the funding agency), no new assessment had been made; no new indicators were given. In 2018, that situation has not changed fundamentally. Existing monitoring efforts (sampling six sites along a 320 km coastline) are insufficient to assess the stock in absolute terms (B_{current} , B_{best} and B_0), but do

allow trend-monitoring (relative changes over time). Additionally, recent analysis of historical information (Magnusson and Dekker, in prep.) 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, B_0 comes at 1154 ton.

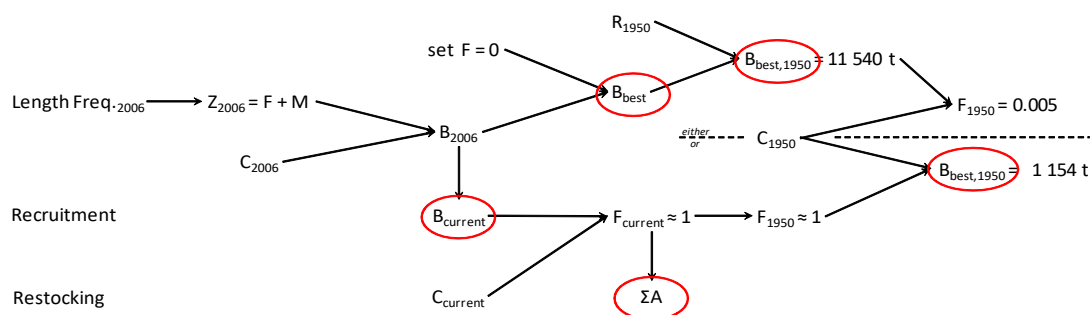


Figure SE.2. Dependencies between data and estimates for the West Coast.

Inland waters—for the inland eel stock, an assessment was made in 2015 (Figure SE.3). Starting with estimates of natural recruitment (trend analysis of trap catches) and databases on restocking and assisted migration, a reconstruction was made of the corresponding amount (biomass, numbers) of silver eel produced in inland waters, which is time and location-specific (the place and time of release, known growth and age, guesstimated natural mortality). For each reconstructed batch of silver eel in each year, the amount caught by the fishery is subtracted. For the remaining silver eel, the route towards the sea is deduced from GIS maps, and the mortality due to the hydropower stations on this route is calculated. Only limited ground-truth information exists, to verify the 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, estimates were presented for $M=0.10$.

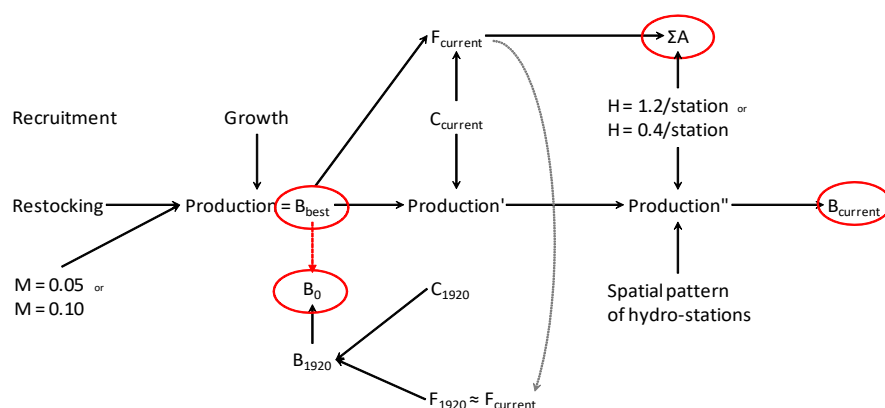


Figure SE.3. Dependencies between data and estimates for the inland waters. The calculation of B_0 , the sum of current day's production based on restocking, and B_{1920} , is a chosen policy, aiming to restore the natural stock and to protect the restocked eels as well.

Trap & Transport of silver eel—not related to a standing stock, recruitment or other anthropogenic impacts (Figure SE.4). The eels for Trap & Transport are taken from the fishery; hence, that impact is already covered. Under this heading, only the release of the silver eel is considered. Calculated escapement is simply set equal to the biomass released; no (negative) mortality is calculated, since the release is not linked to any particular part of the standing stock.

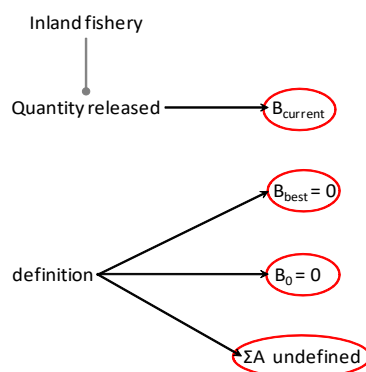


Figure SE.4. Dependencies between data and estimates for the Trap & Transport. Note that the eels are de facto derived from inland fisheries, but their origin affects neither the inland stock assessment nor the Trap & Transport assessment.

Baltic Coast—natural recruitment and restocking, fishery on silver eel (Figure SE.

5). The Baltic Coast (SE-East) stock is a mix of local production and (mostly) immigrants from elsewhere in the Baltic- and it is a mix of restocked and natural eels. In the absence of an assessment of the corresponding yellow eel stock (possibly in the whole Baltic), the impact of the Swedish silver eel fishery has been assessed on the basis of historical mark-recapture experiments (Dekker and Sjöberg, 2013), which have been recontinued since 2012. The fishing mortality in the years 2000–2008 was estimated at 0.1; the 2015 estimate came at $F=0.02$. Estimates of biomass were derived as $\text{Biomass} = C / F$, where C =catch weight. However, since both C and F are now close to zero

in many provinces (län), their ratio (-biomass estimate) was highly uncertain.

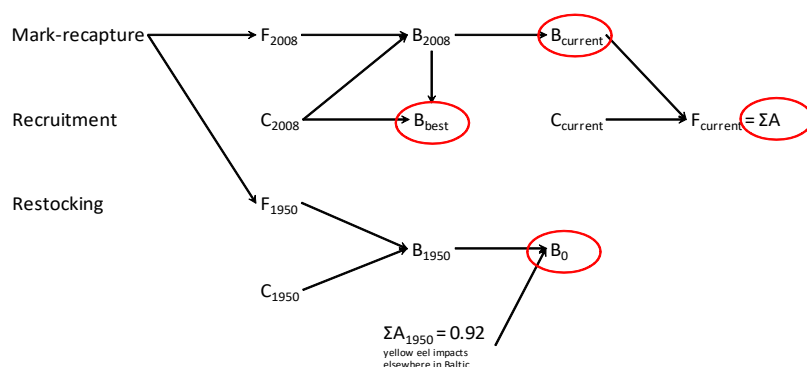


Figure SE.5. Dependencies between data and estimates for the Baltic coast.

Estimate of B_0

Estimates of B_0 are given in **Table SE.1**.

Table SE. 1. Reference period for B_0 .

EMU_code	B_0 (tons)	Reference time period	Whether or not changed from value reported last year (Y/N)
SE-West	1154 – 11540	1950-2010	N
SE-Inland	595 or 300 (with, without restocking)	Varies by year, if restocking is included	Y
T&T	n/a	n/a	n/a
Baltic coast	12,500	1950s	N

Reporting

Selected results from Swedish eel studies are reported to the EU as requested in 2012 and 2015. This is done by the responsible agency SwAM, based on an assessment report published by our department report series Aqua reports (e.g. Dekker, 2012; Dekker, 2015; Dekker *et al.*, 2018). Additionally, relevant data are used also for scientific papers (see the reference list below).

Selected data and results are also reported to ICES and WGEEL when appropriate.

Data quality issues and how they are being addressed

The assessments reported in Dekker (2015) make use of extensive databases on recruitment, elver transport, restocking, landings, age and growth, hydropower installations, river geography, and more; covering an extended geographical area, over a period of many decades. For the 2015 assessments, an extensive re-checking of the basic data has

taken place, applying business rules and comparing to the original sources. More importantly, the assessments making cross-links between the databases, inconsistencies have been revealed and subsequently corrected.

For the west coast, no assessment was produced in 2015. Historical data have now been compiled, (re)-checked and analysed (Magnusson and Dekker, in prep.).

For the inland waters, Dekker (2015) predicted yellow and silver eel abundance from the available information on recruits (natural, translocated, restocked) forward in time, towards the yellow and silver eel stage. No independent verification on yellow or silver eel data had been made. In 2016, investigations have started to include information on yellow eel abundance, derived from electro-fishing surveys. This will require mixing a state-based approach (electrofishing) with a rate-based approach (recruitment, catch). Most of the eel stock is located in lakes, while electrofishing covers mainly rivers, a problem to be addressed.

For the Baltic coastal fishery, Dekker (2015) reported mortality rates on the basis of Survival Analysis of a century of mark-recapture data (Dekker and Sjöberg, 2013). Stock size (biomass) estimates were derived from the Survival Analysis results (fishing mortality), in combination with available landings data. The quality of the landings data appears to put severe constraints on the credibility of the results. Landings data constituting a census (full coverage of all operations) rather than a survey (statistical sampling), the reliability of the landings data cannot be quantified. The targeted silver eel is derived from yellow eel stocks along the Swedish coast, in Swedish inland waters, but probably mostly from coastal and inland waters in other countries all over the Baltic area. In order to cross-check the Swedish escapement biomass estimates, a joint assessment of the whole Baltic stock is required (which in itself will be required to develop joint management of this shared stock). A proposal for an international research project to develop this joint assessment has been compiled (Dekker, 2013), but was not prioritised policy-wise.

Assessment results

For the West Coast, no assessment has been made since 2009, and that one did not assess time-trends.

For the Baltic coast, only an assessment of the impact of the Swedish silver eel fisheries has been made; see Dekker and Sjöberg (2013) for details; **Figure SE.6**. Other impacts, at other life stages of the same eel, have not been considered.

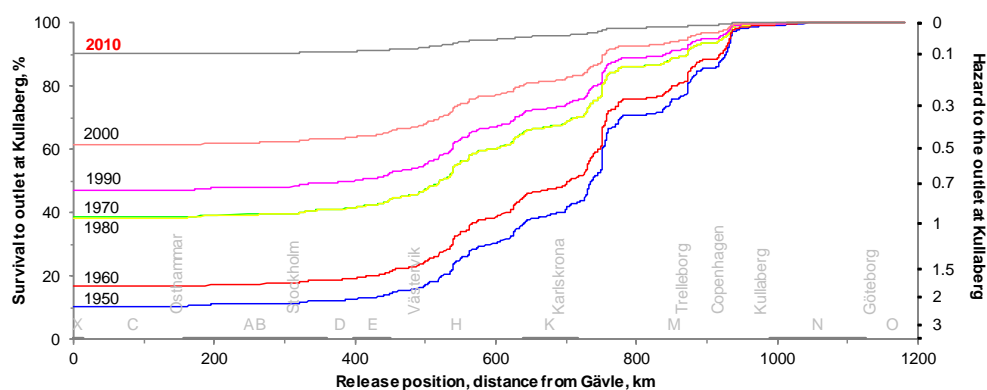


Figure SE.6. Hazard and survival, estimated by Cox proportional hazards model, by decade, without time-dependent covariates. The left vertical axis expresses the net survival from the release position t_0 to the outlet of the Baltic at Kullaberg; the right vertical axis expresses the same in terms of accumulated hazard over that interval. See Dekker and Sjöberg (2013) for further explanation.

For the inland waters, Figures SE.7 and 8 present the assessed trends in eel production (Figure SE.7) and impacts (Figure SE.8).

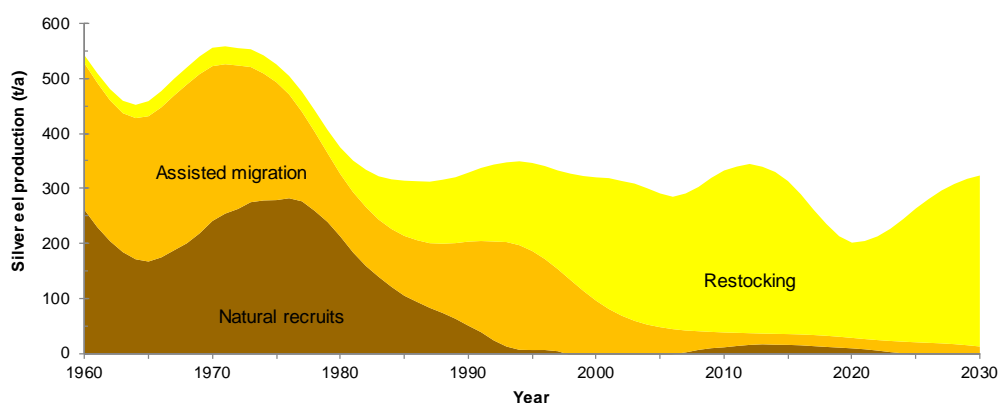


Figure SE.7. Production of silver eel by year and by origin of the eel, that is: the estimated total production before the impact of fishery and hydropower. For these results, a natural mortality rate of $M=0.10$ was assumed.

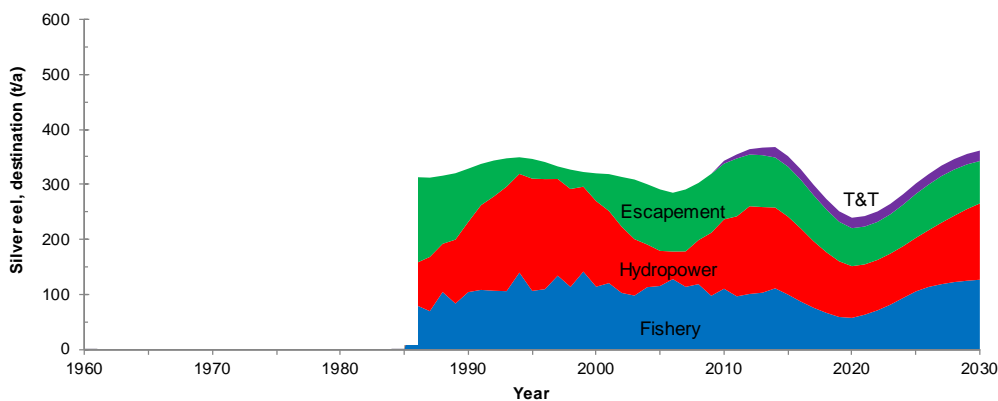


Figure SE.8. Time-trends in the destination of the silver eel produced in inland waters. Data before 1986 are incomplete.

2.2 Significant changes since last report

There have not been any major changes in the status of eel in Sweden since the previous country report. A fishing moratorium in marine waters will occur from November 1, 2018 to January 31, 2019.

3 Impacts on the stock

3.1 Fisheries

3.1.1 Glass eel fisheries

NP; there is no fishery for glass eels in Sweden. The reasons are twofold as there has never been any local demand for such small eels and the fact that high minimum legal size (700 mm) preclude fishing for glass eels.

3.1.2 Yellow eel fisheries

Most eels fished today are silver eels or “half-silver”, i.e. close to the silver stage. The minimum legal size of 700 mm may explain this situation. The remaining fishery almost exclusively targets silver eel; hence, no separate samples are taken of yellow and silver, but mixed samples representative for the catch. The total Swedish catch in 2017 was 102 tonnes from freshwater and 143 tonnes from the brackish/marine waters, i.e. 245 tonnes in total. There are numerous reports on illegal fisheries. In September 2017, SwAM answered (HaV dnr 2432-17) the EU Commission on request that Swedish authorities confiscated 278 illegal eel fishing gears in 2016 (one owner was charged) and 257 gears in January–August 2017 (one owner was identified). Staff at SwAM reported to the news outlet Radio P4 Blekinge on August 28, 2018 that 122 illegal eel gears had been seized so far in 2018.

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 2017, Swedish coastal fisheries had a total catch of 143 tonnes, out of which 100 tonnes were caught in the Baltic Proper. The catch per unit of effort (cpue) in two monitored coastal fisheries of the Baltic Sea had been quite stable in recent years, especially in S Östergötland. (Figure SE.9).

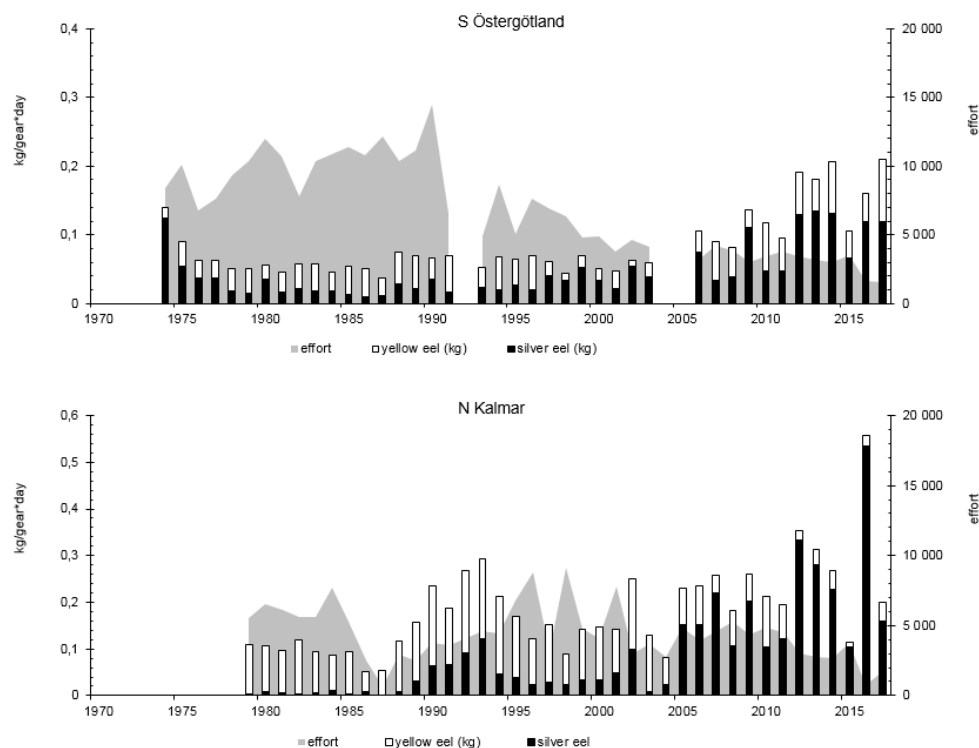


Figure SE.9. Effort and weight per unit of effort (yellow and silver eel) by two fykenet fishermen along the Swedish Baltic Proper coast.

Currently, we cannot evaluate the representativeness of this small number of series.

3.1.3 Silver eel fisheries

Most eels fished today are silver eels or close to the silver stage. The total Swedish catch in 2017 was 102 tonnes from freshwater and 143 tonnes from the brackish/marine waters, i.e. 245 tonnes in total (Figure 10).

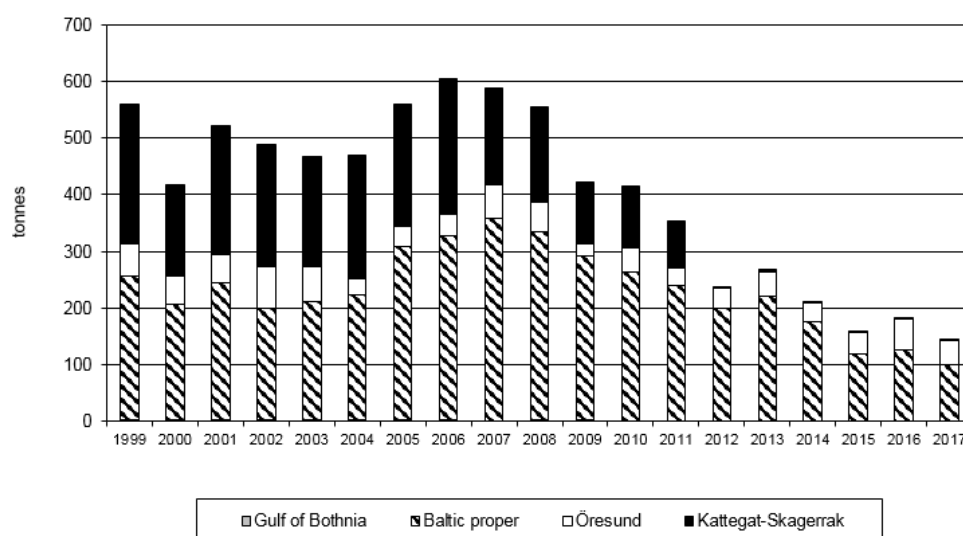


Figure SE.10. Commercial landings of eel in marine waters (based on logbook data).

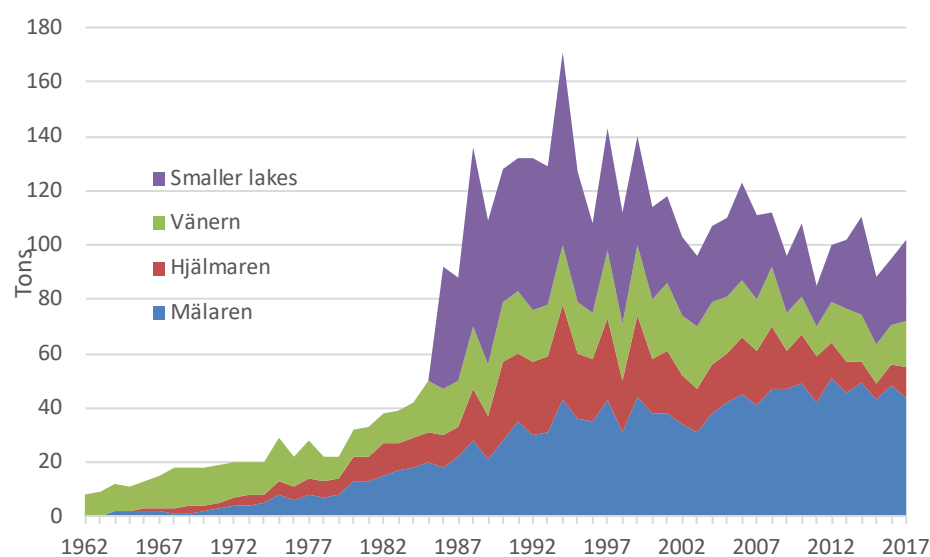


Figure SE.11. Commercial landings of eel in inland water. For the smaller lakes, no data are available for the years prior 1986.

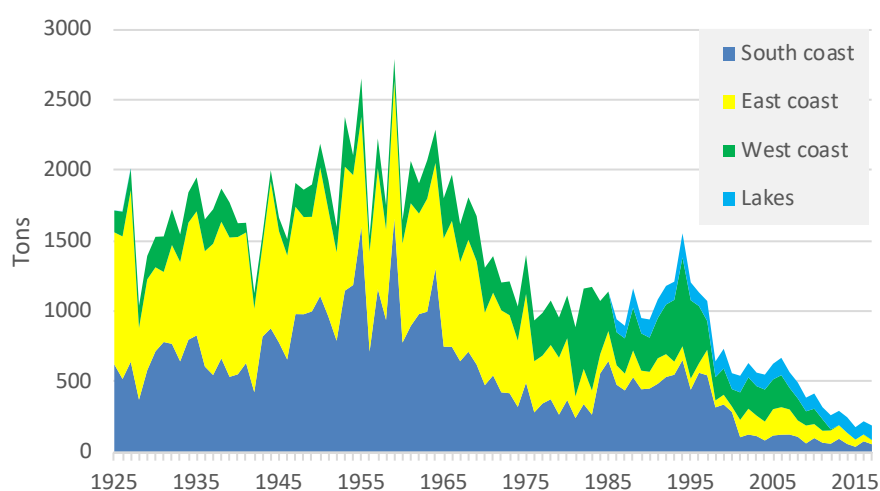


Figure SE.12. Total commercial landings of eel (NB, based on sales notes reports). For the lakes, no data prior to 1986 are available.

Data reported in logbooks on effort and on cpue are not of adequate quality to be used in our assessment work. The capacity, i.e. the number of fishers licensed in 2018 to fish for eels are 202 (**Figure SE.13**). The data come from SwAM, the responsible licensing agency. However, the actual effort is largely unknown.

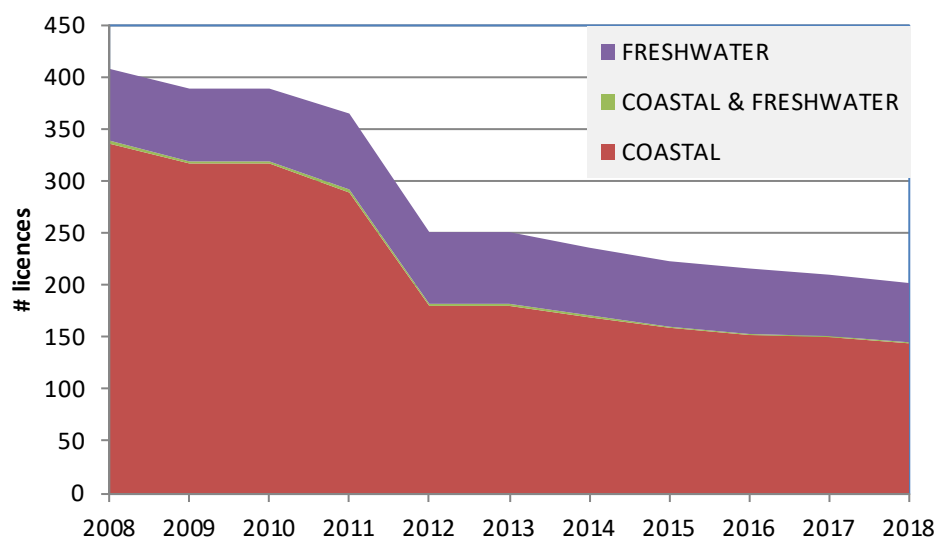


Figure SE.13. Number of fishermen with eel fishing licences.

3.1.3.1 Recreational

Recreational fishing on eel is generally banned in Sweden. However, there is an exception from the general ban on non-commercial eel fisheries in inland waters, and that is above three hydropower installations from where almost no silver eel would be able to pass safely to the sea. At present, we do not know the extent of that fishery, and whether those eels are sold or not. Regarding illegal fisheries, see Section 3.1.2.

3.2 Restocking

The numbers of stocked eels 2018 were 1 584 371 in freshwater and 1 524 268 in coastal waters (Figure SE.14 and SE.15). In addition, 81 500 were exported to Finland. They were all imported from River Severn in the UK. Another 250 000 eels are planned to be exported to Germany in 2018. They will be ongrown to ~5 g on average and originate from the 2017 batch.

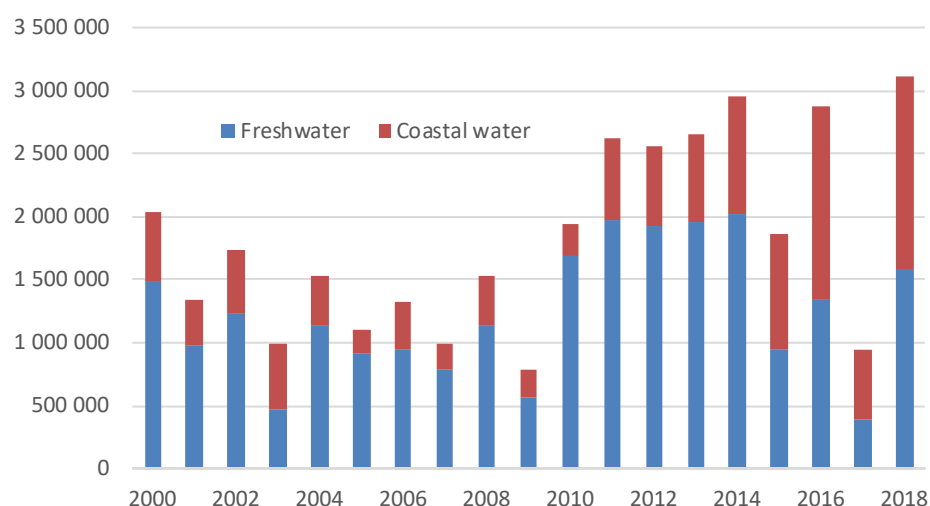


Figure SE.14. Number of restocked eels in Swedish fresh- and coastal waters, respectively.

In Sweden, eels must go through a quarantine period of about ten weeks before being stocked. This is to check for, and to minimise the risk of introducing, different diseases and viruses. During the quarantine period, eels are kept and handled under eel aquaculture conditions. Their mean weight is ca 1 g each or slightly less when stocked. They are not sorted before stocking in Sweden and Finland.

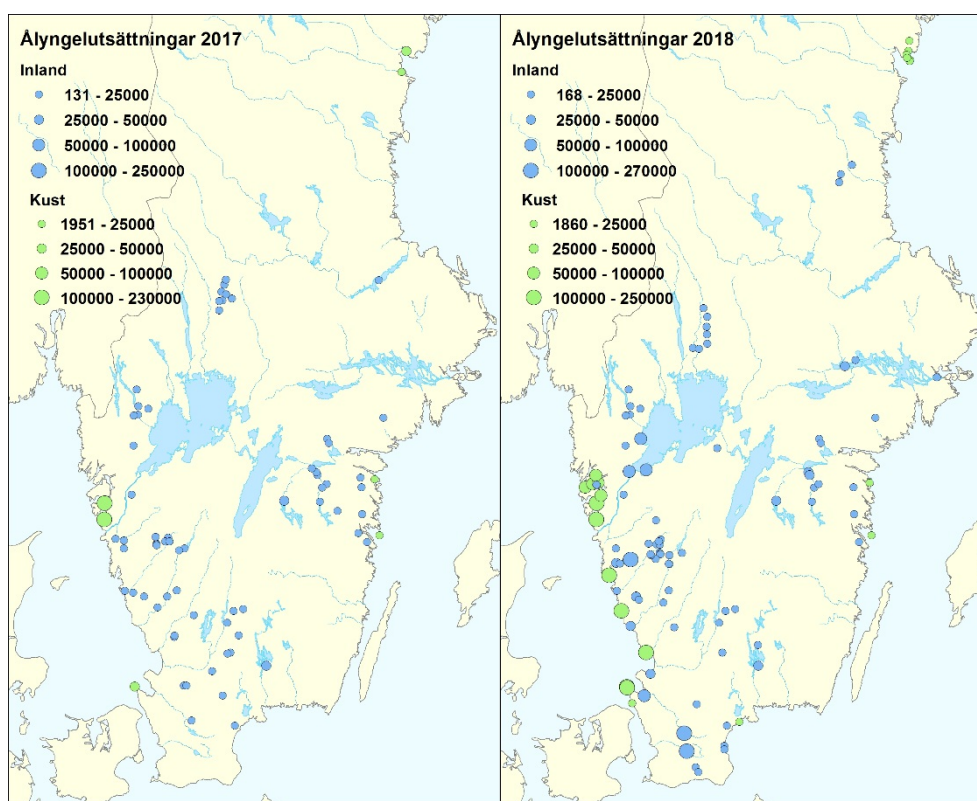


Figure SE.15. Distribution of restocked eels in 2017 and 2018.

3.3 Aquaculture

Aquaculture production for consumption purposes was 76 900 kg in 2017 and that emanates from a single plant. 1250 kg corresponding to 4 111 842 glass eels were imported from the UK in 2018. Their mortality after 80 days in a quarantine was 3.8%. More than 3 million of those eels are used for restocking in Sweden and Finland in 2018, and the remaining part for aquaculture purposes.

3.4 Entrainment

Eel entrainment with deadly consequences primarily occurs at two types of power plants in Sweden: hydropower plants (a major impact in inland waters) and nuclear power plants (probably a marginal impact).

The impact on silver eels descending to the sea from lakes and rivers is high as they most often have to pass several hydropower installations with their intake gratings and turbines before arriving at the sea. This mortality was estimated at 118 tonnes in 2017 (Dekker *et al.*, 2018). The assumptions behind this assessment was a mortality derived from the best available estimate per individual turbine passage of silver eels that would have been produced upstream based on natural recruitment and stocking. As there are several turbines to pass in most rivers (mode: three), the accumulated mortality is quite high and is of the same magnitude as the commercial fishery for eels in freshwater, or higher. Uncertainty in the average impact per hydropower station hardly affects this, due to the high number of hydropower stations to pass (Dekker, 2015).

Sweden has three nuclear power plants by the sea (Ringhals, Forsmark and Simpevarp) which use seawater for cooling, and during this process, eels and other fish species are entrained into or impinged in the cooling water intake or circuit. Glass eels follow the cooling water into the Ringhals nuclear power plant on the Swedish west coast, where they arrive every spring. Glass eel occurrence there is monitored by means of test fishing and the data are used as a recruitment index for Sweden in this report (see Section 5.1). Many glass eels (albeit an unknown number per time unit) pass through the whole cooling system and their mortality has been assessed at 13.4% by Bryhn *et al.* (2014); which is low compared to other juvenile fish. Larger eels (mainly yellow eels) are entrained at this nuclear power plant which has a fish diversion system, which results in an eel mortality of about 14% (Bryhn *et al.*, 2013). However, the absolute number of eel entrainment at Ringhals has not been systematically investigated. The remaining two nuclear power stations do not entrain or impinge glass eel (they do not occur there), but yellow and silver eels have about 100% mortality at entrainment as they die in sieving stations. Bryhn *et al.* (2013) estimated the loss at the Forsmark nuclear power plant at 1900 individuals in 2010 and 1200 in 2011. There is an ongoing discussion with the power plant operator regarding catching eels in fykenets before they reach the sieving station at the cooling water intake, and subsequently releasing them further at sea, but the financing of such an operation had not yet been resolved in September 2018. 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 a deeper and colder coastal water layer where the fish (but not necessarily eel) abundance may be assumed to be lower than at the surface, from whence cooling water was previously taken.

3.5 Habitat quantity and quality

There are numerous, large and small lakes and rivers well suited for eel production in Sweden. The low numbers of recruits and restricted restocking, in combination with

migration obstacles like dams and hydropower turbines, are the limiting factors of today, not lack of wetted areas as such. Historical habitat decreases in inland waters have most likely been substantial but have not been quantified.

Many eels in Sweden spend most of their lives in coastal waters and their habitats are generally of high quality, although the shoreline has in many places been drastically altered by harbours, jetties, bridges and other constructions. However, such habitat change is believed to constrain the eel habitat area to a much lesser extent than historical habitat changes in inland areas.

3.6 Others

In September 2017, SwAM answered (HaV dnr 2432-17) the EU Commission on request that Swedish authorities confiscated 278 illegal eel fishing gears in 2016 (one owner was charged) and 257 gears in January–August 2017 (one owner was identified). See Section 3.1.2 for more information.

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, the collection of silver eels from the commercial fishery is a major part of our EU MAP programme, though also the 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 of stocked origin (Wickström and Sjöberg, 2013). The basis for that is that all eels stocked are since 2009, marked with strontium which makes clear marks in their otoliths, and the rationale of analysis is that stocked eel might bias some of our recruitment (natural) series used for indices, both nationally and internationally. So far very few of the ascending recruits were of stocked origin. Marking also facilitates the evaluation of the restocking programme. From the monitoring of recruitment 2010–2017 using electro fishing, ca. 960 and 650 young eels were aged and analysed for a strontium mark, respectively.

To assess the fishing mortality on silver eels leaving the Baltic Sea a traditional mark-recapture programme, running since the early 1900s, was restarted in (2006) 2012, using mostly eels caught by coastal fishermen. More information on this approach is given under Section 5.3.1.

4.1.1 Data collection

In addition to being applicable for inland waters, EU MAP also applies to Swedish coastal waters. In ICES subdivisions (SD) 23 (Öresund), 25 and 27 (Baltic Proper), 200 silver eel samples are bought from the poundnet fishery. SD 24 no longer has any commercial fishery and SD 25 was not sampled in 2017 due to financial constraints. Length is measured, and at least five eels from each cm class are weighed and aged. Total weight of landings and discards is also registered.

In SD 23 (Öresund), fishery-independent sampling of yellow eel and silver eel is also performed using fykenets. Yellow eels and silver eels are measured by length, but only yellow eels are weighed and aged (at least 200 individuals; a maximum of five from every cm class). Sampling is terminated if more than 500 yellow eels have been caught.

Additionally, fishery-independent sampling of yellow eel and, occasionally (when caught), silver eel is performed in SD 20 (Fjällbacka and Stenungsund in the Skagerrak) and 21 (Vendelsöarna in the Kattegat) using fykenets. Sampling is terminated if more than 500 yellow eels have been caught. Eels are measured according to length and at least 200 yellow eels (a maximum of five from every cm class) are weighed and aged.

4.1.2 Analysis

The coastal fish communities along the Swedish west coast are monitored by standardized fishing with fykenets in shallow water (2–5 m). Yellow eel was among the dominating fish species in August during most years. The overall catch per unit of effort appears to be increasing, although separation of the data into different length classes appears to provide a more complex picture (Dekker *et al.*, 2018). This is being analysed in two ongoing studies (Figure SE.16).

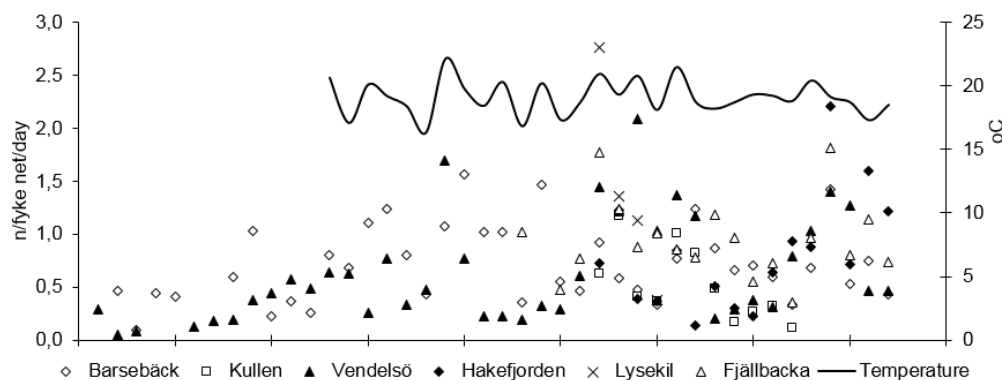


Figure SE.16. Time-series of yellow eel catches in coastal fish monitoring with fykenets in August along the Swedish west coast. Annual mean water temperature at the collection of fishing gears is presented for the Vendelsö area in central Kattegat (SD 21).

4.1.3 Reporting

Selected results from Swedish eel studies are reported to the EU as requested in 2012, 2015 and 2018. This is done by the responsible agency SwAM, but the data that constitute the background are also published in our department report series Aqua reports. Besides relevant data are used also for scientific papers (see the reference list below).

Selected data and results are also reported to ICES and WGEEL when appropriate.

4.1.4 Data quality issues and how they are being addressed

Data are insufficient to provide comprehensive assessments including complete sets of stock indicators for either the east coast or the west coast. This problem could possibly, and at least partly, be solved through a pan-Baltic stock assessment (see Section 4.2.). Funding options for such an assessment are currently being investigated.

Landings data from freshwater are reported according to two different systems opening for errors. Eels used for Trap & Transport might also be miscounted as there are different systems to report also for those eels.

Though recreational fishing for eel is forbidden with some exemptions, it seems its extent isn't insignificant. A few hidden, unmarked fykenets have been discovered along

the coast during the last few years. In some freshwater, there is an eel fishery we have no knowledge about, as it is legal as long as the catch isn't sold.

Unfortunately, the very long recruitment series from Trollhättan in Göta Älv was broken in 2018. This temporary break was explained with lack of personnel.

4.2 Assessment results

The assessments reported in Dekker *et al.* (2018) make use of extensive databases on recruitment, elver transport, restocking, landings, age and growth, hydropower installations, river geography, and more, covering an extended geographical area, over a period of many decades.

For the west coast, no assessment was produced in 2018, but survey-trends (cpue by length class) are presented.

For the inland waters, Dekker *et al.* (2018) predicted yellow and silver eel abundance from the available information on recruits (natural, translocated, restocked) forward in time, towards the yellow and silver eel stage. No independent verification on yellow or silver eel data had been made. In 2016, investigations have started to include information on yellow eel abundance, derived from electrofishing surveys. This will require mixing a state-based approach (electrofishing) with a rate-based approach (recruitment, catch). Most of the eel stock is located in lakes, while electrofishing covers mainly rivers, a problem to be addressed. This work is in progress.

For the Baltic coastal fishery, Dekker *et al.* (2018) reported mortality rates on the basis of Survival Analysis of a century of mark-recapture data (Dekker and Sjöberg, 2013). Stock size (biomass) estimates were derived from the Survival Analysis results (fishing mortality), in combination with available landings data. The quality of the landings data, especially where small, appears to put severe constraints on the credibility of the results. Landings data constituting a census (full coverage of all operations) rather than a survey (statistical sampling), the reliability of the landings data cannot be quantified. The targeted silver eel is derived from yellow eel stocks along the Swedish coast, in Swedish inland waters, but probably mostly from coastal and inland waters in other countries all over the Baltic area. In order to cross-check the Swedish escapement biomass estimates, a joint assessment of the whole Baltic stock is required (which in itself will be required to develop joint management of this shared stock). A proposal for an international re-search project to develop this joint assessment has been compiled (Dekker, 2013), but was not prioritised policy-wise.

5 Other data collection

5.1 Recruitment time-series

The Swedish input to international (WGEEL) recruitment series is based on data on catch of glass eels in the open sea (former ICES YFS, now IBTS, 1st quarter, Figure SE.17), the entrainment of glass eels at the Ringhals nuclear power plant (Figure SE.18) and the amounts of ascending young eels from eel passes in a number of rivers along the Swedish coasts (Figures SE.19–20).

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 Kattgat shore (Figure SE.17). The sampling at Ringhals is performed twice weekly in February–April, using a modified Isaacs–Kidd Midwater trawl (IKMT). The trawl is fixed in the current of incoming cooling water, fishing passively during entire nights. Sampling depends

on the operation of the power plant and changes in the strength of the current may occur.

The arrival of the glass eels to the sampling site varies between years, probably as a consequence of hydrographical conditions, but the peak in abundance normally occurs in late March to early April. The sampling depends on the operation of the power plant, i.e. the amount of seawater needed for cooling. In 2017, sampling was moved to an alternative intake channel (cooling the reactors 3 and 4) a few hundred meters SW along the same shoreline due to discontinued operations of reactors 1 and 2. This new sampling site was used also in 2018 and will become the permanent sampling site. The annual glass eel index has been adjusted for different levels of water current by multiplying by a factor two when only one out of the two reactors was in operation at each site. Corrections like this were done for several years with similar situations. The true relationship between current and glass eel catchability is not known.

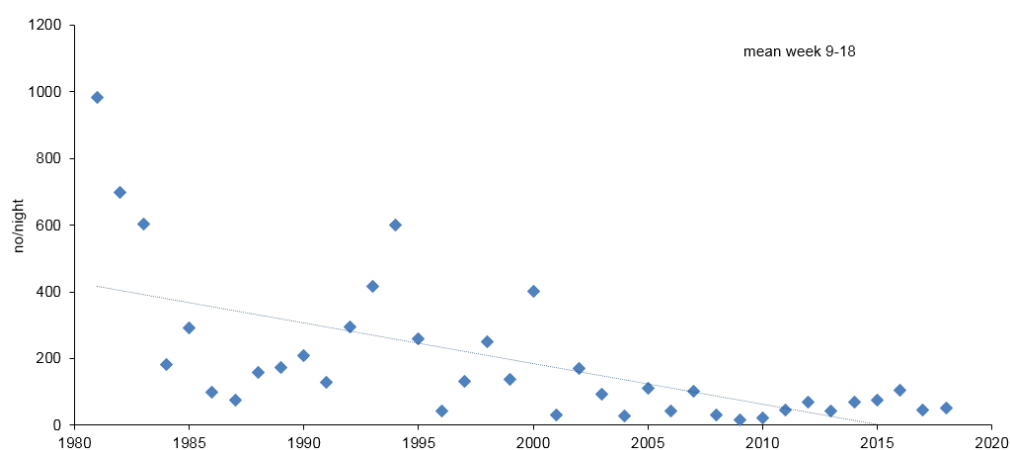


Figure SE.17. Recruitment index of glass eel at the cooling water intake at Ringhals nuclear power plant. The index is calculated as the average number caught per night during weeks 9–18, corrected for the number of nuclear reactors taking in cooling water.

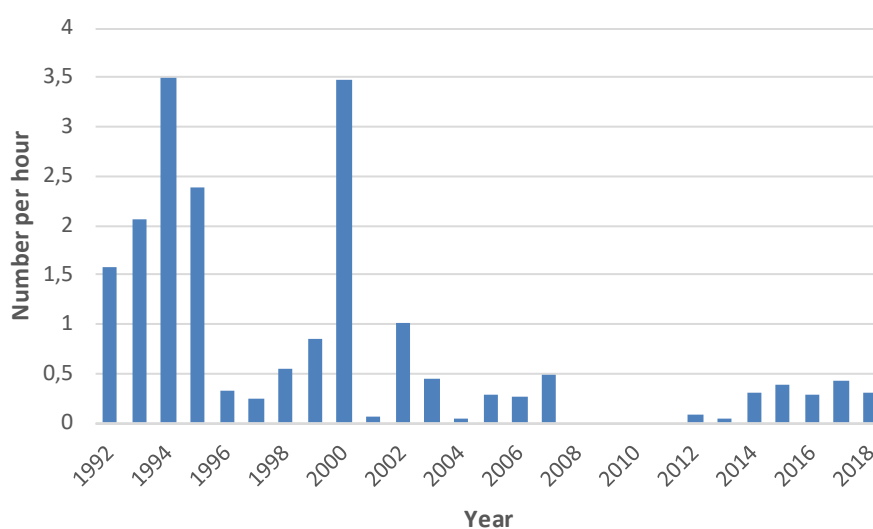


Figure SE.18. Catch in late winter of glass eels in a MIK-trawl in open sea (Kattegat-Skagerrak).

As the catch of ascending young eels has seriously declined in most rivers, the interest and maintenance of the eel passes might have deteriorated in some cases. The removal of dams and the construction of bypasses at some hydropower dams have actually changed the conditions in other rivers. Today, only the most reliable sites are used to construct the recruitment indices. In the long run the closing-down of nuclear power plants might stop one of the two “freshwater independent” indices we have.

The complete dataset up to and including 2017 do not indicate any substantial increase, though there were some promising peaks in the last few years. On the one hand, some preliminary data from two sites near the Swedish west coast in 2018 do indicate the strongest recruitment for 30 years (not given in the graph). On the other hand, one site in the Baltic Sea shows for 2017 an all-time low in recruitment. In 2018 this site had a stronger recruitment. Unfortunately, the longest recruitment series in Europe, River Göta Älv was interrupted in 2018, due to lack of staff.

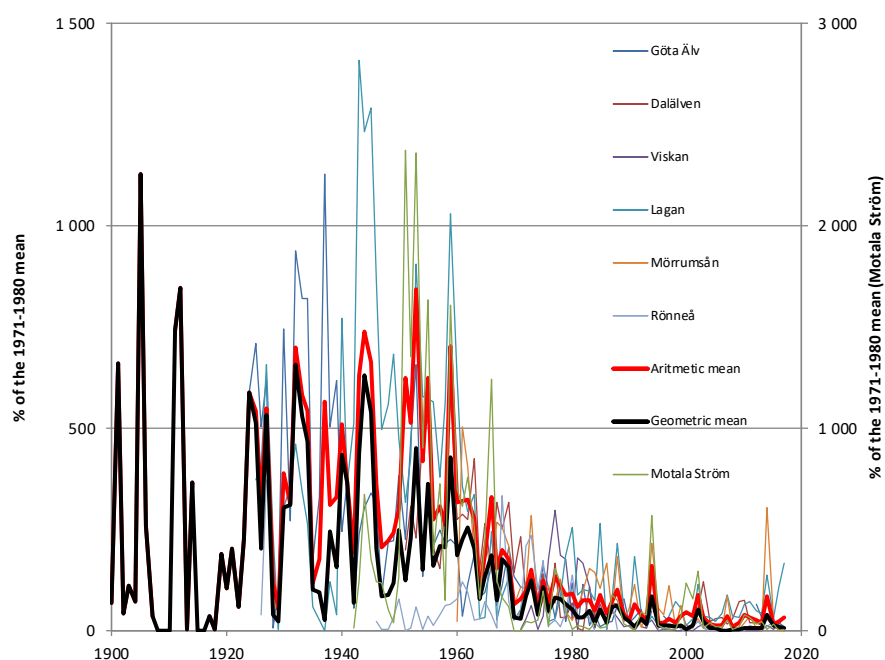


Figure SE.19. Recruitment of young eels in seven rivers (relative to the average for 1971–1980).

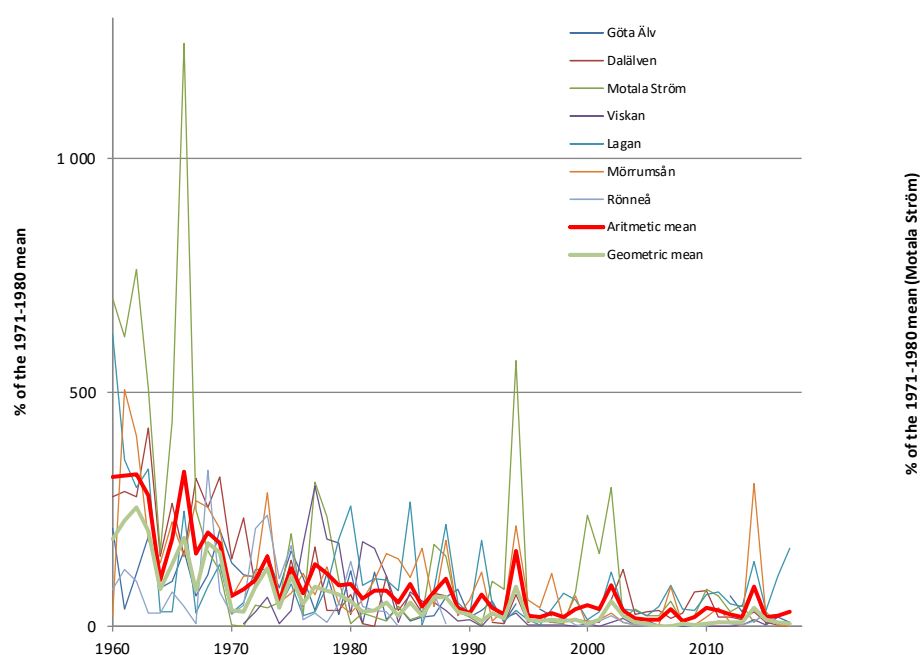


Figure SE.20. Recruitment of young eels in seven rivers (relative to the average for 1971–1980). Same data as above but reduced to 1960–2017 to better show recent years.

To increase and improve this kind of recruitment monitoring, we would like to open one or several stations where young of the year elvers could be monitored along our west coast independently from relying on dam owners, etc. So far, this wish has not been realised. However, there is also an extensive electro-fishing programme running in Sweden. This programme runs in stream and small rivers, is financed from several different sources and the target species are normally salmonids as salmon and trout. However, eels are also caught and reported on. All data are entered into a database (SERS), that we would like to explore and analyse with respect to recruitment and abundance of mainly yellow eels into freshwater systems (cf. Section 4.2).

5.2 Yellow eel abundance surveys

In some minor projects the development in stocked eel populations are followed using fykenets or outlet traps. In 1997 a cove in Lake Mälaren was stocked with 5 000 marked (Alizarin) elvers. This introduced stock has been monitored in a fykenet fishery since. After a few years the local stock was dominated by the stocked eels and their proportion has been about 60% since 2005 (**Figure SE.21**). As more and more eels now become silver and leave this open system after 21 years the cpue and the proportion of marked eels are now declining. Almost 14% of the stocked eels have been recaptured until today. In 2011 this cove was stocked with another 1862 elvers, this time marked with Sr and Ba in their otoliths. Some of them are now among the smallest eels caught, explaining the increasing ratio of unmarked eels (**Figure SE.21**).

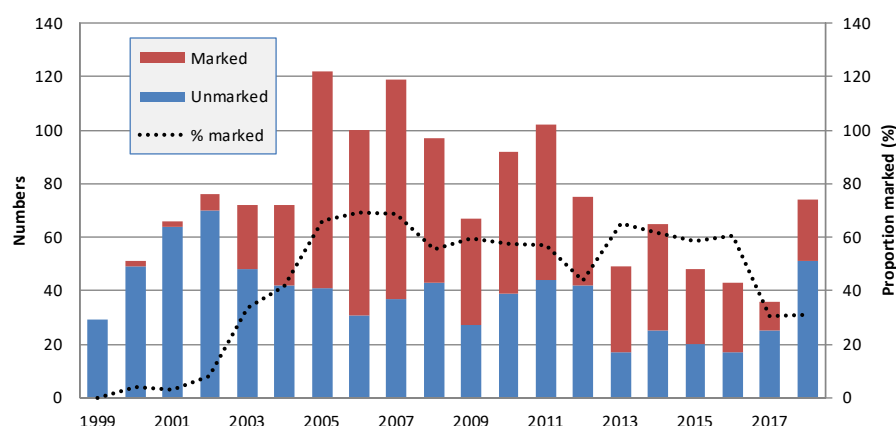


Figure SE.21. Proportion of marked eel in a stocked population.

5.3 Silver eel escapement surveys

Please see Sections 4.1 and 4.2.

5.3.1 The traditional eel tagging in the Baltic Sea

In the Baltic region, tagging experiments started in 1903 and the objective in the first taggings was to gain general information on the migration direction and routes taken (Sjöberg, 2015). Since then, thousands of eels have been tagged, mostly with silver plates and Carlin tags. Recaptures of tagged eel were relatively scarce in the early 1900s, probably because fish taggings were a new phenomenon and the fishers were unaware of the ongoing experiments. In addition, the fishery was not as extensive as it became later. In 1958, Swedish eel landings from the Baltic Sea reached an all-time high of more than 2500 tonnes of silver eel. This was also reflected in the recapture rate (Figure SE.22). After this, catches decreased and so did the recapture rates. However, a bit unsynchronized since the intensity of the fishery started to decrease somewhat later, in the early 1970s (Andersson *et al.*, 2012). Since 2012, tagging has continued with the same method as before (Figure SE.23 and Table SE.2). It has become an important part within the EU's data collection programs (EC No 665/2008) and is the basis for estimating the fisheries impact on spawners leaving the Baltic Sea region (Dekker and Sjöberg, 2013; Dekker, 2015).

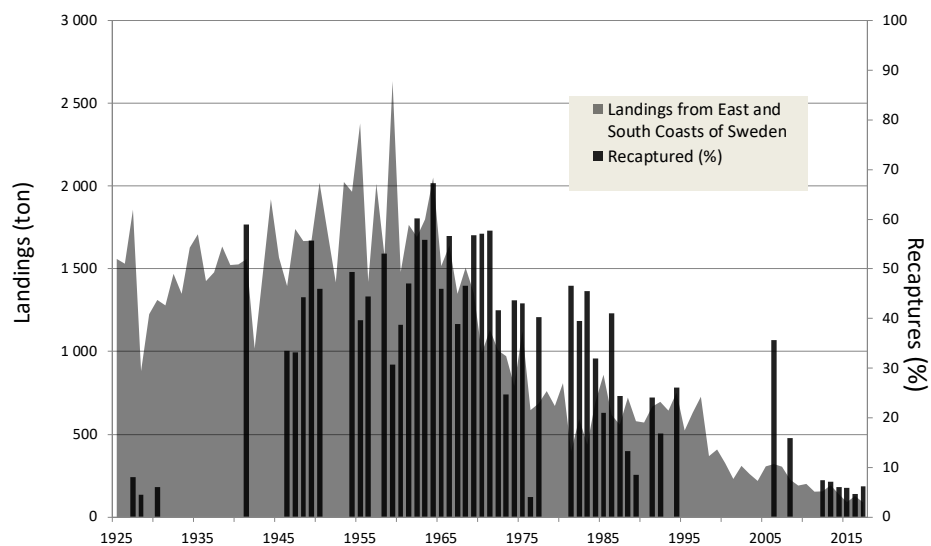


Figure SE.22. Landings from the Swedish fishery on the East and South Coast (grey area). Recaptures from tagged eels made in Sweden, Denmark, Poland and Germany (black bars). More than 90% of the recaptures were made in the Swedish fishery at the East and South coast.

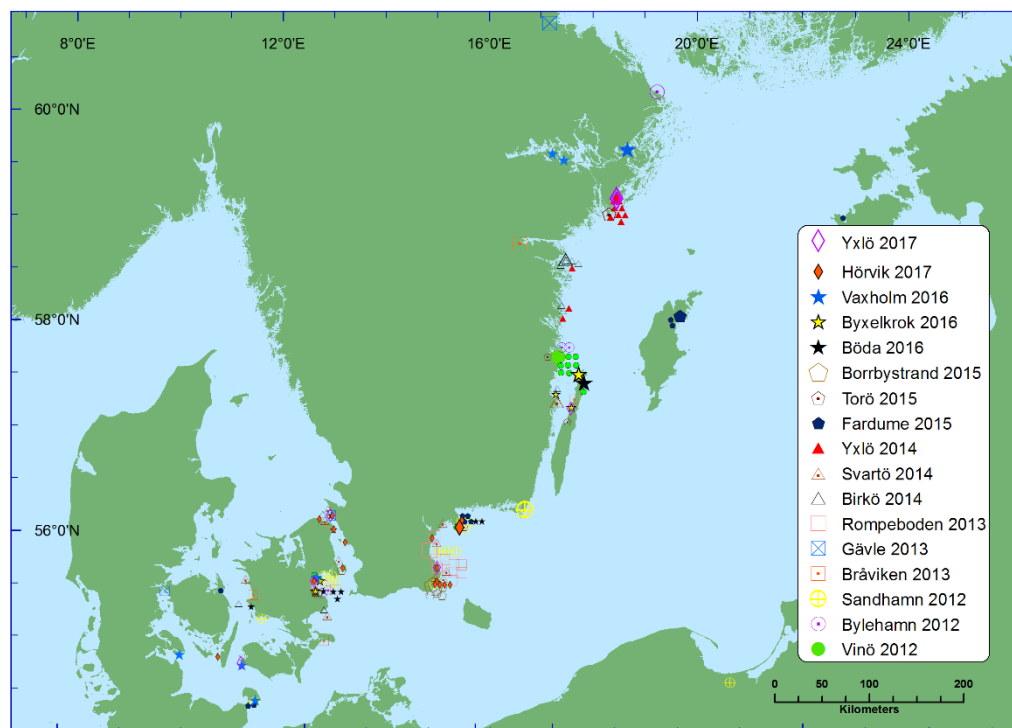


Figure SE.23. Recaptures from tagged eels within the EU MAP program made along the Swedish east coast 2012–2017. For exact recapture numbers see Table SE.2.

Table SE.2. Tagging experiments within the EU MAP program between 2012 and 2017. Total number of released eels, number recaptures and the national distribution among the recaptured fish.

Release Place	Year of release	Nr tagged	Recaptures %	Recaptures Nr	Sweden	Denmark	Germany	Poland	Estonia
Bylehamn	2012	150	3	4	2	2	0	0	0
Vinö	2012	120	9	11	9	2	0	0	0
Sandhamn	2012	150	9	14	8	4	1	1	0
Gävle	2013	34	9	3	2	1	0	0	0
Bråviken	2013	150	2	3	1	1	1	0	0
Rumpeboden	2013	150	14	21	17	4	0	0	0
Yxlö	2014	150	6	9	9	0	0	0	0
Birkö	2014	301	8	24	20	4	0	0	0
Svartö	2014	150	7	10	6	4	0	0	0
Fardume	2015	170	6	11	6	1	2	1	1
Torö	2015	151	5	7	6	1	0	0	0
Borrbystrand	2015	140	9	13	5	8	0	0	0
Vallentuna/Vaxholm	2016	154	5	7	3	3	1	0	0
Byxelkrok	2016	147	3	5	3	2	0	0	0
Böda	2016	151	7	10	4	6	0	0	0
Yxlö	2017	320	4	14	13	1	0	0	0
Hörvik	2017	200	10	20	13	7	0	0	0
Total/average		2788	7	186	127	51	5	2	1

5.4 Biological parameters

All eels handled, when big enough, are analysed with respect to size, sex, stage, age, prevalence and intensity of *Anguillicola crassus*.

Fat is only occasionally measured and that with a Fish Fatmeter (Model FFM-992). Fecundity is not normally estimated, but some results and comparisons between different stocks were given by MacNamara *et al.* (2016).

As part of our EU MAP data collection, eels from a number of commercially fished lakes were sampled since 2010 (**Table SE.3**). The biological analysis is mostly done on previously frozen eels, where relevant variables are corrected for freezing shrinkage. Normally more than 2000 eels from both coastal areas as from freshwater are analysed annually by SLU Aqua.

Table SE. 3. Length, weight, age and growth in all commercially fished eels sampled from freshwater within the EU MAP -programme.

Lake	N	Mean length (mm)	Mean weight (g)	Mean age (yr)	N aged	Growth rate (mm/y)	% aged
Bolmen							
2017	126	689,6	651,8	21,7	126	28,5	100%
Hjälmaren							
2010	125	855,2	1 524,5	16,1	119	48,6	95%
2011	111	861,3	1 511,5	15,7	108	50,1	97%
2012	127	872,1	1 589,9	15,4	125	52,0	98%
2013	127	886,0	1 652,7	14,3	125	56,8	98%
Mälaren							
2010	254	768,4	1 056,1	17,7	239	36,8	94%
2011	252	768,2	1 034,1	17,5	236	37,1	94%
2012	251	787,4	1 114,1	17,9	233	38,3	93%
2013	249	789,1	1 097,5	16,7	236	40,0	95%
2014	236	785,8	1 018,9	18,7	232	35,4	98%
2015	261	781,9	1 013,1	19,3	261	35,6	100%
2016	263	782,0	1 018,1	19,8	262	34,6	100%
Ringsjön							
2011	124	662,6	603,5	16,1	113	36,5	91%
2013	127	683,1	649,1	15,7	117	38,9	92%
Roxen							
2014	88	866,1	1 427,3	15,8	84	50,4	95%
2015	100	858,8	1 417,8	16,5	100	47,5	100%
2016	140	882,4	1 496,9	16,8	137	48,1	98%
2017	105	891,5	1 486,3				0%
2018	29	913,4	1 659,4				0%
Vombsjön							
2014	124	746,5	932,0	15,3	123	43,9	99%
2015	127	746,6	909,6	18,0	127	37,3	100%
2016	125	721,5	865,3	14,5	123	44,6	98%
2017	127	775,3	996,5				0%
2018	130	734,1	805,8				0%
Vänern							
2010	255	765,2	990,7	14,1	247	49,2	97%
2011	258	782,0	1 025,1	16,3	235	43,6	91%
2012	247	802,7	1 144,0	16,9	236	43,1	96%
2013	249	823,9	1 286,9	16,2	235	46,2	94%
2014	231	814,9	1 214,3	16,1	226	46,2	98%
2015	252	801,2	1 127,2	18,0	251	40,4	100%

5.5 Parasites and 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 is reported; at the Institute of Coastal Research, prevalence only. A considerable proportion of eels from most sites are infested, but the prevalence has levelled out. The prevalence in Swedish western coastal waters generally appears to be lower than in lakes (Figures SE.24 and SE.25). 441 eels caught in freshwater during 2017 were analysed and 81% were infested. From test fishing in coastal waters, 1233 eels were analysed in 2017 and 25% were infested.

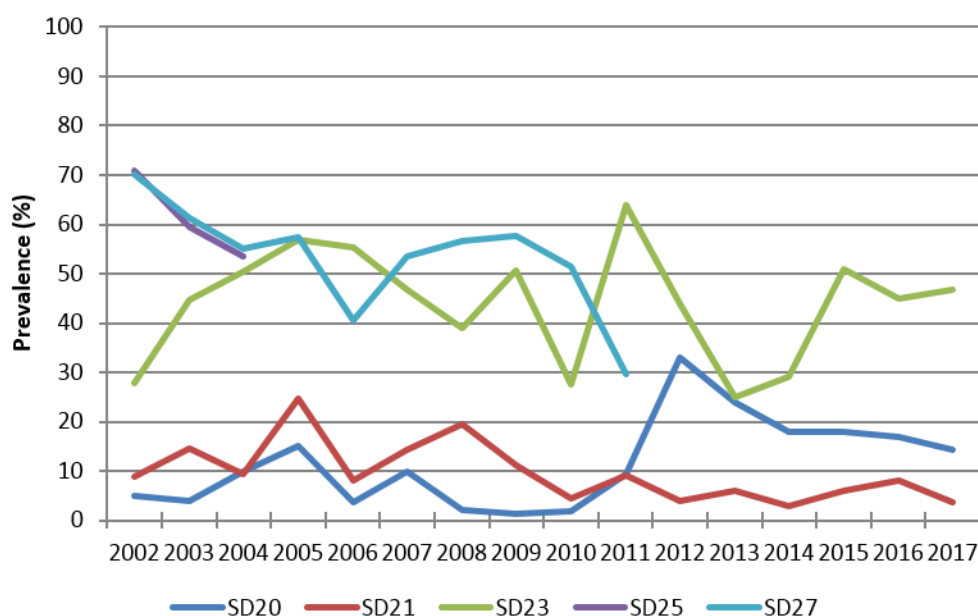


Figure SE.24. The prevalence of the parasite *Anguillicola crassus* in Swedish coastal waters 2002–2017. SD refers to ICES subdivisions in the Baltic Sea.

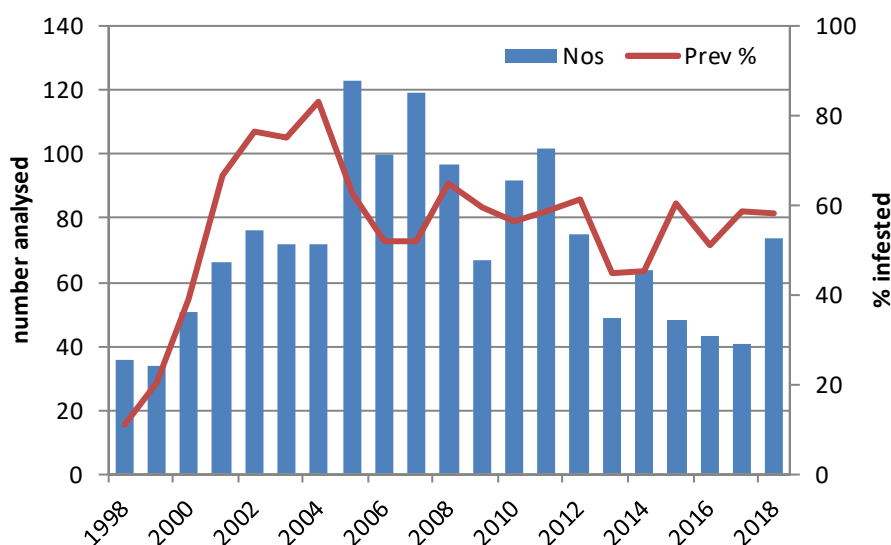


Figure SE.25. Prevalence (%) and number of eels analysed for *Anguillicola crassus* in Lake Mälaren.

Imported eels used for stocking and for aquaculture purposes are monitored by SVA mainly for IPNV during the quarantine phase, investigating both glass eel initially and finally sentinel species (Axén C. SVA pers. comm.).

In 2018, glass eels were imported from River Severn in the UK, and there were no problems occurring during the quarantine period. During that period of 80 days, mortality was 3.8%. Thus, the planned numbers to be stocked was realized.

Parasites and pathogens are diagnosed by the National Veterinary Institute (SVA) in case of suspected disease/ acute mortality, or temporary investigations. At necropsy, standard routine fish necropsy protocol is followed, with examination of skin, gills, fins, eyes, muscle tissue, organs, etc. Bacteriology samples are always taken from the kidney as well as organs with pathological changes. Samples are cultured on agar, and bacteria are typed according to ordinary identification protocol or MALDI-TOF. If findings indicate suspected viral disease, samples are taken for cell cultures. (General cells sensitive for IPN, EVEX and VHS). Growth of virus is further cultured and typed.

During and after the summer 2018 with unusually high water temperatures sick and deceased eels were found and reported from some lakes. At necropsy different findings were noted. From one lake (four eels), superficial to deep skin ulcerations of varying size and numbers were found. Two individuals also had petechial hemorrhage in the skin. Gills were of normal colour (1), moderately pale (2) and anemic (1). There was hemorrhage in the gill filaments and two fish had gill necrosis. The fish with anemic gills also displayed internal signs of anemia; pale heart and kidney. All eels had pale spleens with a marked pigmented pattern (probably melanomacrophage centers). Laboratory analyses have identified sparse growth of *Flavobacterium columnare* in two fish (gills and kidney). This bacterium is associated with skin lesions and gill necrosis in salmonid fish and could be a contributing cause to the disease. No virus was isolated on cell culture. Analysis for eel herpes is to be done during the autumn.

From another lake, six eels were sent. Three eels had skin hemorrhage on large areas of the body. One had gill filament hemorrhage, the others stasis of the gill filaments. Pale livers with some stasis of superficial vessels were seen. One had a pale spleen. The other three eels had varying symptoms: A few superficial skin erosions, minor skin hemorrhage, pale gills, a dark swollen spleen, stasis of liver vessels (fish no 4). Erythema of the head region and pectoral fins, gill stasis (not opened, fish no 5). Erythema and a few petechial hemorrhage spots in the head, a few skin erosions on the tail. Gills white, pale spleen, stasis of liver vessels. Infected with *A. crassus* (fish no 6).

No algae were identified in skin or gill scrapings. No growth of bacteria or virus. Analysis for eel herpes is to be done during the autumn.

5.6 Contaminants

Our department (SLU Aqua) has supplied silver eels from Lake Vänern to the National Food Agency, Sweden. The eels were analysed for dioxins and dioxin-like PCB.

In 2016 and 2017 pooled samples from the northern and the southern parts of the lake were analysed. In both years, eels from one of the sites were at or above the threshold level as sum of dioxins and dioxin-like PCBs (WHO-PCDD/F-PCB-TEQ) (10.0 pg/g wet weight).

Pooled samples from L Vänern were analysed also in 2015. One of the five samples exceeded the threshold value of the summed dioxins and dioxin-like PCB while the rest were at about half that value. ((Cantillana and Aune, 2012; Aune, M., SLV, pers. comm.).

5.7 Predators

Predation by cormorants (*Phalacrocorax carbo sinensis*) as well as by grey and harbour seals (*Halichoerus grypus* and *Phoca vitulina*) have been suggested as possible major causes of eel mortality in Sweden. Studies on the food choice of cormorants normally show quite low prevalence of eel, but as the total numbers of cormorants in lakes and along the Swedish coasts are very high, their total consumption is probably also high. Hansson *et al.* (2017) presented estimates of eel predation by seabirds (mainly cormorants) in the whole Baltic Sea at 340 tonnes per year which was in the same order of magnitude as landings by the commercial fishery. Data are presented as all predation occurs in ICES SD24 but does include also SD25 and a minor part from remaining parts of the Baltic Sea. Eel predation by seals had only been documented as consumption of trapped eels at fishing gears, so the Baltic-wide estimate was 0 tonnes per year (Hansson *et al.*, 2017). There have also been site-specific reports presenting estimates on eel predation by cormorants which were higher than the amounts taken by the commercial fishery (Lundström *et al.*, 2010; Östman *et al.*, 2013; Ovegård, 2017).

6 New information

Simon *et al.* (2018) suggested that silver eels infested with *Anguillicola crassus* may be able to dive as successfully as non-infested eels. Diving skills were studied during the early stages of marine spawning migrations in European continental shelf waters. Watz *et al.* (2017) developed and tested a floating elver trap which has the potential to facilitate assisted upwards transportation in rivers past migration barriers. Tamarío *et al.* (2018) investigated fish behaviour at different dam bypasses and found that eels preferred bypasses with low elevation gradients.

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1 Stock status summary

No available data.

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

2.1.1 EMUs, EMPs

Tunisia potential sites for the presence of eel are more abundant in the north and east zones and Medjerda than in the central east and south zones. They extend generally over an estimated wetted area of about 950 000 ha (Table I) distributed over four Eel Management Units defined by the EMP.

The eel is found mainly in lagoons and to a lesser extent in coastal waters, sebkhas and dam reservoirs. Its exploitation is concentrated, by targeted fishing, in the three main sites of northern Tunisia: The lagoon complex of Ichkeul-Bizerte; Ghar El Melh Lagoon and Tunis Lagoon.

Other exploitation sites correspond to accidental fishing, not specifically targeting eel; they include the dam reservoirs in the north and centre and some weirs in the Gulf of Gabes (Kerkennah and Zarrat).

In terms of area, exploitation sites for eel cover about 124 493 ha. They represent only a small proportion (13%) compared to all the potential sites where it is present in abundance levels equivalent to the exploited sites (both coastal and continental). Moreover, it is noteworthy that among the identified wetlands, 20 sites are listed as Ramsar sites and about 21 more are proposed to be included under this status. This status allows establishing rules for the protection of important habitats.



Map of the geographical location of the four EMUs.

2.1.2 Management authorities

The Eel Management Plan in Tunisia was defined during 2009 and 2010 as part of a wide consultation with stakeholders related to the eel resource. These administrative bodies are:

DGPA (General Directorate of Fisheries and Aquaculture);

DGF (General Directorate of Forestry representative of CITES);

DGBGTH (General Directorate for Dams and Major Hydraulic Works);

Technical agencies: GIPP (Interprofessional Association of Fishery Products);

CTA (Technical Center of Aquaculture);

ANPE (National Agency for Environmental Protection);

APAL (Protection Agency and Coastal Planning)

Organizations of Professional Fishermen represented by UTAP (Tunisian Union of Agriculture and Fisheries);

NGOs (ATSMer: Tunisian Association of Marine Science and AAO: Association des Amis des Oiseaux)

can intervene in the eel management at national and local level in close collaboration with the scientific community represented by INSTM (National Institute of Marine Sciences and Technologies) to be responsible for the scientific coordination of the EMP.

2.1.3 Regulations

The fishing activities in Tunisia are governed by Law No. 94-13 of January 31, 1994, which stipulates *inter alia*:

- Setting a minimum mesh size: square mesh (10 mm);
- Setting the minimum size of capture to 30 cm;
- Establish an export quota of 135 T which represents 90% of the average annual production (150 T) since the consumption of eels is not part of culinary traditions of the Tunisian population.

The plan proposed that Tunisia contains both measures to reduce major mortality factors on which it is statutorily possible to short-term significant results, and others fruit in the longer term, such as those concerning the environmental quality of pollution-related habitats (water, sediment and trophic chain).

2.1.4 Management actions

The Eel Management Plan was set up in 2009 but a few of measures have been applied:

- In each EMU the responsible for resource management must ensure that the escapement of silver eels is at least 40 percent of the potential of the system.
- New regulation of fishing campaign in four months/year in from November to February in the 3 northern sites of targeted fishing.

2.2 Significant changes since last report

Adoption of the Model ESAM to assess the national stock (cf. § 4).

3 Impacts on the stock

3.1 Fisheries

No available data.

3.1.1 Glass eel fisheries

No available data.

3.1.2 Yellow eel fisheries

No available data.

3.1.3 Silver eel fisheries

No available data.

3.2 Restocking

No available data.

3.3 Aquaculture

No available data.

3.4 Entrainment

No available data.

3.5 Habitat quantity and quality

No available data.

3.6 Others

No available data.

4 National stock assessment

4.1 Description of method

4.1.1 Data collection

Sampling only concerned the eels provided by professional fishing with fykenets in the three study sites during the period of winter downstream migration (December to February).

For non-sacrificed fish: Measurements of total length (Lt) and total weight (Wt).

For sacrificed fish: anatomical measurements liver weight (Wl) and gonad weight (Wg,) and age determination by otoliths.

Sex was assessed macroscopically and maturation stage was determined according to Durif's silvering index (Durif *et al.*, 2005).

4.1.2 Analysis

The ESAM (Eel Stock Assessment Model) developed by Schiavina *et al.*, 2015 has been selected for this purpose as it is flexible and easily adapted to data-poor case studies and it has been developed specifically for lagoons that represent the most common habitat for eels in Tunisia. Parameter values can be selected from a set of default settings, based on the available knowledge of how European eel vital rates vary across waterbodies and geographical locations, or specified by the user through an advanced “Model settings” frame.

For simplicity, **recruitment** is kept constant year after year and considered **net of possible mortality** due to glass eel fishing since this activity is absent in Tunisia.

Pristine escapement B_0 is estimated by setting fishing mortality to zero, habitat area to its maximum potential level and recruitment ten times higher than the current one (according to ICES, 2012).

Potential escapement B_{best} is estimated by setting fishing mortality to zero, with habitat area and recruitment at their present levels.

4.1.3 Reporting

Silver eels provided by commercial fishermen during the downstream migration period between November 2017 and February 2018 in Tunis Lagoon (TL) and in Ghar El Melh Lagoon (GEM) all belonging to the EMU Northeast and Medjerda (cf. Map).

4.1.4 Data quality issues and how they are being addressed

Fishing mortality is computed as the product of gear selectivity, eel catchability and fishing effort. Since the gear selectivity is not evaluated in sites we studied, we adopt the default value of the ESAM model to evaluate the biomass **$F=0.4284$** is computed as the product of default selectivity and catchability values and using a default gear density of about 6 nets.km⁻² which is a value close to reality in the TL but four times higher in GEM.

4.2 Assessment results

	TL	GEM
Yield (kg/ha)	23.84	6.78
Habitat area (ha)	3300	2800
Fishing mortality rate (F)	0.4284	1.71
$B_{current}$ (kg)	181 500	11 088
B_0 (kg)	455 400	54 800
B_{best} (kg)	330 000	12 600
Escapement rate (%)	40	20

5 Other data collection

5.1 Recruitment time-series

No available data.

5.2 Yellow eel abundance surveys

No available data.

5.3 Silver eel escapement surveys

Silver eels were collected from commercial fisheries during the downstream migration period between November 2017 and February 2018. A total of 164 eels were sampled in Tunis Lagoon (TL) and 226 in Ghar El Melh Lagoon (GEM).

The results of the survey are summarized in the table below.

	TL	GEM
Number (M)	49	68
Number (F)	114	158
M L _m (mm)	523	390
F L _m (mm)	573	428
M W _m (g)	260	110
F W _m (g)	344	189
% mature (M)	30	20
% mature (F)	70	40

Note:

M: male, F: female

L_m: mean length

W_m: mean weight

All biological parameters measured (length, weight and maturity stages) for both sexes are higher in TL than in GEM.

5.4 Biological parameters

No new data cf. Tunisia Country Report Master 2017.

5.5 Parasites and pathogens

No new data cf. Tunisia Country Report Master 2017.

5.6 Contaminants

No new data cf. Tunisia Country Report Master 2017.

5.7 Predators

No available data.

6 New information

No new data cf. Tunisia Country Report Master 2017.

7 References

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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.

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1 Stock status summary

Table 1 shows the most recent stock indicators of silver eel escapement biomass, mortality rates, and assessed habitat area, for the 14 different Eel Management Units (EMU) reported by the UK. 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.

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

2.1.1 Eel Management Units (EMUs)

Eels are widespread throughout estuaries, rivers and lakes of the UK, with the possible 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 (Figure 1, Table 2). Most of the UK EMUs have been set at the River Basin District (RBD) level, as defined under the Water Framework Directive (WFD). The RBDs in Northern Ireland deviate slightly from those defined for the WFD, owing to their transboundary nature. An Eel Management Plan (EMP) has been implemented for each EMU (see <https://www.gov.uk/government/publications/2010-to-2015-government-policy-freshwater-fisheries/2010-to-2015-government-policy-freshwater-fisheries>).

2.1.2 Management authorities

Responsibility for the management of eel, including human impacts and the delivery of EMPs rests with the Environment Agency (EA) in England and with Natural Resources Wales (NRW) in Wales. In Scotland, Marine Scotland is responsible for the management of all anthropogenic impacts and for the conservation of stocks and the delivery of the Scotland EMP (the EA is responsible for delivery of the Solway-Tweed EMP). In Northern Ireland, overall responsibility for the supervision and protection of eel fisheries, and for the establishment and development of those fisheries rests with the Department of Agriculture Environment & Rural Affairs (DAERA). The Agri-Food and Biosciences Institute for N. Ireland (AFBI) is employed by DAERA to provide the scientific basis for eel management in Northern Ireland. The Marine Institute, Ireland is responsible for the delivery of the transboundary Northwest International EMP (IE_NorW).

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)	B _{curr} / B ₀ (%)	ΣF	ΣH	ΣA
2016	GB_Nort	11816	60876	4970	10243	8.2	0.000	0.723	0.723
2016	GB_Humb	57 853	137859	4463	49581	3.2	0.011	2.397	2.408
2016	GB_Angl	54 373	341084	67785	123715	19.9	0.171	0.430	0.602
2016	GB_Tham	42 811	251699	14397	60336	5.7	0.082	1.351	1.433
2016	GB_SouE	11 443	121340	49096	62932	40.5	0.019	0.229	0.248
2016	GB_SouW	35 850	1327684	7881	548510	0.6	2.667	0.256	2.924
2016	GB_Seve	75 071	899687	81252	707732	9.0	0.763	0.399	1.162
2016	GB_Wale	26 570	429944	30826	43564	7.2	0.103	0.196	0.299
2016	GB_Dece	14 130	636166	16224	28336	2.6	0.019	0.503	0.521
2016	GB_NorW	46 783	865449	19806	47753	2.3	0.178	0.559	0.737
2016	GB_Solw	87 496	1473755	45801	59460	3.1	0.261	0.000	0.261
2017	GB_NorE	5000	4 000	989	989	24.7	0.000	0.000	0.000
2017	GB_Neag	40 000	500000	247000	569810	49.4	1.210	-0.120	1.090
2017	GB_Scot	214241	267717	203521	255510	76.0	0.000	0.227	0.227

Key:

EMU_code = Eel Management Unit code (see Table 2 for list of codes); B₀ = the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock (kg); 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); ΣF = mortality due to fishing, summed over the age groups in the stock (rate); ΣH = anthropogenic mortality excluding the fishery, summed over the age groups in the stock (rate); ΣA = all anthropogenic mortality summed over the age groups in the stock (rate); Assessed area (ha) = combined area total (ha) of transitional and inland waters.



Figure 1. Map of the 15 Eel Management Units across the UK (after SNIFFER, 2005).

Table 2. Names and abbreviations for the 15 Eel Management Units (EMU) across the UK, and the ICES ecoregion(s) that they discharge into. Jurisdiction codes: Sco = Scotland, NI = Northern Ireland, Eng = England, RoI = Republic of Ireland, Wal = Wales.

EMU code	ICES Ecoregion	River Basin District (RBD)	Jurisdiction
GB_Scot	Celtic Sea & North Sea	Scotland	Sco
GB_Neag	Celtic Sea	Neagh Bann	NI
GB_NorE	Celtic Sea	Northeastern	NI
IE_NorW*	Celtic Sea	Northwestern	NI + RoI
GB_Nort	North Sea	Northumbria	Eng
GB_Humb	North Sea	Humber	Eng
GB_Angl	North Sea	Anglian	Eng
GB_Tham	North Sea	Thames	Eng
GB_SouE	North Sea	Southeast	Eng
GB_SouW	Celtic Sea	Southwest	Eng
GB_Seve	Celtic Sea	Severn	Eng + Wal
GB_Wale	Celtic Sea	Western Wales	Wal
GB_Deel	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).

2.1.3 Fisheries and their regulations

All fishing for eel in England and Wales requires authorisation, which is subject to standard national conditions that control seasons, methods, and apply geographic restrictions and other measures to protect bycatch species. The EA, under formal agreement, issues authorisations on behalf of NRW for those fisheries operating in Wales.

Standard conditions allow the use of four instrument types for eel fishing: permanently fixed traps (e.g. weir or rack traps and 'putts'); moveable or temporary nets or traps without leaders or wings and with a maximum diameter of less than 75 cm; moveable or temporary nets or traps with leaders or wings with a maximum diameter of less than 100 cm (usually fykenets); and elver (glass eel) dipnets. Recreational angling is permitted using rod-and-line but all rod-caught eels must be returned alive to the waters from where they were caught. Appendix 1 in the 2007 UK report to the WGEEL provides a summary description of netting and trapping methods used to catch eels in England and Wales.

Conditions also stipulate that all eel (apart from glass eel) less than 300 mm in length must be returned to the water, that no part of any net, wing or leader shall be made of a mesh greater than 36 mm stretched mesh, and that monofilament material is prohibited (except for an elver dipnet or fishing with rod-and-line). It is also a requirement that nets set in tidal waters should not dry out, unless they are checked just before they do so, and that nets should not cover more than half the width of the watercourse, or should not be set closer than 30 m apart (apart from in still waters and tidal waters). All fykenets must be fitted with an otter guard (a 100 mm square mesh hard plastic

frame, fitted in the mouth of the first trap, to prevent otters becoming trapped in the nets). No fishing is allowed within 10 m upstream or downstream of any obstruction. Elver dipnets must be used singly, by hand and without the use of chains, or boats. Small wingless traps and winged traps (fykes) can be used across the whole of England and Wales unless local byelaw restrictions apply.

Since 2010, the yellow and silver eel fisheries have been limited to those individuals who were already licensed, and these individuals are limited to the number of nets that they can apply for based on previous effort. Applications from newcomers are considered, but only for scientific studies, stock monitoring or for personal consumption. Thus, commercial fishing is effectively capped to existing fisherman who can use up to a maximum number of nets.

The glass eel fishery is restricted to two zones: in parts of South Wales and Southwest England, and in parts of Northwest England.

Every authorized instrument must carry an identity tag issued by the EA and it is a legal requirement that all eel and elver fishermen submit a catch return. The EA, under formal agreement, collates catch return information on behalf of NRW. Eel fishers are required to give details of the number of days they have fished, the location and type of water fished, the total weight of eel caught and retained or a statement that no eel have been caught. Annual eel and elver net authorization sales and catches are summarized by the instrument type for England and Wales and reported in the "Salmonid and Freshwater Fisheries Statistics for England and Wales" series (www.environment-agency.gov.uk/research/library/publications/33945.aspx).

Eel fisheries have never been regulated in Scotland, and the last known fishery closed in 2005. Legislation was introduced in 2009 requiring that anyone wishing to fish for eel in Scotland by any method must obtain a licence from the Scottish ministers.

Lough Neagh in Northern Ireland (GB_Neag) is the largest freshwater lake in the UK. Prior to 1983, estimates of annual recruitment of glass eel to the Lough consistently exceeded 6 million and averaged in excess of 11 million (based on a mean weight of 3000 glass eel per kg). Productivity is such that the Lough sustains a large population of yellow eel and produces many silver eels that migrate via the outflowing Lower River Bann.

The system sustains the largest commercial wild eel fishery in Europe, producing 13.8% of total EU landings and supplying 3.1% of the entire EU market (wild-caught + aquaculture) in 2016. Fishing rights to all eel life stages are owned by the Lough Neagh Fishermen's Co-operative Society (LNFCS). The fishery is managed to enable the capture of approximately 250–350 t of yellow eel and 75–100 t of silver eels annually, with an escapement of silver eels at least equivalent to the catch of silvers. While it is illegal to fish for glass eels in N. Ireland, provision is made whereby LNFCS staff are allowed to catch glass eels using dragnets below a river-spanning sluice gate, which creates a barrier to upstream juvenile eel migration, for onward placement into L. Neagh. Elvers are also trapped at the same location and placed into the Lough.

The yellow eel fishery (May–September, five days a week) supports a peak season average of 85–95 boats, each with a crew of two men using draftnets and baited longlines. Eels are collected and marketed centrally by the cooperative. Silver eels are caught in two weirs in the Lower River Bann. Profit from the less labour-intensive (five to six men) silver eel fishery sustains the management of the whole cooperative venture, providing working capital for policing, marketing and stocking activity.

Natural recruitment has been supplemented since 1984 by the purchase of glass eel from outside the EMU. Approximately 111.5 million (37.1 t) additional glass eel have been stocked by the LNFCs. Reviews on the fishery, its history and operation can be found in Kennedy (1999) and Rosell *et al.* (2005).

The transboundary Erne system (IE_NorW* and reported in Ireland Country Report) is comparable in size to L. Neagh and produces a fishery yield in the region of 33 t of eels per year. Within N. Ireland, the Upper and Lower Lough Erne sustained a small-scale yellow eel fishery, which was closed in 2010 under the terms of the EMP. There has been no commercial silver eel fishery on the Erne since 2001, but a trap and truck conservation silver eel fishery was instigated in 2009. Elvers are trapped at the mouth of the River Erne using ladders placed at the base of the hydroelectric facility that spans the Erne, and trucked upstream into the Erne lake system. A comprehensive study into the structure, composition and biology of the eel fisheries on the Erne was conducted by Matthews *et al.* (2001).

2.1.4 Management actions

An updated list of management measures became available in June 2018 within the 2018 UK EMP progress report. Since the implementation of EMPs in 2009/2010, new management actions have delivered:

- Introduction of 100% catch and release for eel by angling;
- Close season for net and trap fishing for eel;
- Limits on the geographical extent of the eel fishery;
- Creation of no fishing areas;
- Restrictions on eel fishing methods and gear;
- A programme of eel-specific monitoring for all eel life stages;
- Between 2009 and 2013, a total of 328 new eel passes were installed restoring access to over 4200 ha of river habitat;
- Between 2014 and 2016 in England and Wales, 23 eel screens and 136 eel passes were installed, opening up a further 2333 ha of habitat and potentially supporting a further 4800 kg of silver eel equivalent.
- Legislation providing new powers to require passes and screening to protect eel (UK Eel Regulation 2009);
- Raised awareness and widespread engagement with key stakeholder groups, including Water Companies, Internal Drainage Boards (IDBs), Power Generation and, Hydro-Power sector representatives.
- In 2016, the LNFCs increased the size of hook used in the longline fishery from a Mustad size 4 to a size 3. This was driven by scientific advice provided by AFBI following intensive studies into reducing the % of undersized (<400mm) eel caught in this fishery.

In January 2010, the [Eels \(England and Wales\) Regulations](#), 2009 Statutory Instrument came into force. This legislation was specifically developed to facilitate the implementation of Council Regulation (EC) No 1100/2007 in England and Wales. The legislation makes provisions to monitor exploitation, imposed a temporary close season on fishing for eels, enabled some control on the fishery and makes provision to protect the passage of eels. Much time and effort has been (and will continue to be) dedicated to the implementation of these Regulations.

In Scotland (GB_Scot) the principal management measure is the prohibition of fishing for eel of any stage by any method without a licence from Scottish ministers (under The Freshwater Fish Conservation (Prohibition on Fishing for Eels) (Scotland) Regulations 2008). To date (August 2018) no licences have been issued for either commercial or recreational fisheries.

In N. Ireland, DAERA produce an annual Fish 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-2018>).

2.2 Significant changes since last report

Changes in fishery catches are reported elsewhere in this document.

The latest triennial assessment of eel escapement in EMUs was submitted to the European Commission in June 2018, and the results are reported here. Most changes in stock status since the 2015 report have been relatively minor, but significant reductions have been recorded in the Humber and Thames RBDs, dropping from 31% to 1.9% and 20% to 5.4%, respectively. In part, these reductions were due to large (ca. two thirds) decreases in observed yellow eel densities and hence in silver eel equivalent biomass estimates (B_{best}). In the Humber, B_{best} declined from 1.14 kg.ha⁻¹ to 0.41 kg.ha⁻¹, while in the Thames it declined from 1.52 kg.ha⁻¹ to 0.56 kg.ha⁻¹.

3 Impacts on the stock

3.1 Fisheries

3.1.1 Glass eel fisheries

3.1.1.1 Commercial

Commercial glass eel fisheries currently exist in only five EMUs: GB_NorW, GB_De, GB_Wal, GB_Seve and GB_SouW (Table 3). The fishery in GB_SouE has not been authorised since 2010 and any commercial fishing for glass eel in other UK EMUs is forbidden (Table 3). The fisheries are prosecuted by hand-held dipnets, in rivers and estuaries draining into the Bristol Channel, in particular from the Rivers Severn and Wye (GB_Seve) and Parrett (GB_SouW), with smaller fisheries elsewhere, such as that in Morecambe Bay, Cumbria (GB_NorW).

Glass eel fisheries are obliged to report their annual catch by weight, effort in terms of days and gears fished, location and water type (coastal, river, still water). Catches reported to the EA have historically been aggregated and reported to the WGEEL as the catch for England and Wales. In addition to these catch returns, annual trade statistics from Her Majesty's Revenue & Customs (HMRC) provided an alternative indication of catches, for the period 1979–2006. Trade reports did not discriminate by eel size or stage, and therefore a procedure was developed to estimate glass eel trade into and out of the UK, and hence net export trade (see the 2010/2011 UK Country report for further details). Comparison between the catch reported to the EA and the net exports HMRC data for 1979–2006 suggested a significant but variable level of underreporting to the Agency, by between five and 15 times.

In 2009, legislation was introduced to improve the traceability of eel caught, such that there are now three sources of data:

- 1) Catch returns to the Agency;
- 2) The quantity of glass eel bought by the dealers from the fishermen (consignment notes);
- 3) The quantity of glass eel exported from the UK or stocked within the UK.

Since 2005, catches and effort have been reported per “nearest waterbody”, allowing the catch data to be assigned to EMUs (Table 3).

Table 3. Commercial catches (kg) of glass eel from England and Wales RBDs reported to the EA, from 2005 to 2018. Note that the 2017 catches are updated from the provisional data reported in the 2017 report, the 2018 catches are provisional (as of June 2018), and that no glass eel fisheries operate in the other EMUs, NP = not pertinent, in this case because glass eel fishing was not authorised in the Southeast since 2010.

Year	GB_NorW	GB_Dece	GB_Wal	GB_Seve	GB_SouW	GB_SouE
2005	166.2	39.0	87.0	784.8	626.5	0.0
2006	116.1	5.5	37.0	631.3	482.7	1.5
2007	200.0	6.3	26.0	1172.5	669.0	0.0
2008	91.6	2.0	3.8	370.7	348.6	0.0
2009	19.6	0.5	0.0	76.8	194.5	0.0
2010	30.3	4.8	1.1	531.7	756.5	NP
2011	75.8	12.9	2.5	897.5	1249.8	NP
2012	35.8	16.9	0.0	1151.5	1568.7	NP
2013	81.0	14.8	23.3	2693.0	3095.0	NP
2014	1.4	0.0	33.9	6125.9	5610.8	NP
2015	105.9	17.0	0.0	1418.7	1154.2	NP
2016	84.0	5.0	36.9	1971.3	1942.9	NP
2017	73.8	9.3	9.5	1585.7	1607.2	NP
2018	104.4	54.5	24.8	2254.1	1573.4	NP

The final catch reported to the EA for 2017 was 3.29 t of glass eel (Table 4). For 2018, the provisional data (as of June) of glass eel catch reported to the EA was 4.01 t (Table 4). Between 2009 and 2014, there was an increase in glass eel catch from the low of 2009 of 0.29 t, to a recent high for 2014 of 11.77 t, which was the highest elver catch since 1996 (Table 4). These figures are thought to have reflected a true increase in the availability of glass eel to the fishery at that time. However, catches have decreased since 2014, the catch of UK glass eel remains at the very low levels compared to those reported in the late 1990s (Table 4). Though underreporting of catch and effort are recognized, the consistency in the data collection over the time period (2005–2018) allows an evaluation of the trend in stock over this time period.

The confirmed 2017 data for the total glass eel fishery cpue was 0.45 kg/day. The confirmed 2017 data for the two main fishery areas, GB_SouW and GB_Seve, were 0.584 kg/day and 0.367 kg/day, respectively. The provisional 2018 total glass eel fishery cpue was 0.650 kg/day (Table 4).

Table 4. Time-series of 'UK' glass eel commercial fishery catches reported to EA, and as estimated from the consignment notes at first sale and dealers purchase, with catch per unit of effort based on fisherman returns from 2010 onwards. *2018 reported catch is provisional, as of June 2018, +Data not available yet.

YEAR	CATCH REPORTED TO THE EA (T)	CONSIGNMENT NOTES (T)	DEALERS PURCHASE (t)	cpue (KG/DAY) EA CATCH RETURNS
2010	1.32	1.72	1.89	0.37
2011	2.24	3.28	3.64	0.31
2012	2.77	3.61	3.82	0.29
2013	5.91	7.79	8.66	0.65
2014	11.77	12.30	11.60	1.98
2015	2.70	2.18	2.80	0.43
2016	4.04	3.82	4.28	0.53
2017	3.29	3.36	3.53	0.45
2018*	4.01	+	+	0.65

3.1.1.2 Proportion retained for stocking

Table 5. Percentage of glass eel caught in the UK and sold for stocking throughout the EU, according to first sale registrations. Note the subsequent fate of glass eel after first sale is sometimes difficult to trace and therefore there is some uncertainty around these values.

Year	Stocking
2009	100.0
2010	53.8
2011	43.9
2012	84.7
2013	72.6
2014	63.0
2015	72.3
2016	54.0
2017	56.3
2018	76.5

*Data not available yet.

3.1.1.3 Recreational

No recreational fisheries for glass eel are permitted in the UK.

3.1.2 Yellow eel fisheries

3.1.2.1 Commercial

Commercial fisheries for yellow eel deploy fykenets in ten EMUs of England and Wales (Table 6). A draftnet and longline fishery exists in GB_Neag (in NI, which is reported separately to that for E&W). There are no commercial fisheries for yellow eel in GB_Scot, GB_NorE or IE_NorW.

The total UK yellow eel fishery for 2017 amounted to 259.13 t, the lowest value of the period 2005–2017 (Table 6).

Prior to 2005, catches were reported as annual values for the whole of England and Wales, and for yellow and silver eel, combined. Since 2005, catches have been reported separately by stage and EMU (Table 6). The reported yellow catch for 2017 was 22 126 t for England and Wales, which was a 19.8% decrease on the previous year, 2016 (27 593 t), and 27.2% lower than the average annual catch of the past five years, 2012–2016 (30 437 t).

Commercial fisheries for yellow eel in the GB_Neag EMU use draftnets and longlines. Catches since 2005 are presented in Table 6, but it must be noted that a daily quota operates per boat in this fishery. Eel fishing on Lough Neagh is controlled by the LNFCS who license the fishery to approximately 200 fishermen, though in 2017 this number ranged from 40 to 186 fishermen operating at different times during the fishing season. Around 1990, there were 200 boats (400 fishermen) fishing the Lough, but this number has steadily declined to the present day peak of season average of 85 to 95 boats as a result of an ageing fisher population, availability of alternative employment and falling market prices for eel. Boat size on L. Neagh is restricted to 8.6 m long and 2.7 m wide. Information on licence applications, number of boats, fishing activity, recruitment to the fishery and the catch of yellow and silver eels from L. Neagh is collected and maintained by the LNFCS with several aspects of these data spanning over 100 years. This information is made available to DAERA and AFBI for scientific analysis and the provision of management advice.

Twenty percent of the Lough Neagh yellow eel catch is derived from draftnets, the other 80% from longline fishing using a maximum of 1200 standard sized hooks baited with earthworms, fish fry or the larvae of the flour beetle (meal worm). The fishery is run on a quota-based system driven by management decisions in consideration of conservation target compliance and commercial needs (usually 50 kg per boat per day). Economic margins have decreased due to increasing operational and distribution costs in conjunction with currency fluctuations. A record is kept of each individual boat's daily (Monday–Friday) catch, and noted against that day's quota. New technologies such as hydraulic draftnet haulers have been introduced over the last 20 years, thereby reducing the labour needed in the fishery or enabling fishermen to fish for longer if required.

Yellow eel catches in L. Neagh in 2017 amounted to 237 t, a 25 t decrease on 2016. This is the lowest yellow eel catch since 1959 (Table 7). 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 reduced number of boats fishing in the Lough, but fishermen have commented that it takes longer to catch their quota. Such comments continued in 2017 and in the light of the fact that boat numbers have remained somewhat comparable to recent years this increase in necessary effort is likely a reflection of stock decreases as a consequence of decreases in historic recruitment. Provisional data for 2018 suggest similar landings to 2017.

The quota-based catch management system, combined with varying boat numbers (on an almost daily basis) means it is impossible to calculate an annual cpue for the yellow eel fishery. However, a comparison of catch against average boat numbers (95 boats) produces a mean catch of 3505 kg boat⁻¹ in 2007–2011 and 2936 kg boat⁻¹ in 2012–2017, (decrease of 16.2%). 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 6. Commercial catch (t) of yellow eel for all UK EMUs with a fishery during the reporting period, together with total UK catch, 2005–2017.

Year	GB_Nort	GB_Humb	GB_Angl	GB_Tham	GB_SouE	GB_SouW	GB_Seve	GB_Wale	GB_Dece	GB_NorW	GB_Neag	Total
2005	0.005	1.295	13.065	7.175	0.406	3.787	0.565	0.240	0.034	1.619	317.10	345.29
2006	0.001	1.160	6.282	5.688	3.069	6.788	0.170	0.475	0.028	1.250	242.20	267.11
2007	0.000	2.138	3.739	6.963	1.807	2.019	0.068	0.273	0.023	0.211	351.30	368.54
2008	0.000	1.429	9.903	5.548	0.602	6.626	0.027	0.118	0.642	0.474	290.00	315.37
2009	0.045	0.411	6.616	4.745	7.029	2.546	0.000	0.022	0.070	0.114	345.20	366.80
2010	0.060	3.033	10.708	5.655	1.432	2.722	0.150	0.345	0.053	0.150	337.40	361.71
2011	0.000	4.857	16.478	6.082	1.879	3.792	0.350	0.252	1.082	1.477	342.00	378.25
2012	0.000	3.267	15.335	1.815	2.116	5.966	0.000	0.647	0.478	2.972	302.00	334.60
2013	0.000	3.865	9.315	3.991	0.286	8.688	0.000	0.100	0.152	0.669	321.00	348.07
2014	0.000	3.522	16.875	3.222	0.284	10.117	0.000	0.000	0.415	0.087	297.00	331.52
2015	0.000	1.381	8.379	2.696	0.957	16.828	0.000	0.000	0.074	0.093	255.50	285.91
2016	0.000	0.155	12.273	2.473	0.825	10.261	0.000	1.345	0.073	0.187	262.00	289.59
2017	0.000	1.542	6.129	2.264	0.364	11.168	0.000	0.000	0.333	0.326	237.00	259.13

3.1.2.2 Recreational

No recreational fisheries for yellow eel are permitted in the UK. Where eels are caught in rod-and-line fisheries they must be returned alive to the water where they were caught. No information is collected on these catch rates nor on post-release survival rates.

However, the undersized yellow eels (<400 mm long) captured via longline in Lough Neagh are returned to the Lough at the point of capture with hooks in place. Every month 100 undersized eels are sampled at the fishery, their hook location recorded and in conjunction with analysis of the catch composition, attempts are made to quantify possible losses to the fishery through hook mortality.

3.1.3 Silver eel fisheries

3.1.3.1 Commercial

Commercial fisheries in the ten EMUs of England and Wales are prosecuted using both fixed weir-traps and mobile fykenet gears (Table 7), while there is a coghill net silver eel fishery in GB_Neag. There are no commercial silver eel fisheries in GB_Scot, GB_Solw, GB_NorE or IE_NorW.

Noting above that yellow and silver eel catches in England and Wales have been reported separately for yellow and silver eels and assigned to separate EMUs since 2005. The reported silver eel catch for 2017 was 3.57 t, a decrease of 32.3% compared to 2016 (5.27 t) and a decrease of 43.4% on the five year rolling average catch (6.30 t) over the years 2012–2016.

Silver eel from Lough Neagh were caught in the River Bann using coghill nets fished on three weirs at two locations, but from 2012 the LNFCs reduced this to two weirs as an additional conservation measure. The number of coghill nets fished at each weir depends on weather and river flow conditions, and normally ranges from 2–4 nets per fishing night. The record of nightly catch is estimated at the time. True daily catch is only obtained if the catch is processed and sold the following day. Otherwise, catches are retained in tanks and sold as and when market conditions are more favourable. Therefore, a 'single' catch sale record may be a total for several nights fishing. This practice does not affect the annual catch reporting. Fishing capacity is recorded as the number of licensed silver eel weirs in operation.

The two weirs operate at different efficiencies dependent upon river flow rates. The data on silver eel catch are not available per net per night per weir. Given that a night's catch from the silver eel fishery in the River Bann may not be marketed the next day, but is combined with several nights' capture (with this reported at the time of sale as the "catch"), it is difficult to calculate a cpue for the silver eel fishery that would provide a meaningful indicator of stock abundance. The 2017 catch of 57.9 t continues the decreasing trend over the reporting period (2005 onwards), being only 5 t above that of 2016 (Table 7).

Table 7. Commercial catch (t) of silver eel for all UK EMUs with a fishery during the reporting period, together with total UK catch, 2005–2017.

Year	GB_Nort	GB_Humb	GB_Angl	GB_Tham	GB_SouE	GB_SouW	GB_Seve	GB_Wale	GB_Dece	GB_NorW	GB_Neag	Total
2005	0.00	0.24	6.66	1.07	3.59	1.89	0.40	0.01	0.01	0.20	116.5	130.57
2006	0.00	0.32	2.42	0.97	4.10	1.90	0.15	0.03	0.01	1.10	104.4	115.40
2007	0.00	2.19	0.20	0.48	2.62	0.23	0.12	0.14	0.01	0.09	75.9	81.98
2008	0.09	0.86	1.97	0.40	1.65	0.55	0.12	0.01	0.02	0.26	78.3	84.23
2009	0.01	0.11	0.59	0.12	3.20	0.30	1.22	0.04	0.01	0.08	87.9	93.58
2010	0.00	0.20	0.74	0.07	0.82	0.17	0.10	0.01	0.02	0.07	96.8	99.00
2011	0.00	0.26	2.01	0.51	0.69	0.07	0.38	0.01	0.12	0.27	73.3	77.62
2012	0.00	1.63	2.98	0.20	0.65	0.53	0.00	0.00	0.00	0.46	72.8	79.25
2013	0.00	0.26	2.49	0.31	1.99	0.95	0.00	0.00	0.03	0.11	72.8	78.94
2014	0.00	0.48	5.02	0.38	0.75	1.17	0.00	0.00	0.03	0.03	66.8	74.66
2015	0.00	0.74	3.76	0.20	0.11	0.91	0.00	0.00	0.03	0.06	49.3	55.11
2016	0.00	0.05	3.66	0.15	0.25	0.95	0.00	0.15	0.02	0.03	52.5	57.76
2017	0.00	0.02	2.11	0.01	0.03	1.12	0.00	0.00	0.02	0.25	57.9	61.46

3.1.3.2 Recreational

No recreational fisheries for silver eel are permitted in the UK. It is thought unlikely that silver eel would be accidentally caught in rod-and-line fisheries but if this were to occur then they must be returned alive to the water where they were caught. No information is collected on these catch rates nor on post-release survival rates.

3.1.4 Illegal, underreported or unrecorded catch

No data exist for illegal, underreported or unrecorded catches in England and Wales EMUs for silver or yellow eels. All eel fishing in Scotland is illegal without licence (and no commercial licences have been issued since the introduction of legislation in 2009), however, no data on the extent of illegal activity are available.

3.1.5 Bycatch

No data are collected on the bycatch of other species in gears targeting eel but any catch is anticipated to be small.

No data are collected on the bycatch of eel in gears targeting other fish species.

3.2 Restocking

3.2.1 Amount stocked

Stocking in the UK

Glass eel have been stocked into ten UK EMUs in recent years (Table 8). Data on the amounts stocked are available from the Neagh Bann EMU since 1984, and from other EMU since 2009. In most years the glass eel originated from the commercial fisheries in the Severn and Southwest EMUs. However, in 2010, the 996 kg of glass eel stocked in Neagh Bann originated from fisheries in San Sebastian, Spain and the west coast of France, and in 2011 and 2012, stocked material was sourced from France and the UK fisheries. There was no stocking of glass eel into Lough Neagh in 2016 because of issues with availability and supply from the UK fishery. Glass eel are not routinely quarantined before stocking into Lough Neagh, but arrive from UK Glass Eels Ltd with a Veterinary Health certificate and approved biosecurity protocols. However, following the recent purchases from outside the UK, 1 kg of each new delivery is held in tanks at the LNFCs HQ and survival rates monitored for several weeks by AFBI.

Table 8. Recent amounts (kg) of glass eel stocked into various UK EMUs. Note that the source of stocked materials usually UK fisheries, except that the stocking of GB_Neag in 2010 was solely from France and Spain, and in 2011 and 2012 were from France and UK.

Year	EMU									GB_NorE
	GB_Humb	GB_Angl	GB_Tham	GB_SouE	GB_SouW	GB_Seve	GB_Wale	GB_NorW	GB_Neag	
2006									330.0	
2007									1000.0	
2008									428.0	
2009	18.5	4.6	0.0	0.0	0.0	0.0	0.0		215.0	
2010	38.0	15.2	0.0	0.0	0.0	0.4	0.0		996.0	
2011	0.0	11.3	0.0	0.0	0.0	38.8	0.0		1035.0	
2012	10.0	1.5	3.2	0.0	5.0	21.5	0.0		1300.0	
2013	3.0	9.1	2.00	7.0	12.8	37.0	1.0		1866.0	
2014	3.8	0.0	14.0	7.5	8.7	21.5	0.0	0.0	2690.0	20.0
2015	0.0	0.0	0.0	0.0	0.3	17.0	0.0	0.0	604.0	
2016	0.0	0.0	0.0	0.0	0.6	17.0	0.0	0.0	0.0	
2017	0.0	0.0	0.0	0.0	0.0	17.0	0.0	0.0	817.0	
2018	0.0	0.0	0.0	0.0	0.0	17.0	0.0	0.0	754.0	

GB_Neag

A form of assisted migration is also conducted in the Neagh Bann EMU, where glass eel 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 9).

Table 9. 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	870.8

Stocking of UK glass eel into other countries

Glass eel from UK fisheries are also stocked into other European countries (see Table 10), but the fate of exported glass eels is often not known.

Table 10. The export destinations and kg of glass eel caught in the UK

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Belgium					4					2
Bulgaria								70		
Czech Rep			30	76	470	594	32	80	63	70
Denmark		200	515	400		400	250			
Estonia			307	90	480	420	250	152	150	162
France						863	100	185		320
Germany		97	882	384	470	1199	323	1074	1134	1006
Greece			411		1005	650	40	600	96	
Latvia			100	343	15	483		10	290	226.8
Lithuania					180	330		120	158	505
Netherlands		1288	593	100	1620	2232	350	51	109	157.5
Poland				120	95	15	5	127		35
Slovakia		85	80						14	
Spain						500		460		
Sweden	205			1200	1300	1400	672	892		1250

3.3 Aquaculture

There is no eel aquaculture in the UK. Some glass eel are exported to other EU countries for aquaculture and these are reported in Section 3.4.

3.4 Glass eel use

There are historic issues of underreporting the catch which mean that it is not appropriate to derive a proportion stocked from this historical catch data. New measures to accurately record catch and proportion retained for stocking have been implemented as part of the EMPs and therefore these proportions are available from 2009 onwards (Table 11).

Table 11. Percentage of glass eel caught in the UK and sold for stocking, aquaculture or direct consumption, according to dealers reports. [Note these percentages may not add up to 100% because of mortality and weight loss after capture].

Year	Stocking	Aquaculture	Direct consumption
2009	100.0	0.0	0.0
2010	53.8	36.5	0.0
2011	43.9	45.3	0.0
2012	84.7	10.5	0.0
2013	72.6	27.4	0.0
2014	62.9	28.2	6.7
2015	72.3	27.2	3.70
2016	54.0	45.7	0.3
2017	56.3	43.7	0
2018*	76.5	3.8	

3.5 Entrainment

Tidal flaps/gates

A total of 1048 tidal sluices exist within England and Wales. A study was undertaken to produce a nationally consistent, prioritised list of tidal outfall structures in England and Wales where upstream and/or downstream fish passage is adversely affected (HIFI, unpublished). The decision of which sluices to assess was initially made on the basis of channel width, with the narrowest watercourses (those <5 m wide) rejected because these are unlikely to provide large quantities of habitat for eel (even if channel length is long). This reduced the number of structures from 1048 to 449. These 449 were prioritised based on (1) fish stock status; (2) passage efficiency; (3) channel length; (4) channel width and (5) habitat quality.

An initial assessment of the impact on eel production was estimated for the top 106 of the prioritised tidal structures. Assuming that all the area upstream of the tidal gates/flaps is lost production, the total loss in terms of silver eel biomass was derived from total wetted area upstream * B_{best} production (kg/ha) in that EMU. In the absence of site-specific information on impacts, a conservative approach was taken to assume total loss of eel production upstream of the top 10% of tidal structures, and no loss of production from the remainder. This assessment will likely be revised as and when further information becomes available.

Pumping stations

In England and Wales, there are 321 pumping stations identified as having the greatest potential to impact on eel, based on: 1) distance from head of tide (shorter distance = greater impact) and 2) the predicted presence of eel.

To estimate the impact, it has been assumed that all the area upstream of the pumping station is lost to eel production. The total annual loss in terms of silver eel biomass is derived from wetted area upstream * B_{best} production (kg/ha) for the relevant EMU.

Surface water abstraction sites

Surface water is abstracted at 29 863 sites in England and Wales. Those sites with the greatest potential to impact on eel were identified using the following criteria: distance from head of tide, size of the abstraction, predicted presence of eel, the sensitivity of the waterbody to abstraction; and were quality assured by consultation. 772 sites were identified as posing the greatest threat to eel.

A study of eel entrainment and mortality has been carried out at twelve surface water abstraction sites. The average number of eel entrained at these twelve sites was 627 eels per year, with the average age of those eel being two years (~150 mm). The equivalent in terms of silver eel biomass is estimated to be 0.03 kg per entrained eel. This equates to 18.81 kg per year entrained per abstraction.

Hydropower facilities

In England and Wales, there are 212 hydropower facilities in operation affecting 11 188 ha of eel producing habitat. The impact of each hydropower facility is estimated according to the B_{best} production (kg/ha) for the relevant EMU, the area of habitat upstream, the presence or absence of screens (preventing eel entrainment) and the type of turbine. For those sites with screens, the proportion of eel entering the turbine(s) was assumed to be zero if the spacing between the bars/mesh was <15 mm, 50% if the spacing was between 16–29 mm and 100% if >30 mm: 27.6% of hydropower schemes (excluding Archimedes screws) are adequately screened to prevent the entrainment of eel (i.e. spacing was <15 mm). The estimates of turbine mortality were taken from the WGEEL 2011 report and were; Archimedes screw 0%, Francis Turbine 32%, Kaplan turbine 38%. All hydropower facilities have some form of bypass channel that provides an alternative route for fish around the turbine. On this basis, it has been assumed that approximately 50% of the silver eels produced upstream of a turbine will become entrained therein.

On those river systems where there is more than one hydro facility, the loss of production from the upstream turbine(s) has been accounted for in estimating the potential impact of turbines further downstream, i.e. the cumulative impact of all turbines has been calculated.

In Scotland a more conservative assessment approach has been adopted in which, in the absence of further information, eel production upstream of hydropower facilities is assumed to be zero.

3.6 Habitat quantity and quality

GB_Neag

Amount and characteristics of eel habitat

Lough Neagh comprises 38 600 hectares of open water and has a mean depth of 9.5 m with a maximum of 30 m (Figure 2). 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.

Passability to upstream and downstream migrating eel

The outflow from Lough Neagh through the lower River Bann is regulated by a series of weirs and sluices (Plate 1). These sluices are operated by the Northern Ireland Rivers Agency under legislation designed to maintain water levels in Lough Neagh within narrow bounds to facilitate lake–shore agriculture, navigation, and drinking water abstraction. Eel passes are in place on all sluice gate systems, and these passes are annually maintained by LNFCS with traditional methods (straw rope coverings) to facilitate upstream migration of any young eels which by-pass the trap and transport operation, although under current recruitment levels, most are helped upstream by the trap and tanker transport operation undertaken by LNFCS from tidal head traps 40 km to Lough Neagh. Under the high recruitment conditions in the early and mid-1900s there was considerable natural upstream migration, given the lack of anthropogenic influences in the system at that time.

Any silver eels which use the minimum 10% free gap past active silver fisheries are therefore free to run to sea. The outflowing River Bann is free of any turbine, power generation system or major water abstraction which might impede the escapement of silver eels to the sea.

Chemical quality

The chemical quality of Lough Neagh and the River Bann is assessed by the Northern Ireland Environment agency at sites in the Lough and the outflowing River Bann at quarterly intervals. Three determinants are used to score the quality according to the UK: biochemical oxygen demand (BOD), dissolved oxygen (DO) and ammonia, and categorised under the UK General Quality Assessment (GQA) system. In this system, there are six quality classes ranging from Very Good through Fair to Bad. Monitoring results for rolling 3-year sampling periods are used. Thus, for example, the GQA chemical classification for 2003 is based on a combination of the results obtained during 2001, 2002 and 2003. Lough Neagh currently scores at GQA class 3 (fairly good) which means that it is suitable for potable supply after treatment, all other abstractions, good cyprinid fisheries, and is capable of supporting a natural ecosystem.

Trophic status

AFBI monitors nutrient levels (forms of Nitrogen and Phosphorus, Silica, Algal species and quantity) on a fortnightly basis, along with Chlorophylla and Secchi disk transparency. These data class Lough Neagh as eutrophic or hypertrophic on the OECD/Vollenweider system, as a result of mainly agricultural but also some domestic N and P inputs. While this is a concern for other interests (e.g. the salmon and trout fisheries), the turbidity and high biological productivity are actually positive factors to the eel, and probably account for the Lake's capability to produce extraordinary quantities of eel relative to glass eel inputs. Some eel food items, particularly chironomid larvae, are present in very high abundance.

Contaminants

Lough Neagh has an essentially agricultural catchment with very low levels of industrialisation and only small or medium sized towns. Hence, in the absence of routine monitoring of eel quality, it is inferred that there is no local problem of contamination of eel with organic chemical residues, heavy metals, or other pollutants which would give grounds for concern for human consumption or indeed for eel spawner viability.

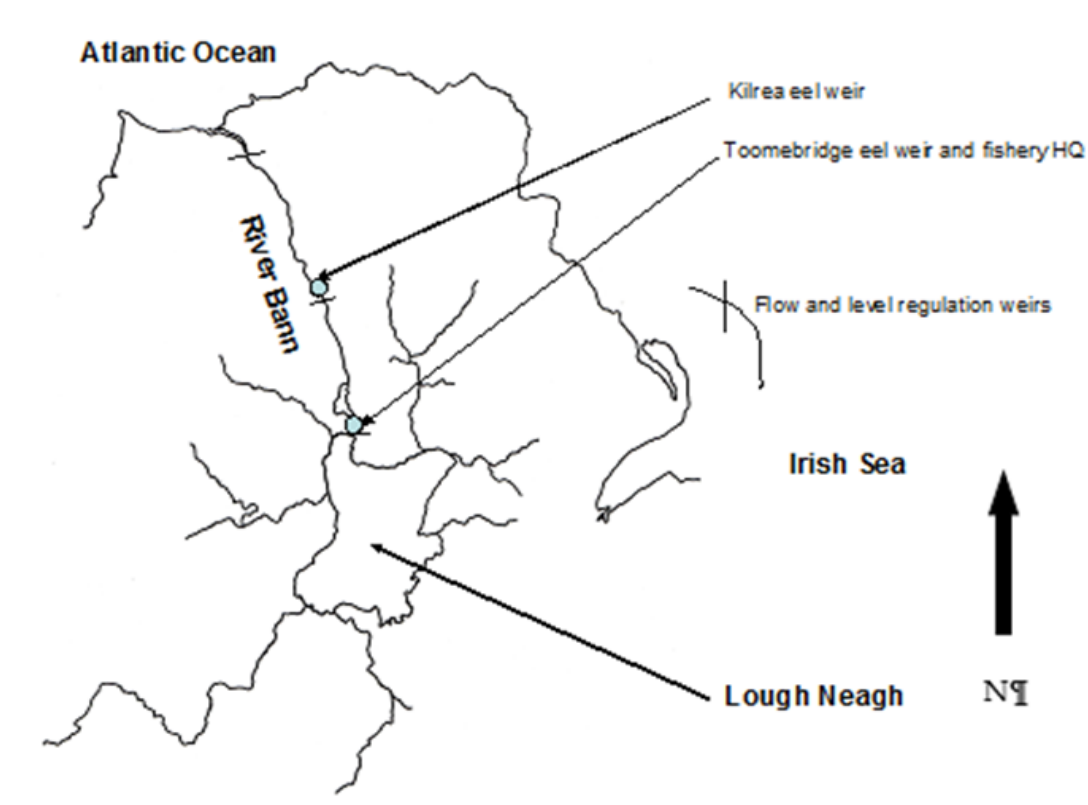


Figure 2. Schematic map of Lough Neagh in N. Ireland indicating silver eel weirs and sluice gates along the River Bann corridor.

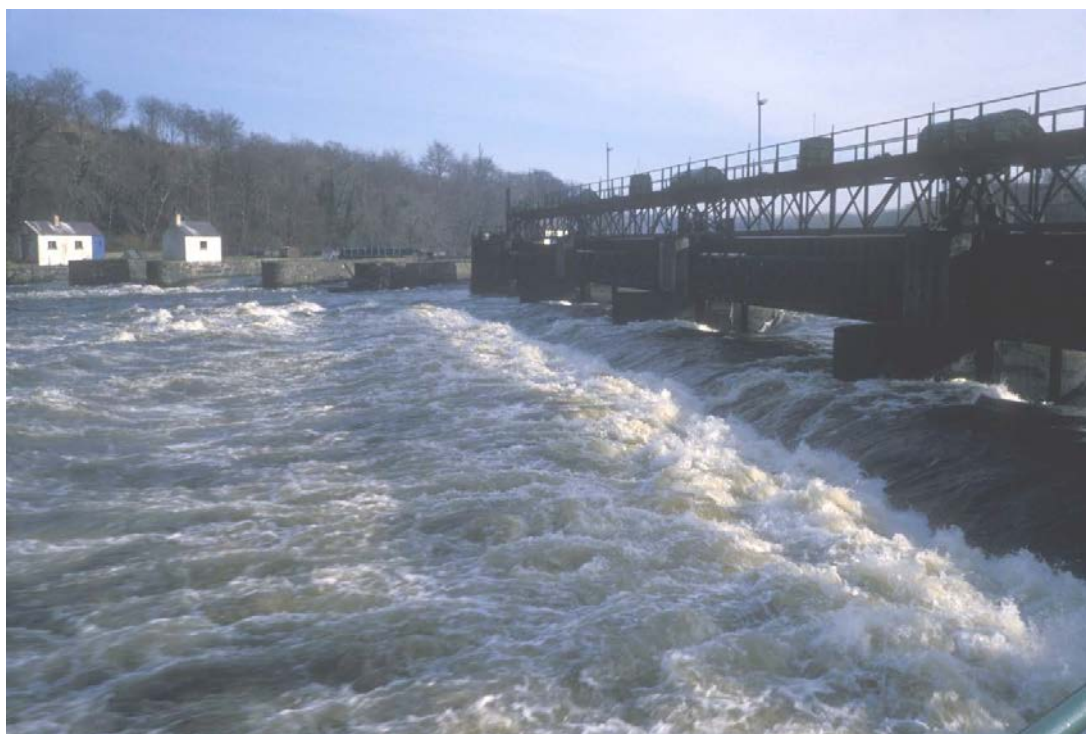


Plate 1. Sluice gates on the Bann corridor.

GB_NorE

This EMP covers the Northeast coastal fringe of Northern Ireland, comprising the Northeastern River Basin District as defined for Ecoregion 17 (The Island of Ireland) for WFD purposes, with the addition of those County Down coastal catchments draining into Carlingford Lough from Northern Ireland and those parts of the river catchments of South County Armagh not draining north to Lough Neagh but draining southward to the Irish Republic.

This EMP is entirely contained within one Member State (UK, Northern Ireland). A small part of the area contains the headwaters of streams draining to the Fane catchment in the Republic of Ireland (RoI). The Republic of Ireland Eastern EMP will include the RoI portion of the River Fane system.

This EMP contains a diverse range of river and lake habitats, ranging from highgradient mountain streams of low productivity and little or no production of eel, to lowland inter-drumlin lakes in areas of high productivity and with significant capability, at least on a per unit area basis, to produce eel. The potential eel productive area in the region is largely in two of these sections or catchment groups, i.e. the River Lagan and associated rivers entering the Irish Sea at Belfast, and the collected catchments draining to the fjord-like Strangford Lough.

4 National stock assessment

4.1 Description of method

Different methods are applied in different jurisdictions within the UK.

England and Wales: GB_Nort, GB_Humb, GB_Angl, GB_Tham, GB_SouE, GB_SouW, GB_Seve, GB_Wale, GB_De, GB_NorW, GB_Solw

Silver eel escapement estimates for these EMUs are derived from yellow eel electric fishing surveys extrapolated to silver eel escapement using the SMEP II model and various analyses to estimate losses due to fisheries and other human impacts.

The numbers of potential silver eel emigrants arising from the yellow eel population in the survey year, is estimated from the abundance and length distribution of those eels considered to be long enough to have a probability >0 of becoming silver eels in that year. The biomass of silver eels is estimated from the numbers-at-length using a length-weight relationship derived from data for over 16 000 eels sampled throughout England and Wales (Arahamian *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} (Arahamian, 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) (Arahamian, 1988).

The methods used to estimate other human-induced mortality rates are described in the 2018 UK EMP report.

Estimation of B_0

The 2015 triennial UK Eel Management Plan (EMP) progress report had an updated methodology for the calculation on historical biomass (B_0) compared to the 2012 and 2013 assessments. The improved model better reflected the actual state of eel stocks in rivers. Although the basic life-history model used for compliance calculations did not change, some of the assumptions and key datasets used within the model changed significantly (for more details on the methodology, see annex A in the 2015 UK EMP report). The same method was used in for the 2018 UK EMP Report. Although our model has been improved, the confidence limits around the biomass estimates are inherently wide.

Scotland: GB_Scot

Stock assessment methods have been developed for the Scotland EMU based on quantification of upstream and downstream eel movements at traps on three rivers. The estimates of B_0 , B_{current} and B_{best} rely heavily on the extrapolation of data from small study areas to the EMU as a whole, with the inherent possibility of bias. To derive an estimate of current production and anthropogenic mortality for the EMU from the available data has required a number of assumptions; these have tended to be precautionary in nature (i.e. likely to underestimate current production and overestimate current anthropogenic mortality (see Scotland RBD EMP, 2010 for details). Some of these precautionary assumptions could be tested, and the production/mortality estimates adjusted accordingly, if resources become available.

Scotland RBD EMP is available at: <http://www.gov.scot/Resource/Doc/295194/0118349.pdf>

From 2013, and following the methods used in England and Wales, Scotland has adopted the inclusion of a silver eel production estimate for transitional waters based on the simplistic assumption that this is equivalent to silver eel production in the low-land 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 (ΣA) 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 ΣA for the Scotland EMU.

Pristine escapement, B_0 , was estimated via three different methods: one based on historical measures of escapement from the Girnock Burn 1967–1980; one based on reference to a similar habitat elsewhere (Burrishoole data); and one based on the Irish Catchment Geology model. Details are presented in the Scotland RBD EMP (<http://www.gov.scot/Resource/Doc/295194/0118349.pdf>). All three methods yielded broadly similar results, and accordingly the mean value for pristine escapement of the three methods was adopted as B_0 . Since the EMP was published the estimate of B_0 has been slightly increased to take account of trap efficiency in one of the estimated methods. Further details can be found in the UK 2015 EMP progress report to the EC.

Northern Ireland

GB_NorE

The estimate of pristine escapement from the Northeast RBD was calculated with reference to the ecology and hydrology of similar systems (option c Article 5 of the Regulation) as described in Section 2.4.1 of the EMP. Current escapement was monitored in autumn of 2017 providing an extrapolated B_{current} across the EMU of 969 kg. All rivers and upland lakes which are suitable for eel have been assessed as having no barriers to migration. As such under adequate recruitment levels and an adherence to the criteria laid down in the Northeast RBD EMP, this EMU should reach or better the 40% target naturally.

GB_Neag

The monitoring of silver eel migration and subsequent estimations of silver eel escapement from the GB_Nea EMU are carried out by direct measurement. Given the geography of the RBD, in particular the single outflow point of Lough Neagh via the Lower River Bann at Toome, an annual mark–recapture programme of silver eel emigrating from Lough Neagh was initiated in October 2003, to estimate silver eel escapement (B_{current}) past the weir fishery, which is subject to a trap-free gap in the river channel, a three-month fishing season (some silver eel movement occurs outside this season), and inefficient fishing when river flows are very high. Recaptures occur both during the year of release and at least one or even two years afterwards. To date, 8918 silver eels have been tagged and maximum estimates of escapement, based on the proportion of recaptured FloyTM tagged eels, range from 111 t to 343 t during 2003 to 2017 (Table 13). No tagging was undertaken in 2007 due to the sporadic nature of the silver eel run. The Neagh/Bann estimate of B_{best} is derived from a known history of natural recruitment plus enhancement stocking, time-lagged for known growth rates of silver eel. The current fishery management arrangements significantly contribute to the outputs from this system.

IE_NorW*

The assessment methods for the Northwestern International RBD (IE_NorW*) are detailed in the original EMP (Section 8; Action 2a). Stock assessment was carried out on the Erne as part of the Erne Eel Enhancement Programme which ended in 2001 (Matthews *et al.*, 2001).

The values for B_0 for the UK derived from these various assessment measures are shown in Table 12.

Table 12. 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_Deel	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 13 Results of mark–recapture estimation of silver eel escapement from the Lough Neagh silver eel fishery 2003–2017.

Year	No. Tagged	Recaptures					Total annual silver catch (t)	Max.possible escapement estimate (t)
		Toome	Kilrea	Carry over	Total	Rate		
				to catch,		(%)		
				(T+1,T+2y)				
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
							14 year mean	249.6
							1st EMP mean	153.2
							2nd EMP mean	278.9
							3 rd EMP mean	181.4
							TARGET	200.0

4.1.1 Data collection

GB_Neag

Eel are sampled regularly as part of a long-term research programme which investigates all life stages throughout the year. Yellow eel catches are sampled weekly over 20 weeks (from May to September). A sample of 20 eels is chosen to reflect all size ranges caught, and analysed for age and length. In addition, the entire, ungraded landing of two fishing crew on one day each month is sampled, usually comprising 400–600 eels captured by longline and a similar number by 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 of 2017.

4.1.2 Analysis

No information available.

4.1.3 Reporting

No information available.

4.1.4 Data quality issues and how they are being addressed

No information available.

4.2 Assessment results

4.2.1 Habitat quantities

The wetted area used for calculating the stock assessment indicators for each EMU are shown in Table 14. Such wetted area habitats include rivers, lakes, inland waters, lagoons, coastal waters, and estuaries.

Table 14. 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_Deel	1579	Y	1623	Y	10 928	Y	0	N/A	0	N/A
GB_NorW	9076	Y	9780	Y	27 927	Y	0	N/A	151 109	N
GB_Solw	10 933	Y	6760	Y	69 803	Y	0	N/A	191 300	N
GB_Scot	138 557	Y	48 104	Y	60 502	Y	0	Y	4 589 412	N
GB_Neag	0	N	38 000	Y	0	N	0	N/A	0	N
GB_NorE	0	N	5000	Y	0	N	0	N/A	0	N

GB_Scot

The wetted area of rivers and lakes in the GB_Scot were calculated from UK Ordnance Survey MasterMaps, scales 1:10 000 and 1:1250. Below a certain channel width (defined as normal winter flow width) the digital network represents channels as a single dimensional line, which thus provides no data on the width of river channels. On 1:10 000 scale maps this occurs nominally on channels below 5 m in width; at the 1:1250 scale, it is for channels below 1 m. To provide a reasonable measure of the true extent of water area represented by all non-determined widths of channels, these were attributed 1 m width. In some cases, this will overestimate and in others underestimate the true width and hence wetted areas.

Area of the WFD defined transitional waters, combining estuarine and lagoon waters, was also calculated in GIS, with a value of 60 502 ha.

4.2.2 Silver eel biomass indicators

See Table 1.

4.2.3 Anthropogenic mortality rates

Fisheries and other anthropogenic mortality rates for each EMU are shown in Table 16a to d. Anthropogenic mortality rates include hydropower, surface water abstractions, pumping stations (recorded under Hydro & Pumps) and barriers (including tidal).

Commercial fisheries and hydropower installations have been assessed for all EMUs, with tidal gates, pumping stations and surface water abstractions being additionally assessed in the eleven EMUs of England and Wales. Since the last report, a new assessment of the impacts of other 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 2018 report. The impacts of the recreational fishery, predators and contaminants and parasites are treated as part of natural mortality and therefore not accounted for in these estimates.

Table 15a. Glass eel fisheries and other sources of anthropogenic mortality per EMU. The loss is in kg for each impact or as MI = not assessed minor, MA = not assessed major, AB= impact absent. Where data are pooled for several years, the average annual loss for those years is shown. Note, glass eel fisheries are not equivalent to mortality as a proportion of the catch is restocked (see Table 11).

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO PUMPS	& BARRIERS (INCLUDING TIDAL)	RE STOCKING	PREDATORS	INDIRECT IMPACTS
2009–2011	UK	GB_Nort			MI		MI	MI	MI/MA
2009–2011	UK	GB_Humb			MI		MI	MI	MI/MA
2009–2011	UK	GB_Angl			MI		MI	MI	MI/MA
2009–2011	UK	GB_Tham			MI		MI	MI	MI/MA
2009–2011	UK	GB_SouE			MI		MI	MI	MI/MA
2009–2011	UK	GB_SouW			MI		MI	MI	MI/MA
2009–2011	UK	GB_Seve			MI		MI	MI	MI/MA
2009–2011	UK	GB_Wale			MI		MI	MI	MI/MA
2009–2011	UK	GB_Dece			MI		MI	MI	MI/MA
2009–2011	UK	GB_NorW			MI		MI	MI	MI/MA
2009–2011	UK	GB_Solw			MI		MI	MI	MI/MA
2009–2018	UK	GB_Nea	0.0	0.0	AB	MA	NA	MI	MI/MA
2009–2018	UK	GB_Scot	0.0	0.0	MA	MA	AB	MI	MI/MA

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO PUMPS & BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2014–2016	UK	GB_Nort	0.0	0.0	MI	MI	MI	MI/MA
2014–2016	UK	GB_Humb	0.0	0.0	MI	MI	MI	MI/MA
2014–2016	UK	GB_Angl	0.0	0.0	MI	MI	MI	MI/MA
2014–2016	UK	GB_Tham	0.0	0.0	MI	MI	MI	MI/MA
2014–2016	UK	GB_SouE	0.0	0.0	MI	MI	MI	MI/MA
2014–2016	UK	GB_SouW	2902.7	0.0	MI	MI	MI	MI/MA
2014–2016	UK	GB_Seve	3172.0	0.0	MI	MI	MI	MI/MA
2014–2016	UK	GB_Wale	23.6	0.0	MI	MI	MI	MI/MA
2014–2016	UK	GB_Dece	7.3	0.0	MI	MI	MI	MI/MA
2014–2016	UK	GB_NorW	63.7	0.0	MI	MI	MI	MI/MA
2014–2016	UK	GB_Solw	0.0	0.0	MI	MI	MI	MI/MA

Table 15b. Yellow eel fisheries and other sources of anthropogenic mortality per EMU. The loss is in kg for each impact or as MI = not assessed, minor, MA = not assessed major, AB = impact absent. Where data are pooled for several years, the average annual loss for those years is shown.

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RE STOCKING	PREDATORS	INDIRECT IMPACTS
2009–2011	UK	GB_Nort					MI	MI	MI/MA
2009–2011	UK	GB_Humb					MI	MI	MI/MA
2009–2011	UK	GB_Angl					MI	MI	MI/MA
2009–2011	UK	GB_Tham					MI	MI	MI/MA
2009–2011	UK	GB_SouE					MI	MI	MI/MA
2009–2011	UK	GB_SouW					MI	MI	MI/MA
2009–2011	UK	GB_Seve					MI	MI	MI/MA
2009–2011	UK	GB_Wale	3.0	0.0	10.0	14.0	0	MI	MI/MA
2009–2011	UK	GB_Deel	124.0	0.0	20.0	12.0	0	MI	MI/MA
2009–2011	UK	GB_NorW	94.0		2.0	64.0	MI	MI	MI/MA
2009–2011	UK	GB_Solw	1.0	0.0	3.0	5.0	MI	MI	MI/MA
2017	UK	GB_Nea	237000.0	0.0	AB	AB	MI	MI	MI/MA
2008	UK	GB_Scot	ND	ND	MA	MA	AB	MI	MI/MA
2009–2018	UK	GB_Scot	0.0	0.0	MA	MA	AB	MI	MI/MA
2014–2016	UK	GB_Nort	0.0	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Humb	966.7	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Angl	13204.9	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Tham	3577.8	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_SouE	585.1	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_SouW	13286.7	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Seve	0.0	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Wale	454.3	0.0	MI		MI	MI	MI/MA

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2014–2016	UK	GB_De	225.1	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_NorW	136.1	0.0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Solw	0.0	0.0	MI		MI	MI	MI/MA

Table 15c. Silver eel fisheries and other sources of anthropogenic mortality per EMU. The loss in kg for each impact or MI = not assessed, minor, MA = not assessed major, AB = impact absent. Where data are pooled for several years, the average annual loss for those years is shown.

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RE STOCKING	PREDATORS	INDIRECT IMPACTS
2009–2011	UK	GB_Nort	3	0	10	14	0	MI	MI/MA
2009–2011	UK	GB_Humb	124	0	20	12	0	MI	MI/MA
2009–2011	UK	GB_Angl	94	0	2	64	1	MI	MI/MA
2009–2011	UK	GB_Tham	1	0	3	5	0	MI	MI/MA
2009–2011	UK	GB_SouE	2	0	2	17	0	MI	MI/MA
2009–2011	UK	GB_SouW	6	0	9	4	0	MI	MI/MA
2009–2011	UK	GB_Seve	0	0	0	9		MI	MI/MA
2009–2011	UK	GB_Wale			MI		MI	MI	MI/MA
2009–2011	UK	GB_Deer			MI		MI	MI	MI/MA
2009–2011	UK	GB_NorW			MI		MI	MI	MI/MA
2009–2011	UK	GB_Solw			MI		MI	MI	MI/MA
2017	UK	GB_Nea	57900	0	AB	AB	MI	MI	MI/MA
2008	UK	GB_Scot	ND	ND	3721	24257	AB	MI	MI/MA
2009	UK	GB_Scot	0	0	6409	39706	AB	MI	MI/MA
2010	UK	GB_Scot	0	0	3250	19475	AB	MI	MI/MA
2011	UK	GB_Scot	0	0	3051	19672	AB	MI	MI/MA
2012	UK	GB_Scot	0	0	3349	23908	AB	MI	MI/MA
2013	UK	GB_Scot	0	0	4063	26006	AB	MI	MI/MA
2014	UK	GB_Scot	0	0	11330	67089	AB	MI	MI/MA
2015	UK	GB_Scot	0	0	6851	41169	AB	MI	MI/MA
2016	UK	GB_Scot	0	0	6132	38218	AB	MI	MI/MA
2017	UK	GB_Scot	0	0	6698	45290	AB	MI	MI/MA

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RE STOCKING	PREDATORS	INDIRECT IMPACTS
2014–2016	UK	GB_Nort	0.0	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Humb	181.3	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Angl	3312.3	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Tham	178.7	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_SouE	409.1	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_SouW	1669.2	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Seve	16.7	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Wale	53.3	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Deer	38.6	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_NorW	126.0	0	MI		MI	MI	MI/MA
2014–2016	UK	GB_Solw	0.0	0	MI		MI	MI	MI/MA

Table 15d. Silver eel Equivalents of fisheries and other sources of anthropogenic mortality per EMU. The loss in kg for each impact or MI = not assessed, minor, MA = not assessed major, AB = impact absent. Where data are pooled for several years, the average annual loss for those years is shown.

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RESTOCKING	PREDATORS	INDIRECT IMPACTS
2009–2011	UK	GB_Nort			MI		MI	MI	MI/MA
2009–2011	UK	GB_Humb			MI		MI	MI	MI/MA
2009–2011	UK	GB_Angl			MI		MI	MI	MI/MA
2009–2011	UK	GB_Tham			MI		MI	MI	MI/MA
2009–2011	UK	GB_SouE			MI		MI	MI	MI/MA
2009–2011	UK	GB_SouW			MI		MI	MI	MI/MA
2009–2011	UK	GB_Seve			MI		MI	MI	MI/MA
2009–2011	UK	GB_Wale			MI		MI	MI	MI/MA
2009–2011	UK	GB_Deer			MI		MI	MI	MI/MA
2009–2011	UK	GB_NorW			MI		MI	MI	MI/MA
2009–2011	UK	GB_Solw			MI		MI	MI	MI/MA
2017	UK	GB_Nea	295000	0	AB	AB	MI	MI	MI/MA
2008	UK	GB_Scot	ND	ND	3721	24257	AB	MI	MI/MA
2009	UK	GB_Scot	0	0	6409	39706	AB	MI	MI/MA
2010	UK	GB_Scot	0	0	3250	19475	AB	MI	MI/MA
2011	UK	GB_Scot	0	0	3051	19672	AB	MI	MI/MA
2012	UK	GB_Scot	0	0	3349	23908	AB	MI	MI/MA
2013	UK	GB_Scot	0	0	4063	26006	AB	MI	MI/MA
2014	UK	GB_Scot	0	0	11330	67089	AB	MI	MI/MA
2015	UK	GB_Scot	0	0	6851	41169	AB	MI	MI/MA
2016	UK	GB_Scot	0	0	6132	38218	AB	MI	MI/MA
2017	UK	GB_Scot	0	0	6698	45290	AB	MI	MI/MA

YEAR	COUNTRY	EMU CODE	COMMERCIAL FISHING	RECREATIONAL FISHING	HYDRO & PUMPS	BARRIERS (INCLUDING TIDAL)	RE STOCKING	PREDATORS	INDIRECT IMPACTS
2014–2016	UK	GB_Nort	0.0	0	2359.5	2976.7	0.0	MI	MI/MA
2014–2016	UK	GB_Humb	1148.1	0	19114.0	25860.9	75.2	MI	MI/MA
2014–2016	UK	GB_Angl	16517.2	0	6133.1	35163.9	0.0	MI	MI/MA
2014–2016	UK	GB_Tham	3756.4	0	7122.6	36219.3	277.2	MI	MI/MA
2014–2016	UK	GB_SouE	994.1	0	4157.3	11479.5	148.5	MI	MI/MA
2014–2016	UK	GB_SouW	532210.3	0	4882.1	7562.5	189.7	MI	MI/MA
2014–2016	UK	GB_Seve	565264.3	0	1121.6	61157.8	1098.9	MI	MI/MA
2014–2016	UK	GB_Wale	4713.8	0	1687.7	5349.1	0.0	MI	MI/MA
2014–2016	UK	GB_Deer	1570.6	0	1631.6	9085.4	0.0	MI	MI/MA
2014–2016	UK	GB_NorW	11621.2	0	7524.7	8885.5	0.6	MI	MI/MA
2014–2016	UK	GB_Solw	0.0	0	135.0	13524.1	0.0	MI	MI/MA

5 Other data collection

5.1 International recruitment time-series

The ICES Recruitment Analysis uses the total UK commercial glass eel catch time-series (catch returns from the EA) and is shown in Figure 3 below.

As the glass eel catch data reported directly to the EA are now recorded against each EMU, and have been so since 2005, these time-series could be considered for the ICES analyses at some point in future.

5.2 Other recruitment time-series

Fisheries-independent glass eel recruitment data are available from several sites in four EMUs.

Table 16 contains data on glass eel/elver recruitment for three counter sites in in GB_Angl and one in GB_SouW. Data are available for the Brownhill site on the River Great Ouse between 2011 and 2018, although in 2012 the trap was not operational for a long period due to summer flooding and represents a partial count. The trap operation in other years was consistent throughout the time-series. Data for glass eel traps on the river Stour (Flatford, Judas Gap site) and the river Chelmer (Beeleigh Weir site) are available respectively from 2007 and 2006 onwards, although data from 2017 and 2018 have not been finalised yet. The numbers of glass eel and elvers (<120 mm) using a camera trap at the Greylake site on river Parrett (GB_SouW) are available from 2009–2018.

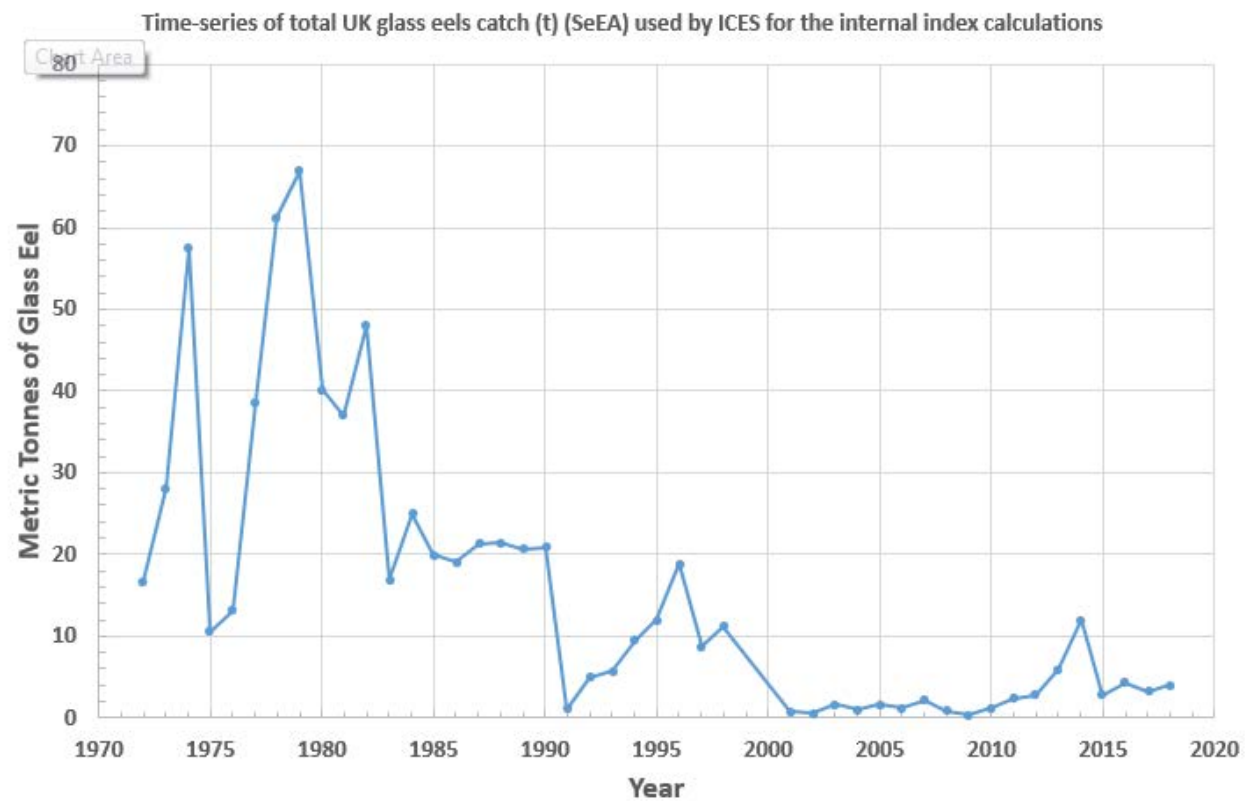


Figure 3. Time-series of UK glass eels catch (t) index datasets used by ICES for the internal index calculations.

Table 16. Recruitment measures for glass eel/elvers in different length categories in England and Wales: Brownshill on the Great River Ouse (GB_Angl), Flatford, Judas Gap on the River Stour (GB_Angl), Beeleigh Weir on the River Chelmer (GB_Angl) and at Greylake on the River Parrott (GB_SouW).

Site	Brownshill*		Flatford		Beeleigh Weir ‡		Greylake‡	
Year	<80 mm	>80<120 mm	<80 mm	>80<120 mm	<80 mm	>80<120 mm	<80 mm	<120 mm
2006	-	-	-	-	1290	NA	-	-
2007	-	-	11135	16671	3055	NA	-	-
2008	-	-	9979	481	4055	NA	-	-
2009	-	-	3145	153	776	NA	NA	33414
2010	-	-	NR	NR	1240	NA	NA	12170
2011	5175	21331	4171	449	992	NA	NA	12810
2012	24	560	17199	974	371	NA	NA	39005
2013	36908	139531	NR	NR	33338	NA	NA	22345
2014	633	24101	16316	2579	17554	NA	NA	33351
2015	476	79178	8529	997	17863	NA	NA	19265
2016	50	38735	10295	2191	10388	NA	NA	48074
2017	97	32839	TBA	TBA	TBA	NA	NA	37726
2018+	212	30337	TBA	TBA	TBA	NA	NA	12435

*2012 represents a partial count for this site.

*Data for 2018 is provisional as of June 2018

‡ Camera trap records a mixture of glass eel and elvers (<120 mm).

GB_Scot

An ascending yellow eel monitoring trap was set up in 2008 on the Girnock Burn, fishing from May to September. The trap was destroyed by flooding in December 2015, and rebuilt to different design in April 2017. A time-series for glass eels at the Shieldaig river mouth in Wester Ross (N 57°30.65, W 5°38.72), using pinhole traps at the upper tidal limit, fishing from March to July inclusive, was instituted in 2014. A second series using skirt traps in still water at the barrier formed by the Shieldaig trap (50 m upstream of the tidal limit, was instituted in 2017 (Table 17), fishing from March to September inclusive.

Table 17. Recruitment monitoring in GB_Scot: the number of ascending yellow eel at the Girnock Burn and glass eel (<90 mm) at the mouth of the Shieldaig River (at tidal limit), and at the Shieldaig trap. 2018 data up to 25/08/2018.

Year	GIRNOCK BURN (YELLOW EEL)		SHIELDAIG TIDAL LIMIT (GLASS EEL)		SHIELDAIG TRAP (GLASS EEL)	
	Number	Mean length (mm)	Number	Mean length (mm)	Number	Mean length (mm)
2008	572	156				
2009	370	155				
2010	89	156				
2011	48	158				
2012	273	158				
2013	181	154				
2014	276	159	177	70.1		
2015	23	149	45	68.7		
2016	ND	ND	24	69.9		
2017	242	159	103	69.9	408	69.5
2018	302	159	129	73.2	989	72.3

GB_Neag

The LNFCS catch glass eels using dragnets with an area of 0.94 m², fished below a river-spanning sluice gate, which creates a barrier to upstream juvenile eel migration on the River Bann. Total catch per night is recorded, but not catch per individual net. These, and elvers trapped at the same location, are transported upstream to be stocked into the Lough. These catches provide a time-series of 'natural' recruitment into the Lough (Table 18). 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. The catch increased over the following three years, to 189.3 kg, 384 kg and 698.5 kg, respectively. For 2017, recruitment was very similar to 2016 (432 kg) at 429 kg. 2018 showed a marked increase with the number of glass eels doubling to 860 kg by July. For the fifth year in succession (previously reported in 2013, 2014, 2015 and 2016) elvers were once again captured very late in the season while migrating silver eels were leaving the same system.

Table 18. Glass eel recruitment to the River Bann, Northern Ireland, 1996 to 2018. (Full historical dataset in electronic tables).

Year	Natural elver run (kg)
1996	2668
1997	2532
1998	1283
1999	1345
2000	563
2001	315
2002	1092
2003	1210
2004	342
2005	852
2006	456
2007	444
2008	24
2009	158
2010	68
2011	16
2012	189
2013	344
2014	699
2015	317
2016	432
2017	429
2018	870

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 was, 712.5 kg in 2015 and 881.5 kg in 2016 but fell markedly in 2017 to 150.3 kg. The run in 2018 showed a significant increase with a catch of 1969.7 kg. The full time-series index of glass eel recruitment to this basin is reported in the Republic of Ireland Country Report.

In addition to the glass eel sampling at the River Bann, other sampling is undertaken at several coastal sites: the Foyle Estuary, the River Lagan (Belfast), River Quoile (Strangford Lough) and Carlingford Lough Estuary.

GB_NorE

See Section 6 (New Information) in relation to the establishment of a new glass eel monitoring site at Strangford Lough.

5.3 National programme for EU Data Collection Framework or other

No information available.

5.4 Yellow eel abundance surveys

Rivers

England and Wales EMUs

The EA and NRW survey yellow eel abundance across EMUs using a six-year rolling programme of electrofishing surveys. In 2018, eel specific monitoring of yellow eel was planned on ten rivers at a total of 88 sites in England (Table 19). These data are used to assess the biomass of silver eel escaping from each eel management unit (equivalent to a River Basin District), as required by the EU Eel Regulation (1100/2007), using SMEP II + Impacts Models. These data have yet to be processed, but previous years' data are summarised in Table 1 for when the last time the model was run. At each site the following data are collected; number and size (mm) of each eel, together with the site's dimensions (length and average width).

Table 19. Eel-specific monitoring carried out during in English EMUs in 2018.

EMU	River	Number of sites
GB-SouW	Fowey	9
GB_NorW	Gowey	9
GB_NorW	River Bela	10
GB_NorW	Ribble River	10
GB_Nort	Northeast Eel sites	10
GB_Humb	Eel Specific Survey	10
GB_Seve	River Severn	9
GB_Angl	Stour Catchment	10
GB_Seve	Warkwickshire Avon	1
GB_Angl	Welland Catchment	10

GB_Scot

Since 2008, the Scottish Environment Protection Agency (SEPA) has undertaken routine electrofishing surveys for all fish species, including eels. In 2015, 119 sites were fished, of which 18 were multipass and 101 single pass. The minimum density of eels estimated from three pass electrofishing at the 39 sites fished in 2008 ranged from 0.3–23.7 eels per 100 m², giving a mean minimum density across GB_Scot of 6.7 eels per 100 m² (or 5.4 eels per 100 m² including those sites from which eels were absent).

A further eleven electrofishing sites above the Girnock and Baddoch traps (GB_Scot) are fished annually by Marine Scotland Science.

One further site monitored by Marine Scotland Science is the Allt Coire nan Con Burn, which is situated in the Strontian region of western Scotland and drains into the River Polloch, an inflow to Loch Shiel, GB_Scot. The catchment covers 790 ha and its altitude falls from 756 m to 10 m at the sampling point, where the river is 5–6 m wide. Riparian

vegetation at the sampling sites is predominantly mature deciduous woodland. Annual electrofishing surveys show no clear evidence of declines in yellow eel densities since 1992 (Adams *et al.*, 2013).

Standing waters

England and Wales EMUs

A fykenet survey was undertaken on the River Avon (GB_Seve), on the stretch that had been fished in 1996, 2000, 2006 and again in 2012–2014 (Table 20). The survey was undertaken over a four-week period in summer (July/August), similar to the timing in previous years. There is evidence of a decline in catch over the ten-year period from 1996–2006, with an increase in 2012–2014.

The 2014 survey showed a rise in the population, apparently above that of 1996 level. However much of that (2014) weight was made up of silver females (unlike previous years). As these eels are migratory, these results have to be treated with caution as these eels were probably passing through. Numbers of yellow eels were slightly down but the presence of elvers was evident throughout and in very large numbers, although not quantified. The traps were possibly more efficient as the survey was carried four weeks earlier than previous surveys (July 15–August 15). This site was surveyed in 2015 and 21.9 kg of eels were recorded, however the timing of the sampling period was later than usual. As of 2016, no more data will be recorded at this site because the third party operator who provided this information is no longer recording the information.

Table 20. Total catch of yellow and silver eel per ten codends between 1996 and 2016 on the river Avon, GB_Seve, (Roger Castle, pers. comm.).

Year	Catch (kg)
1996	50.0
2000	28.0
2006	12.0
2012	30.0
2013	37.0
2014	62.0
2015	21.9
2016	NR

GB_Scot

Data from eel captured on trash screens of a pumping station (1982–2003) on Loch Lomond showed no evidence of a decline in yellow eels (Adams *et al.*, 2013) during the period.

GB_NorE

Eel are known to be present but there are limited scientific data. Yellow eel populations are present in every lake examined thus far, though there were significant differences between two of these sites in length and age distribution. Results were incorporated into the reviewed EMP for this RBD in 2012. Killlough (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 was carried out in 2016 (data in Ireland Country Report). Results found similar findings to the 2014 survey in terms of cpue indicating the effects of the closure of the commercial yellow eel fishery. However, there was a noticeable decrease in the catches of small eel (<40 cm) compared to the levels seen in every previous survey and is believed to reflect historical recruitment trends into the Erne catchment. Similarly, this survey was repeated in summer 2018, with results available in next year's report.

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).

5.5 Silver eel escapement surveys

GB_Scot

Downstream migrating silver eels have been trapped at three sites in Scotland: the Girnock Burn and Baddoch Burn (two adjacent tributaries of the river Dee, emptying ultimately into the North Sea), and the Shieldaig (an entire small catchment on the western seaboard). The biomass of migrating silver eels for each available year have been converted to area production rates (kg/ha) and are reported in Table 21.

Table 21. Silver eel escapement from three catchments in GB_Scot (kg.ha⁻¹).

Year	Girnock	Baddoch	Shieldaig	Year	Girnock	Baddoch	Shieldaig
1966	0.53	-	-	1992	-	-	-
1967	0.44	-	-	1993	-	-	-
1968	1.42	-	-	1994	-	-	-
1969	1.02	-	-	1995	-	-	-
1970	0.86	-	-	1996	-	-	-
1971	1.25	-	-	1997	-	-	-
1972	0.84	-	-	1998	-	-	-
1973	1.59	-	-	1999	-	-	0.57
1974	1.07	-	-	2000	-	-	-
1975	2.23	-	-	2001	-	-	-
1976	1.91	-	-	2002	-	-	0.69
1977	1.42	-	-	2003	1.05	-	0.51
1978	1.25	-	-	2004	-	-	-
1979	1.07	-	-	2005	0.86	-	-
1980	0.61	-	-	2006	-	0.32	1.59
1981	1.02	-	-	2007	0.51	0.35	0.63
1982	-	-	-	2008	0.42	0.57	0.55
1983	-	-	-	2009	0.44	0.53	1.0
1984	-	-	-	2010	-	0.10	0.53
1985	-	-	-	2011	0.30	0.47	0.38
1986	-	-	-	2012	0.78	0.45	0.43
1987	-	-	-	2013	0.44	0.34	0.61
1988	-	-	-	2014	0.23	0.66	1.87
1989	-	-	-	2015	0.36	0.08	1.11
1990	-	-	-	2016	0.48	0.46	0.96
1991	-	-	-	2017	1.26	0.46	0.94

GB_Neag

Samples of ten eel chosen to reflect all size ranges in the catch are removed every week over a 12-week period at Lough Neagh and analysed for age and length. At weekly intervals the previous night's haul is measured for length. The number analysed can vary widely but on average covers at least 400 fish within a nights catch of >1 t. In addition, the weekly silver eel samples are also analysed for length, weight, fat content, sex, prevalence and intensity of *Anguillicola crassus*, stomach contents, and gastrointestinal endohelminths. Sex ratio of the silver eel population is also examined by counting the numbers of individuals contained in the graded (depending upon size) 15 kg boxes. The fishery records the number of boxes of small (male) and large (female) eels sold, and from this the sex ratio and number of silver eels can be estimated.

GB_NorE

This EMU was assessed using modified large D ring fykenets for silver eel migration in autumn 2017.

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.

5.6 Biological parameters

GB_Scot

Individual growth rates of PIT tagged eels are measured by Marine Scotland Science in two tributaries of the River Dee, GB_Scot. To date, growth rates for eels with more than a season between capture and recapture have ranged from 0.8 to 35.2 mm.yr⁻¹, with mean \pm s.e growth of 8.85 ± 0.62 mm.yr⁻¹ (n = 78). On the Baddoch, the range of growth rates was 0.0–14.5 mm.yr⁻¹, with mean \pm s.e growth rates of 6.36 ± 0.84 mm.yr⁻¹ (n = 26). These may be the lowest growth rates ever reported for the European eel.

Since 2008, yellow eel recruitment into the Girnock Burn, has been assessed by Marine Scotland, using an eel pass. Eels are measured, weighed, and between 2008 and 2012 most were individually marked, either using PIT tags or VIE elastomer. Mean length of these ascending yellow eels is about 157 mm, ranging from 96–254 mm (see Table 18). Glass eels are measured annually at the River Shieldaig, mean lengths are shown in Table 18.

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).

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\[1\].pdf](http://www.lochaberfish.org.uk/cust_images/Lochaber_eel_report_2010[1].pdf)

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 22). However, in 2008, 2009 and 2010, this trend has reverted to close to 1:1 (48, 52 and 47% females) with a slight fall in 2017 to 43% females. Taking account of differing sizes and weights of males and females, 70% of the recorded silver eel biomass is now female.

Table 22. 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.

Year	MALES				FEMALES			
	%	Mean L (cm)	Mean Wt (g)	Age	%	Mean L (cm)	Mean Wt (g)	Age
1927	0				100		567	
1943	27				73			
1946	40				60			
1956	61				39			
1957	62				38			
1965	10		180		90		330	
2004	51	40.6	122	11.0	49	58.6	386	18.0
2005	52	41.4	126	11.4	48	58.1	393	18.2
2006	37	40.1	117	12.3	63	59.5	368	18.7
2007	38	40.2	121	11.0	62	62.3	370	18.4
2008	52	40.3	122	12.0	48	59.5	367	18.0
2009	54	40.9	128	11.7	46	61.7	378	17.7
2010	54	40.1	117	12.3	46	56.7	365	17.8
2011	57	40.2	118	12.2	43	61.4	375	20.1*
2012	54	38.4	117	11.9	46	61.2	396	19.6*
2013	51	41.1	125	12.8	49	61.4	372	18.1
2014	53	39.6	120	11.8	47	58.1	342	17.6
2015	51	40.3	121	11.1	49	62.3	380	16.9
2016	52	40.5	121	10.9	48	63.5	379	n/a
2017	57	39.7	120	n/a	43	60.9	383	n/a

*age data to be QA verified.

5.7 Parasites and pathogens

GB_Neag

- No evidence of anguillid herpes virus in any life-history stage of the wild European eel population of Lough Neagh.
- Eel virus European (EVE) and Eel virus European X (EVEX) were found but at a very low prevalence, suggesting that the presence of these diseases has not reached levels of concern to the population's health status.

England

Herpes virus anguillae (HVA) was detected during disease investigations of European eel, *Anguilla anguilla* L. at two still-water fisheries in central England. These represent the first records of HVA from UK eels. Both mortalities were eel specific and took place during August 2009 and July 2010 at water temperatures between 17° and 19.4°C. Pathological changes consistent with HVA infection included haemorrhaging in the fins, skin lesions and necrosis within the gills and liver. Transmission electron microscopy revealed active virion replication within the gill tissue. An initial assessment of risk is presented, indicating that HVA represents a high disease risk to UK eel stocks. However, further studies are required to establish the distribution of HVA before a reliable assessment of impact may be obtained. Until then, the detection of HVA hold

important implications for eel conservation and management, in particular eel stocking activity.

In 2017, 61.3% of yellow eels (N= 320) and 86% of silver eels (N=100) were found to be infected with the nematode *A. crassus*, the highest infection parameters observed since 2008. As noted in previous Country Reports, the mean intensity of individual worms per infected eel remains significantly higher in silver eels with on average ten worms per fish compared to four in yellow eels.

European eel health and disease investigations

Eel health and diseases in England and Wales are monitored through mortality investigations, targeted surveillance and screening of eels prior to restocking.

Since 2013, two eel-specific mortalities have been reported from still water fisheries in England. Field investigations and detailed post-mortem examinations confirmed the primary cause for these losses to be Anguillid herpesvirus 1 (AngHV-1). These events, combined with previous outbreaks reported in 2009 and 2010 (Armitage *et al.*, 2013), bring the total number of mortalities associated with this virus in England to four.

All four outbreaks of AngHV-1 have involved large eels, measuring between 70 and 120 cm in length. These fish had estimated ages of between 17 and 29 years and many eel examined showed morphological characteristics of silvering. Affected eels were lethargic and unresponsive with signs of external haemorrhaging, skin lesions and severe gill necrosis. Histopathological examinations revealed marked necrosis, haemorrhage and inflammatory changes within the gills, kidney, skin, liver and spleen.

Post-mortality sampling suggested that up to 70% of the eel populations were lost from these waters. It is proposed that the onset of silvering, with associated physiological changes and migration pressure, were triggers for these disease events, which so far have all occurred in still waters with barriers to escapement. Further sampling is underway to assess the prevalence, persistence and impact of the virus within these waters.

Since 2011, efforts have been made to establish the distribution of AngHV-1 in wild eels in England and Wales. This collaborative study between the Environment Agency and Cefas, has involved taking blood samples from live eels captured and returned during routine monitoring activities. To date, 685 eels, from 36 rivers in eleven EMUs have been tested for antibodies to AngHV-1. An additional 429 glass eels have been tested, from 14 sites in five EMUs. This work has confirmed that AngHV-1 has a relatively widespread distribution, but exists at a low prevalence (~5%) in most of the rivers sampled. This work will help inform existing disease risk assessments for this virus. Efforts are also underway to assess the presence and distribution of other eel viruses in England.

Since 2013, yellow eel from two rivers and glass eels from three rivers have been screened for parasites and disease prior to movement/stocking. *Anguillicola crassus* was found in all of the yellow eel samples at a prevalence of between 50 and 93%. Within these populations mean intensity of infection ranged from six to seven parasites respectively. Of the glass eels examined, only one of the samples revealed infections of *A. crassus*, at a prevalence of 37% and intensity of 1–7 nematodes (mean 2.4). These data are consistent with historic surveys of this nematode, now widely distributed throughout England and Wales. It is thought that a small number of catchments and some isolated rivers in North Wales and Northern England remain either sparsely infected or

tentatively free of the parasite. No other parasites or diseases of concern were recorded during these examinations.

In May of both 2015 and 2016, dead eels were reported in parts of the river Dee catchment, GB_Scot. In 2016 some of these were identified at the Girnock monitoring site, and the Fish Health Inspectorate isolated *Flavobacterium psychrophilum* from moribund specimens.

A number of collaborative projects are underway to progress understanding of European eel health interactions. This includes development of a standardised protocol to harmonise assessments of eel spawner quality and maximise retrieval of data from UK monitoring activities (Lewin *et al.*, 2014).

A study in collaboration with Southampton and Cardiff Universities was also conducted to assess the influence of parasites on the behaviour and passage of silver eels in freshwater. This involved observations of 150 silver eels in response to a range of flow regimes within flume facilities. It has been shown that infections of *A. crassus* alters the behaviour of silver eels, causing avoidance of high flow velocities, in turn delaying downstream migration (Newbold *et al.*, 2015). This could have important implications for eel passage, escapement and eel spawner quality.

The effect of *Anguillicola crassus*, *Pseudodactylogyrus bini* and *Pseudodactylogyrus anguillae* infection on the behaviour of downstream migrating adult European eels as they encountered accelerating water velocity, common at engineered structures where flow is constricted (e.g. weirs and bypass systems), was evaluated in an experimental flume. The probability of reacting to, and rejecting, the velocity gradient was positively related to *A. crassus* larval, adult and total abundance. High abundance of *Pseudodactylogyrus* spp. reduced this effect, but *A. crassus* was the strongest parasitic factor associated with fish behaviour, and abundance was positively related to delay in downstream passage. Delayed downstream migration at hydraulic gradients associated with riverine anthropogenic structures could result in additional energetic expenditure for migrating *A. anguilla* already challenged by *A. crassus* infection (Newbold *et al.*, 2015).

In Lough Neagh, the glass eel/elvers are monitored for the presence of *Anguillicola crassus*, and the weekly samples of yellow eels are also examined for length, weight, fat content, sex, age, stomach contents, the prevalence and intensity of *A. crassus*, and gastrointestinal endohelminths. In 2015, the prevalence of *A. crassus* in yellow and silver eels was 52% and 71%, respectively.

5.8 Contaminants

GB_Neag

Levels of contaminants were generally extremely low, and in many cases, among the lowest recorded in similar studies. Concentrations of those contaminants regulated by the European Commission (2006) with regard to human health (Pb, Cd, Hg, dioxins and PCBs) were all within current limits. 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.

GB_Scot

A comparison of recent lipid and pollutant levels in Scottish yellow eel tissue with data from 1980 showed lipid levels were notably higher in the more recent eel samples (Oliver *et al.*, 2015).

5.9 Predators

The UK regards predation on eels as part of natural mortality, and predation levels are therefore not assessed.

6 New information

Downstream movements of migrating adult eels were not only dependent on the river discharge when encountering multiple potential passage routes on the river Stour (England). Specifically, distribution was partially explained by avoiding areas of floating debris and mostly within 2–4 m from channel walls (see Piper *et al.*, 2017 for more details).

GB_NorE

A new glass eel monitoring site was established at Strangford Lough to replace the River Quoile site in 2012 and is now part of a longer term monitoring programme for this EMU. It is now considered an established monitoring site and will be reported from 2017 onwards (Table 23).

Table 23. 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
Total glass eel	150	362	3290	2256	9282	1231	481
Weight (kg)	0.048	0.058	1.053	0.539	0.723	0.394	0.178

*2012 values refer to trailing methods (estimate).

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