National Measures for the European Eel in the Rhine Catchment 2014-2016

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1. Introduction

In 2007, the European Union issued Council Regulation (EC) No. 1100/2007 for the protection and future management of endangered eel populations in Europe, establishing measures for the recovery of the stock of European eel (hereinafter referred to as 'the EU Eel Regulation'). It also focuses on reducing the anthropogenically influenced mortality of eels. On the basis of this regulation, all EU Member States with natural eel stocks had until the end of 2008 to draw up and submit national eel management plans to the European Commission.

Article 6 of the EU Eel Regulation stipulates that a common eel management plan for cross-border eel river basins shall be established by the member countries concerned. Due to the high time pressure in the drafting of the national eel management plans in 2008, it was not possible to prepare a joint eel management plan for the Rhine-bordering countries before December 31, 2008.
In order to promote the coordination of measures in the entire Rhine catchment area within the context of the EU Eel Regulation (cf. recital no. 10 of the EU Eel Regulation), the expert group FISH of the International Commission for the Protection of the Rhine (ICPR) has discussed national measures to stabilise the eel stocks in the Rhine catchment area.

In the "Master Plan Rhine Migratory Fish" (see ICPR Technical Report No. 247) and in the ICPR Technical Report No. 207 "National measures according to the EU Eel Regulation (EU Regulation No. 1100/2007) in the Rhine catchment 2010-2012" published in 2013, the most important measures mentioned in the national plans were summarised in short chapters.

This report summarises the situation of the eel population and the status of implementation of the national measures to stabilise the the population in the Rhine catchment area, for the eel management cycle 2014-2016. The data are based on the national implementation reports for the period 2014-2016, which were submitted to the EU Commission in accordance with the EU Eel Regulation 2018.

Figure 1. European eel (*Anguilla anguilla*, photo: Jörg Schneider)

Implementation of the EU Eel regulation into national law

The stipulations of the EU Eel Regulation have become part of the fishing rights of all EU countries in the Rhine catchment area:

In the **Netherlands**, various measures described in the national eel management plan have been included in the implementation regulation (Uitvoeringsregeling visserij), including, inter alia, in:

- Article 23a, according to which there is an obligation to directly release any eel caught with a fishing rod or jigging equipment in the fishing zone, marine area or coastal waters, and it is prohibited to own eel.
- Articles 23b and 28b, which prohibit fishing with eel fishing equipment in areas where the eel has high levels of dioxins and PCBs.
- Article 32a, which prohibits sea, inshore and inland fishing with eel fishing equipment from 1 September up to and including 30 November.

In the Dutch water law, a provision was included that turbine management must be adjusted where there is no effectively functioning fishway.
In accordance with the conditions for the "De Vispas" fishing licence, sports fishermen in the inland waters of the Netherlands are obliged to directly release any eels caught.

In accordance with the EU Eel Regulation, the Netherlands produced its third evaluation report in 2018 on the results of the Dutch Eel Management Plan up to 2016.

In the **German** Rhine catchment area, stocking measures, increasing the minimum catch size to 50 cm and a five-month seasonal closure for the main stream of the Rhine are the minimum requirements for fishery eel protection measures, in accordance with the Rhine Eel Management Plan. The measures have been included in the following standards:

- in the fishery law and fishery ordinance North Rhine-Westphalia - https://www.umwelt.nrw.de/naturschutz/jagd-und-fischerei/fischerei-und-aquakultur/fischereirecht/
- in the Rhineland-Palatinate fishery law, supplemented by a general ruling regarding a temporary ban on eel fishing in the Rhine - https://wasser.rlp-umwelt.de/servlet/is/1196/
- in the fishery law for the state of Hesse: http://www.rv.hessenrecht.hessen.de/lexsoft/default/hessenrecht_rv.html#docid:169524,1,20130709
- in the Baden-Württemberg fishery ordinance - http://www.rechtliches.de/BaWue/info_LFischVO.html
- the ordinance on the implementation of the Bavarian fishery law (AVBayFiG; http://www.gesetze-bayern.de/Content/Document/BayAVFiG-12) and the general decree for the management of eels in the Bavarian waters of the Rhine eel river basin.

In 2016, the amendment to the Hessian fishery ordinance also introduced a nationwide ban on the stocking of eels in closed waters.
Further details can be found in the appendix to the 2018 implementation report on the eel management plans of the German states (page 55, www.portal-fischerei.de).

The German Rhine eel management plan also contains measures and proposals for non-fishing measures that were taken up in the context of the implementation of the Water Framework Directive, in the state water laws and in special decrees (e.g. cormorant):

- Bavaria: Exemption ordinance relating to species protection
- Baden-Württemberg: Cormorant ordinance of July 20, 2010

- Rhineland-Palatinate: State ordinance for the controlled development of cormorant stocks of February 9, 2009
- North Rhine-Westphalia: Decree to protect native grayling stocks and to prevent considerable damage to the fishing industry by the cormorant of 9 May, 2014
- Hesse: Decree to protect the naturally occurring aquatic wildlife and to prevent considerable damage to the fishing industry by the cormorant - Cormorant decree of 25 November, 2013
- Lower Saxony: Lower Saxony cormorant ordinance (NKormoranVO)

In line with the EU Eel Regulation, **France** has set up an eel management plan (PGA) with two focal areas:

- A national section under the leadership of the Ministry of Food, Agriculture and Fisheries (MAAP) and the Ministry for an Ecological and Solidary Transition (MTES), in which the goal is to adopt the main requirements of the EU Regulation and to provide a homogeneous working framework.
- An district-related section with implementation in the 9 catchment areas, which falls within the competencies of the Comités de Gestion des Poissons Migrateurs (COGEPOMI). The COGEPOMI for the Rhine-Meuse catchment area is coordinated by the prefects of the Grand Est region.

Several ordinances regulate the various protection and restoration measures for this species. The most important are:

Ecological passability:

- Article L.214-17 of the Environmental Protection Act, which defines the classification of rivers in two supplementary lists (Lists 1 and 2) (see also Chapter 3.3)
- MTES decrees dated December 28, 2012 with the creation of the two lists of rivers from Article L.214-17

Fishing for eel:

- Decree of the Ministry of Ecology, Energy, Sustainable Development and Marine Environment (MEDDEM) of 22.10.2010 on the obligation to report the catch of the European eel in inland fishing
- MTES decree dated 05.02.2016 on data on fishing for European eel in the yellow eel and silver eel stages
- Annual decrees of the prefects in the departments of Haut-Rhin and Bas-Rhin for the permanent regulation of inland fishing (also for yellow and silver eel)
- Decree of the prefects of Bas-Rhin (06.02.2017) and Haut-Rhin (18.04.2017) regarding the ban on the putting into circulation and consumption of certain fish species that strongly accumulate mercury and are caught in the Ill and its tributaries

Restoration of habitats and water quality:

- Framework for water management (SDAGE) for the Rhine-Meuse catchment area from 2015 to implement the WFD (cf. www.eau2015-rhin-meuse.fr)
- Framework for water management Ill groundwater and Rhine from 2016

The French report on the implementation of the national eel management plan for the period 2014 to 2016 was submitted to the European Commission in summer 2018 after its adoption by the national eel committee. This report consists of two parts:

- A section on knowledge and monitoring: Index flows, catches of professional fishermen, EDA model
- Section on aquatic environment: Assessment of the passable design of structures in rivers of the priority areas of measures for the eel or List 2

Since the EU Eel Regulation can be officially directly implemented in **Luxembourg**, the obligations have not been incorporated into national law. For the protection of the eel,

the following laws currently define the minimum closed season and minimum size (see Tab. 1):

- Law of 28 June, 1976 regulating fishing in inland waters;
- Law of November 21, 1984 approving the agreement between the Grand Duchy of Luxembourg and the German federal states of Rhineland-Palatinate and Saarland on the re-regulation of fishing in border waters (condominium), signed in Trier on November 24, 1975.

Switzerland is not obliged to implement the EU Eel Regulation. However, the harmonisation of the relevant regulations on the High Rhine with Baden-Württemberg takes place within the framework of cooperation within the High Rhine Fisheries Commission.

2. Description of the current eel population

The environmental goal according to the EU Eel Regulation is to ensure the migration of at least 40% of the biomass of silver eels into the sea, in comparison to the natural stock (reference value).

Various models are used nationally to describe the eel population in the sub-regions of the Rhine catchment area and to check whether targets have been achieved in the respective member states.

2.1 Description of the eel stock models

In the **Netherlands**, a yellow eel model has been developed, through which the number of migrating silver eels can be estimated. Input parameters include eel catches, results of transponder studies, eel monitoring (population build-up), glass eel monitoring, random sampling of silver eel migration, etc.

The **German eel stock model** GEM IIIb, which is used, inter alia, for the German Rhine catchment area, was originally developed in 2007 in a collaborative project between the Institute for Inland Fisheries Potsdam-Sacrow and the Thünen Institute for Baltic Sea Fisheries Rostock (cf. Oeberst and Fladung 2012), and has since been extended or revised several times.
The GEM IIIb is a modular, age-based and gender-specific eel stock model. The model variant adapted to the German Rhine catchment area assumes a freshwater life phase of the eels of a maximum of 20 years and includes the periods 1985-2004 (model lead-up phase), 2005-2016 (estimate of current silver eel migration) and 2017-2057 (forecast period). On the basis of the stock input quantities (stock, natural increase), the model estimates the migrating amount of silver eel on the basis of quantities, taking into account various mortality factors (natural mortality including cormorants, commercial and recreational fishing, hydropower plants). It also offers the possibility of considering any silver eel catches from "catch & transport" campaigns.
As a result of the modelling, the eels leaving the stock due to various mortality factors and silver eel migration are represented separately for each year, each factor, each age group and both eel sexes, in quantity and biomass. The corresponding conversions of the calculated quantities are made using integrated age-length-weight ratios.
The GEM IIIb, with corresponding modifications, is used for the German sub-basin of the Rhine covering around 610 km², for estimating: the reference value "B0", the current silver eel migration "Bcurrent", the best possible silver eel migration "Bbest" and future silver eel migration (forecast).

In **France**, the EDA model is used to assess the current silver eel biomass (Briand et al., 2018). It uses the electrical fishing data available for all of France from 1985 to 2015. This model is updated with every report. The explanatory variables used are the eel

management unit, the type of electrical fishing, the accessibility (combination of distance from the sea and the cumulative height of the obstacles to settlement), length class, width of the river. It is a general additive model (GAM), which combines a model for occurrence (Δ) and abundance (Γ). This is combined with a model that indicates the proportion of silver eels in the eels caught by electric fishing (Beaulaton et al., 2015). The results are compared with the data of the estimated silver eel flows in the French index flows.
Mortality and biomass without anthropogenic effects are estimated on the basis of these results and the different fishing data and mortality from EDA. A dynamic model using Baranov equations is used (Beaulaton and Briand, 2018).

2.2 Description of the eel population

The evaluation report on the **Dutch** Eel Management Plan 2018 contains a detailed description of the current eel population in Dutch waters on the basis of current data. For the calculation of the eel stock using the Dutch yellow eel model, three different scenarios were used depending on the catch efficiency of the fishing equipment and the spatial distribution of the eels. Depending on the scenario, the Dutch model calculates the current silver eel stock (Bcurrent) at 503 t, 1365 t and 1698 t. With a reference biomass (B0) of 10,400 t according to the Dutch Eel Management Plan 2009, silver eel migration to the sea is around 5%, 13% and 16% in relation to the natural population. Figure 2 shows the development of the glass eel index as part of long-term monitoring near the locks at Stellendam in Haringvliet (cf. Griffioen et al. 2016). The index is calculated based on the glass eels caught in April and May, by dividing the number of glass eels caught (catch) by the number of attempts (effort). Sampling takes place after sunset, the net is thrown out and taken up again three times per evening. Since the 1980s, there has been an overall decreasing trend with particularly low values since 2003.

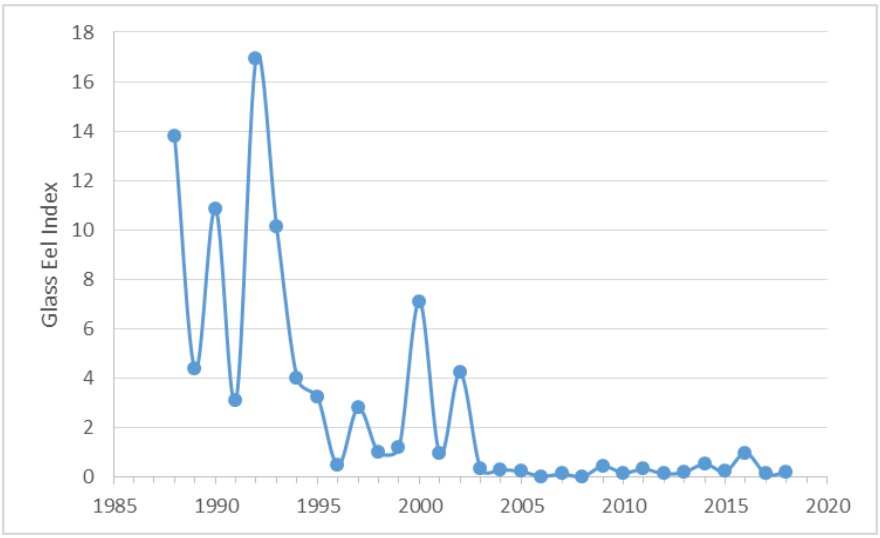


Figure 2. Development of the glass eel index within the framework of long-term monitoring near the locks at Stellendam in Haringvliet in the Netherlands.

In **Germany**, according to the model (GEMIIIb), the amount of silver eel migrating from German eel waters in the Rhine catchment area is estimated at 223 t for the period 2014-2016. Measured against the reference state without anthropogenic influence (B0), the current silver eel migration is 42%. The minimum target size specified in the EU Eel Regulation is thereby achieved.

In the German Rhine in 2014-2016, increasing or constant eel densities were found during local stock tests in different river sections.

In 2014, remarkably high catch numbers and biomass were determined for the **North Rhine-Westphalian** Rhine and its floodplain within the framework of a project to develop a fish monitoring concept (LIMNOPLAN 2015). The eel was the third most common species here.
In the course of long-term fishing monitoring by LANUV NRW on the Lower Rhine, a slight increase in the relative abundance of eels in total catch compared to the previous year was demonstrated in 2014 and 2015; 2013 showed a long-term minimum of 2.7% (see Figure 3).

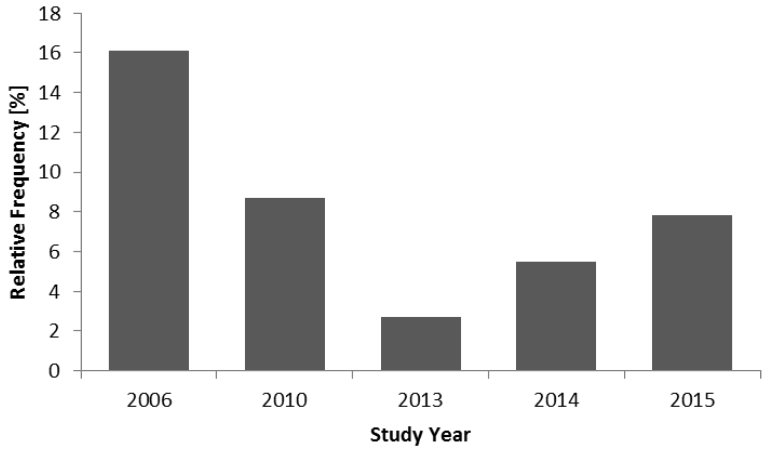


Figure 3. Development of the relative frequency of the European eel in total catch within the framework of long-term fishing monitoring on the Lower Rhine (LANUV NRW, 32 fishing routes)

In the **Rhineland-Palatinate** section of the Rhine in 2014-2016 there has been a steady rejuvenation of the stocks since 2013, more noticeably than in the Moselle, which is difficult to access for yellow eel and probably largely only characterised by the stocking. The eel density in 2015 in the Rhineland-Palatinate section of the Rhine was between 20 and 90 individuals/ha (electrofishing), likewise in the Moselle, where thinning due to catching plays a greater role than in the Rhine. In the Upper Moselle (Moselle at the border) and in the lower Saar, the stocks are significantly lower (<10 individuals/ha); stock is found only to a small extent in the Saar. The Lahn reflects a middle position as a body of water with stock, with 43 individuals/ha. The stock in the lower Nahe, which is sparsely stocked and freely accessible to eels from the Rhine, shows a balanced stock build-up with 12 individuals/ha broken down by length classes. The Rhineland-Palatinate eel monitoring point Lehmen on the Moselle showed a temporary decrease in eel catches in 2015, but the number of eels caught was higher again in 2016 (see Figure 4).

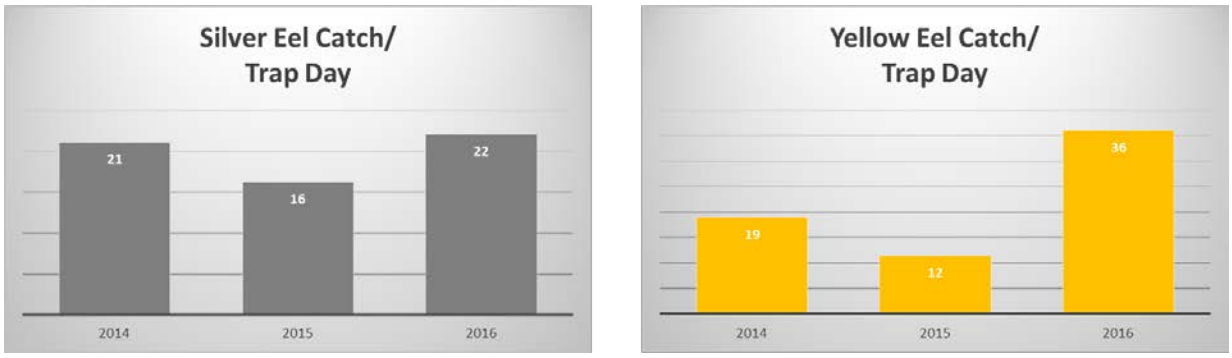


Figure 4. Average catch of silver eels (left) and yellow eels (right) per trap day during eel monitoring in Lehmen on the Moselle 2014-2016.

No monitoring of eel stocks was carried out in Hesse during the reporting period.

Developments similar to those on the Lower Rhine were also observed in the Upper Rhine at **Baden-Württemberg** as part of eel monitoring in two 1 km-long river sections (see Figure 5): Here, the eel densities decreased until 2013 and partially increased again since 2014 (Rhine km 408-409).

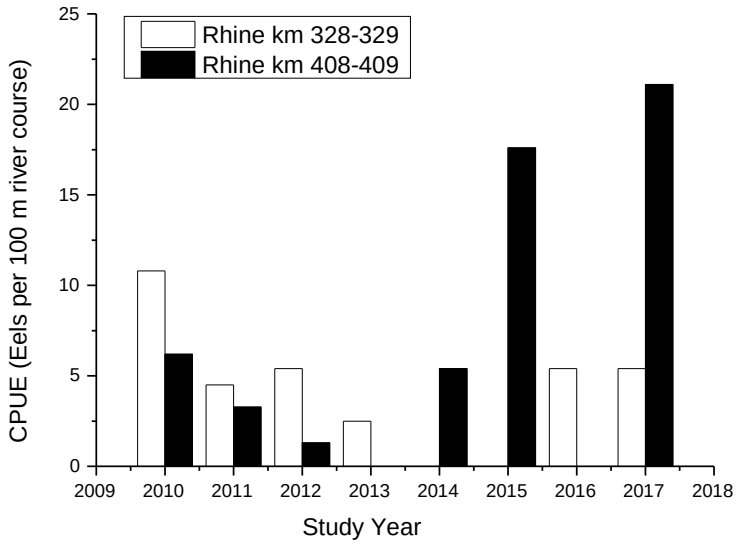


Figure 5. CPUE (caught eels per 100 m river course) for the two eel monitoring routes in the Upper Rhine

The composition of the catch in the eel monitoring routes shows that in recent years the proportion of eels of the lower length classes has increased slightly in one monitoring route (Rhine km 408-409) and continuously in the other monitoring route (Rhine km 328-329) (cf. Figure 6). A strong ageing of the stock, as for example was still found between 2010-2013 in Rhine kms 328-329 (very small proportions of individuals under 40 cm in length), can no longer be identified.
Overall, therefore, positive trends can be seen: The ageing of the eel stock has been interrupted (the stocking measures increase the proportion of young eels), and the stock density is increasing (due to longer closed seasons and increased minimum sizes).

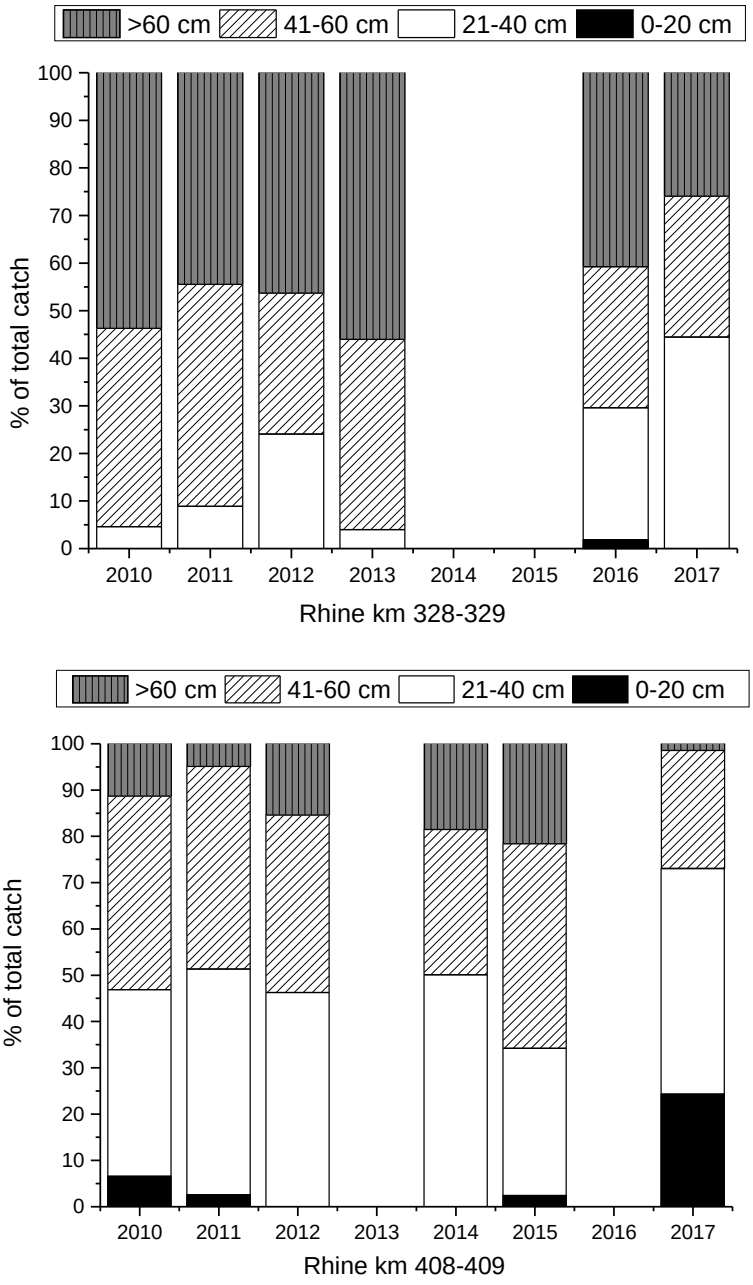


Figure 6. Percentage of individual length classes in the total catch of eels in the eel monitoring routes

With less than 10,000 eels per video count annually at Gambsheim between 2014 and 2016, the increasing population above the Upper Rhine seems to have declined significantly compared to the period 2006-2012, when almost 20,000 individuals were counted annually (cf. Figure 7).

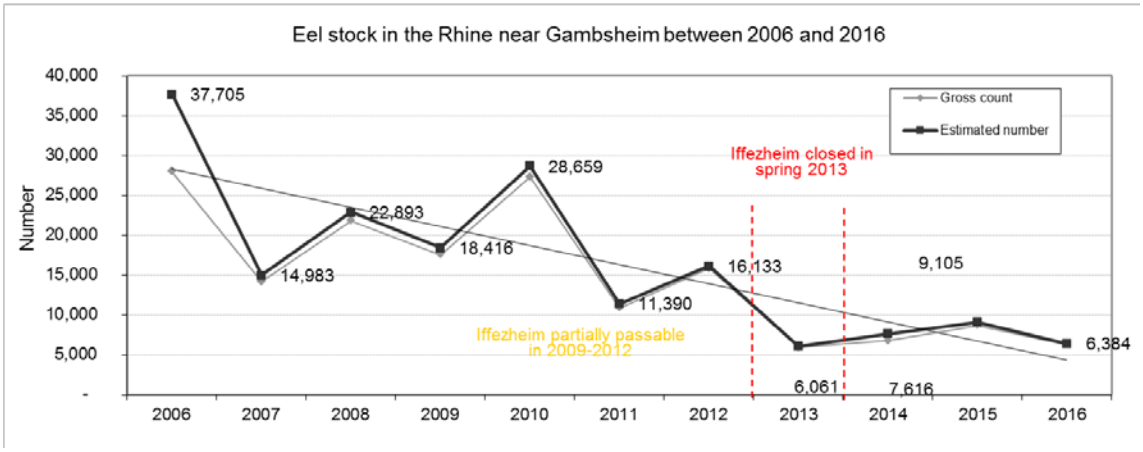


Figure 7: Number of registered eels in the Rhine near Gambsheim from 2006 to 2016 with information on the downstream Iffezheim fishway

For the Rhine eel management unit (Rhine + French part of the Moselle), the **French** EDA model (Briand et al., 2018) rates the current biomass (Bcurrent) at 9,000 silver eels (i.e. 9 t).
Beaulaton and Briand (2018) assess the currently best achievable biomass without anthropogenic effects (Bbest) at 35,000 silver eels (i.e. 33 t) and the reference biomass (B0) at 186,000 silver eels (i.e. 176 t). The ratio Bcurrent / Bbest is therefore 26.6%, and the sum of anthropogenically influenced mortality (fishing and obstacles to advancement) is estimated at 1.32 (i.e. 74% mortality). The ratio Bcurrent /B0, i.e. the silver eel migration rate into the sea is 5%. The projection of the total anthropogenic mortality rate (which reflects current management) is between 0.39 and 1.32 depending on the chosen scenario.
The assessment of the Rhine eel management unit belongs to the same national model. For the Rhine eel management unit, the EDA model indicates an average eel density (yellow eel) of 0.1 eels/100 m2 (in water) and 0.01 silver eels/100 m².
This data should be viewed with great caution, as the field data from the Rhine catchment area that contributed to the construction of the model are only available to a small extent (however, substantial field data from other French catchment areas were used for the model).

Since the beginning of the eel protection initiative in **Luxembourg** in 2004, the annual eel yield has been roughly estimated at 1 to 1.5 t on the basis of the results of the draw net and trap fishing above the hydropower plant at Rosport/Sauer during the descent phase in autumn and winter. However, this number has declined sharply since 2012, when the mass of migrating eels (based on trap and draw net fishing) in the Sauer are considered.

As no systematic size or weight information was collected as part of the Luxembourg eel protection initiative before the hydropower plant in Rosport-Ralingen, no corresponding class distribution can be specified here.

3. Measures to stabilise and monitor eel stocks according to the EU Eel regulation

The measures to restore the eel population, which are taken as part of the implementation of the eel management plans agreed by the EU, aim to ensure that the target of at least 40% of the silver eel biomass, which can migrate into the sea - in relation to the natural population (reference value) - is achieved in the long term.

In the Rhine catchment area, the EU countries and Switzerland are also implementing various measures within the framework of the Master Plan Migratory Fish Rhine (see ICPR Technical Report No. 247), which will also benefit the eel.
Measures related to aquaculture are not listed below as they are not relevant to the Rhine.

3.1 Reduction of commercial fishing and restriction on sport fishing

In the **Netherlands**, eel fishing is prohibited in September, October and November (see Table 1).
Since April 1, 2011, primarily with regard to the catchment area of the large rivers (Maas, Waal, Neder-Rijn/Lek and IJssel), due to the high level of dioxins and dioxin-like PCB, there is a total ban on eel fishing. This also applies to the entire estuary area including Haringvliet, Volkerak and Biesbosch, Hollandse IJssel and the North Sea Canal. In addition, sport fishermen are obliged to release eels caught. Due to the ban on fishing in areas contaminated with dioxins, the main migration routes of eels and other migratory fish are free of eel fishing equipment. In the rest of the Netherlands, there is a fishing ban during the migration of silver eels.

In **Germany,** the closed season for migrating silver eels across the entire Rhine main stream extends from October 1 to March 1; in Hesse the closed season also applies to all Rhine tributaries. In Baden-Württemberg, in the period under consideration (2014-2016), the closed season for the Rhine main stream from the dam of the Eglisau power plant in the High Rhine and for secondary arms and canals that Rhine water flows through along this route, including the connected oxbows and dredging lakes, was extended to the whole year. Also in the Neckar, there is a year-round closed season from the dam of the Neckar mouth power station to the mouth. For the other waters in Baden-Württemberg there is a closed season from October 1 to March 1 or a reduced closed season from November 1 to March 1. There is no closed season in Lake Constance, but the minimum size of 50 cm applies. In Bavaria (eel catchment area Rhine) a closed season applies from November 1 to February 28.
Due to the report that total maximum levels set out in food laws for dioxins, furans and dl-PCBs were exceeded, the marketing of eels from the Rhine (main stream) has practically come to a halt transnationally; accordingly, almost no eels are caught professionally.

In **France**, according to the ministerial decree of February 5, 2016, fishing for yellow eel is prohibited in all river areas of the Rhine-Meuse management unit with the exception of the period April 15 to September 15. The fishing of silver eel is prohibited there all year round.
These provisions are confirmed in the departments of Haut-Rhin and Bas-Rhin by annual decrees issued by the prefects. These decrees specify a night fishing ban as well as permitted fishing methods and species.
Any individual who catches a yellow eel - either with a fishing rod or a net - is obliged to record his catch in a catch registry to be drawn up per season in accordance with French environmental law. Fishermen with fishing gear and nets also require individual approval from the prefect and must report their eel catches monthly.
Due to the high mercury content, a decree by the prefect of the department of Bas-Rhin (2017) prohibits the sale and consumption of eels over 1500 g from the Ill and some Ill tributaries.
A ministerial decree sets the catch quotas for European eels under 12 cm for professional sea fishermen every two years, as well as the modalities for the management and distribution of this quota. This only affects the coastal areas.

At the level of fisheries in the Rhine catchment area, three professional fishermen are still active, but only one of them works full-time. The other fishermen describe themselves as amateurs with fishing gear and rods.

In **Luxembourg** there are no approvals in place. It is currently not known in fishing circles that recreational anglers target eels, so it can be assumed that fishing for eel is negligible.

In **Switzerland** there is no strong tradition of catching and consuming eel. As eels are rarely fished in Switzerland in a targeted manner and their contribution to reproduction and species conservation was considered negligible (high turbine mortality during migration in the power plant chain), there have so far been no general protective measures. On the Swiss side of the High Rhine, there is sometimes a protective measure of 50 cm. In the updated fish atlas in Switzerland, the eel is now classified as “threatened with extinction”. With the planned revision of the ordinance regarding the federal law on fisheries, there will be a general ban on fishing from 1.11.2020.

Table 1. Measures to reduce eel fishing in the Rhine-bordering states

State / country	Closed seasons	Minimum sizes	Night fishing ban	Obligation to release	Ban on certain fishing gear
The Netherlands	September 1 to December 1	28 cm	Not applicable	For commercial fishing: September 1 to December 1 For recreational fishing: all year round	From September 1 to December 1 there is a ban on the use of eel fishing gear. The use of eel fishing gear is prohibited all year round in the large rivers.
DE Lower Saxony (eel catchment area only Rhine tributaries)	None	45 cm (under implementation)	No	For undersized or eels caught during the closed season	No
DE-North Rhine-Westphalia	1.10. – 1.3. (Rhine main stream)	50 cm	No		No
DE-Rhineland-Palatinate	1.10. – 1.3.	50 cm	Partial		Heavily regulated
DE-Hesse	1.10. – 1.3.	50 cm	No		No
DE-Baden-Württemberg	Main stream of river Rhine: all year round	50 cm	Yes		No
DE-Bavaria	11.1. to 28.02. In the eel river basin	50 cm	No		No
Luxembourg	1.1. to 28.2 (or 29.2.) in inland waters; in border waters (general closed seasons): Our: 1.1. to 31.3; Sauer, Moselle: 1.3. to 14.6.	50 cm (inland and border waters)	Yes	No	All except hand fishing rod
France	15.9. - 15.4.	No	Yes	No	Yes
Switzerland	Total ban on fishing planned from 1.11.2020	50 cm	Yes	No	Only fishing with rod

3.2 Restocking measures

In the **Netherlands**, the state provides 375,000 Euro annually towards restocking with glass and farmed eels. A special protocol was developed for restocking. This protocol describes how and where glass eel restocking should take place (e.g. distributed as quickly as possible over the water body, directly on the bank in shallow water, primarily in turbid water and/or on a bank with a high degree of coverage of habitats offering protection, etc.). The number of glass eels released each year is monitored, but the restocking eels are not marked. Detailed information on the Dutch restocking measures can be found in the report 'Evaluation of glass eel and ongrown eel restocking practices in The Netherlands' by Dr. T. van der Hammen from Wageningen Marine Research.

In **Germany**, eels in the entire Rhine catchment area, with the exception of the High Rhine, have been restocked by various government agencies and fishing associations for many decades (Lake Constance: for over 120 years) (see Figure 8).
The state of North Rhine-Westphalia stocks barrier-free water areas of more than 10,000 ha. The quality and health of the stock animals are examined. Funding for eel restocking measures takes place within the framework of regularly updated, staggered funding arrangements, with up to 40 pre-financed eels/ha from funds from the European Fisheries Fund and state funds (fishing tax, see ICPR Technical Report No. 207). Eel restocking in closed waters and waters in which high eel mortality is to be expected due to technical systems during migration, is not financed.
In Rhineland-Palatinate, the Moselle has been regularly restocked with eels, particularly since the weir regulation in the 1960s. The relevant fishing rights here lie with the state of Rhineland-Palatinate. A stock that had been halted in the Rhine has been resumed by the state since 2004 after clearly visible stock losses. The Hessian section of the Rhine has been regularly populated with eels since 2016 in cooperation with fishing organisations and local fishing associations. In the other Hessian eel catchment area, authorised eel restocking is carried out independently. Upon application, the measures are financially supported by means of the fishing tax. Measures are scientifically monitored in the Rhine and Lahn.
On the Bavarian Main, restocking is organised by the fishing associations.
Eel restocking has been practised in Baden-Württemberg since the 1970s, initially with glass eels, and from the 1990s, also with farmed eels. In years with low glass eel availability, only farmed eels were restocked (2015). In the past few years (from 2016) both glass and farmed eels have been restocked.
In the eel management area of the German Rhine, according to plans, restocking measures for around 750,000 glass eels and 1.1 million pre-financed eels are anticipated.

There are no restocking measures in the **French** part of the Rhine-Meuse catchment area. This is justified by the fact that no ecological benefit is seen in restocking, as with eels it is carried out on the basis of wild individuals taken from their natural habitat and not, as with salmon, from stocking animals produced in farms for breeding. The restocking affects the monitoring of the development of the eel stock in the catchment area (increasing or decreasing trend of the populations/there is an improvement due to the management plan). Since there is no glass eel fishing in the Rhine delta, the French delegation did not consider restocking measures to be necessary for the conservation of the species.

There is also no eel restocking in **Luxembourg** and **Switzerland**.

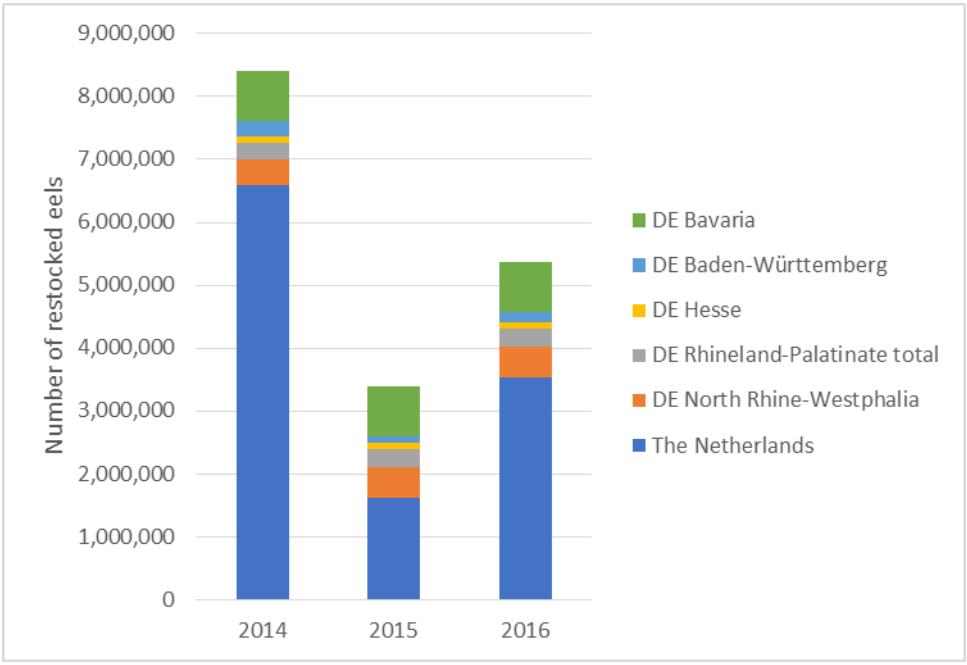


Figure 8. Number of eels restocked (farmed eel and glass eel) in the Rhine area. See Appendix 1 for details

3.3 Improving passability, fish protection and habitat measures

In the entire Rhine catchment area, the states are implementing measures to improve the passability and habitats within the context of the Master Plan Rhine Migratory Fish (cf. ICPR Technical Report no. 247). As part of the implementation of the Water Framework Directive, numerous hydromorphological measures are also being carried out, which will also benefit the eel (cf. ICPR 2015).

In the **Netherlands**, a proportion of the protective measures for eels with regard to weirs and pumps was implemented by 2015. Some of the measures were postponed to post 2015 due to austerity measures. Further measures will be implemented by 2027.
In the Netherlands, no special habitat measures are anticipated in the eel management plan.
An action plan for hydropower plants has been developed in the Netherlands (Vriese et al. 2013).
For the eel, the action plan describes a maximum allowable damage of 10% for hydroelectric power plants on dammed river sections. For the Meuse, the section between Eijsden up to and including Lith is affected; for the Rhine the dammed section in Nederrijn-Lek. If there are several hydropower plants, the overall mortality rate must not exceed 10%. When calculating or estimating mortality, it is possible to adjust the proportion of outflow that does not go through the hydropower plant.
For the other, ecologically significant rivers, for example the free-flowing sections of the large rivers and the water bodies near the end dike and the Haringvliet, there is an obligation to compensate for the negative effects of existing measures on fish migration. This corresponds to a mortality of zero (≤0.1%) per body of water.

In **Germany**, around 90 weirs in Rhine tributaries have been retrofitted with protective devices and/or bypasses since 2008.
In the Sieg, a pilot system for the protection of migrating fish, especially silver eels and salmon smolts, was completed at the Unkelmühle hydroelectric power station (North Rhine-Westphalia) (see Figure 9). In Hesse, the bypass channel at the lowest Main dam, Kostheim, was completed at the end of 2009, however, functional tests showed deficits in the fish ladder in both directions. At the request of the approval authority, the operator

plans to build a second entrance in 2019. The planned renovation at the next main dam in Eddersheim is a pilot system of the WSV; implementation is planned before 2021. In the period under review, a total of 21 hydropower plants in Baden-Württemberg were redesigned to be “eel-friendly”. The measures led, among other things, to the fact that the two Rhine tributaries Elz and Kinzig were made entirely passable for the eel within the management area.

Figure 9. Vertical rake (10 mm) of the fish descent system at the Unkelmühle hydropower plant.

France introduced the concept of priority measures for eels at a national level in 2010, as part of the eel management plan. The aim was to identify those sections in which biological benefits can be achieved within 6 years if the weirs there are designed to be passable (priority weirs). As part of the eel management plan, 48 structures were identified to be designed as priority areas of activity in the Rhine-Meuse management unit. In accordance with national reporting to the European Commission, a revision takes place every 6 years. By December 31, 2017, 36 structures (specified or not mentioned in the eel management plan) in the priority areas had been redesigned or removed.
In France, decrees on the classification of rivers according to Article L.214-17 of the French Environmental Act have led to two lists at national level:

- List 1: Ban on building new structures
- List 2: Obligation to redesign structures within 5 years

The Rhine-Meuse Management Plan 2016-2021 approved at the end of 2015 (SDAGE) defines new directions in order to restore a fundamental balance to the aquatic environment. In particular, it recommends that the studies be continued, in accordance with which descent aids can be developed and tested, before the next deadlines for the renewal of licences in the Rhine system. The associated good practice guide proposes specific (administrative and conceptual) measures for ecological passability and weirs in connection with the decrees for the classification of rivers (priorities for conservation and restoration), in accordance with the management plan for migratory fish (PLAGEPOMI).
Some recent exemplary measures:

- Commissioning of a fishway at the Strasbourg hydroelectric power plant in 2016
- Establishment of a fishway in the Rhine region near Kembs (licence renewal)
- Construction of a fishway in the Ill south of Strasbourg in 2017, to bypass the Illkirch-Graffenstaden hydropower plant and establishment of fish-adapted water extraction

- Complete redesign of the Steinsau dam on the Ill in 2017 and equipping of the turbines with an Archimedes' screw. This modernisation process went hand in hand with the construction of a new fishway with video counting station.

ONEMA, EDF and other partners signed a framework agreement for research and development cooperation on French rivers in 2008 as part of the national eel management plan.
One of the measures planned in this framework agreement concerned the investigation of the mortality of migrating eels in the turbines of two hydropower plants managed by EDF (Fessenheim and Ottmarsheim) in the Franco-German Rhine section. The eel mortality due to the 4-blade Kaplan turbine at the Fessenheim power plant was around 7% after 48 hours. The mortality rate at the Ottmarsheim power plant equipped with a 5-blade Kaplan turbine was around 21%. Other tests carried out by the Normandeau Society and in the laboratory with other types of turbines have shown that the number and shape of the turbine blades, in particular the distance between the components, is crucial for the survival of fish. Further investigations are planned on this subject.

Another measure of the completed programme included a study to overcome successive obstacles in the Rhine. The aim of the study was to use the NEDAP monitoring system to deliver certain elements to the descent conditions for silver eels. The study, which was initially planned for 1 year and could then be extended, was continued (with more than 1,300 marked eels) until the end of 2017.
Without taking into account the fish that migrated within 7 days after being released, the survival rate (overcoming the location Kembs via the weir) is 13%. The migration activity predominantly takes place during the winter months October to February and April-May. Two thirds were recorded at night.
Since it was not possible to catch enough eels in the upper reaches of the Rhine, eels of different origins had to be used, but only from the catchment area. 2/3 of the eels were made available due to the cooperation of the German fisheries authorities, 50% of which came from the German Rhine and 20% from the German Moselle. The remaining eels came from the French Rhine catchment area.
The method used (telemetry with implanting of an internal transmitter) and the different origins of the eels may have led to a distortion in the distribution on migration routes. More than 17% of the fish have never been detected. This number is comparable to the results of other experiments with telemetry monitoring of the eels' descent, regardless of whether NEDAP or another technique was used.
The results and the final report prepared by EDF on the analysis of preferred migration routes and the relationship between migration and environmental parameters are expected in the near future.
Around thirty silver eels equipped with NEDAP transponders that had been released in the Upper Rhine have been detected in the Dutch antenna network. These fish, which were released near Kembs in the winters 2010 to 2012/2014, took between 13/10 days and more than a year for the 850 km migration downstream. With these individuals, one can differentiate between 3 groups depending on migration speed: a group that requires on average less than 10 km/day and a total of 8 months for the migration downstream; one that takes 10 to 50 km/day, i.e. an average of 1 month, for the migration downstream, and the fastest group that covers more than 50 km/day and reaches the estuary within 2 weeks.

The program of measures of the current **Luxembourg** management plan (2015-2021) includes a total of 52 priority weirs nationwide, of which 12 have since become passable for fish migration; 31 weirs are currently in the planning phase. As yet there is only one preliminary study for the remaining 9 weirs.

In addition to the priority weirs, a total of 163 passability measures are planned in the Moselle catchment for the periods 2015-2021 and 2021-2027, which will make additional spawning habitats accessible. The programme of measures also includes renaturation

projects to restore spawning and juvenile habitats on some stretches of water in Luxembourg's main and secondary waters.

In order to improve passability, the primary aim is the option with maximum impact, namely the demolition of the weir where it is not used for hydropower.
The Luxembourg Water Act of 2008 invalidated all previous water permits at the end of December 2012. When renewing permits, a site-specific overall plan for establishing passability, i.e. for fish ascent and descent, as well as for fish protection, must be developed from now on.

All **Swiss** power plants must be renovated in terms of their fish passability by 2030 at the latest. On the High Rhine, the cantons have set the deadlines for the renovation of ascent options for 2022. The deadlines remain open for two plants on the High Rhine. The deadlines for the renovation of the power plants were coordinated with the resolutions of the ministerial conference in Basel in 2013, which made the return of the salmon mandatory in Basel by 2020.

3.4 Catch and transport measures

3.4.1. Catch and transport measures in the Rhine area

In the Rhine catchment area, fishing and transport activities on the Sauer (Luxembourg), the Saar (Saarland), the Neckar and the Main have been initiated in recent years (cf. Figures 10 and 11 and Annex 2), with the respective power plant operators on the Main and Neckar acting as the leading parties. The harmonisation of measures has not yet taken place.

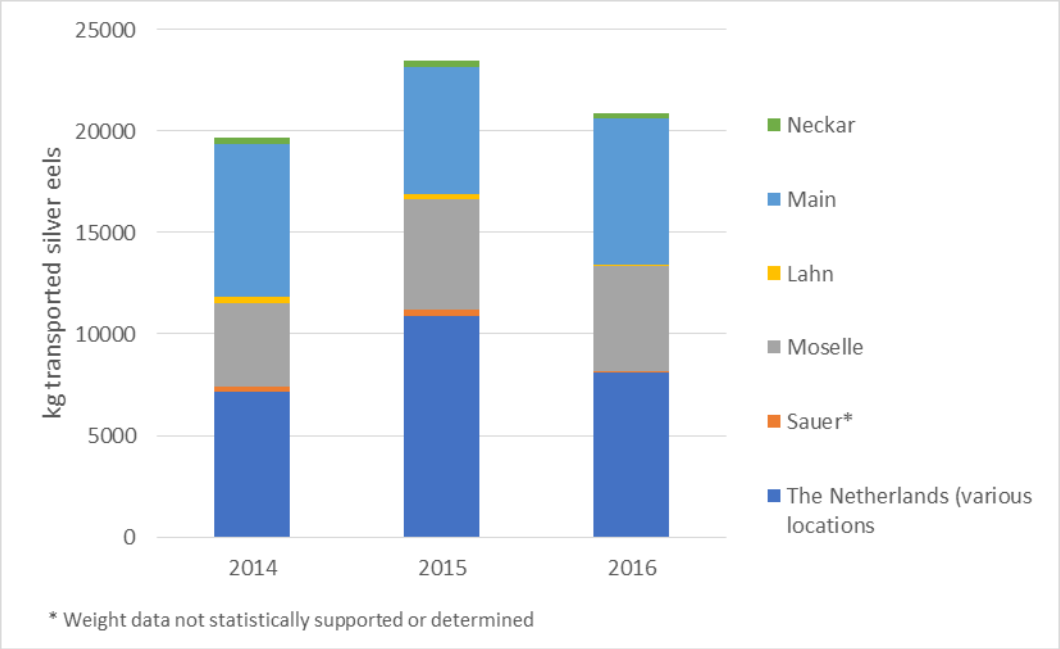


Figure 10. Amount of silver eels transported (in kg) in various rivers in the Rhine catchment area (for details see Appendix 2).

In the **Netherlands**, silver eels have been assisted in some pumping stations in Zeeland, Noord-Holland and Friesland since 2011, to overcome the obstacles to migration (DUPAN initiative "Silver eels over the dike"). In 2014, 2015 and 2016, "gross" amounts of 3926, 5971 and 3113 kg of silver eel were assisted over the selected obstacles. However, according to Winter et al. (2013), a proportion of the silver eels may have been able to overcome the obstacles to migration without assistance. Based on the expected mortality (Bierman et al. 2012; Winter et al. 2013) when overcoming the selected migration obstacles, a net amount of eel can be calculated (cf. Appendix 2). The amount of additional silver eels that have successfully migrated due to the efforts of the "Silver eels over the dike" initiative is estimated to be 828 kg in 2014 and 5,971 kg in 2015.

In **Germany**, the eel protection initiative, founded in 1995 by the state of Rhineland-Palatinate and the power plant company RWE Power AG (today: innogy SE), provides a long-term, multi-part system of measures to protect the eel in the Moselle and Saar. In addition to researching technologies to avoid or significantly reduce turbine-related fish damage (while safeguarding the interests of power plants), an immediate action programme was initiated right at the outset, which was implemented by the professional fishermen affected in the Moselle, in the intensive fishing of migrating eels. The immediate action programme commenced in 1997 and concerned all 10 weirs of the Moselle and the first of the Saar located in German territory. From the 3rd year of the project, the annual catches levelled off to approx. 4-6 t due to constant improvements in the methodology, which corresponds to an average number of approx. 7000 female eels (approx. 99% of the eels in the Moselle are female). From July each year, the 10 family-run fisheries catch as many silver eels as possible in the immediate vicinity of the inlet areas of the hydropower turbines (usually 4 Kaplan turbines x 100m³/s) in extensive trap areas. In order to do this, they receive support in terms of equipment and material. The silver eels are kept by the professional fishermen until they are picked up on a weekly basis by a special transport. The professional fishermen receive an allowance corresponding to the catch amount. Due to the methodology of the fishing, the measures cease when the winter floods come or water temperatures fall below approx. 8 °C. In the 18 years of the project, approx. 83 tonnes of eels were transported around the Moselle power plants and released into the Rhine. Collection transport and release are accompanied by a state fishery supervisor. The

release point in the Rhine is located as far down the river as possible, so as to be outside any commercial fishing activity in Rhineland-Palatinate.

In the Lahn, the migration of the eel is hindered by hydropower plants. Solutions for the unimpaired descent of eels, by installing technical descent options and by turbine management, are currently being worked upon.
However, it may take some time before these measures are fully implemented and take effect. A so-called "catch and transport system" for silver eels on the Lahn was instigated by some fishing associations and has been implemented since 2012. In the region of the middle Lahn, specially trained members of a fishing association catch eels in cooperation with a fishery biologist. Depending on the location and the local conditions, different fishing methods are used to catch the silver eels, which were compared in a report by the fishery biologist. Due to the good catch results from eel fishing at a mill, an old eel catch was even reactivated, and is being set up by members of the fishing association in the forecast eel migration period. These so-called “eel observation points” monitor the catching device and remove the eels. After successfully catching the migrating silver eels and briefly keeping them, they transport the animals to the mouth of the Lahn in the Rhine.

In Baden-Württemberg eels are caught in the Neckar by commercial fishermen between Besigheim (mouth of the river Enz) and the mouth of the Neckar into the Rhine upstream of 15 weirs and brought to the Rhine at Mannheim. This measure, which is financed by the energy company EnBW, has been in place since 2009. The aim is to protect silver eels from the deadly passage of hydropower turbines. So far, almost 4 tons of silver eels have been caught in the Neckar and transferred to areas in the Rhine from which they can migrate safely (here: without hydroelectric mortality). In parallel to the catches of silver eels, the catches of yellow eels are documented. This data flows into the evaluation and development of the eel stocks in the Rhine system in Baden-Württemberg.

In the Lower Franconian Main, since 2009, an average of 6 tonnes of silver eels that are ready to migrate have been intercepted before the hydropower plants on behalf of the power plant operator RMD AG, and transported to the spawning area in the Rhine for unimpeded migration.
The basis for this system is an agreement between the Lower Franconia Fisheries Association, UNIPER Kraftwerke GmbH, and the State Ministry of Food, Agriculture and Forestry, which regulates the catch and the transport of the spawning eels into the Rhine. In order to protect the migrating silver eels from the passage of hydropower turbines, which is fatal to a high percentage, they are caught by commercial fishermen, kept for a short time and then brought to the Rhine. The coordinating association and the commercial fishermen are responsible for all implementation activities. The fishermen are recompensed by UNIPER Kraftwerke GmbH for catch and transport and for the eels themselves. This agreement was first made on 26./28.10.2009 and updated on 26./27.06.2011. It is applicable indefinitely. The processes were agreed and documented by representatives of UNIPER Kraftwerke GmbH and the Lower Franconia Fisheries Association as the sole responsible contractual partners. Observation or control by third parties is not required.

The hydropower plant (HPP) in the **German-Luxembourg** border waters of the Sauer near Rosport-Ralingen, which has two vertical-axis Kaplan turbines with a flow rate of 70 m^3/s, represents the largest and, so to speak, the only potential source of danger for migrating eels in the catchment area of the Sauer.
The Sauer catchment area is about 4,300 km^2 and approximately 100% of it drains into the Sauer at the height of Rosport before this then flows into the Moselle 15 km further downstream.

To protect the eels migrating to the sea from turbine damage, the descending silver eels have been removed from the headwater of the turbine weir in the engine channel since

2004. Depending on the seasonal flow rates, two fishing methods are generally used from June to December: trap fishing for medium-sized run-offs and draw net fishing for higher run-off quantities after heavy rain events. When the eels are subsequently transported to the Rhine, the overall survival rate is comparatively large, as the 10 Moselle power plants below from Trier to Koblenz (D) do not have to be passed. Depending on the amount of eels removed, the transport is either carried out directly from Rosport to Koblenz by the professional fisherman commissioned, or the eels are then brought to the Rhine via the eel collection point in the Moselle-Saar catchment area.

The annual eel yield based on the results of draw net and trap fishing before the Rosport/Sauer hydropower plant during the descent phase in autumn and winter is estimated at 1 to 1.5 t. This corresponds to an individual count of 66 to 282 eels per year, which were fished between 2014 and 2016 with a sharply declining tendency and then transported safely to the Middle Rhine.

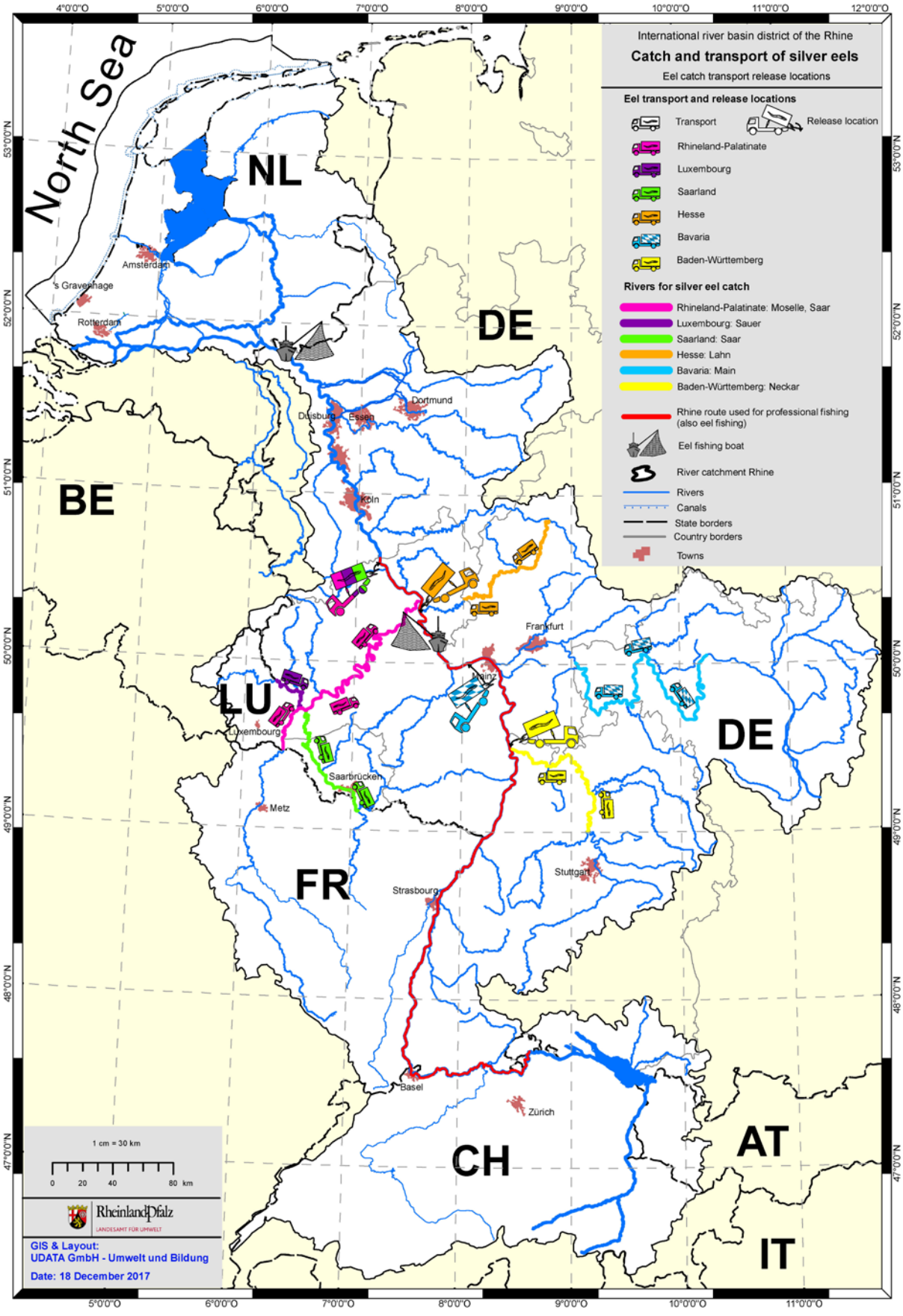


Figure 11. Catch and transport of silver eels

3.4.2. Indicators of the effectiveness of catch and transport measures

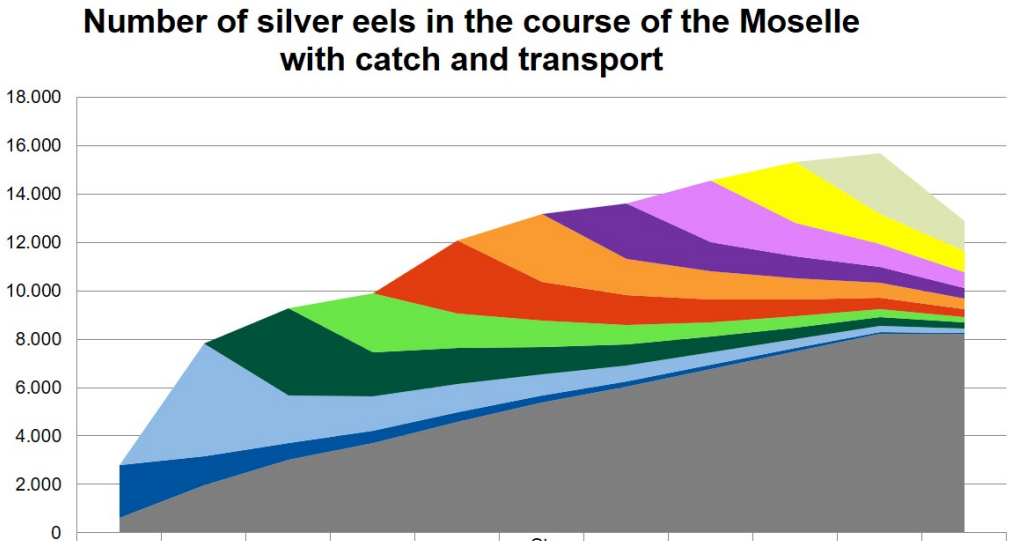
Indicators of the population dynamic impact cannot be determined with sufficient accuracy due to the unknown stock and recruitment sizes. In addition to purely qualitative indicators such as "every fish released for possible reproduction contributes to reversing the negative population trend", the detectable objective indicators can only relate to estimation methods in a relatively narrow area of a water system.

Indicators of biological effectiveness (success) within the Eel Protection Initiative Rhineland-Palatinate/innogy SE (Moselle, Saar) are:

- Estimation of the number of migrating eels per section of water
- Estimation of the average damage rate per power plant location
- Estimation of the overall survival rate in a water system under observation
- (Average) number of eels removed through catch and transport
- Estimation of the increase in survival rate due to catch and transport measures in the water system under observation

Calculations have shown that the overall survival rate of eels migrating from the Moselle to the Rhine without the catch and transport measure is around 23% (cf. LfU 2016). The overall survival rate along the power plant chain of the German Moselle increases to around 45% if a proportion of the silver eels seeking to migrate are transported to the Rhine by catch and transport measures with 0% damage due to the turbine. Figure 12 shows how the total number of silver eels that reach the Rhine from Trier without damage is increased by the measure.

An additional indicator could be denoted by the ratio of funds used to the number of transported silver eels (“cost-benefit value”). Here, the lowest possible number should be the objective, without specifying a permissible upper limit. The “cost-benefit value” in Rhineland-Palatinate is approx. 13.



	Trier	Detzem	Wintrich	Zeltingen	Enkirch	St. Aldegund	Fankel	Müden	Lehmen	Koblenz	Rhine
Damage figure	23%	41%	28%	18%	25%	24%	24%	25%	30%	31%	0%
Migrated silver eels from Koblenz										2499	1228
Migrated silver eels from Lehmen									2540	1266	874
Migrated silver eels from Müden								2532	1352	947	653
Migrated silver eels from Fankel							2281	1235	926	648	447
Migrated silver eels from St. Aldegund						2809	1521	1156	867	607	419
Migrated silver eels from Enkirch					2993	1599	1215	924	693	485	335
Migrated silver eels from Zeltingen				2431	1419	1065	809	615	461	323	223
Migrated silver eels from Wintrich			3605	1848	1516	1137	864	657	492	345	238
Migrated silver eels from Detzem		4670	1962	1413	1159	869	660	502	376	263	182
Migrated silver eels from Trier	2163	1187	700	504	413	310	236	179	134	94	65
Transported eels (cumulative)	622	1966	3004	3704	4565	5373	6029	6758	7489	8208	8208

Figure 12. Representation of the theoretically calculated number of migrating silver eels in the course of the Moselle, taking into account the catch and transport measures carried out (cf. LfU 2016)

On the navigable Main, there are 34 weirs with 33 hydropower plants.
The number of eels removed is an indicator of the effectiveness of catch and transport measures on the Main.

According to the estimates made in Luxembourg, a migration rate of around 90% from the Luxembourg area has been achieved for 12 years.
Exact results or estimates of the mortality and injury rate of the eels by passing the turbines at the Rosport/Sauer hydropower plant are not available, since the determination of parameters such as the number of migrating eels per section of water, the average number of damaged eels per power plant location, and the total survival rate in a water system under observation at a single location - as is the case in the Sauer region - is not possible.

3.4.3 Assessment criteria for the application and admissibility of catch and transport measures

The use of hydropower should be state of the art - the use of technical devices or technologies for fish protection and fish descent should be tested within the framework of licensing procedures. With damming, in terms of the functional interruption of the ecological river continuum as well as the high degree of endangerment of animal life at an individual and population level, problem areas are described for which a satisfactory solution must be found in the medium to long term. Through the catch and transport of silver eels from inland waters into waters from which they can migrate unhindered into the Sargasso Sea, the time for the development of technical devices or technologies for

fish protection and fish descent in large hydropower plants with a flow rate > 150 m^3/s can be bridged, and can therefore be used with reasonable justification.

Assessment criteria allow the classification of catch and transport measures into a possible set of measures, or set the framework for their admissibility for larger hydropower plants at a flow rate >150 m^3/s, for which the problem of fish descent remains unsolved. The criteria are:

1. the migration behaviour or the reproductive strategy of the eel
2. the current and forecast level of risk
3. the lack of an acceptable alternative in the form of technical devices or fish-saving technologies
4. the binding nature of a catch and transport agreement reached within further, collective protection efforts
5. the equal partnership, transparency and the common will to solve problems in general
6. the definition of the objectives beyond/in addition to the catch and transport measures as well as measures according to schedules

Since 1995, the aim of the Eel Protection Initiative Rhineland-Palatinate/RWE Power AG (today: innogy SE) has been to prevent or significantly reduce the damage from turbines to eels migrating in the Moselle and Saar. The core of this project consists of medium to long-term, interdisciplinary research projects around possibilities for a functional adaptation of the old structures to meet the desired objective. This objective has not been achieved in the 20 years of the project. However, additional research results regarding eel protection are nearing completion, which justify the still ongoing bridging measure “catch and transport”, by the fact that without catch and transport, hundreds of thousands of spawning animals could not have completed their life cycle and without the measure the existing interest in general problem solving would wane.
If measures for catch and transport are embedded in a comprehensive fish (eel) protection project with a view to the long term, insights gained from the initiated process can be subjected to constant review. For example, “fish protection” specifically was still largely unknown 15 years ago, while today it is already actionable with continued research interest in hydropower plants with a flow rate of 50-100 m^3/s.

The catch and transport measures that have been carried out since 2004 to protect the migrating eels as part of the eel protection initiative at the only hydropower plant in the Sauer border region were accepted by the hydropower operator as a temporary solution. The dialogue between the water management authority and the hydropower operator is to be continued in the future, in order to keep the electricity operator accountable and to make it clear that the operator is obliged to follow the technological developments on the subject of fish protection and descent, and accordingly to strive for a long-term technical solution and to implement it as soon as possible.

3.5 Fish-adapted operation of hydropower plants

In some hydropower plants in the Rhine catchment area, the turbines are fish-adapted, to protect the eel.

According to the new **Dutch** water law, owners of hydropower plants must have a licence. For this licence, fish-friendly turbine management is included as a prerequisite for the operation of the plant. In 2010, discussions with the electricity producers took place. In the run-up to the definitive award of the new licences, since November 17, 2011, the operators of the three large hydropower plants have been implementing adapted turbine management during the months in which the silver eels migrate towards the sea. This should reduce eel mortality. At the same time, an investigation is taking place as to how the numerous pumping stations can be made "fish-safe".

Since 2013, the **Moselle** power plants have been operated on a trial basis using a fish-adapted turbine control system (faT), developed between the power plant operator and the project management “Eel Protection Initiative Rhineland-Palatinate/innogy SE). In the reporting period, there were steady improvements in the area of detection/observation (two exemplary locations with professional fishing gear) and the reporting system (shortening or and/automatic driving of the faT when certain environmental conditions are present). A fish protection AG was founded with the operator innogy SE for the hydropower plants Schoden and Serrig (Saar) in order to improve fish protection in the existing facilities.

Some power plants in the **Main** and its tributaries also have an operating mode adapted to the main seasons of eel migration.

On the Hessian Main, the operator of the Offenbach and Mühlheim hydropower plants recently implemented eel-friendly operational management (as of 2017), based on the example of eel-protecting operational management (EFOM) as used in Lower Saxony or Bavaria. The difference between eel-friendly and eel-protecting operational management lies in the complete shut-down of the turbines during detected waves of migration. Furthermore, a turbine management system based on expected discharge and precipitation was established in the interim for the Kostheim (Hesse) hydropower plant.

Abiotic warning systems have been developed based on the evaluation of hydrological parameters and their correlation with the migration conditions of the eels, e.g. B. MAP software programme (cf. Wendling, 2017). The commonly evaluated parameters include run-off, season and moon phases, turbidity and water temperature. As other parameters can also influence migration, the precision of these warning systems is limited.

3.6 Predator management

The limited shooting of cormorants to protect eel and other fish stocks has been allowed in some German states.

In **Rhineland-Palatinate**, for example, the shooting of cormorants can be authorised in accordance with the cormorant ordinance. As a rule, the sensitive water stretches of the grayling species conservation programme (e.g. Kyll) and the measures to reintroduce the salmon (e.g. Nister) are considered here. Furthermore, all species protection-relevant provisions (closed season, minimum length) have been overridden for the catfish.

In **Baden-Württemberg**, there is a cormorant ordinance that allows the shooting of cormorants during the winter months. However, since large parts of the eel management area are located in bird and nature protection zones in which deterrents for cormorants are only possible by means of exceptional permits, there is only a small amount of

deterrent activity. The influence of the ordinance on the removal rate of eels by cormorants is therefore considered to be relatively low.

Cormorants feeding on eels affects mainly the age groups 2 to 4, in which there are noteworthy losses of 15-26%.

3.7 Measures regarding other strains on eel stocks

Certain fish species in the Rhine and its tributaries, including the eel, are still partially contaminated with pollutants (dioxins, furans, dl-PCB, mercury, occasionally also the indicator PCB, hexachlorobenzene = HCB or perfluorooctanesulfonic acid = PFOS) from contaminated sites (cf. ICPR Technical Report No. 195).

According to the 2nd internationally coordinated management plan for the Rhine (cf. ICPR 2015), all measures to reduce emissions have been taken with regard to PCBs and no direct PCB discharges are known. In addition, the Rhine-bordering states have committed to cleaning up heavily contaminated water sediments as far as possible (see ICPR Technical Report No. 175 and ICPR 2015).

In the **French** Rhine catchment area, the consumption and placing on the market of certain fish, including the eel (weight over 1500 g), are regulated by two decrees, due to the considerable accumulation of mercury:

- Department of the Haut-Rhin (18.04.2017) ban on placing on the market and consumption of eels from Ill and Thur;
- Department of the Bas-Rhin (06.02.2017) ban on placing on the market and consumption of eels from Ill and tributaries;

In addition to the different contaminants, pathogens also affect the reproductive capacity of the European eel. For this reason, several animals from the North Rhine-Westphalian Lower Rhine were examined for viral infections in **Germany** in 2014 as part of health investigations carried out by the LANUV NRW as part of an eel stocking project (funded by the European Fisheries Fund). Several virus-positive animals were identified using cell culture technology. In addition to eel herpes viruses (HVA), several unclassifiable viruses were isolated from the samples. As part of the current stocking project (funded by the European Maritime and Fisheries Fund), molecular biological detection methods have been developed that enable the detection of other eel-pathogenic viruses. In this way, two animals from 2014 were identified that were infected with eel picornaviruses (EPV-1). In addition to testing for HVA and EPV-1, the stocking animals as well as the fish from fishing are examined in the laboratory of the LANUV NRW for the European eel virus X (EVEX).

In the current project, yellow and silver eels are also examined parasitologically and bacteriologically.

The effect of the different contaminants, pathogens and parasites on the mortality of eels or the reproductive success can still not be quantified and was therefore not taken into account in the current modelling of the eel population in Germany.

3.8 Special measures in the Rhine catchment area

In the **German state of Hesse**, the stocking of eels in stagnant waters, which are constantly blocked in terms of any exchange of fish, has been prohibited since December 2016.

In **France**, the Agence française pour la Biodiversité (AFB) carries out electrical fishing to monitor the eel population.
The population and recruitment dynamics are assessed on the basis of counts at video monitoring stations.

4. Forecasts for achieving a long-term migration rate of 40 %

The calculation model used in Germany allows a longer-term forecast. According to this, the total stock in the Rhine catchment system only seems to decrease slightly, then remaining at one level in the longer term from 2017 onwards. The downward trend in the overall stock was therefore halted, due to the measures initiated (restriction of fishing, restocking measures). The above observations (see 2.2) confirm these calculations. In the future, however, stocking eels will increasingly grow into the age group cohorts of the silver eels, which in turn will lead to increasing damage rates from the hydropower plants, meaning that there exists the risk of the EU's migration rate falling below 40% - also in the Rhine system (as in most other German eel management areas).

According to the 2018 German implementation report, hydropower plants are currently responsible for approx. 72.5% of all eels killed in the Rhine system, and anglers, professional fishermen and cormorants for the remaining 27.5%. With the onset of migrating silver eels, mortality from hydropower plants is becoming increasingly significant from age group 6. This, according to the modelled assumptions, only affects silver eels. From age group 12, the largest cause of loss in the eel population is anthropogenic. However, the information to estimate the reduction in eel mortality as a result of measures taken is not available or is only available to a limited extent in most German eel catchment areas, meaning that it was only possible to take this into account to an insufficient extent when calculating the total silver eel mortality from hydropower plants. A stable silver eel migration rate in the Rhine of over 40% will therefore be difficult to achieve in the Rhine system through further restrictions on fishing alone. Intensive deterring of cormorants will also only be able to change the overall situation to a very small extent, due to the extraction quantities of cormorant which are considered extremely low. An increase in the eel migration rate in the Rhine system could best be achieved through further protection schemes at hydropower plants.

More information on the forecasts in the other German eel management areas can be found from p. 13 in the German implementation report.

5. Recommendations and outlook

In order to support the positive development trends, it is advisable to reduce the anthropogenic mortality of these animals. Internationally coordinated, uniform and specific goals should be set for each hydropower plant in the areas with a significant presence of eels, in the form of mortality limits to be achieved for the international eel management areas along the Rhine, in line with the recommendations of the International Council for the Exploration of the Sea (ICES 2018). In particular, the establishment of downward passability of migration routes continues to gain importance. It is therefore recommended to increase the survival rate of migrating silver eels in the Rhine system, by taking further protective measures at hydropower plants. A temporary solution that can be implemented relatively quickly in justified individual cases would be, for example, “catch & transport” projects. The professional coordination of the places of release in the Rhine of eels caught as part of catch and transport measures on the Moselle (including Saar, Sauer), Main, Neckar and Lahn as well as an examination of usable synergies, is recommended. In the long term, a more sensible and significantly more sustainable measure than the catch and transport measures would be to adapt the turbine shafts to prevent traversing, through the use of appropriate protective rakes, and to install turbines with lower damage rates. Turbine management can also be deployed very quickly, which, during the main eel migration period, becomes protective eel management (currently being tested in the Weser, Fulda, Werra, Moselle and on the Main, for example).
Telemetric investigations with marked eels can provide precise information on mortality through turbine passage and/or actual migration success.

Further research on marked stock eels is supported, in order to be able to better estimate the effectiveness of restocking measures. In addition, the health status of all stocking animals should be fundamentally examined.

6. References

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Annex 1. Restocking with eels in the Rhine system in 2014, 2015 and 2016

2014			
Country / water (section)	**Stock**		
	Stage	**Quantity**	**Glass eel equivalent**
The Netherlands	Glass eel Farmed eel	5,697,997 902,673	1,728 4,389
DE-North Rhine-Westphalia	Farmed eel	394,000	
DE-Rhineland-Palatinate total	Farmed eel	279,100	
Rhine (DE-RP)	Farmed eel	145,000	
Moselle	Farmed eel	130,000	
Saar	Farmed eel	4,000	
DE-Hesse	Glass eel Farmed eel	42,350 49,495	
DE-Baden-Württemberg	Farmed eel Glass eel	109,000 138,900	
DE-Bavaria	Farmed eel	784,300	
Luxembourg	No restocking		
France	No restocking		
Switzerland	No restocking		
TOTAL		**8,676,870**	

2015			
Country / water (section)	**Stock**		
	Stage	**Quantity**	**Glass eel equivalent**
The Netherlands	Glass eel Farmed eel	863,226 742,375	278 3,374
DE-North Rhine-Westphalia	Farmed eel	499,200	
DE-Rhineland-Palatinate total	Farmed eel	277,000	
Rhine (DE-RP)	Farmed eel	142,000	
Moselle	Farmed eel	130,000	
Saar	Farmed eel	5,000	
DE-Hesse	Glass eel Farmed eel	52,850 49,952	
DE-Baden-Württemberg	Farmed eel	101,500	
DE-Bavaria	Farmed eel	793,700	
Luxembourg	No restocking		
France	No restocking		
Switzerland	No restocking		
TOTAL		**3,656,501**	

2016			
Country / water (section)	**Stock**		
	Stage	**Quantity**	**Glass eel equivalent**
The Netherlands	Glass eel Farmed eel	3,042,000 490,000	875 1,432
DE-North Rhine-Westphalia	Farmed eel	489,100	
DE-Rhineland-Palatinate total	Farmed eel	276,300	
Rhine	Farmed eel	141,000	
Moselle	Farmed eel	130,000	
Saar	Farmed eel	5,000	
DE-Hesse	Glass eel Farmed eel	38,850 72,965	
DE-Baden-Württemberg	Farmed eel Glass eel	88,550 81,000	
DE-Bavaria	Farmed eel	701,500	
Luxembourg	No restocking		
France	No restocking		

Switzerland	No restocking		
TOTAL		**5,556,300**	

Annex 2. Eels caught as part of transport measures in the Rhine catchment area

State / country	Catch water, location	Transport to (water, location)	Year	Catch in kg
The Netherlands	Pumping stations before several dikes in Zeeland, North Holland, Friesland	over dike	2014 2015 2016	3926 (828*) 5971 (1123*) 3113
	Hydropower plant Maurik / Nederrijn Lek	over dike	2014 2015 2016	1839 2257 2919
	Hydropower plant Alphen / Meuse	over dike	2014 2015 2016	1412 2688 2089
Luxembourg	Sauer, Rosport-Ralingen	Middle Rhine	2014 2015 2016	239** 310** 73**
DE-Rhineland-Palatinate	Moselle (in all dams; mainly in front of the power plants), Saar (Schoden)	Middle Rhine at Rolandseck or Bad Breisig	2014 2015 2016	4,100 5,390 5,151
DE-Hesse	Lahn	Middle Rhine	2014 2015 2016	332 306 86
DE-Bavaria	Main	Rhine near Wiesbaden	2014 2015 2016	7527.5 6256 7203
DE-Baden-Württemberg	Neckar, within 15 dams before power plants between the Neckar estuary in the Rhine and Besigheim (river km 137)	Rhine near Mannheim	2014 2015 2016	319.5 280.0 252.5

* kg of transported eel, taking into account predicted mortality in the case of a migration obstacle

** Weight information has not been statistically proven or determined individually, as only random samples are weighed and only the total number of eels is determined.