"Master Plan Migratory Fish Rhine 2018"

- an update of the Master Plan 2009

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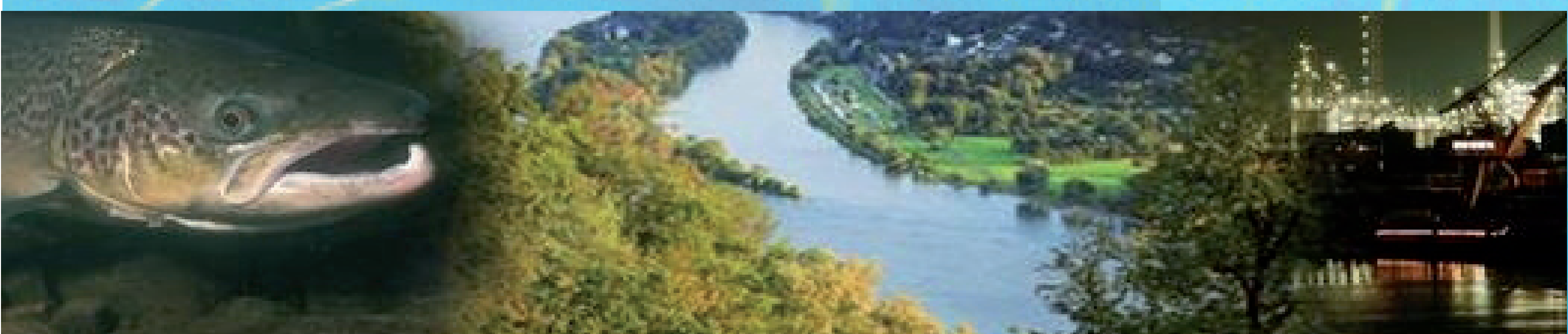

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Content

Master Plan Migratory Fish Rhine 2018

Summary

During their life cycle, long-distance migratory fish such as salmon, sea trout, sea lamprey and eel migrate from the sea into freshwater or from freshwater into the sea. For their life cycle, they therefore require open migration routes between the river systems and the marine environment. Within their lifecycle some freshwater fish species such as the nase also migrate extensively, but this is limited to water bodies within river systems. In the Rhine and the rivers in its catchment there is great need for action to restore and improve river continuity for anadromous migratory fish species (migrating from the sea to spawn in freshwater), for potamodromous species (migrating within river systems) as well as for the catadromous eel (spawning in the sea). Transverse structures such as weirs and sluices are severe obstacles for up- and downstream migration of these species. The Haringvliet dam in the Rhine delta and the weirs at hydropower plants in the Upper Rhine figure among these obstacles. Furthermore, due to a multitude of obstacles, numerous potential spawning and juvenile waters in the tributaries are today not accessible at all or only to a very limited extent.

The updated Master Plan (MP) Migratory Fish Rhine describes the measures already implemented in the different sections of the Rhine, measures still planned and, based on present knowledge it makes recommendations for further important measures aimed at an ecological improvement of river continuity in the Rhine catchment and at the reintroduction and maintenance of stable migratory fish populations which represent the overarching objective of the Master Plan Migratory Fish. As in the first Master Plan Migratory Fish (see ICPR report no. 179), the maintenance and quantitative as well as qualitative development of spawning and juvenile habitats, the restoration of upstream and downstream river continuity, the development of stocking strategies, the reduction of bycatches, illegal fishery and predation figure among the important operative targets. In addition, the evaluation and control of fishways, of measures combatting illegal fisheries near impoundments and of stocking strategies are to be mentioned.

The Rhine bordering countries, instances supporting the maintenance of navigation lanes and operators of hydropower plants have already implemented a certain number of measures aimed at improving river continuity (see Chapter 3.1). Today, in the main stream, fishways exist at the barrages at Iffezheim (since 2000), Gambsheim (2006) and Strasbourg (2016) and, in the Rhine Delta (Nederrijn/Lek) there are bypasses at three barrages (2004). Once the 'Kier'-project will have been implemented as of 5 September 2018, one or more sluices in the Haringvliet estuary will always be open - even at high tide. In 2018, the construction of a fish migration river, a several kilometres long migration corridor between the North Sea and Lake IJssel will begin in the estuary of the Lake IJssel enclosure dam. Since the opening of the fishway at Strasbourg in May 2016, the ecological continuity of the main stream of the Rhine is restored as far as downstream the Gerstheim barrage. At this hydropower plant a fishway is under construction which will be ready for operation in 2018. In the Rhine tributaries, existing obstacles have been equipped with fishways or the obstacles have been removed. The implementation of these measures has given access to 21 % of potential salmon spawning and juvenile habitats in the Rhine tributaries. Within the MP, investments of more than 600 million € are planned until 2027 (see Annex 1). Between 2010 and 2015 and as a part of restoration measures, more than 10 million salmon of different age stages, mostly juvenile fish have been stocked in the Rhine system.

Since the MP Migratory Fish Rhine was published in 2009, considerable progress has been achieved with respect to improving the river continuity and access to habitats (see ICPR report no. 206). The increasing number of upstream migrating adult salmon, allis

shad and other migratory fish species demonstrate the positive effects of measures implemented.
Nevertheless, the stocks of several important migratory fish species are not yet self-sustained and depend on stocking of juvenile fish and the implementation of further hydromorphological measures, in particular habitat improvements and the restoration of river continuity. In many smaller tributaries there is a great potential of valuable habitats for juvenile fish which may only be exploited once the continuity of and access to these river sections will be achieved.
Therefore, and taking into account climate change and its expected impacts on the fish fauna, optimizing and restoring the ecological continuity remains an important measure (see ICPR report no. 219).
During the past years, many measures were focussed towards improving upstream migration, now, increasingly, there is a shift towards equally improving river continuity for their downstream migration. In individual cases, there still is a need for further investigations. However, for smaller hydropower plants, implementable concepts for fish protection and downstream migration are already available.

1. Master Plan Objectives

The overarching objective of the Master Plan (MP) Migratory Fish Rhine is to restore self-sustaining stocks of migratory fish in the Rhine catchment.

In 2013, the Conference of Rhine Ministers confirmed that one of the challenges of the MP Migratory Fish Rhine, the restoration of river continuity in the main stream of the Rhine as far as Basel and in the salmon programme waters is an important management issue when implementing the EU-Water Framework Directive[1] and within the Swiss law on water protection. Also, the importance of migratory fish for the implementation of the EU-Marine Strategy Directive[2] was stressed. Furthermore, the MP takes into account protection regulations for migratory fish species and their habitats according to Annex II (special species protection areas), Annex IV (strict protection) and Annex V (management measures concerning uses) of the Habitats Directive[3] as well as the objectives of the European Eel Regulation[4]. Additionally, the Master Plan represents an important part of the planned Habitat Patch Connectivity along the Rhine. Important measures aimed at achieving these objectives for migratory fish such as salmon and eel are programmes aimed at restoring water quality, biodiversity and the habitat patch connectivity of the Rhine, such as Rhine 2020[5]. On the other hand, the stocks of migratory fish are good success indicators for these programmes, as they do not only react upon the state of the main stream, but also that of its tributaries and their spawning areas and juvenile habitats. The long-distance migratory fish mentioned in the Master Plan, such as salmon and eel represent all migrating fish species, including endangered species according to IUCN and species exclusively migrating in inland waters (potamodromous species). The measures implemented have positive effects on many more fauna and flora species and are suitable to sustainably improve the entire ecology of the Rhine.

During their life cycle, anadromous long-distance migratory fish species (migrating upstream to spawn in fresh water) such as salmon, sea trout, sea lamprey and the catadromous eel (spawning in marine waters) migrate from the sea into fresh water or from fresh water into the sea. Potamodromous fish species such as nase migrate within river systems towards spawning or wintering grounds which may partly be far away from their feeding grounds.

For their life cycle, migratory fish thus require open migration routes between the river systems and the marine environment and within river systems.
Waters in the Rhine catchment with good spawning and juvenile habitats for migratory fish have been identified as programme waters for their reintroduction; the measures concentrate on these waters (see map in Annex 5).

In the past, much has been achieved with respect to improving water quality and the restoration of upstream river continuity of the Rhine and its tributaries.
Since the ICPR published the MP Migratory Fish Rhine in 2009 as required by the Conference of Rhine Ministers in 2007, there have been new developments and findings (see ICPR report no. 179 and no. 206). Complementary measures, e.g. concerning the protection of downstream migrating fish, the evaluation and surveillance of fishways, of measures fighting illegal fishery and of stocking strategies as well as statements concerning other fish species than salmon and sea trout have thus been added to the updated MP Migratory Fish at hand. Also, the 200 ha of juvenile salmon habitats identified in the Swiss Aare catchment and the High Rhine tributaries downstream the mouth of R. Aare extending the known salmon and juvenile fish habitat in the Rhine catchment to 1200 ha have been taken into account. The German federal state Baden-

[1] WFD,Directive 2000/60/EC
[2] MSD, Directive 2008/56/EC
[3] Directive 92/43/EEC
[4] No. 1100/2007
[5] Rhine 2020, ICPR 2001

Württemberg is presently checking the designation of further programme waters on the German side of the High Rhine.

The most important measures of the updated Master Plan at hand which are particularly focussing on migratory fish are:

- Maintaining and developing the quantitative and qualitative aspects of spawning and juvenile habitats;
- The "restoration"[6] of up- and downstream river continuity;
- The protection of downstream and upstream migrating fish;
- The reduction of bycatches and illegal catches as well as predation.
- Fish stocking measures

Additionally, the efficiency of fishways, of measures against illegal fishery and of stocking strategies will be evaluated and controlled.

From an expert perspective, the Master Plan includes all major proposals for measures aimed at an ecological improvement of the Rhine catchment with a view to reintroducing and maintaining stable migratory fish populations. The efficiency of the measures proposed is described on the basis of the present state of knowledge. In cases, where experience and concrete investigation results are not available, the impact of possible measures has been assessed with the help of precisely defined assumptions and model calculations based on expert knowledge and literature. Additionally, and as a further development of the first MP Migratory Fish of 2009, new indicators for the success of the MP have been drawn up and assessed, such as the development of the stocks of different diadromous migratory fish species and genetic studies. Based on achievements so far, the updated MP defines priorities for a phased implementation of future measures, lists orders of magnitude for costs and indicates further required investigations.

With this comprehensive in-depth analysis the states, regions and federal states in the Rhine catchment have received a basis in order to decide, which proposals for measures are of priority importance for the objective "restoration of migratory fish". These nationally decided measures (see Chapter 4.1 and Table in the Annex) will continue to be part of the national programmes of measures according to the WFD, the programme "Rhine 2020" / "Salmon 2020" (phased implementation until 2015/2018 resp. 2020/2027) resp. the "Sea Trout Programme" and legally binding nature protection measures (e.g. following the Habitats Directive).

[6]As far as possible, river continuity is to be restored.

2. Why a Master Plan Migratory Fish Rhine?

2.1 The life cycle of migratory fish

During their life cycle, anadromous long-distance migratory fish (spawning in fresh water) and the catadromous eel (spawning in sea water) migrate from the sea into fresh water or from fresh water into the sea.

Salmon, for example, spend their main growth period in the sea, but return to the rivers for spawning (Figure 1). They follow their sense of smell and their remembrance of the smell of the home waters. This behaviour is called “homing”. The majority of individuals only sets out once to this journey.
The eel migrates in the opposite direction. It spends most of its life cycle in the river and spawns in the Sargasso Sea, a part of the Atlantic Ocean south of the Bermuda Islands (Figure 2). After 3 years the eel larvae reach the European coastal waters and become glass eel which often migrate upstream the rivers in great swarms. During several years of life in the rivers they then grow to full size. Once they are mature (females after 12-15 years) they return to the Sargasso Sea to spawn.

The Rhine catchment and its big tributaries such as the R. Main, Moselle and Sarre used to be a very important habitat for migratory fish in Europe. Quite naturally, the Rhine was free of any obstacles from the North Sea to the falls of the Rhine at Schaffhausen. From the spawning and juvenile regions in the tributaries, even in the Alps, in the Black Forest and the Vosges juvenile salmon could migrate downstream into the North Sea and the Atlantic Ocean almost without surmounting any obstacles and return to their home waters once they were ready to spawn. Thus, the life cycle of long-distance migratory fish was continuous and the conservation of self-sustaining populations was granted.

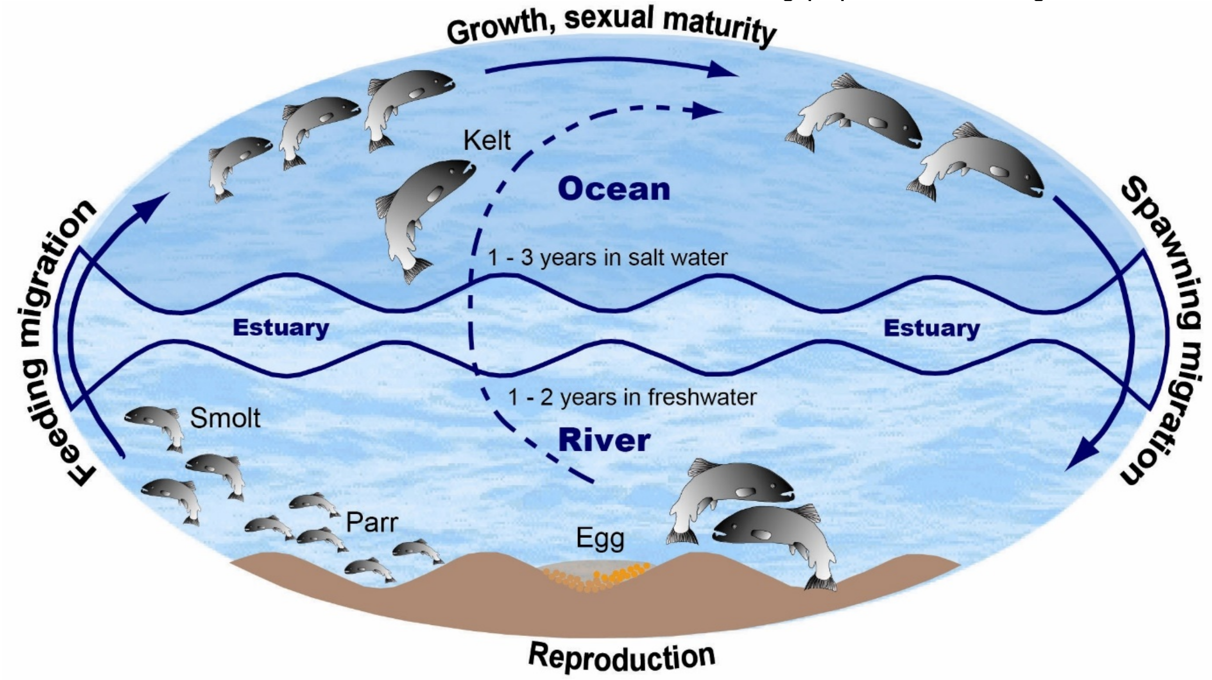

Figure 1: Salmon life cycle. Source: Bundesanstalt für Gewässerkunde (BfG)

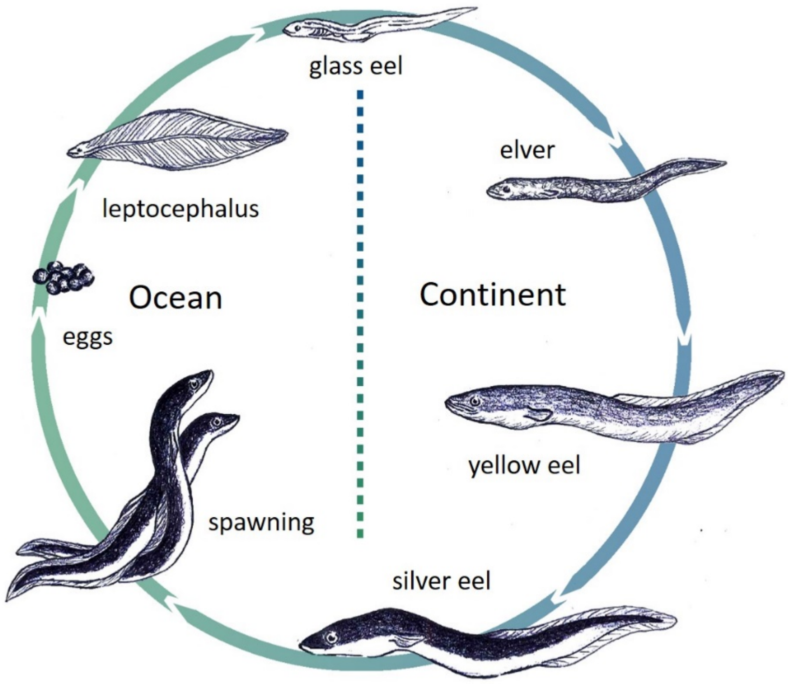

Figure 2: Eel life cycle. Source: Lisa Horn (LANUV NRW)

2.2. Development of salmon stocks in the Rhine

Originally, several hundreds of thousands of salmon used to migrate upstream the Rhine. The Rhine as far as the falls of the Rhine at Schaffhausen and several tributaries were their habitat (see Map 1 in the "Master Plan Migratory Fish Rhine 2009", ICPR report no. 179, www.iksr.org).

According to a study of 2016, the salmon population already declined by up to 90 % between the early Middle Ages (450-900 AD) and early modern times (ca. 1600 AD), a period coinciding with the extension of the technology of water mills in Europe (Lenders et al., 2016).
More than 150 years ago, a great decline of stocks was recorded, stocking measures were implemented, and concerted protection measures were decided on in an international so-called "Salmon Treaty" (1885). The decline of the populations of salmon and other migratory fish species such as river and sea lamprey, sturgeon, allis shad, sea trout and houting in the Rhine catchment correlate with the construction of migration obstacles, the deterioration of water quality ("chemical barrier") and river training. The loss of suitable habitats concerned migration routes as well as spawning areas. Finally, overfishing of the population resp. its remainders showed its effects.

Systematic river training on the Upper and High Rhine, on major tributaries such as the rivers Aare, Neckar, Main and Moselle and along several further tributaries in the entire catchment has heavily interfered with river continuity in the Rhine system. Transverse structures such as weirs, hydropower plants and sluices are severe obstacles for up- and downstream fish migration. Both the Haringvliet dam in the Rhine Delta and the barrages at hydropower plants in the Upper Rhine figure among these obstacles.
Due to the changes in the water systems, which are mostly irreversible and usage-dependant, the spawning grounds and juvenile fish habitats of migratory fish have partly been destroyed, are no longer accessible or access is considerably restricted.

The outstanding and exemplary species "salmon" serves as a "flagship" for measures aimed at restoring the populations of long-distance migratory fish in the Rhine catchment. As salmon show strong homing, which means that it returns to its home waters with high precision, selection processes over several generations lead to a specific adaptation to these home waters. Therefore, it is comparatively improbable that deserted river sections will repopulate by natural means, so that only stocking measures may lead to stocks of salmon conditioned to our waters. Waters in the Rhine catchment with good spawning and juvenile habitats for migratory fish have been identified as programme waters for their reintroduction; measures focus on these waters.

Most stocking measures began in the 1990s, after the ICPR "Salmon 2000" programme had set out the ambitious target to close the gap in the species inventory of the Rhine and to support the return of the salmon and of other fish species. The „Comprehensive Fish-Ecological Analysis including an Assessment of the Effectiveness of on-going and planned Measures in the Rhine Catchment with Respect to the Reintroduction of Migratory Fish" (ICPR report no. 167) was the basis for the first Master Plan Migratory Fish Rhine (see ICPR report no. 179). Within the implementation of the WFD and the ICPR programme "Salmon 2020" coordinated with the WFD and within nature protection (e.g. habitat management), the Rhine bordering states have since then gradually implemented several concerted measures.

3. Balance of measures implemented during 2009-2015: What has been achieved so far?

The chapter at hand provides an assessment of the most important measures and recommendations of the Master Plan 2009:

- the restoration of river continuity as well as access to and restoration of habitats;
- reduction of pressures by fishery and predation;
- protection of downstream migrating fish.

The total costs for measures implemented so far and the cost estimate for measures under construction or planned in the programme waters for anadromous migratory fish in the Rhine catchment amount to more than 600 million euros. A detailed survey including costs of measures and representing the state of implementation by end 2015 is included in Annex 1 (see 2nd Management Plan for the Rhine, ICPR 2015).
A progress report on the “Master Plan Migratory Fish Rhine” for the period 2010 - 2012 has been published as ICPR report no. 206.

Apart from restoring river continuity and the access to habitats investments were made aimed at improving a further source of life for migratory fish: the water quality in the Rhine system. The result is that water quality is no longer considered to be a limiting factor for the fish fauna of the Rhine (ICPR report no. 228). In future, further investments will be made into the water quality (e.g. upgrading wastewater treatment plants, new treatment stage for micro-pollutants).

3.1 Results concerning the restoration of river continuity and suitable habitats

The Rhine bordering countries, instances supporting the maintenance of navigation lanes and operators of hydropower plants have already implemented a certain number of measures aimed at improving river continuity, thus opening the way into many spawning grounds and juvenile habitats in the Rhine tributaries.

Today, 256.3 ha, approx. 21 % of the potential salmon spawning habitats in the Rhine system are accessible (Figure 3), compared to 216.3 ha in 2008. Annex 5 (K30 of the 2nd Management Plan for the Rhine, ICPR 2015) illustrates the success with respect to the restoration of access to spawning grounds and juvenile habitats in the programme waters for migratory fish until the end of 2015.

Due to new findings of 2013 in Switzerland, the Aare catchment (e.g. Aare as far as Bielersee, Limmat, Reuss, Sihl, Reppisch, Bünz, Suhre, Wigger) and tributaries to the High Rhine (e.g. Thur, Töss, Glatt, Möhlinbach) comprise further 200 ha of habitats for juvenile salmon (included in the uppermost bar in Figure 3) which extends the total so far known surface of spawning grounds and juvenile habitats in salmon programme waters in the Rhine catchment to 1200 ha.

With the adoption of the “Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora” (Habitats Directive), and in coordination with the EU, important stepping stones within the River Rhine were declared to be part of a coherent European ecological network, Natura 2000.

In Hesse, for example, in 2017 a habitat management plan was drafted for the Habitats Directive area 5914-351 “Migratory fish in the Rhine” concerning seven focus areas (subareas) (Regierungspräsidium Darmstadt 2017). Outside the shipping channel the subareas include resting areas with a differentiated substrate and different structural elements as suitable areas of life for long-distance migratory fish and indicate an important potential for further development. The Habitats Management Plan is to indicate the requirements for a lasting restoration of favourable states of preservation for existing habitat types and species determined. The Management Plan is restricted to an assessment of existing fauna data, projects implemented so far and specific management proposals.

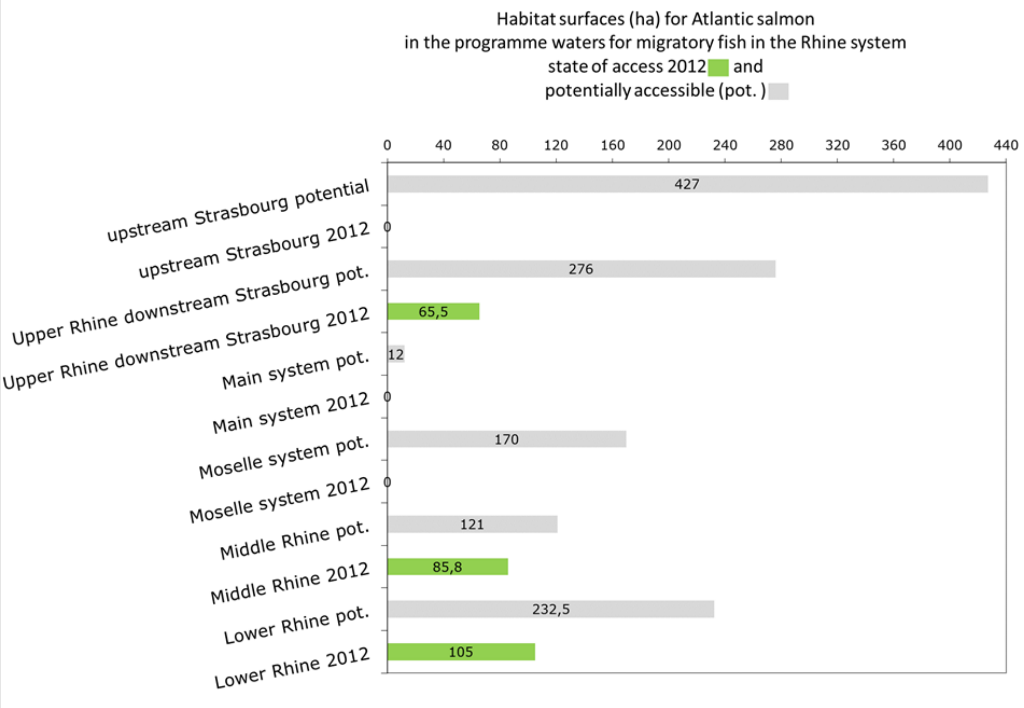

Figure 3: Potential and accessible juvenile habitat surfaces for salmon and sea trout in the Rhine system.

All in all, during 2000 to 2012, 480 measures aimed at improving upstream river continuity in the programme waters have been implemented (Figure 4).

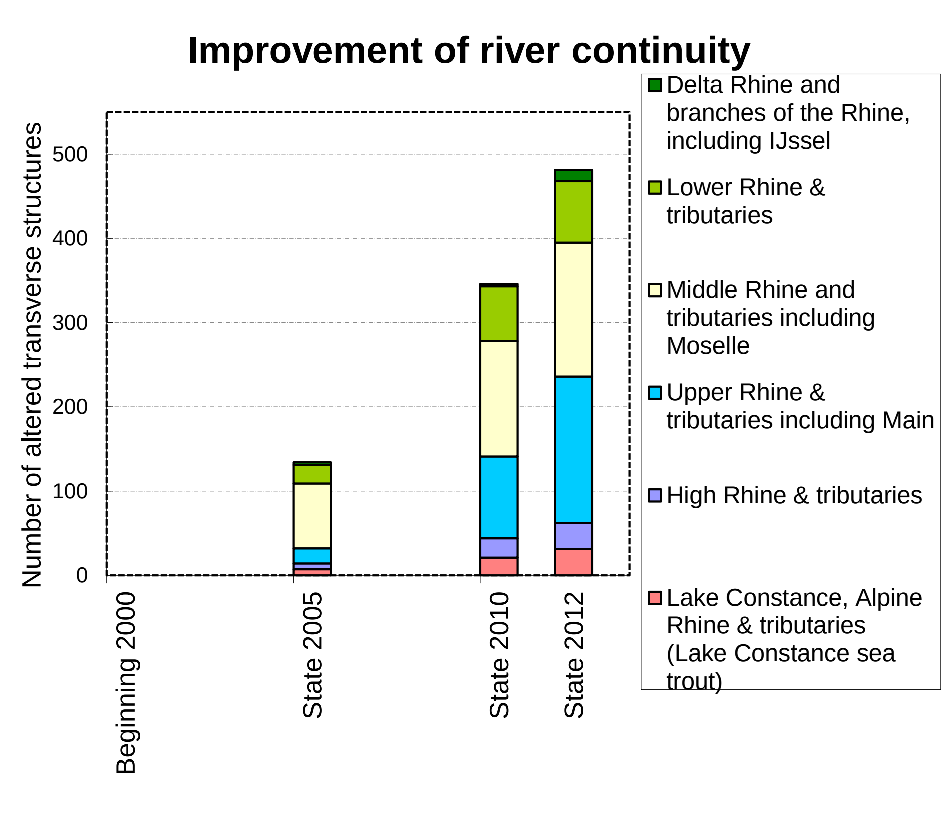

Figure 4: Improved upstream river continuity of the Rhine and its tributaries, in particular of programme waters for migratory fish: number of altered transverse structures. State June 2013

The survey in Annex 1 is taken from the second internationally coordinated management plan for the international Rhine river basin (2nd Management Plan for the Rhine, see ICPR 2015) and indicates, in which programme waters for migratory fish up-, respectively downstream river continuity has been restored at transverse structures (marked green).

A survey of measures to be carried out for migratory fish at transverse structures in programme waters by 2018 (marked yellow) and by 2027 or later (marked orange) representing the status by the end of 2015 is equally included in Annex 1 and Chapter 4.1. Also, information is given on the improvement of the quality of habitats in these water bodies.

When drafting the 1st management plan for the international river basin district Rhine (see ICPR 2009) an analysis was made, where which measures are required and purposeful.
Priority measures were determined based on aspects of efficiency (proportionality), technical feasibility and financing possibilities and a timetable was established for their implementation by 2015, 2018 or 2027.
Due to challenges in connection with technical implementation and required (international) coordination, the constructional implementation of many measures will only be possible after 2015.
In Germany, a federal priority concept exists for all federal waterways aimed at improving upstream river continuity (BMVBS 2012). The federal administration for waterways and navigation is legally in charge of measures aimed at improving upstream river continuity at impoundments of the navigable parts of the rivers Moselle, Main, Neckar and Lahn.

In France, national decrees classifying rivers according to Article L.214-17 of the French environmental law have resulted in two lists[7]:
- "List 1" concerns a conservation target, includes rivers of great importance for diadromous migratory fish and prohibits the construction of new obstacles to the ecological continuity of these rivers.
- "List 2" concerns a restoration target and includes all those rivers, the ecological continuity of which (fish migration and sediment movements) is to be restored within 5 years after the publication of these lists.
A river may at the same time be classified in List 1 and List 2 along its entire length or for river sections.
For the Rhine-Meuse-catchment, the "Management Plan for Migratory Fish in the Rhine-Meuse-catchment for the period 2016-2021 (PLAGEPOMI)" includes measures aimed at reducing the pressure on migratory fish and their habitats. It is based on the guidelines of the Management Plan (SDAGE) Rhine-Meuse 2016-2021 recommending the implementation of all required measures for transverse structures when they are constructed or during their management, in order to secure the longitudinal continuity of rivers. Guidelines and underlying regulations detail the important issues.

In the following, measures already implemented and aimed at restoring upstream and downstream river continuity in the sections of the Rhine as well as their state of implementation by the end of 2015 (see 2nd Management Plan for the Rhine, ICPR 2015) are presented. As information on measures aimed at ecologically sustainable continuity for fish relevant for the Upper Rhine are regularly updated for work of the ICPR Project Group ORS constituted mid-2015, the state of implementation beginning 2018 can be indicated for these measures. Above all, this concerns measures implemented and aimed at improving river continuity for fish in the main stream of the Rhine and in the Dutch arms of the Rhine and the state of implementation planning for further measures relevant for the continuity of the Upper Rhine.
A new inventory of all measures implemented by 2018 aimed at improving habitat conditions for migratory fish in the Rhine catchment will be drafted 2018 for the balance of the programme "Rhine 2020" for the years 2000-2020 and will serve as a contribution to the 3rd Management Plan according to the WFD.

3.1.1 Delta Rhine

Fish migrating upstream from the sea, such as Atlantic salmon, sea trout and allis shad may today freely migrate upstream from the North Sea via the **Nieuwe Waterweg** near Rotterdam and the (shipping lane) **Waal**.
Due to the ramification of the Rhine just downstream of Lobith, the total runoff of the Rhine spreads over all three arms (about 2/3 Waal, 2/9 Nederrijn-Lek und 1/9 IJssel).
Migrating fish may also use the route passing by the **Nederrijn-Lek**, as, during 2001-2004, fishways resp. bypasses were constructed at the 3 barrages (Driel, Amerongen, Hagestein) for a total cost of 9.2 million euros.
On the Dutch enclosure dam of Lake IJssel, two of three projects have already been implemented:

- Den Oever fishway (sluices at the western side of the enclosure dam; costs: 1.9 million euros)

[7] https://www.legifrance.gouv.fr/affichCodeArticle.do;jsessionid=A29B53C5604A08A3D024406292424F20.tpdila11v_3?idArticle=LEGIARTI000033034927&cidTexte=LEGITEXT000006074220&dateTexte=20170103

http://circulaire.legifrance.gouv.fr/pdf/2013/02/cir_36497.pdf

Planning of the Den Oever fishway:

2009	Begin of investigations into fish migration at the enclosure dam
2013	Beginning preparation of the fishways and the salt water drainage system
2014 to 2015	Construction of fishways in the enclosure dam at Den Oever
December 2015	Accomplishment of the fishway

The fishway was officially inaugurated on the occasion of the World Fish Migration day, 21 May 2016.

According to first monitoring results tens of thousands of glass eel and small sticklebacks use the fishway every night.

- Fish-friendly sluice management at Den Oever and Kornwerderzand (total costs: 5 million €)

Planning of fish-friendly sluice management:

2009	Begin of investigations into fish migration at the enclosure dam
2013	Begin of investigations into optimizing fish-friendly sluice management
	Beginning preparation of the construction of the salt water drainage system
2014	Tests with fish-friendly sluice management
2015	Construction of the saltwater drainage systems
	Accomplishment of the saltwater drainage systems
	Introduction of fish-friendly sluice management

The fish-friendly sluice management has now been operated since 2015.

3.1.2 Lower Rhine

There are no transverse structures in this section of the Rhine; the continuity of the main stream of the Rhine is thus given.

Measures in the Lower Rhine tributaries

On the **Lower Rhine**, the tributaries R. **Wupper** and its tributary, R. **Dhünn,** and the R. **Sieg** with its tributaries R. **Agger** and **Bröl** with more than 200 ha juvenile salmon habitats are of great importance for the reproduction of migratory fish and for establishing a stable salmon population.

In the Westphalian part of R. **Sieg** more than 60 smaller weirs and transverse structures have been removed or continuity has been restored.
After constructing a fishway at the only remaining obstructing weir as far as the Dhünn barrage at the Freudenthaler Sensenhammer, **R. Dhünn** (a tributary to R. Wupper) is the first programme water in North Rhine-Westphalia with complete river continuity. The Wupperverband has largely deconstructed the Pfälzer Steg weir in Wuppertal-Barmen and the Membrana weir has been transformed into al 70 m long ramp opening the way upstream for fish and other organisms living in the river. At the Auerkotten weir a first fish protection device was installed and its functionality for salmon smolts and silver eel has been checked[8].

[8] http://www.brd.nrw.de/umweltschutz/wasserrahmenrichtlinie/PDF/HDX-Monitoring-Wupper-2013-14.pdf

Due to the technically unsolved downstream migration at large hydropower plants, the Management Plan of 2015 did not identify **R. Ruhr** as a water body for migratory fish target species.

3.1.3 Middle Rhine

There are no transverse structures in this section of the Rhine so that river continuity is not affected.

Measures in the Middle Rhine tributaries

Following vast ecological restoration measures, the **R. Ahr** is today freely meandering before pouring into the Rhine and presents potential spawning and juvenile habitats amounting to some 80 ha. 46 of the more than 49 transverse structures and river bed sills were modified or dismantled by the end of 2015 (costs approx. 4 million €). Thus, along its first 70 km, the R. Ahr is again passable.

The **R. Nette** is directly flowing into the Middle Rhine and is passable along 6.6 km in upstream direction. So far, river continuity has been restored at 7 of the 24 existing transverse structures (costs: 445,000 €)

After concluding modification works at the Isenburg waterfalls in 2008, river continuity has been restored at the last of the 12 transverse structures on the **R. Saynbach**. During the past 15 years, measures amounting to about 0.5 million € have been implemented within the programme “Salmon 2000”.

Along large stretches, the most important tributary of the Middle Rhine, the **Moselle**, is a regulated federal waterway with hydropower utilization and a connecting water body, the main function of which is to grant as unhindered fish migration into the upstream spawning and juvenile habitats for migratory fish as possible. In sections, where the Moselle is a connecting water, it does not dispose of any spawning or juvenile habitats for migratory fish. Due to its linking function, the importance of the Moselle is however comparable to that of the other programme waters. In 2011, the existing fishway at the first barrage on the Moselle in Koblenz was completely reconstructed according to modern criteria (costs: 4.5 million €). Entrances for fish with different swimming capacities were arranged on the river bed, as well as in the freely flowing water in the area of the attractant current of turbines. In order to support these entrances, an additional turbine has been installed.
In order to develop the spawning and juvenile habitats in the catchment of **R. Sûre**, in tributaries to the Moselle and **R. Syr**, an immediate tributary of the German-Luxembourgian Moselle, 48 transverse structures were determined in a first step, at which river continuity should be restored by 2015. During the first management cycle, measures aimed at restoring upstream river continuity were implemented at six of these 48 priority transverse structures. In addition, seven weirs of the 52 priority transverse structures of the country declared in the programme of measures of the present Luxembourgian management plan (2015-2021) were altered to offer river continuity for fish migration. In the **Elzbach**, a tributary of the Moselle, one of 13 obstacles to migration was altered.

From the mouth at Lahnstein upstream to the mouth of R. Ohm the R. **Lahn**, a regulated formal federal waterway with vast utilization of hydropower, is an important linking water body to tributaries with spawning and juvenile habitats; in the hyporhithral further upstream the Lahn itself disposes of such habitats.
Upstream the lower course of the Lahn in Rhineland-Palatinate, river continuity of the Hessian part of the Lahn was successively achieved at seven weirs or drop structures.

10 km of a further tributary to the R. Lahn, the R. **Elbbach**, are today accessible as far as Hadamar, offering potential spawning and juvenile habitats for migratory fish. So far, investments amount to some 1.1 million € (6 fishways). Since 1995, about 3 million € have been invested in the R. **Dill** catchment to restore ecological river continuity.

Due to its length, the **R. Nahe** is one of the most important programme waters in Rhineland Palatinate, representing 25 ha of potential spawning and juvenile habitats (estimate to be checked). There are more than 33 transverse structures along the 110 river kilometres, 8 of which are already passable. Today, river continuity is granted along the first 5 km upstream the mouth near Bingen.

R. **Wisper** flows directly into the Rhine and has been designated as spawning and juvenile water along 14 km of its downstream and middle stream section. In order to create river continuity, one weir was altered in this section (190.000 €).

3.1.4 Upper Rhine and tributaries

Until south of Strasbourg the main stream of the Rhine allows free fish migration.

From its outlet into the Rhine at Mainz / Wiesbaden as far as the mouth of R. Regnitz into the Main at Bamberg the **R. Main** is being used as federal waterway. Due to numerous barrages in the Main and further transverse structures in the tributaries to the Main, many migratory fish, in particular long-distance migratory fish are presently not able to reach the spawning and juvenile habitats. The following figure among the potential salmon rivers: the Hessian tributaries to the Main **Schwarzbach / Taunus, Nidda** (with **Usa** and **Nidder**) and **Kinzig** (with **Bracht**, **Salz** and **Bieber**)**,** the Bavarian **Main** with its tributaries **Kahl, Aschaff, Elsava, Mömling, Mud, Erf, Haslochbach, Hafenlohr, Gersprenz, Lohr** (with **Aubach**), **Sinn** (with **Kleiner Sinn**) and **Fränkische Saale** (with **Schondra** and **Thulba**), as well as the **Tauber** in Bavaria and Baden-Württemberg.

In order to reach the tributaries mentioned and the upper Main, 17 barrages must already be surmounted from the mouth of the Main until that of the Fränkische Saale so that there is little chance for a recolonization of these waters with salmon.
There are several concepts and studies for waters in the Bavarian Main catchment indicating the relevance for the fish fauna and priorities of implementing measures to improve the river continuity in the different waters (see: "Durchgängigkeitsstudie schiffbarer bayerischer Main[9]"; an overall concept in cooperation with power plant operators and the Federal Administration for Waterways and Navigation, WSV).

In Hesse, the bypass at the lowermost barrage on the Main at Kostheim was completed end 2009, function controls have however pointed out deficits of the upstream and downstream migration fishways.

The lowermost 208 km until Plochingen of the total 367 km of the R. **Neckar** are being used as federal waterway.
The R. Neckar and its tributaries are no central migration routes or habitats for anadromous fish species. When planning and implementing measures, long-distance anadromous migratory fish species such as allis shad and the eel as a catadromous migratory fish species will be taken in to account. Creating a network of spawning and juvenile habitats is of particular importance for the development of the fish fauna, above all in the 208 km long navigable section of R. Neckar between Mannheim and Plochingen. Within the concept for action and priorities with respect to restoring the continuity of federal waterways (MBVBS 2012), a fishway has already been created at the lowermost transverse structure at Ladenburg.

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[9] http://www.lfu.bayern.de/wasser/durchgaengigkeit/konzepte_studien/index.htm

R. **Alb** and its tributary **Moosalb** all in all present approx. 10 ha suitable spawning and juvenile habitats. Here, seven obstacles to migration have already been altered. The 63 km long **R. Lauter (Wieslauter)** is partly a French-German boundary water body pouring directly into the Upper Rhine. At four transverse structures in the lower course of R. Lauter river continuity has already been restored (costs: just below 1 million €).

The fishway in the **main stream of the Rhine at Iffezheim** (costs: 10 million €, not including studies) opened in **2000** offers an access to the Rhine tributaries **Ill** (FR) and **Rench** (DE).
Potentially, the spawning habitats in the Ill river system and its tributaries comprise some 100 ha (Ill: 5 ha; Bruche: 25 ha; Giessen: 8 ha; Liepvrette: 6 ha; Weiss: 8 ha; Fecht: 15 ha; Lauch: 7 ha; Thur: 16 ha; Doller: 11 ha).
River continuity has already been restored at 13 barrages in the main stream of the **Ill** and several habitat improvements have been carried out. Several measures have contributed to improve free fish migration into the reproduction areas in this catchment area. In 2015, 10 measures were accomplished in the catchments of the rivers Ill (among others rehabilitation of the Huttenheim barrage), Fecht, Weiss and Doller.
In the priority migration area of **R. Bruche** the Heiligenberg barrage was equipped in 2014.
In 2016, 15 % of the potential habitat areas in the Ill catchment were accessible (compared to 2 % in 2008 and 6 % in 2012). Since 1995, several natural reproduction areas have been observed in the Lower R. Bruche, in R. Fecht (2010) and in the upper R. Bruche they are established since 2014. In 2016, spawning grounds were for the first time observed in the R. Giessen and Ill (section in the Departement Haut-Rhin).

River continuity was restored at 15 barrages in **R. Rench** (19 ha spawning and juvenile habitats) and several habitats have been improved.

The fishway opened at **Gambsheim** in **2006** including a visitors' centre, an observation and counting station (costs: 12 million euros, excluding studies) gives access to the 68 ha of spawning and juvenile habitats in **R. Kinzig** (DE-BW). River continuity for migratory fish has been restored at 19 barrages in the salmon-recolonization area of R. Kinzig and numerous habitats have been improved.

In December 2015, the **Strasbourg** fishway (pond system fishway and bypass with counting station, costs: 19 million € excluding studies) was fed with water. It was officially inaugurated on 19 May 2016 within the Nature Day and the World Fish Migration Day.

The permit for construction work for a fishway at Gerstheim was granted in 2015 and work began in the second half of 2015 (costs: 15 million €).

In the **Elz-Dreisam** river system which will again be accessible once river continuity will have been restored at the Gerstheim barrage and at the three sills in the old bed of the Rhine in the loops at Gerstheim and Rhinau, some 38 transverse structures have been altered between 2000 and 2015. Thus, in the Elz-Dreisam area, continuity is already given along 85 km.

Since 2010, numerous measures have been carried out within the renewal of the concession for the Kembs hydropower plant in the **old bed of the Rhine** upstream of the agricultural weir at Breisach. On the French banks, further hydromorphological processes will again be made possible (controlled erosion at two locations). An INTERREG project with the participation of technical institutes from Alsace (F) and Baden-Württemberg (D) was concluded in 2012 (influx of bedload due to controlled gravel input). Material excavated for the new hydropower plant at Kembs has been used for influx of bedload.

Mid-2016 and within the renewal of the concession, a new fishway (with turbine for water supply) was put into service at the hydropower plant located at the upper end of the old bed of the Rhine at **Märkt/Kembs** (costs: 8 million €). At the new power plant, 7 m^3/s will be led into a side arm installed leading to the Old Rhine. This side arm was officially opened on 5 June 2015. The new hydropower plant is also equipped with fish protection and downstream fish migration systems. In addition, a part of the island in the Rhine was ecologically restored.

3.1.5 High Rhine

In the German part of the High Rhine river system R. **Wiese** upstream its downstream section in Switzerland and some of its tributaries have been identified as areas for reintroducing salmon. In this area, river continuity has already been restored at 15 transverse structures and the river structure was improved.

3.1.6 Lake Constance / inlets to Lake Constance / Alpine Rhine

Several measures aimed at improving river ecology have been implemented in the area of operation **Alpine Rhine / Lake Constance**. The focal points for improving the ecological status/potential of rivers include measures:

- to improve river continuity for fish; in this connection, the Lake Constance lake trout is publicly perceived as an important “symbol species” in the catchment of the Alpine Rhine/Lake Constance;
- to improve the water regime in river sections impacted by diversions (residual flow) or discharges (hydro-peaking);
- to improve river morphology and widening the watercourse corridor.

For the lake trout, the continuity of the **Alpine Rhine** is provided from the mouth in Lake Constance at River Kilometre 94 to the confluence of the Posterior Rhine and the Anterior Rhine at River Kilometre 0. The river bed sills at Buchs (River-Km 49.6) and Ellhorn (River-Km 33.9) are surmountable for the lake trout but constitute artificial limits of distribution for other fish species. In 2000, a technical fishway was constructed at the Reichenau power plant (river-km 7). Permanent monitoring proved that this plant does not obstruct upstream migration of the sea trout.

River continuity of the **Spirsbach (Spiersbach)**, a torrent partly flowing in parallel to the Alpine Rhine is granted, since its mouth in the Rhine was redesigned in 2008. Between 1980 and 2000, all transverse structures were eliminated in the **Liechtensteiner Binnenkanal.**

The river continuity of the **Vereinigte Argen** is already given. The first hydropower plant in the **Obere Argen** has been modified and has since then been partly open to lake trout migration. Planning has been engaged for the following installations but is presently not being continued. The lowermost obstacle and one more transverse structure in the **Untere Argen** have been modified. Thus, river continuity has been restored along 18 km.

The river **Schussen** is accessible to lake trout along some 30 km, as at the gauging station Lochbrücke/Gebertshaus, limited continuity is already granted.
In the **Seefelder Aach** the hydropower plants at Mühlhofen and Salem-Neufra have been equipped with fishways. The mouth is already passable to a limited extent.
In the **Stockacher Aach** and its tributaries 21 transverse structures have already been altered so that 14 km of this river are now free of obstacles for lake trout.

The **Leiblach** and **Oberreitnauer Ach**, two lake trout waters located in Bavaria are equally spawning waters of the souffia, a heavily endangered fish species listed in Annex II of the Habitats Directive.

River continuity has already been restored in the Oberreitnauer Ach and, in the meantime, the required modification of relevant transverse structures has been accomplished.

3.2 Results of measures aimed at reducing bycatches, illegal catches and predation

The laws of all states in the Rhine catchment prohibit catching and taking salmon from the waters.

In the following, the national implementation of the recommendations aimed at reducing bycatches and illegal catches included in the first MP Migratory Fish will be described (see also Chapter 4.2).

3.2.1 Delta Rhine, Lower Rhine

Delta Rhine, Netherlands

Additional investigations: The first MP Migratory Fish already recommended further investigations in order to gain insight into the real reasons for the loss of migratory fish and to reduce their mortality.
The ICPR commissioned an investigation carried out in 2015 which concerned fishery in the Dutch coastal areas between Kornwerderzand and Breskens. The Ooster- and Westerschelde, the Voordelta and a section of the Nieuwe Waterweg as far as Maaslandkering also belong to the area investigated. The result of investigations is that, in the coastal region, only a limited number of permits resp. only a part of the permitted capacity is really exploited. Most salmonids are caught near the Haringvliet sluices.
According to estimations, between 1500 and 7500 fish are caught. The majority of them are sea trout (about 90 %). Thus, between 150 and 750 salmon do not participate in the spawning process in the Rhine catchment. Had they not been caught, no more than 10 % of these salmon, i.e. 15 to 75 individuals would have reached areas in Germany or further upstream. It is not known, where the remaining 135-675 would have migrated. A share would migrate into the river but for some unknown reason they would rapidly return to the sea and continue their migration. These individuals would possibly migrate further south or north together with others. Telemetry investigations do not indicate that these fish make a second attempt to migrate upstream the river (see Vriese et al. 2010).
In the course of the years, much has been modified in Dutch fishery and legislation and has its effect on the fishing pressure and possibilities of salmon bycatches. The obligation to use separator trawls in shrimp fishery, the introduction of a closed season for eel fishing, a fishing ban in certain areas due to problems with dioxin and compensatory nature-related measures have reduced the probability of salmon (by-)catches.

Legislation: In the Netherlands, catching salmon and sea trout is forbidden by law. At the same time, there is an obligation to return salmon eventually caught as bycatches (law on fisheries of 1963, regulations, minimal size and protection periods of 1985, article 2c and 2d). Infringements may be prosecuted.

Information: At the time being, information on migratory fish targeted at sports anglers and leisure anglers is enhanced by the angling license (VISpas) and the behavioural codex on marine sports fishing. Professional fishermen, fisheries surveillance and persons working for the fish market and fish mongers receive the same information.

River continuity at constructions and other obstacles: The three barrages on the Nederrijn (Dutch Lower Rhine) were equipped with fishways as early as in 2001 to 2004, so that salmonids may migrate upstream without major delay. The partial opening of the Haringvliet sluices will improve the situation on the coast as of 2018.

Synergy with measures following the Eel Regulation: Since 1st October 2009 a ban on fishing eel with fyke-nets between September and end of November has been introduced at a national level.

Synergy with measures following the ban on dioxins: Since 1st April 2011 there is a ban on professional eel and Chinese crab fishing in the major parts of the great catchment of big streams as well as in certain big navigation channels. There is now a ban on professional fishing with fyke-nets and trawls (see the agreement in Dutch Staatscourant of 25 March 2011, no. 194017).

Implementation: In 2012, in the rivers Neder-Rijn, Maas, Lek and Overijsselsche Vecht, angling was forbidden along a reach of 75 m downstream a barrage, in fishways as well as 25 m upstream the upper outlet of a fishway. The ban does not apply to periods when the barrages are not operated. In the Netherlands, 3 anti-poaching teams are operating. During the winter half-year (corresponding to the salmon run) and following the recommendations of the ICPR, the Dutch board of control (NVWA) has operated targeted controls of the obligation to release bycatches. No infringements were stated during these controls. Infringements at transverse structures are being established by RWS and reported to the police.

Even though the share of bycatches and illegal catches in the Delta Rhine in the restricted development of the salmon population is not negligible, recent findings from telemetry studies reveal that the disappearing of salmon returning from the Delta Rhine back into the sea at an early stage is of much greater importance than mortality due to fishery (see above).

Lower Rhine, DE-North Rhine Westphalia

Legislation: According to the Fisheries Regulations for North Rhine Westphalia, the closed season for salmon and sea trout covers the entire year. These species must immediately be put back into the fishing waters with due care and diligence. If their death is to be assumed, they must be killed and buried immediately if no other kind of disposal is stipulated for the fishing water concerned. Even if they are dead when caught, they may not be used. Catches must be indicated to the subordinate fisheries authority within seven days (§§ 1 and 4 LFischVO NRW).

In the past, there were indications of targeted angling at the mouth of the rivers Sieg and Wupper into the Rhine with the risk that big salmonids might equally be caught. Thus, in cooperation with local authorities, the ministry, the state office and fisheries associations and anglers' clubs, the following measures were adopted and implemented:

Protected fish zones: The Higher Fisheries Authority of the regional authority of Cologne has designated two fish protection areas in the mouth of the R. Sieg and Wupper according to the fisheries legislation of the Land. They imply a general ban on angling during the main upstream salmon migration from 1st September until 31st December. The two fish protection areas were published in the official journal of the regional authority in Cologne and entered into force on 30 March 2010.

Information: The LANUV has drafted a flyer "Helfen Sie, Lachs & Co zu schützen" (Contribute to the protection of salmon & co) informing anglers. This flyer has been widely spread and made known by fisheries associations and anglers' organisations.

Increased control: In protected zones officially nominated fish wardens increasingly control catches and are supported by the responsible subordinate fisheries authority. The latest evaluation of controls gave evidence of infringements.

3.2.2 Middle Rhine / Moselle / Northern Upper Rhine

DE-Rhineland-Palatinate and DE-Hesse

In spite of the low discharges in 2011, there were hardly any indications of illegal fishing during 2010 to end 2012.

With a view to informing anglers, the Hessian Ministry of Environment, Energy, Agriculture and Consumer Protection (HMUELV) has published a leaflet entitled "The salmon is returning - support efforts towards restoring the stock of an impressive fish species".

Luxembourg

In Luxembourg, there is a legal ban on catching salmon and sea trout. So far, there is no evidence of returnees. In 2011, the fishing department organized a training course for customs officers with respect to controlling fisheries. Today, illegal fishery and bycatches are no problematic issues in Luxembourg.

3.2.3 Southern Upper Rhine, High Rhine

Baden-Württemberg

According § 1 of the fisheries regulation of the Land (Landesfischereiverordnung), salmon and sea trout are protected all year. Salmon and sea trout caught must immediately be returned into the river, if they are still viable. In fishways and 30 m (in the Rhine 50 m) up- and downstream of their entrance and outlet, there is a ban on any kind of fishing according to § 7 of the fisheries regulations of the Land. During the past years, individual, inadvertent salmon catches have been reported.

France

The interministerial decree of 16 February 1994 on catches of diadromous migratory fish applies to rivers and channels pouring into the sea, their tributaries and secondary tributaries and connected standing waters from the very moment, when the presence of such species is detected. It is laid down in the Articles R436-44 to 68 of the French environmental law[10].

In the French part of the Rhine catchment there is a ban on catching salmon. It had been planned to make a fence once the work on including a fifth turbine into the hydropower plant Gambsheim was concluded thus blocking the access to the area of the entrance into the fishway. Since the project for a fifth turbine has been postponed, discussions with respect to securing this area must be resumed. Selective police controls are carried through. The introduction of a general ban on fishing downstream of weirs is planned (100 m in the Rhine and 50 m in other rivers).

Switzerland

In Switzerland, there is a ban on fishing salmon. Salmon released after catching or observed during angling must immediately be reported to the fisheries authority of the canton. Together with the cantons and associations the Federal Office of Environment has

[10] *https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000730215&dateTexte= https://www.legifrance.gouv.fr/affichCode.do?cidTexte=LEGITEXT000006074220 „**Part Regulations** / Book IV: Natural heritage / Section III: Fishery in inland waters and management of fish resources / Chapter VI: Conditions for exerting fisheries rights / Section 3: Management and fishing of species alternately living in freshwater and saltwater“*

distributed an information flyer to fishermen describing what to do when a salmon is observed. This flyer was drafted after a hobby angler had inadvertently caught a salmon in Basel in 2008 which he again released.

3.3 Results of measures protecting downstream migrating fish

Already the first MP Migratory Fish defined the restoration of downstream river continuity to be an additional important measure. Due to improved knowledge, measures increasingly focus on the protection of downstream migrating fish. The conference of ministers in 2013 asked the ICPR to intensively work on the joint determination of innovative techniques facilitating downstream migration at transverse structures in order to reduce the losses of salmon or eel in the turbines during their downstream migration.

Apart from the inventory of big transverse structures and already existing downstream fishways (see Map K 8 in the second Management Plan for the Rhine, ICPR 2015), the Rhine bordering countries are presently discussing activities going on in all states in the Rhine catchment concerning fish protection and downstream fish migration, including the success control and contribute to events on these issues[11]. On 6 and 7 October 2016, an international workshop on the issue of “downstream fish migration” initiated by the ICPR was staged in Roermond (NL) (see Chapter 4.3.2). Within the ‘Forum Fischschutz und Fischabstieg (http://forum-fischschutz.de/) founded by the German Environment Agency more than 200 persons from the German-speaking countries are committed to the issue under technical aspects. Within work done so far, a uniform understanding has been drafted for the whole of Germany, which requirements and solutions are to serve as a basis for corresponding measures and considering the present state of knowledge and art[12]. Insight was thus gained indicating that due to a greater risk of predation, every obstacle to downstream migration has negative effects. Thus, measures taken at existing hydropower plants should not be understood as an invitation to construct further plants.

During the past years, many downstream migration facilities have been built at small and medium hydropower plants and their functionality was tested. Today, some 100 downstream migration facilities are installed at hydropower plants in watercourses in Baden-Württemberg. In many cases and with a view to fish protection, fine screens have been installed. In smaller waters, “fish-friendly” hydropower plants such as Archimedes’ screws (hydrodynamic screws) are being used. That e.g. applies to the R. Ill catchment in France, R. Bruche near Muhlbach-sur-Bruche (Mullerhof) (2013/2014) and R. Weiss near Hachimette (Lapoutroie). Others are being installed on R. Ill near Erstein (Steinsau barrage) or are planned near Mutterholz (Ehnwihr hydropower plant). Some hydropower plants are operated in a “fish-friendly” way (e.g. stopping or reducing operation during the main eel migration period).

Pilot installations, the effectiveness of which is monitored for several years, have been installed in Germany, e.g. in 2011 at the hydropower plant Auerkotten, in 2012 at the hydropower plant Unkelmühle on tributaries to the Lower Rhine and in 2014 on R. Regnitz and the Fränkische Saale, two Main tributaries. The power plant located at Märkt/Kembs on the upper end of the Old Rhine which started operating in 2016 has also been equipped with fish protection and downstream fish migration systems. In tributaries to the High Rhine, the Stroppel power plant (Limmat) and the Rüchlig power plant (Aare) have been equipped with fish protection devices and downstream migration facilities. In Switzerland, research continues with respect to restoring downstream fish migration at

[11] E.g. see http://www.wa21.ch/de/NewsAgenda/Fachtagungen-WA21/2014-Fischwanderung, https://fishpassage.umass.edu/ - Fish Passage 2015

[12] Synthesis: http://forum-fischschutz.de/synthesepapier-empfehlungen-und-ergebnisse-des-forums-fischschutz-fischabstieg

Expert opinion: http://forum-fischschutz.de/fachgutachten-arbeitshilfe-zur-stand%C3%B6rtlichen-evaluierung-des-fischschutzes-und-fischabstieges big hydropower plants. Also, two pilot projects have started on downstream migration in R. Aare. In the Netherlands, several pumping stations have been/will be fitted with fish protection devices particularly aimed at protecting eel.

On the whole, the following applies to the present state of knowledge in the Rhine catchment:
For existing **small hydropower plants** with a nominal discharge up to 50 m^3/s we dispose of experience with well-functioning downstream migration facilities. Switzerland also disposes of experience with functioning devices for existing hydropower plants up to 100 m^3/s.
At **medium-sized power plants** with a nominal discharge **up to 150 m^3/s** many investigations were made in the past years and these plants were retrofitted. For this order of magnitude several power plants have been equipped with functioning downstream migration facilities.

For **big hydroelectric plants** with a nominal discharge **above 150 m^3/s** and in particular for the big hydropower plants along the Rhine there does not yet exist any satisfactory, implementable technique. At installations of this size reliable protection mechanisms cannot be implemented using the known and effective concepts or their implementation would be excessively costly. There still is urgent need for research and development with respect to these issues. Also, the concepts must be investigated into under fish-ecological aspects, in order to determine their functionality (see Chapter 4.4). However, during downstream migration, **operational measures** (e.g. turbine operation (full load instead of partial load) and periodical opening of weir fields) can already now potentially reduce losses. The corresponding biological evidence is still lacking. Therefore, the different installations should also be examined with respect to their potential for optimization and effect (see Chapter 4.3).

4. Existing and additional measures for the MP 2009 aimed at diadromous migratory fish

As for the first Master Plan Migratory Fish, the following measures continue to be important:

- Maintaining and developing the quantitative and qualitative aspects of spawning and juvenile habitats.
- Restoration of up- and downstream river continuity;
- The protection of downstream and upstream migrating fish;
- The reduction of bycatches, illegal catches as well as predation
- The initial and supporting stocking measures in reintroduction waters.

In addition, the evaluation and control of fishways, of measures against illegal fishing and of stocking strategies are to be mentioned. Also, statistical or genetic overall studies should be done, in order to find answers to technical questions and to determine eventual bottlenecks. Further control stations for fish should be strived for in order to dispose of more information on the return of migratory fish into inland waters, in particular the lower course of the Rhine.
Since diadromous migratory fish spend a part of their lives in the sea, the exchange of information on investigations into the stocks of migratory fish in the Atlantic Ocean, e.g. with organisations such as ICES (International Council for the Exploration of the Sea), NASCO (North Atlantic Salmon Conservation Organization), NASF (North Atlantic Salmon Fund) is important.

4.1 Restoration of river continuity and habitats

The target to gradually restore the continuity of the main stream of the Rhine as far as Basel and in the salmon programme waters so that by 2020 migratory fish such as salmon may again reach Basel and the spawning areas for migratory fish in the rivers Birs, Wiese and Ergolz was once again confirmed during the Conference of Rhine Ministers in Basel in 2013. Apart from migratory fish many indigenous fish species in the Rhine profit from the restoration of river continuity and the resulting network of their habitats. On the whole, the issue is the continuity of the main stream of the Rhine for fish until the Falls of the Rhine at Schaffhausen, which is the natural limit of distribution for migratory fish.

As a matter of principle, the restoration of river continuity concerns the **up- and downstream** migration of fish. However, few technical possibilities are known with respect to the question of how to protect downstream migrating fish at hydropower plants (see Chapters 3.3 and 4.3). Therefore, along the main stream of the Rhine, measures still focus at improving upstream migration. For smaller rivers, and this also applies to some Rhine tributaries identified as programme waters, functioning fish protection concepts already exist and in these cases the development and application of technical protection measures for downstream migration will also be a focal point and included into the Master Plan for these rivers. In this connection please also refer to Chapter 3.3 and Chapter 4.3.

In most cases, the measures of the Master Plan Migratory fish depend upon one another and have to be implemented in parallel in order to achieve optimum effectiveness. In many cases new or improved upstream fishways and/or bypasses are combined with an improvement of spawning and juvenile habitats. Apart from improving the quality of habitats, existing spawning and juvenile habitats must be preserved.

Therefore - and starting with the delta area of the Dutch Rhine arms - the situation of upstream migrating fish towards their spawning habitats in the Upper Rhine and the High Rhine or their tributaries in order to reproduce must be improved.

The following measures may particularly reduce the effects of floods, low water and the rise of temperature due to climate change to be expected in the Rhine catchment (see ICPR report no. 219):

1. **Protect and restore habitats**: Flora and fauna habitats are to be protected and to be made more near-natural. Examples along the Rhine and its tributaries are
    - freely flowing sections, in particular those with spawning grounds for rheophile fish species;
    - oxbow lakes, bypasses and other backwaters connected to the main stream;
    - brackish water sections (more near-natural transition from freshwater to salt water);
    - more near-natural redesigned banks (along smaller and medium tributaries it is recommended to plant shrubs or to let them spread naturally, in order to create shade limiting the rise in water temperature;
    - all replacement habitats for habitats vanished due to training measures in the riverbed and their qualitative improvement.

2. **Habitat network connectivity:** During periods of critical water temperatures and oxygen deficits, most fish and invertebrates are capable of migrating to a more suitable environment, as far as available and migration routes are unobstructed. In this process, the Rhine valley between the Upper Rhine and the Delta Rhine plays a particular role as extensive migration corridor. Also, it is important that higher lying river sections in the Rhine tributaries and lateral connections to backwaters in the floodplain are available, as, during hot spells in summer, their shade and cold groundwater seepage offer local areas to withdraw to. Also, terrestrial habitats along the water bodies should be interconnected. Here, too, the implementation of the “Habitat patch connectivity along the Rhine” (see ICPR 2006) will make an important contribution.

On-going and future measures in the sections of the Rhine

In the following, measures aimed at restoring river continuity will shortly be presented which are being or will be implemented in the sections of the Rhine and the state of implementation by the end of 2015 will be given (see 2nd Management Plan for the Rhine, ICPR 2015). As information on measures aimed at ecologically sustainable continuity for fish relevant for the Upper Rhine are regularly updated for work of the ICPR Project Group ORS constituted mid-2015, the state of implementation beginning 2018 can be indicated for these measures. Above all, this concerns measures implemented and aimed at improving river continuity for fish in the main stream of the Rhine and in the Dutch arms of the Rhine and the state of implementation planning for further measures relevant for the continuity of the Upper Rhine.
A new inventory of all measures implemented by 2018 aimed at improving habitat conditions for migratory fish in the Rhine catchment will be drafted in 2018 for the balance of the programme “Rhine 2020” for the years 2000-2020 and will serve as a contribution to the 3rd Management Plan according to the WFD.

The balance of measures already implemented at transverse structures in the programme waters for migratory fish by 2015 (resp. 2018 when relevant for the Upper Rhine) are presented in Chapter 3.1.

4.1.1 Delta Rhine (see Chapter 3.1.1)

In two areas of the estuary fish still meet the following obstacles:

(1) **Haringvliet sluices:**
After the disastrous flooding in 1953 (1830 casualties) the connection between the estuary and the sea was disrupted by several dams and flood barriers. The aim was to shorten the coastline and thus to guarantee safety. The dam in the Haringvliet was closed in 1971. The consequence was that the former tidal Haringvliet area with salt water developed into a lake with freshwater and hardly any tidal influence.
The dam was equipped with locks to drain the water of the Rhine and the Meuse. During low tide the sluices are opened and closed during high tide. Due to the high flow velocity in the lock chambers, most fish are unable to migrate from salt water to freshwater
Once the ‘Kier’ project (costs: 80 million €) will be implemented as of 5 September 2018 (official opening), one or more sluices will remain open also during high tide. This will create a brackish water area. The dam will not be completely open. The degree of dam opening will depend on the discharge of the Rhine and the Meuse and is designed to grant that salt water remains west of Middelharnis (about half of the Haringvliet). If the discharge of the rivers is very low and there is thus a possibility that salt water may cross the line between Middelharnis and Siel, the floodgates will remain completely closed and the Haringvliet will be ‘flushed with freshwater’.

(2) **Lake IJssel - enclosure dam**:
The Dutch state aims at restoring the ecological connection between the Wadden Sea and Lake IJssel. That is positive for nature and in particular for the fish in these two important nature areas. Until the seventies of the last century, when fighting water, nature was mainly considered as an enemy to be kept out. Gradually, this attitude has changed. Increasingly, hydraulic engineering aims at preserving nature. It is a challenge and necessity at the same time to achieve a more gradual transition from land to water.

At the enclosure dam, one of the three projects remains to be implemented:
In 2018, construction work on a fish migration river (complex of sluices at the eastern side of the enclosure dam; presumable costs: 55 million €) will begin at Kornwerderzand to establish a several kilometres long wildlife passage between the North Sea and Lake IJssel.

4.1.2 Lower Rhine

There are no transverse structures in this section of the Rhine; the continuity of the main stream of the Rhine is thus given.

Measures in the tributaries to the Lower Rhine (see Chapter 3.1.)

Up- and downstream river continuity of the **R. Sieg** and its tributaries **Sülz** and **Bröl** are to be further improved (see Programme for Migratory Fish North Rhine-Westphalia). Remaining weirs and hydropower plants will be equipped with functioning fishways and improved with state-of-the-art fish protection devices for downstream migrating salmon and silver eel. A pilot system has been installed at the Unkelmühle power plant. The effectiveness of protection and downstream migration devices will be tested during a three year monitoring period. At the end of the on-going monitoring the results will be discussed with all institutions concerned in order to decide on the further procedure for fish protection and hydropower in North Rhine-Westphalian migratory fish waters. In the R. Agger and Bröl a hydromorphological improvement of spawning habitats for fish spawning in the gravel bed is going on. Existing pollution due to urban wastewater is being analysed according to the NRW guidelines on water management and ecological rehabilitation of salmonid waters and will eventually be restored.

In **R. Wupper,** the upstream and downstream river continuity will be further improved so that important spawning habitats in R. Wupper and larger tributaries such as Morsbach and Eschbach will again be accessible. In order to protect downstream migrating juvenile salmon and silver eel and to reduce mortality (max. 5 % damage per hydropower plant) fish protecting systems will be installed at hydropower plants. Additionally, the hydromorphological state of R. Dhünn and R. Wupper will be further improved, e.g. by dismantling river bank stabilizations in order to permit a dynamic development.

River continuity of further important water systems for migratory fish, in particular for eel, such as **R. Erft** and **R. Lippe** will be restored in the course of the WFD implementation and the interlinking of existing alluvial areas and the main channel will be improved.

4.1.3 Middle Rhine

There are no transverse structures in this section of the Rhine so that river continuity is not affected.

Measures in the tributaries to the Middle Rhine (see Chapter 3.1.3)

3 more transverse structures on **R. Ahr** will be modified and measures aimed at improving habitats are planned.

At present, 3 more weirs on **R. Nette** are being modified (costs: 205,000 €). On the medium term, the entire river is supposed to become undisrupted along 50 km in upstream direction.

Along the federal waterway **Moselle**, compensatory payments for the construction of 6 second lock chambers at the 10 barrages in Koblenz, Lehmen, Müden, Fankel, St. Adelgund, Enkirch, Zeltingen, Wintrich, Detzem and Trier will systematically improve the continuity of the Moselle (in upstream direction from the confluence).
In cooperation with Luxembourg, a long-term project is being implemented to re-open habitats in **R. Sauer** (70 ha).
The upstream river continuity of R. Sauer will be improved at the most important migration barrier in the Lower Sauer at the barrage Rosport-Ralingen when the hydropower plant Rosport (Luxembourg) will be rehabilitated. Within this project, and apart from installing a minimum flow rate turbine, two bigger upstream fishways will be installed, one at the main weir, and a ramp at the power plant with a connection to the ecologically restored loop of R. Sauer (construction work will probably begin in 2018; costs: 7 million €). A feasibility study on fish protection and downstream fish migration at this location is planned for 2018.
The programme of measures of the present Luxembourgian Management Plan (2015-2021) includes a total of 52 priority transverse structures across the country, seven of which now allow free fish migration while planning is going on for 32 weirs. For the remaining 13 weirs so far only a preliminary study exists.
Apart from the priority transverse structures, a total of 163 measures aimed at river continuity are planned in the Moselle catchment for the period 2015-2021 resp. 2021-2027 which will open the access to additional spawning habitats. Besides, the programme of measures for some of the main waters and tributaries in Luxembourg includes projects aimed at ecologically restoring spawning and juvenile habitats.
In cases with no use of hydropower, the maximum variant aimed at improving river continuity, that is the demolition of the transverse structure is preferred.
The Luxembourgian water law of 2008 puts an end to all existing water permits by the end of December 2012. In future, and within the renewal of permits, a site-specific overall concept for restoring upstream and downstream river continuity and for fish protection will have to be drafted.
Further measures are planned for **R. Elzbach**, a tributary to the Moselle.

Nineteen barrages - 4 of which are surmountable - in the lower section of the R. **Lahn** in Rhineland-Palatinate block this river. The technical solution for river continuity at the Lahnstein barrage is at present being analysed by the Federal Waterways Engineering and Research Institute with the help of a physical model. 51 further transverse structures in the upper Lahn and 32 transverse structures in tributaries suitable for migratory fish will be modified by 2018, resp. 2027 in order to restore river continuity. Within an integrated LIFE project entitled “Living Lahn”, the Land Hesse and its project partners (federal administration for waterways and navigation, Rhineland-Palatinate) will be able to work intensively on aspects of ecological enhancement of the R. Lahn, including the restoration of river continuity during the years to come.
In another tributary of the Lower Lahn, the R. **Mühlbach**, the modification of 2 weirs in the near future (costs: approx. 180,000 €) is supposed to restore river continuity along 6

km upstream in order to open the access to a further surface of 4.3 ha of spawning and juvenile habitats.
If access is to be granted to the entire grayling region up to the mouth of **R. Lasterbach** near Heuchelheim, river continuity must be restored at 9 more obstacles (1.5 million €).
On the medium term, access for migratory fish to the grayling region as far as the mouth of the **Aubach** upstream of Haiger will be given, once 3 weirs will have been modified.
On the medium term, the last approx. 5 km of the grayling region of **R. Weil** will equally be made accessible by modifying a weir.

On the medium term, measures are planned at 14 weirs in **R. Nahe**.

In order to make further suitable sections located in the upstream region of **R. Wisper** accessible, at least one more weir must be modified, entailing costs of approx. 300,000 €.

4.1.4 Upper Rhine and tributaries (see Chapter 3.1.4)

The main stream of the Rhine offers free migration until south of Strasbourg.

Following a formal notice of the approving authority, the operator of the lowermost barrage on **R. Main** at Kostheim is planning the construction of a second entrance. The planned modification of the next barrage on R. Main at Eddersheim is a WSV pilot installation. Here, not only the restoration of upstream river continuity will be investigated but also reduced damage to downstream migrating fish due to the installation of a more "fish-friendly" turbine. Construction is planned to begin in 2022. Once both these measures will have been implemented, **R. Schwarzbach** in the Taunus mountain range and **R. Nidda** will again be accessible for spawning. Furthermore, the construction of fishways at two more Hessian barrages on R. Main in Offenbach and Mühlheim have been agreed (construction work will presumably start by 2021). At present, the upstream fishway at the barrage Rothenfels/Main is being accomplished. Vast success controls will be carried out at this location. The pilot installation at the Wallstadt barrage is being planned, construction work will presumably begin in 2020.
In the Main catchment, different concepts aimed at downstream fish migration and fish protection have been implemented. Within a Bavarian pilot project two retrofitted conventional hydropower plants are intensively investigated with respect to fish-ecological aspects.

The federal authorities have drafted a concept for action and priorities for restoring river continuity along federal waterways (BMVBS 2012) which equally includes the 27 barrages in the federal waterway **Neckar**. Apart from restoring the ecological continuity of the entire navigable R. Neckar, measures aimed at creating habitats for species living in the river are to be carried out in the sections of the old Neckar. These sections present the best potential for the river fauna. Thus, sufficient water feeding is crucial. The structurally impoverished surrounding sections of the Neckar can only be re-colonized from these locations. Furthermore, for species living in stagnant waters and species without specific requirements, measures must be taken to create habitats in side waters connected only at one end and thus without flow (replacement structures for floodplains) or in parallel channels resp. riverbank structures protected against the lapping of waves. At the time being, the two upstream fishways at Kochendorf and Lauffen are being planned (beginning of construction work presumably by 2021). Furthermore, the upstream fishway located at the weir/hydro power plant Wieblingen, the sluice/hydro power plant Horkheim and Gundelsheim are in their planning phase.

Redesigning some further 19 transverse structures in **R. Alb** aims at restoring river continuity until the mouth of the **Maisenbach** in Marxzell along 36 km by 2027.

An inventory of salmon and juvenile habitats has been drawn up for the French part of the **R. Lauter**; 3 transverse structures near Wissembourg will be modified. On the long term, one further transverse structure in the German upper section of the R. Lauter in the Pfälzerwald will be redesigned.

The **Murg** is one of the important programme waters in Baden-Württemberg and presents a high potential for reintroducing anadromous migratory fish. Their reintroduction is being strived for as far as the upper course at Baiersbronn (about 48 ha). All in all, river continuity is to be achieved at 30 obstacles to migration in these river sections; additionally, structurally intact habitats are to be reactivated by granting a sufficient minimal water flow. Until 2021, the restoration of free fish migration is planned along 70 km of R. Murg. For this purpose, fish protection devices and downstream fishways will be installed at all hydropower plants.

Work and studies concerning the **R. Ill** catchment in Strasbourg and further upstream are continuing. The further improvement of river continuity for fish in **R. Bruche** is under consideration.

In **R. Rench** measures are planned at two more barrages until 2018, at further 11 barrages until 2027 (total costs Rench: 7.5 million €).

In 2018 the attractant stream and the fishing/counting station at the **Iffezheim** fishway will be improved, entailing costs of 252,500 euros.

Within the implementation of the WFD and also outside the area for salmon reintroduction, river continuity will be restored at additional 83 transverse structures in **R. Kinzig** by 2018 and at further 34 by 2027 (total costs Kinzig: 39.5 million €).

Construction work for a fishway at **Gerstheim** is going on, the fishway will start operating in 2018. A counting station for fish is intended.

The new fishways at Strasbourg and Gerstheim will open the access to 59 ha of potential (salmon) spawning habitats in the **Elz-Dreisam** system if upstream migration will at the same time be made possible at the three sills (height of fall 1-2 m) in the old bed of the Rhine at the loops in Gerstheim (1) and Rhinau (2) so that fish may migrate upstream via the Leopoldskanal.
Since their construction, these agricultural weirs in the loops of the Rhine at Gerstheim and Rhinau have been equipped with a basin passage on the right bank and a Denil fishway on the left bank, but river continuity is still very restricted; some fish succeed in migrating upstream, but this statement has not been confirmed by any monitoring. A study commissioned by the ICPR in 2006 for each of the cultural weirs proposes 3 scenarios with different levels which all include the construction of a new functional fishway at least on one bank (s. ICPR report no. 158). Germany is of the opinion that this is necessary in order to open the access to the Elz-Dreisam river system. France, on the other hand proposes solutions aimed at improving the existing fishways on the left bank. A solution is presently being discussed in the Franco-German Committee A. The ICPR will be informed of the results of these discussions.
By 2018, river continuity will be restored at 10 further transverse structures in the Elz-Dreisam-system, at some further 30 by 2027 (total costs Elz and Dreisam: 25 million €).

At the time being, the following barrages on the Upper Rhine at **Rhinau, Marckolsheim** and **Vogelgrün** are insurmountable obstacles between the long downstream stretches of the main stream of the Rhine without any obstacles and the waters with restricted access for migratory fish upstream. Today, upstream migrating salmon have no access to existing salmon waters in the Old Rhine/residual Rhine and tributaries with restored continuity in the Basel area, such as the R. Birs, Ergolz and Wiese and further tributaries to the High Rhine and R. Aare.

The PG ORS has elaborated possible technical solutions for the entrance of upstream fishways and two solutions considered to be technically feasible and aimed at sustainable ecological upstream fishways at the barrage Vogelgrün/Breisach.

In 2008, a new fishway was constructed on the left bank of the **agricultural weir Breisach** giving access to the residual Rhine. A discussion of the process to improve its retrievability is planned in the Franco-German Committee A. The ICPR will be informed of the results.

The **Old Rhine / Residual Rhine** upstream the Breisach agricultural weir does not present any obstacles to fish migration. In this river section there are about 60 ha of high-quality spawning and juvenile habitats for migratory fish, e.g. for salmon.
On the German banks between Kembs and Breisach, flood prevention and at the same time the ecological quality of water and alluvial habitats are being sustainably improved. These measures are expected to considerably enhance the entire ecosystem of the old bed of the Rhine.

4.1.5 High Rhine (see Chapter 3.1.5)

In Switzerland, the measures of the Master Plan Migratory Fish are being extended to the tributaries of the High Rhine and of River Aare so that, once they will have reached Basel, migratory fish may continue further upstream towards the spawning and juvenile habitats (according to new knowledge acquired in 2013, these are located in the R. Aare catchment, e.g. R. Aare until Bielersee, Limmat, Reuss, Sihl, Reppisch, Bünz, Suhre, Wigger and tributaries to the High Rhine such as Thur, Töss, Glatt, Mählinbach - about 200 ha for salmon).

According to the strategic plans of the cantons, the 10 power plants on the High Rhine (+ Schaffhausen[13] = not relevant for anadromous migratory fish) will be restructured. The continuity of R. Aare as far as the Bieler See (15 transverse structures) will be restored; in addition, there are 2 transverse structures in **R. Birs** (7 have already been altered), one in R. Ergolz, 6 in R. Biber and one in the Swiss section of **R. Wiese**.
Total costs are estimated to at least 200 to 300 million CHF. In Switzerland, research continues with respect to restoring downstream fish migration at big hydropower plants. Also, two pilot projects have started on downstream migration in R. Aare. This indicates that great importance is also attached to downstream fish migration in the High Rhine and the other Swiss rivers.

Restructuring work of all Swiss power plants must be accomplished by 2030 at latest. For the High Rhine the cantons have fixed the deadline for restoring upstream migration by 2022. For two plants on the High Rhine no deadlines have yet been fixed. The deadlines for restructuring the power plants have been set according to the decisions of the Conference of Ministers in Basel in 2013 requiring the return of the salmon to Basel by 2020.

In the German part of the High Rhine river system the modification of 29 more transverse structures in the river system and additional habitat measures are stepwise planned until 2027. All in all, 22 ha of spawning and juvenile habitats are planned to be made accessible.

[13] 2022: Restructuring of the Schaffhausen power plant. The Falls of the Rhine at Schaffhausen constitute the natural limit of distribution for the Atlantic salmon.

4.1.6 Lake Constance / inlets to Lake Constance / Alpine Rhine (see Chapter 3.1.6)

On the river **Ill,** river continuity is to be restored by modifying a weir (Dabaladawehr, hydropower production) and two drop structures (regulation) as far as the Montafon and the Klostertal. The habitat will be enhanced by expansion measures and creating lateral networks to serve as spawning and juvenile water body.
In the **Bregenzerach,** river continuity for the lake trout and other migratory fish from Lake Constance will be improved from the mouth up to the Bregenzerach canyon. To this end, measures must be implemented at existing ramps and at an existing technical fishway.
Further river sections are to be enhanced as habitat in R. Spirsbach **(Spiersbach)** so as to fulfil the function of a spawning and juvenile habitat.
Additional measures aimed at improving spawning and juvenile habitats and at restoring morphological variety are planned in the tributaries and the **Liechtensteiner Binnenkanal** itself.
At the time being, measures aimed at ecologically enhancing the **Old Rhine** are being implemented, beginning at the mouth in Lake Constance.
Technical feasibility, financing and ecological effects of measures concerning the **Dornbirnerach**, the **Schwarzach**, the **Bregenzerach**, the **Frutz**, the **Ehbach** and the **Ill** are presently being investigated into.

Further improvements are planned for **R. Schussen**. Thus, the hydropower plant in Berg plays a key role: if river continuity cannot be granted at this location, neither the further course of the Schussen itself, nor the **Wolfegger Aach** or the **Ettishofer Aach** will be accessible.

Further improvements are also possible at the mouth of the **Seefelder Aach**.

5 more transverse structures in the **Stockacher Aach** and its tributary Mahlspürer Aach are being planned.

In the Bavarian R. Leiblach carrying lake trout, additional measures, particularly aimed at restoring river continuity are necessary.

The basic report "Habitat for the Lake Constance Lake Trout" commissioned by the IBKF (IBKF 2009) includes a framework programme integrating and coordinating the national programmes of measures aimed at enhancing the Lake Constance lake trout. The common target is to restore and improve the habitat function of the water bodies. The measures the report proposes for the tributaries of the Alpine Rhine will be implemented according to national priorities (see Annex 1). The report is an important basis for international cooperation of the water management authorities in the common catchment (coordination group for implementing the Water Framework Directive in the area of operation Alpine Rhine / Lake Constance). The report points out the particular importance of the continuity of the tributaries to Lake Constance for the Lake Constance lake trout. An Interreg project particularly aimed at filling gaps of knowledge about the lake trout commissioned by the IBKF was implemented during 2010-2013. The final report was presented in 2014 (see IBKF 2014).

The „Development Concept Alpine Rhine" (2005) drafted by the "International Government Commission Alpine Rhine" (IRKA) in cooperation with the International Rhine Regulation" (IRR) fixes the improvement of flood protection and of river ecology along the Alpine Rhine as primary objective.
The following priority measures aimed at improving flood protection and river ecology from the mouth of the Ill until Lake Constance are proposed and are presently being drafted in the competent bodies:

- River bed widening and bed load management aimed at enhancing runoff capacity to improve river ecology and to stabilize or elevate the river bed and thus the groundwater level;
- Restore river continuity and connectivity with the tributaries to improve river ecology;
- Resolve the problem of hydropeaking as a prerequisite for a substantial improvement of ecological conditions; at the time being, this question is under discussion with the electricity generating industries.

The flood protection project Rhesi for the international section of the Rhine (mouth of R. Ill until Lake Constance) is the first big step towards implementing the development concept for the Alpine Rhine. The General Project will be drafted as of 2016 and will be followed by the detailed project and the construction project. Construction work will presumably last for about 20 years.

4.2 Reduction of pressure from fisheries and predation

The rate of returnees can only be increased, if the problem of bycatches and illegal catches of salmonids on the coast, in the Rhine delta and along the further course of the river is solved. Furthermore, there seem to be indications that predation of downstream migrating smolts e.g. by cormorants impact the rate of returning individuals. In the Rhine bordering countries measures aimed at deterring cormorants have either been made possible thanks to national regulations, provisions or special permits aimed at protecting the indigenous fauna. However, no quantitative investigation into the impact of predators and the effect of deterring measures has been carried out for the entire Rhine catchment.

4.2.1 Reduction of bycatches and illegal catches

In the entire Rhine catchment and in the Dutch coastal area, catching and possessing salmon and sea trout is forbidden by law (see Chapter 3.2). Nevertheless, from today's point of view, illegal fishery must be considered as a limiting factor for big salmonids and allis shad, as implementation is deficient. For sea lamprey, negative effects can be excluded as this species is of not of interest for fishery. Losses of all other migratory fish occur in the entire Rhine catchment and the coastal area and are due to mortality during catches (e.g. injuries and stress), accidental catches (including inadvertent bycatches) and poaching. In particular, there are no reliable data on targeted illegal catches.

Information, intensified controls and the consequent use of penal law will considerably reduce salmonid mortality due to illegal fishery.
Chapter 3.2 describes the national implementation of the recommendations with a view to reducing bycatches and illegal catches included in the first MP Migratory Fish.
The recommendations made in 2009 are still applicable:

1) Supplementary and improved investigations

Supplementary investigations may give an improved insight into the real reasons for disappearing salmon and fish mortality. Telemetry studies with marked smolts will be conducted to follow downstream migrating fish and the effects of measures. Investigations into adult individuals are equally considered to be important but often more difficult to implement.

2) Adequate regulations

a. As far as salmonids are concerned, regulations for catches and sale as well as obligations to release caught salmonids back into the water are solidly anchored in law.
b. Sanctions for infringing these interdictions (e.g. fines) will correspond to the (financial) advantage in connection with catching and selling salmon and will be sufficiently "deterrent". In case of infringement of the regulations, professional fishermen may experience that their permit will not be prolonged or even cancelled.
c. Bans must be enforceable.

3) Information

a. Active information of certain target groups
- Sports anglers (angling and leisure fishing)
- Professional fishermen
- Police and fisheries' surveillance
- Collaborators at fish auctions and fish mongers

The information material will explain

- why it is so important not to take any salmonids;
- how accidental damage to salmon caused by fishing for other species may be reduced;
- interdictions applied to catching and selling salmons. Fines and other eventual penalties must also be mentioned.

b. Information of the public (also by means of the press) on the return of the salmon and sea trout into the Rhine and the Meuse, on the success of measures implemented and why it is so important not to take any salmonids in order to be able to restore their populations. Exceptions may only be made in order to support the programmes aimed at restoring salmon and sea trout populations (e.g. catch parent fish for breeding).

4) Functioning river continuity at constructions and other obstacles

a. Functioning river continuity at constructions according to the most recent state of the art not only mean that more salmonids (and other fish species) may migrate upstream to spawn. It also reduces the time salmon spend at the foot of impoundments and an aggregation of the species in all places, where the upstream migration route is difficult to find – a situation, in which salmonids are particularly vulnerable (predators, fishery).

b. When improving river continuity, it is recommended to strive for an optimal synergy with measures resulting from the Eel Regulations.

c. The creation of a zone without any fisheries, i.e. for which a complete ban of fishing applies is recommended for particularly attractive areas for big salmonids at weirs, sluices, fishways and natural sills if, during their migration, fish are likely to gather in these areas. A complete ban on fishing in these endangered areas may make sense and be enforceable under the Law on Fisheries in order to prevent increased and untargeted catches of big salmonids.

5) Implementation

a. According to indications of the Rhine bordering countries, only individual illegal catches of salmon, sea or lake trout have been registered so far. However, studies and personal communications made by anglers and fisheries experts indicate repeated illegal catches in the different sections of the Rhine. The bans on catching and selling salmon, sea and lake trout, and the obligation to release these species back into the waters after accidental catches will be strictly applied, so that, in practice, interdictions will be effective. If being caught after infringements of such regulations is highly improbable, bans are little effective, in particular if catching salmonids is combined with economic interests.

b. Regulatory and controlling authorities should commission „salmon rangers" in individual areas under protection or at well known "hotspots” of illegal catches to collect information together with anglers on site about locations, time and precise circumstances of illegal bycatches. This should be done in close cooperation with the water police.

c. It is furthermore recommended to try to cooperate with administrators of the impoundments with a view to implementing a fishing ban in areas without fishing activities around the constructions. Many constructions are equipped with a closed loop video system and camera surveillance for operation and administrative purposes. To a limited extent, and respecting data protection regulations, this system might also be used for implementing a ban on fishing.

d. Authorities in charge of food control are requested to examine the origin of salmon for sale in shops or gastronomy.

6) International reporting

Within the annual ICPR meeting of migratory fish experts there is an exchange of information on the implementation of these recommendations in the states in the Rhine catchment and on their practical effects.

4.2.2 Investigations into predation risks

Migratory fish are particularly endangered in the transition between marine waters and freshwater and when surmounting barrages or weirs. In all cases fish may at times be distracted or even disoriented and predators will take advantage of this situation. Passable constructions according to the latest state of the art will reduce the dwell time of salmonids confronted with barrages and a concentration of individuals in any place where it may be difficult to find the way further upstream and thus contribute to a lesser predation risk for salmonids and other migratory fish.

Little is known about the quantitative impact of cormorants or other predators such as birds and predator fish on the salmon populations which have again settled in the Rhine. Telemetric surveys of marked smolts carried out in the German Lower Rhine and in the Delta Rhine in order to trace the way of downstream migrating fish and the effects of partly opening the Haringvliet sluices clearly indicate predation of salmon smolts on their migration towards the North Sea.
Furthermore, during the past years, to some extent 2-year-old salmon smolt marked with transponders were searched for in some cormorant colonies near stocking locations on the R. Sieg, Wupper and Dhünn. According to preliminary results, about 10 to 20 % of the marked 2-year-old smolts were caught by cormorants staying in breeding colonies in the vicinity of the stocking locations.
It must however be taken into consideration that, in this case, 2-year-old smolts from hatcheries are concerned, which have not yet been exposed to any natural environment and thus do not have any experience with predators. Therefore, these investigation results cannot readily be transposed to “wild populations”.
Figure 5 indicates that, in Europe, cormorant populations have greatly increased between 1970 and around 2004 and have since remained at a comparatively stable level.

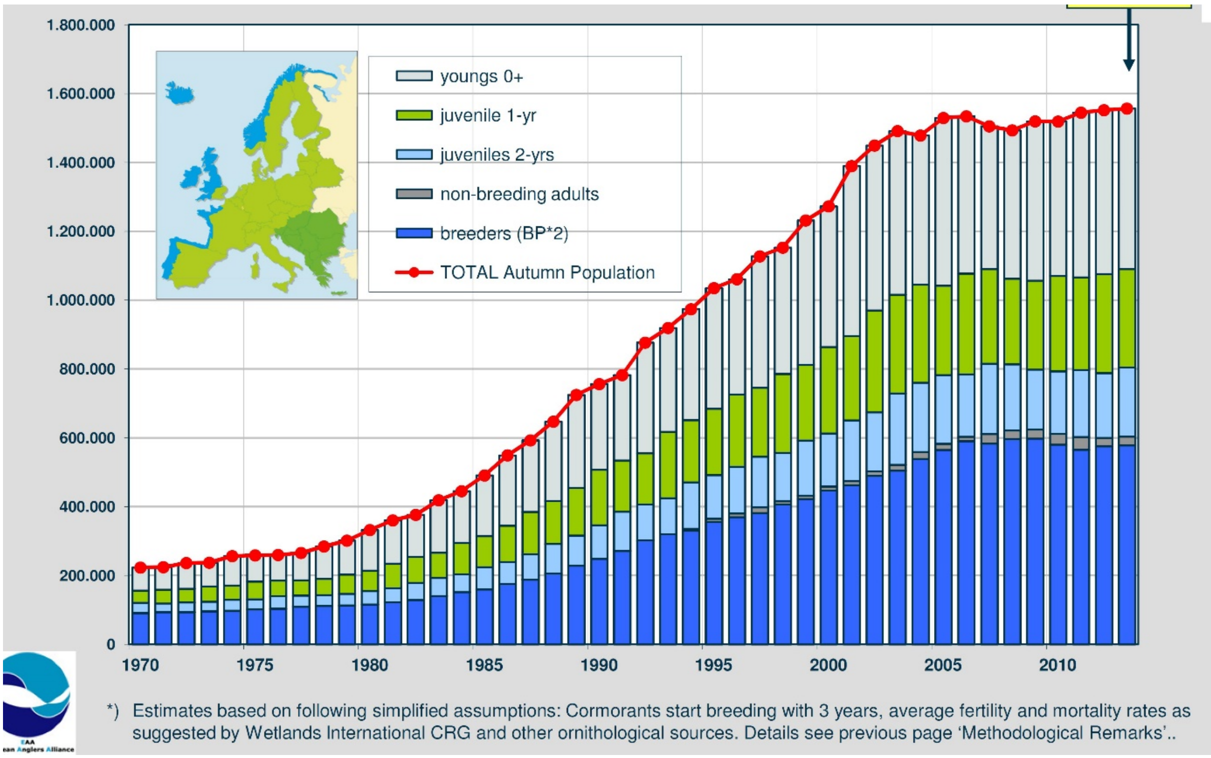


Figure 5: Estimation of cormorant populations (different age classes) in Europe 1970 - 2014 (Kohl, 2015)

4.3 Protection of downstream migrating fish

In many places with weirs and in particular with hydropower use, downstream migration of salmon, sea trout and lake trout smolts and of silver eel towards the North Sea and the Atlantic Ocean (resp. Lake Constance as far as the Lake Constance Lake Trout is concerned) is problematic. Normally, the losses of juvenile salmon and eels are stated to a varying extent; often the severe injuries to the individuals lead to direct or delayed mortality. The rate of losses depends on the type of turbine. In addition, injuries or the disorientation of the downstream migrating fish may cause increased predation in the tailwater of the plants. Barrages retard downstream migration and lead to increased predation (see Okland et al. 2016).

In this connection please also refer to the technical ICPR Report no. 140 on the "Impact of hydropower plants in the Rhine tributaries on downstream fish movement". Thus, injuries caused by turbines or the loss of orientation of downstream migrating fish pose a threat in particular to the migratory fish populations.

Due to cumulative effects, a succession of hydropower plants in river sections may result in a massive deterioration of downstream moving populations. This is of particular importance in cases when, within the reintroduction of migratory fish species, it is not possible to do without functional spawning grounds and juvenile fish habitats upstream of hydropower plants (e.g. case of the salmon) or when an existing migratory fish population, the stock of which is endangered (e.g. eel) has important habitats in such sites.

This chapter presents different techniques aimed at protecting downstream migrating fish which, according to the present state of knowledge may be implemented depending on the nominal discharge of the hydropower plant in order to mitigate negative effects on fish populations. There is still much need for research and development concerning big hydropower plants with a nominal discharge above 150 m^3/s (see Chapter 3.3).

Before implementing fish protection techniques for downstream migration, the possibility of dismantling installations should be considered.

4.3.1 Innovative protection techniques for fish passing transverse structures

The 15th Conference of Rhine Ministers staged in Basel on 28 October 2013 commissioned the ICPR to jointly work on the determination of innovative downstream migration techniques at transverse structures.

Today, several techniques may be used to protect downstream migrating fish: Comparatively high rates of protection may be achieved by physical barriers not letting fish of a certain size pass and combined with downstream fishways (bypasses). Behavioural barriers and management measures such as stopping the turbines for a certain period of time may have a supporting effect. Transitional solutions such as “catch and carry” measures are also applied. As a matter of principle, “fish-friendly” turbines/concepts of hydropower may also contribute to less damage rates.

4.3.1.1. “Fish-friendly” inlet structures

According to the present state of knowledge, a fish-friendly inlet structure must enable the following:

- It must be able to stop the fish and prevent them from migrating downstream through the turbines (physical barrier),
- They must be led to the entrance of a bypass system (behavioural guiding);

- They must then be led into an alternative migration route (bypass) and into the tailwater of the barrage, the overall target being to achieve a high degree of efficiency (Raynal et al. 2013).

All individual components of a fish protection and downstream migration facility at a transverse structure are connected and functionally interlinked, in order to achieve an as intact downstream fish migration as possible in a continuous river corridor without causing injuries. Thus, a downstream fish migration structure is only functional if all individual components are functional and adjusted both to the target species and to the constructional framework conditions of already existing hydropower plants.

Physical barriers adapted to the expected minimal diameter of the fish bodies must prevent that target species and sizes pass. They may have the form of a rack screen or other, physical barriers which cannot be passed. Inflow velocities should be conceived so as to avoid that fish are pressed against the barriers and suffer lethal injuries (<0.5 m/s for smolt and eel). As the fish protection device is also supposed to have a guiding function, it must be oriented such that the entry towards the downstream migration structure is found easily and without any physical damage. Two different screen orientations have been investigated into: screens with an inclined orientation compared to the channel walls leading the fish to one or more outlets on the bank and screens inclined as compared to the river bed, leading fish to one or more surface-near bypass conducts (Figure 6).

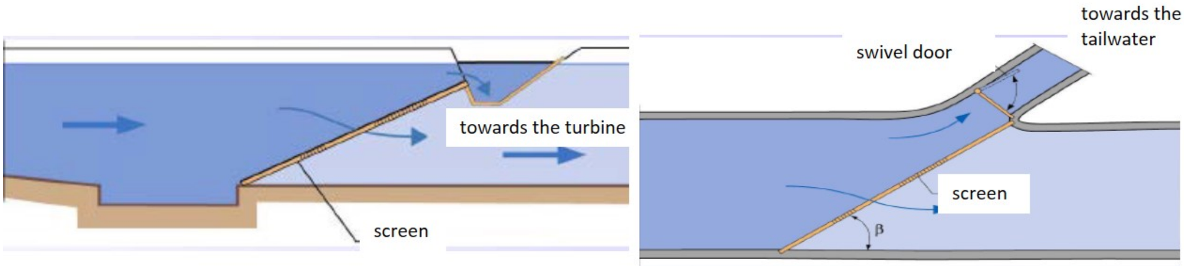


Figure 6: Screen inclined compared to the river bed (to the left, seen from the side) and grids inclined compared to the channel walls (to the right, seen from above) (Dumont et al, 2005).

The location of the inlet structure leading into the bypass and its hydraulic design are of decisive importance. In the inlet structure, flow velocity must progressively and regularly increase and a non-turbulent transition from the watercourse into the downstream migration structure should be achieved. Normally, a bypass is an open or closed channel, smooth on the inside, its size and runoff are sufficient in order to lead fish without any damage and problems like disorientation alongside of an obstacle and into the free downstream migration corridor.

Recent field tests in France (Tomanova et al, 2016; Sagnes, 2016), Germany (Okland et al, 2016) and Sweden (Heiss, 2015; Calles et al, 2013) indicate that 80 % to 90 % of smolts pass through a bypass with sufficient discharge.

Effectiveness tests with inclined screen have been carried through at all hydropower plants with less than 50 m^3/s, effectiveness tests with orientated screens have been carried out at power plants with up to 72 m^3/s (Calles et al, 2013 on the Ätran near Ätrafors). In the US, orientated screens are mostly being installed on smaller and medium-sized inlets, the biggest inlet being that at the Hudson Falls power plant on R. Hudson (max. turbine discharge 227 m^3/s).

Different configurations may be planned at small inlets, such as the Coanda screen (< 5 m^3/s) and the TUM hydro shaft power plant concept (Geiger et al, 2015), etc.

For **behavioural barriers** the same applies as for physical barriers: they are only effective if alternative migration routes exist. That particularly applies to diadromous species for which these devices are of little effect (Bös et al 2012).
The principle is based on the fact that fish are guided according to their reaction towards optical or acoustical obstacles. Thus, water turbidity, ambient noises and in particular hydraulic conditions may lead to altered reactions (Courret & Larinier, 2008). Laboratory tests show positive effects of behavioural barriers, which however largely depend on biotic and abiotic conditions. At the time being there is no planning security for the use of behavioural barriers (BMUB, 2015).
Bös et al (2012) mention a positive rheotaxis of fish, but the stimulation due to the discharge must be above the individual threshold value of each species. Schmalz et al. (Bundesumweltministerium, 2015) state that reactions to a signal (light, acoustic, electrical, etc.) are specific for the individual species. Light will f. ex. attract young salmonids or allis shad but will dissuade eel (Courret & Larinier, 2008). The effectiveness of the behavioural barrier depends on the reaction of the fish and thus on the interaction between the signal and its intensity.
Experimental curtains in a laboratory environment have led to promising results. Peter et al (2015) and Albayrak et al (2015) have tested 34 configurations of bar racks in physical tests and tests using a numerical model. 5 cm screen width led to a good guiding effect for barbel, eel and trout but not for greyling. However, there are only few tests available carried out in full-size installations and often their results are considerably less promising (EPRI, 1994; 2001a; Gosset & Travade, 1999 in Courret & Larinier 2008).

4.3.1.2 “Fish-friendly” turbines and concepts of hydropower

Due to their design, certain turbines may lead to less mortality and injuries of fish. Therefore, these are often called “fish-friendly”. In really fish-friendly turbines and in particular due to the cumulative effects of hydropower plants, the mortality should be around 0 %.
So far, more or less comprehensive fish-ecological analyses have been carried out with certain turbines. Hydrodynamic screws, VLH (very low head) turbines (Courret & Larinier, 2008) and the Mobile Hydropower Plant have been analysed on site. Further analysis of these kinds of power plants is going on. Apart from that, tests of the following are going on: Fairbanks Nijhuis turbines (Winter et al., 2012; Bruijs & Vriese, 2013; Vriese, 2015) and the Voith Minimum Gap Runner (Robb, 2011). Additional theoretically “fish-friendly” turbines (ALDEN, tidal power plants, paddle wheels, etc.) have so far only been submitted to few, strict field trials.

The biggest hydrodynamic screws are designed for 10 m³/s at maximum and a height of fall up to 12 m. VLH turbines can be constructed for 30 m³/s and 2.8 m fall height. The manufacturer of the Fairbanks Nijhuis indicates a turbine discharge of up to 150 m³/s and 15 m height of fall.

Some designs of hydropower plants have been tested with respect to the survival rate of certain species, however, the loss of orientation of fish leading to increased mortality due to predation has not been looked into. So far, little is known about long-term effects on fish having migrated through a hydropower plant.

4.3.1.3 Turbine management

There should be a low number of turbines per hydropower plant so that each turbine will be in full-load operation as often as possible. This is not only optimal from a hydraulic point of view, but it will equally cause least damage to fish (Landesamt für Umwelt Rheinland-Pfalz, 2016).
More precise knowledge of the migration rhythm of the different fish species would make it possible to reduce mortality either by adapting the mode of operation, by targeted

shutting down of turbines or by increasing the discharge in the bypass in order to reduce the number of fish passing through the turbines. Generally, when reducing the turbine operation and not completely shutting it down it should be taken into account that a narrower position of impeller blades increases potential damage when passing through the turbine.

Prediction systems

Prediction systems such as the Migromat® device have been developed in order to announce downstream eel migration. The effect of such devices remains limited, as peaks of fish migration will partly be recognized rather late. The alarm generated will be given during the peak times but only after they have already been going on for several days. In comparison, the observations of professional fishermen prove to be more effective when it comes to anticipating downstream migration periods of eels (Baran & Basilico, 2011). According to the recommendations of the Forum Fischschutz (forum for fish protection) of the German Environment Agency, research on downstream migration devices combined with warning systems must be continued (BMUB, 2015).
Other surveillance techniques use sensors controlling the movement of fish: Cameras, echo sounders, hydrophones and further systems. Their operation is however strongly dependant on maintenance and it may be difficult to differentiate between biological activities and increased floating trash or volumes of floating sediments.
Abiotic warning systems based on evaluating hydrological parameters and their correlation with migration conditions of eels, e.g. the M.A.P. Software (Wendling, 2017) have been developed. Discharge, season of the year and lunar phases, turbidity and water temperature figure among the parameters usually evaluated. Since further parameters might influence the results, the precision of these warning systems remains limited.

4.3.1.4 Catch and carry

Until the required technologies will have been developed, downstream migrating silver eels are equally caught and transported to reduce their mortality in hydropower plants. In Moselle and Sarre, fishing campaigns with fyke nets targeting silver eel have been carried out from May to November since 1997. Annually, some 5 tons of silver eel are caught upstream the barrages in R. Moselle and transported into the Rhine. Thus, the theoretical eel mortality in the 12 power plants has been reduced from 77 % to 55 % (Kroll, 2015). Such measures are also applied in the Bavarian Main catchment, in R. Neckar in Baden-Württemberg, in the reaches of the Middle Lahn, in the German-Luxembourgian border river Sûre and at some pumping plants in the Delta Rhine.

But it is difficult to do this upstream each hydropower plant and, in big rivers, the percentage of saved eel will be difficult to determine.

4.3.1.5 Conclusion

Even downstream migration facilities corresponding to the latest state of knowledge and art will never grant completely safe downstream river continuity. All depending on the quantitative functionality of downstream migration structures there do exist limits with respect to combining hydroelectric power production and the constitution and preservation of migratory fish stocks.

Turbine management and catching and transporting fish remain difficult to implement and the effectiveness of these measures will vary from one year to the next and according to efforts directed towards the hydraulic framework conditions. Mainly, they are targeted at eels.

4.3.2 Results of the international workshop on the issue of "downstream fish migration" in Roermond

On 6 and 7 October 2016, an international workshop on the issue of "downstream fish migration" initiated by the ICPR was staged in Roermond (NL). Discussions within the thematic workshops led to the following findings:

1) Improve the transfer of knowledge

In Europe, there are different approaches towards removing obstacles at hydropower plants in smaller rivers. Partly, these differences are due to spatial facts, but they can also be explained by a lack of knowledge transfer. In Germany, an internet-based atlas[14] was brought on the way in 2016 into which sites with measures aimed at fish protection and downstream fish migration in German-speaking countries can be entered.

2) Gain of knowledge due to more pilot projects and long-term monitoring

In order to be able to assess the total effect of individual measures, more pilot projects with a more thorough and above all longer monitoring are required. The chance for pilot analysis could be improved, if the legal framework conditions were harmonised or at least adapted correspondingly.

3) Determination of standards

There are no standard procedures in order to fulfil the legal requirements of the EU Water Framework Directive (WFD). In most cases, there are only site-specific applications which may lead to different measures being implemented at different hydropower plants in one and the same river.

Everywhere in Europe fish migration and the effect of measures protecting migratory fish are being examined. In order to achieve comparable investigation methods and results, generally accepted standards of the efficiency of "fish-friendly" measures are required, among others taking into account the mortality acceptable at a hydropower plant. Such a standard combined with the results of standardised investigations would equally convey more legal assurance to operators implementing measures aimed at fish protection/downstream fish migration.

4) Establishment of a system aimed at assessing ecosystem performances

Another problem discussed was the lack of a system assessing ecosystem performances compared to the economic values of a river. In Europe, there are many small hydropower plants contributing little to the overall energy production but heavily impacting the environment.

4.3.3 Ecological continuity and fish protection in the legislation of the Rhine bordering countries

The Rhine bordering countries have drafted the following targets and recommendations for fish protection:

Netherlands:

In 2014, a political guideline was published in the Netherlands concerning the grant to use water http://wetten.overheid.nl/BWBR0035841/2015-01-01 which is based on a test frame for hydropower plants 'Voorstel voor een toetsingskader voor waterkracht-centrales (WKC's) in Nederlandse Rijkswateren' (report no. 20130475/03, 20 September 2013, drafted by Rijkswaterstaat WVL assisted by the consultants ATKB).

[14] http://forum-fischschutz.de/atlas-standorte

Germany:

The Water Resources Act (Wasserhaushaltsgesetz - WHG) is the key legal instrument within water management. The §§ 33 to 35 WHG regulate the minimal water discharge, the preservation and restoration of river continuity and the use of hydropower in connection with suitable fish protection measures. Apart from that, all German federal states have passed individual Fisheries Acts including additional regulations to protect fish populations.

DE - North Rhine-Westphalia:

According to the NRW fisheries regulation, a clearance of 10 mm between the bars of a screen apply to salmon target waters, for eel it has been set to 15 mm (§ 13, section 3 LFischVO). However, inflow velocity at the screen may not exceed 0.5 m/s (§ 13, section 4 LFischVO). Downstream fish migration must be granted by a bypass in the near vicinity of the screen, which must be open during the migration periods of the fish species.

DE Rhineland-Palatinate:

Apart from § 35 WHG, § 44 of the Landesfischereigesetz (LFischG) of Rhineland-Palatinate (Damage preventing measures at water intake structures and power units) is relevant. Generally, it is required to use fish-repelling 15 mm vertical screens (only eel waters) or 10 mm vertical screens (salmon waters) or a fish repelling 15 mm horizontal screen for material fish protection.

DE-Baden-Württemberg:

In September 2016, the state institute published two online publications on fish protection and downstream fish migration at hydropower plants which include recommendations on the technical foundations, permits under the Water Act and function control. These are free of charge and are available here:

- Handreichung Fischschutz und Fischabstieg an Wasserkraftanlagen (Fachliche Grundlagen): http://www4.lubw.baden-wuerttemberg.de/servlet/is/263550/?shop=true
- Handreichung Wasserrechtliche Zulassung von Fischschutz- und Fischabstiegsanlagen (FSA) bei Wasserkraftanlagen: http://www4.lubw.baden-wuerttemberg.de/servlet/is/263553/?shop=true

DE-Hesse:

According to the Hessian Fisheries Law (Hessisches Fischereigesetz - HFischG) the principle of avoidance applies with respect to fish protection at water intake structures and power units (hydropower plants) which means that fish must be prevented from entering the structure. It is up to the individual operator to ensure this. § 10, Section 4 of the Hessian Fisheries Regulation (HFischV) puts this requirement into concrete terms: The operator of a plant must thus use a screen with max. 15 mm clearance between the bars if no equivalent procedure according to the state of science and art is applied preventing fish from entering and enabling safe downstream migration in accordance with animal welfare for all fish species. In individual cases, authorities may decide on stricter minimal requirements for protection devices and discharge.

Luxembourg:

Presently, the Water Act of Luxembourg does not include any basis/regulation taking into account measures and implementation criteria concerning fish protection and downstream fish migration. However, the Fisheries Act of 28 June 1976 requires operators of hydropower plants to install protection devices at intake structures, resp. at

the entrance to the turbines in order to grant the protection of incoming fish. Comparable to Rhineland-Palatinate, the Fisheries Act is however not implemented accordingly. The implementation of requirements for fish protection and downstream fish migration in Luxembourg today mainly concerns existing hydropower plants as the size of most surface waters and the corresponding topographic conditions do not convey any profitability and thus no applications for the construction of new hydropower plants have been filed during the past years. Corresponding measures are legally required for new applications under the Water Act. Due to the Water Act of 19 December 2008, all permits under this law have been invalid since December 2012, meaning that they are no longer valid and each hydropower operator must file a new application.
For all present and future projects aimed at restoring river continuity at existing plants the directives for fish protection according to the latest state of scientific knowledge and art apply. Thus, every detailed planning will take into account the valid requirements of fish protection for the target species and thus also for the target waters. The suitable type of screen, inflow velocity, the maximum clearance between bars (10-15 mm vertical, resp. horizontal screens depending on the target species of the relevant water body) as well as the inflow angle are determined according to the latest technical expert reports.

France:
The law on water and aquatic habitats of 2006 includes a reform of the law on river continuity for migratory fish. Article L214-17 of the environmental law stipulates a classification of rivers identified for "migratory fish" based on two lists and depending on their importance for fish migration (list 1: Interdiction of new obstacles and list 2: Equipment of constructions to achieve river continuity for migratory fish). A river may at the same time be classified in List 1 and List 2 along its entire length or for river sections. This e.g. applies to the Rivers Ill, Doller, Lauch, Bruche, Weiss, Liepvrette, Moder, Sûre, Giessen, Fecht, Lauter - just to name the most important ones.

For the purpose of the law, river continuity concerns up- and downstream migration, when important waters are concerned (rivers for big migratory fish or trout rivers) for which an obligation as to results (not as to means) exists. Thus, there is no specific legislation ruling downstream river migration. The Agence de l'Environnement et de la Maîtrise de l'Energie (ADEME) has published "Guidelines for the design of fish friendly intake structures for small hydropower plants". (Courret & Larinier, 2008) Download: http://www.onema.fr/sites/default/files/pdf/2008_027.pdf

Switzerland:
The Federal Fisheries Act of 1991 stipulates that within each technical interference with a water body, free fish migration is to be granted and that it is to be avoided that fish and crabs are killed or injured by constructions or machines. The revised Water Protection Act which entered into force in 2011 obliges owners of hydropower plants to eliminate ecological impairments caused by the use of hydropower by 2030. The interference with fish migration figures among these impairments. Obstacles which considerably interfere with fish migration must be rehabilitated by 2030 at latest. The cantons have determined the precise deadline for the different hydropower plants within their strategical plans (accomplished in 2014). As constructional rehabilitation measures may not yet be carried out for big hydropower plants in rivers, the restoration of downstream fish migration at these installations may be separated from that of upstream fish migration and may be implemented later (but before 2030). However, operational optimization has already been investigated into when looking into the variants and must be implemented in any case. It is expected that, when analysing variants, all possible constructional and operational solution approaches and the probability of damages in the different downstream migration corridors are being evaluated. When restoring upstream migration, it must be demonstrated that possible construction measures aimed at downstream migration are not impeded. Also, strategical planning can include measures

aimed at habitat protection near hydropower plants which do not concern up- and downstream fish migration. The owners of hydropower plants receive complete compensation for the implementation of measures (when transboundary waters are concerned according to the national share). The Federal Office for the Environment has published a publication on the implementation of restoring fish migration (BAFU, 2012).

4.4 Evaluation and control of measures

The sustainable success of the Master Plan Migratory Fish Rhine not only requires to implement measures, but also to verify their functionality. The results of studies already carried through must be published and shared, in order to pass on positive experience to decision-makers and to prevent inefficient measures in future.

4.4.1 Evaluation and control of the functionality of fishways

There are different methods to check the functionality of fishways. The continuous video surveillance at fishways such as in Iffezheim counts fish, identifies them and thus contributes to the collection of longstanding data on upstream migration at a site.

Telemetric methods to monitor fish migration are technically well developed and used with success for certain applications, depending on the system.

In the different Rhine bordering countries, evaluation and control are carried out as follows:

<u>Netherlands:</u>

The fishways on the Nederrijn near Hagestein, Amerongen and Driel are cleaned occasionally. In future, this will at least be done once a year.

<u>DE - North Rhine-Westphalia:</u>

The effectiveness of fish protection and of downstream fish migration devices for salmon smolt and silver eel is being analysed within a three years telemetric monitoring (among others at the pilot installation Unkelmühle/Sieg). The target is to be able to recommend protection schemes which have shown to be effective to operators. Comparable to the construction of upstream fish migration devices which must follow existing regulations this aims at eliminating the necessity of labour intensive and expensive future monitoring. However, operators must grant for the maintenance of up- and downstream fish migration and fish protection devices so that these can permanently be operated and their ecological functionality remains granted.

<u>DE - Rhineland-Palatinate:</u>

In general, authorities will require the applicant of a new/newly edited water right (for operating a hydropower plant) to implement a monitoring of the functionality of a newly constructed fishway. Often the applicant (in particular private companies) and authorities will have a hard fight concerning a conclusive assessment and it will be necessary to negotiate compromises.

<u>DE - Hesse:</u>

In the Hessian section of R. Main a series of evaluations and controls of fishways are carried out within on-going water legislative procedures. As these procedures are going on and the operators will normally have been obliged to carry out investigations within ancillary clauses of water law decisions, not all results have yet been published. The investigations required concern early warning systems, mortality and migration routes at transverse structures.

The functionality of the fishways for up- and downstream fish migration at the hydropower plant Kostheim on R. Main was e.g. checked between March 2011 and April 2012. The monitoring concerned the functioning of the bypass river, mortality when passing through turbines, use of downstream migration corridors, of the bypass, the eel bypass and downstream salmon migration. Results show that vast improvement measures are required to optimize the functionality, as injuries due to the cleaning of the screens and when passing by the screens (loss of scales, haematomas) and injuries in turbines lead to a total mortality of about 50 %.

DE - Baden-Württemberg:

The procedures launched under water legislation aimed at approving fishways are based on the state of the art and site-specific fish-ecological requirements. Once a device has been accomplished authorities review the correct constructional work. The correct operation and maintenance of fishways are being monitored by the water authority and the fisheries authority in charge. In the light of events individual devices can be subjected to biological function controls.

DE - Bavaria:

Within the procedures launched under water legislation aimed at approving fishways, requirements according to § 35 (protection of fish populations) are checked. Once a device has been accomplished, authorities review the correct constructional work. Within the technical supervision of water bodies, the correct operation and maintenance of fishways are being monitored by the water authority and the fisheries authority in charge. In the light of events individual devices can be subjected to fish-ecological function controls. Within a pilot project in the catchment of R. Main, two conventional hydropower plants retrofitted with fish protection and downstream fish migration devices are the subject of intensive fish-ecological investigations.

There is a state of the art for the construction and operation of upstream fishways (DWA M-509, resp. Praxishandbuch Fischaufstiegsanlagen in Bayern). If the construction of fishways differs from this state of the art, their function must be demonstrated by biological monitoring.

Federal waterways (Germany - across the Länder):

At the new fishway at Koblenz/Moselle the German Federal Institute of Hydrology (BfG) in Koblenz and the Waterways Engineering and Research Institute in Karlsruhe are carrying out fishery biological investigations, among others with video, sonar and transponder technique. Furthermore, investigations are carried out concerning the movement patterns of fish downstream the barrage at Kostheim/Main and etho-hydraulic laboratory investigations are carried out in the test channels of the Federal Waterways Engineering and Research Institute concerning the fish behaviour in parts of installations of upstream fishways with differing designs. Findings will be used for the operational and design optimization of existing and planned upstream fishways in federal waterways. In the Rhine area, the barrages on the Lower Ruhr, Moselle, Lahn, Main and Neckar are concerned. The BfG plans a comprehensive monitoring of retrievability and passability of upstream fishways at different pilot sites in the Rhine catchment.

Luxemburg:

For new projects aimed at restoring river continuity at existing obstacles there will be a success control to determine the functionality of the fishway. The monitoring will comprise an inventory of the fish population in the tailwater of the barrage, water structures relevant for fish and of abiotic physical-chemical parameters (e.g. flow velocity) downstream and upstream the obstacle before implementing the measure and a second inventory of the fish fauna upstream the obstacle after completion of the fishway.

Existing fishways are being maintained by regional offices of the Water Authority in Luxembourg, in many cases by the operator of the plant if flotsam has to be removed from the fishway.

France:

For the catchment of Rhine and Maas the regulations of the SDAGE 2016-2021 recommend that authorities carry out an inspection when fishways are constructed. A decree completing the water law will then determine the characteristics of the fishway and the obligations of result and maintenance applicable after each flood and before the migration period of certain species.

Due to national regulations the prefect has the competence to grant exemptions or to adopt provisions taking into account the particularities of the rivers in his departement.

The prefects' decrees permitting a fishway comprise the obligations of the licence holder: construction, measurements, maintenance (removal of debris jam) and monitoring. Once construction work is completed, the French Agency for Biodiversity (part of which is the former ONEMA) checks the conditions for the patency of the construction for each fish species with the help of its own ICE-protocol (ICE = Informations sur la Continuité Ecologique = Information on Ecological Continuity).

With respect to eventual sanctions in case of a breach of the provisions provided, the prefects' decrees refer to the Environmental Code[15]. During the construction and operation the state agents of the services of the departements and the water police have access to the installations at any time in order to control whether the provisions of the decrees are being respected.

Switzerland:

Success control is an integral part of a project (restoration and reconstruction/construction) and is entirely compensated in case of projects restoring river continuity. In this matter, the Swiss Federal Environment Agency has published the "Implementation of measures aimed at restoring river continuity". This publication is available under https://www.bafu.admin.ch/bafu/de/home/themen/wasser/fachinformationen/massnahmen-zum-schutz-der-gewaesser/renaturierung-der-gewaesser/fischgaengigkeit.html. A comprehensive manual is being drafted.

4.4.2 Evaluation and control of measures fighting illegal fishery (particularly around barrages)

In the different Rhine bordering countries evaluation and control are carried out as follows:

Netherlands:

Illegal fishery is exclusively controlled by the fisheries control (regulatory, authoritative, sworn, and private) under the Fisheries Act.

DE - North Rhine-Westphalia:

Illegal fishery is exclusively controlled by the fisheries control (regulatory, authoritative, sworn, and private) under the Fisheries Act of the Land.

DE - Rhineland-Palatinate:

[15] https://www.legifrance.gouv.fr/affichCode.do?cidTexte=LEGITEXT000006074220 „Legislative part / Book II: Physical environment / Chapter VI: Provisions on controls and sanctions"

Illegal fishery is exclusively controlled by the fisheries control (regulatory, authoritative, sworn, and private) under the Fisheries Act of the Land. During the last 20 years it has been stated that due to safety reasons less persons engage in executing the law.

DE - Hesse:

Illegal fisheries are exclusively controlled by the fisheries control (regulatory, authoritative, sworn, and private) based on regulations of the Hessian Fisheries Act (HFischG) and its implementation regulation (HFischV). As fishing rights in the Hessian part of the Rhine range under the competence of the Land Hesse, harvest control rules with respect to the period of the time of the year, the area concerned and with respect to quality aspects can be determined in the so-called general conditions of the fishing permit for the Rhine.

DE - Baden-Württemberg:

The fisheries control is based on the Fisheries Act for Baden-Württemberg. The Fisheries Authority is responsible for its implementation and appoints state and voluntary fish wardens.

DE - Bavaria:

Illegal fishery is exclusively controlled by the fisheries control (regulatory, authoritative, sworn, and private) under the Bavarian Fisheries Act.

Luxembourg:

Sporadically and eventually following hints from the public or the water authority, officials of the Nature Management Authority or police officers implement controls of illegal fishery. In this context it must be observed that there is no professional fishery in Luxembourg.

France:

The general regulation of fisheries in inland waters and the management of fish resources are brought together in Book IV, Section III of the French Environmental Code.[15] The fisheries inspection belonging to the French Biodiversity Agency, fishing cooperatives and French state agencies are in charge of controlling that regulations are respected. The conditions for controlling fishery in inland waters, stating breaches and sanctions are determined in Articles L437 and L438 of the Environmental Code.

Switzerland:

Illegal fishery is exclusively controlled by the fisheries control (regulatory, authoritative, sworn, and private) under the Fisheries Act.

4.4.3 Success control of stocking measures by means of genetic investigations

Genetic investigations are a new indicator since the first Master Plan Migratory Fish was published and is used for success control and optimization of migratory fish stocking exercises.
The genetic investigation of the DNA of fish is a comparatively new tool offering various possibilities of supporting the Master Plan Migratory Fish for the Rhine. Genetic investigation means that tissue samples of parent fish in salmon hatcheries are analysed and will later on be compared with samples taken from future returning adult individuals. ICPR fisheries experts have stated that such analysis is of great interest and that coordinated genetic investigations of Atlantic salmon in the Rhine catchment would thus

make sense. Within a pilot test during the winter 2016/2017 samples were taken from parent fish in several salmon hatcheries.

In future, this method may contribute to find answers to the following questions:

- Have the returning salmon been part of stocking exercises and if yes, where and when?
- Which stocking strategies prove to be efficient?
- When will it be possible to reduce or stop salmon stocking exercises?
- Has a self-sustainable Rhine population developed?

On a national scale, genetic investigations of Atlantic salmon in the Rhine catchment has already been carried out in Switzerland, France, Germany and the Netherlands.

Within a pilot project[16] carried out in Switzerland, genetic samples were taken from parent fish in a hatchery which are used for harvesting fish eggs used for stocking measures. In the following, fish to be released were equally genetically screened and correctly identified and assigned to the parent fish following a paternity test.

In France, the national research institute for agriculture[17] did a comprehensive screening of salmon from the Allier catchment. Annually, tissue samples are taken from all parent fish in the hatchery in Chanteuges. In the following, returnees caught were genetically analysed several times (3 age groups) using the SALSEA-Merge method in order to determine the efficiency of stocking measures.

On the Upper Rhine, the “Association Saumon-Rhin” has been analysing all returnees since 2008 which were caught in the fishways in Gambsheim and Iffezheim.

In 2014, and on behalf of the German Länder Rhineland-Palatinate and Hesse, tissue samples were taken from 79 salmon (juvenile fish of the same year for stocking purposes, generation 2013) in the hatchery “Hasper Talsperre” and analysed in the Agri-Food and Biosciences Institute Northern Ireland (AFBINI) in Belfast using the SALSEA-Merge method and microsatellite markers. Most samples could be ascribed to the donor population from R. Ätran (Sweden), some rare samples were ascribed to its neighbouring river Lagan and Irish salmon populations. There was just one sample with slight clustering with “Allier” origin. This means that apparently there are hardly any stray fish and, apart from ascribing to Irish salmon populations, there are no traces of the mixed stocking in the 1990s. Also, no indications were found hinting at substantial losses of genetic variability, incest or kinship.
The analysis of 11 salmon from R. Nette, where there are no stocking exercises showed origins from Great Britain, Ireland and in one case Norway.
In 2016, the German Land North Rhine-Westphalia ordered the analysis of samples taken from some 700 salmon within the NRW programme for migratory fish of age classes 2004-2015 and which were equally analysed by AFBINI (SALSEA-Merge method). The analysis concerned returnees to R. Sieg and their descendants from the Wildlachszentrum Rhein-Sieg and the fish hatchery/parent fish farm Albaum (LANUV NRW). First results show that: Most of the associations with origins in UK & Ireland and Sweden/Eastern Norway indicate the donor populations used in the course of the years (Burrishole/Ätran), in individual cases they pointed towards salmon of French origin (Loire/Allier). At the time being there is no danger of losing genetic variability due to fish breeding.

[16] Aquabios 2015. Genetisches Monitoring Rheinlachse – Phase II: Pilotversuch Schweiz. Aquabios GmbH, Auftraggeber: Bundesamt für Umwelt (BAFU), Departement Bau, Verkehr und Umwelt, Sektion Jagd und Fischerei, Kanton Aargau.
[17] Institut National de la Recherche Agronomique (INRA)

Within genetic investigations in the Netherlands (Rhine delta), 46 of the 75 evaluated samples dating back to 1999-2013 could be associated with a probability > 80 % to one of the 18 regions of origin determined by SALSA-Merge (Study 2014: Dennis Ensing AFBI NI). Most individuals were of Irish origin. These salmon may be descendants of salmon from this region which, in the past, were used for stocking exercises in the Rhine and Meuse. 12 individuals were of Loire origin and may thus presumably be traced back to stocking exercises in the Upper Rhine (Allier strain). 29 individuals could not be traced back to any region of origin. These individuals might have a mixed genome including both types from northern and from southern Europe. It is most probable that the 4 individuals from Norway, resp. Russia have escaped from aquaculture farms.

Within the European project SALSEA-Merge[18], a set of microsatellite markers was made up which is used in as many genetic studies of Atlantic salmon as possible. The method has been compared by the different laboratories and results are stocked in a centralized data base in Scotland. Thus, data of all laboratories are comparable and for evaluation purposes the data base is available for all of them. Recent analysis of different delegations is already based on this method.
The future coordination of genetic investigations of Rhine salmon may equally make use of this standardised method.

5. Effects of measures implemented: What do the stock of migratory fish species and the Rhine ecosystem look like today?

Migratory fish such as salmon and eel are good success indicators for the Master Plan and programmes aimed at restoring water quality, biodiversity and the habitat patch connectivity along the Rhine, e.g. Rhine 2020 (see ICPR 2001).

Progress made during the past 15 years with respect to opening spawning waters of anadromous migratory fish or restoring river continuity is today seen in the increasing number of returnees, in particular of salmon and sea lamprey and in the considerably increasing number of proofs of reproduction in accessible waters. After a temporary decline of evidence of returning big salmonids such as salmon and sea trout during 2009 to 2013, a hitherto unprecedented number of salmon (228) was counted at the control station Iffezheim (Upper Rhine) in 2015 (Figure 7). As a result of the measures already taken, at least several hundreds of salmon have annually returned to the Rhine since the end of the 1990s and are documented by more than 8800 detected salmon until the end of 2016 (Figure 8). However, salmon populations are not yet self-sustaining and the number of returnees varies from one year to the next. Apart from salmon, the number of returning sea trout and sea lamprey has equally risen again since 2014.

Due to the past stocking exercises in Hesse and North Rhine-Westphalia and the now starting natural reproduction, the number of returning allis shad should distinctly increase in the years to come. Counts at the Iffezheim fishway in the Upper Rhine confirm this assumption. A large number of upstream migrating allis shad (157) was first documented in Iffezheim in 2014; on 10 July 2013, the first allis shad was registered in the Moselle (Koblenz control station) since 60 years and 1, resp. 2 and 4 allis shad were recorded in the Delta Rhine in 2012, resp. 2013 and 2014. In 2015, 3 allis shad were counted in R. Main, in R. Neckar their number even amounted to 36.

Due to the now improved Rhine water quality and the already implemented measures targeted at improving river continuity and at enhancing structural variety, the biocoenosis of the main stream of the Rhine has recovered: many original invertebrate Rhine species have returned; the species composition of the fish fauna is almost complete, even though this does not apply to all river sections and to the original dominant species proportions. Given the today and in future heavily modified Rhine

[18] http://www.nasco.int/sas/salseamerge.htm

system, the historic population densities of salmon and other species migrating over long distances will presumably not be achieved. Measures aimed at reducing the phosphorous content of the water body have resulted in a distinct attenuation of peaks of phytoplankton development so that Rhine water is today clearer than it used to be. Due to an improved "light climate", aquatic plant communities typical of rivers and floodplains could again establish in sections of oxbow lakes and protected groynes of the Rhine and thus improve the habitat offer for phytophilic fish species. Measures implemented within the Master Plan Migratory Fish will continue to enhance the positive development of the Rhine ecosystem.

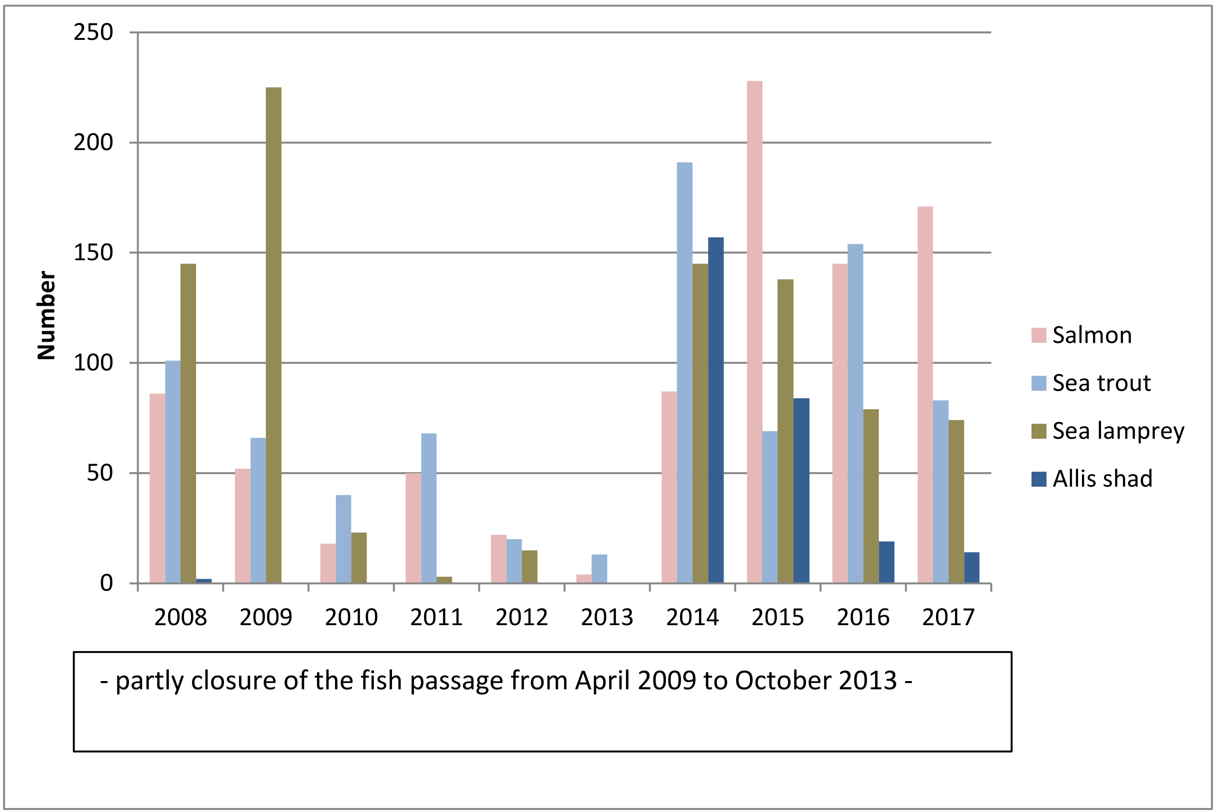


Figure 7: **Number of returning individuals of 4 migratory fish species at the Iffezheim fishway**

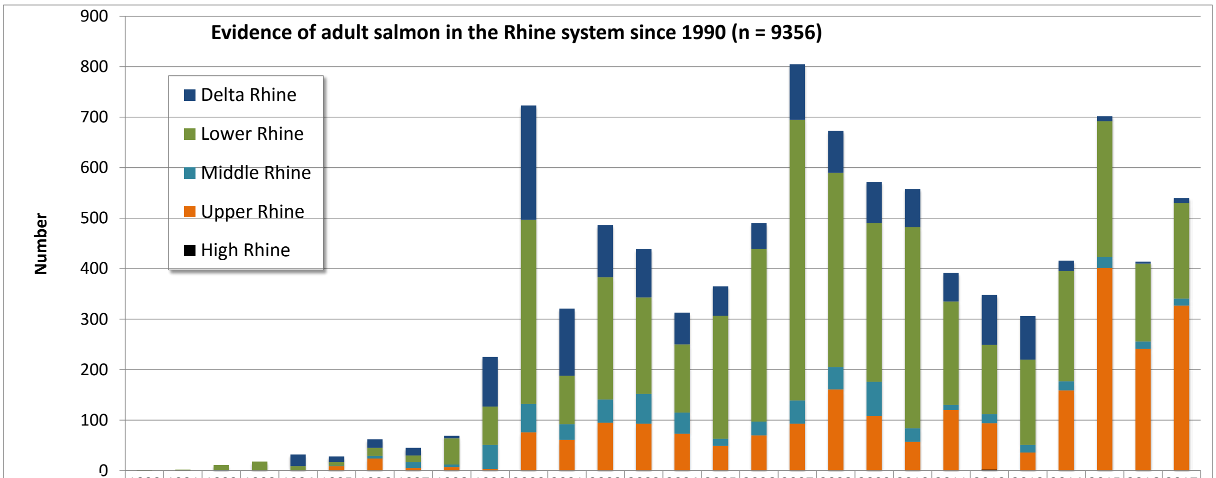
5.1 Atlantic salmon

The first salmon stocking measures in the Rhine catchment date back to 1988, when salmon were first stocked in two R. Sieg tributaries (Bröl and Naafbach, Lower Rhine, DE-NW). As early as 1990, the first returning adult salmon was detected during an electro-fishing campaign in R. Bröl. Since then, stocking as well as monitoring has been intensified in all programme waters in the Rhine catchment.

Annex 2 informs about what stocking stage was used in which waters in the Rhine catchment; the stocking rivers are listed in Annex 3.

Returnees:
In general, and after an intermediate peak in 2007, the identified number of returnees decreased during the years until 2013 (Figure 8). It must be taken into account that, until 1999, returnees were almost exclusively documented due to electric fishing. Since 2000, monitoring stations have been operating at Iffezheim/Rhine and Buisdorf/Sieg. Thus, due to a change of method, the number of identified returnees abruptly rises in

2000. The temporary rise in the number of identified returnees in 2007 coincides with the cessation of Irish drift net fishing. The decreasing number of returning individuals between 2008 and 2013 has been registered in all water systems and thus also concerns both donor origins (Upper Rhine: Allier; Middle Rhine and Lower Rhine including Main: Ätran). On an international level, increased “marine mortality” has been registered in many regions in Europe and America during the past 15 to 20 years without really sufficiently understanding the mechanisms of action. The decreasing number of adult salmons in the Rhine equally correlates with a decrease of the number of identified sea trout and this leads to conclude that the Rhine corridor (including the coast) faces multispecies problems. According to ICPR fish experts, catching and considerable predation as well as the still unsatisfactory continuity of the Haringvliet in the Delta figure among these problems. For the period 2014 to 2017 the Figures 1, 2 and 3 in Annex 7 again show increasing numbers of adult salmon identified at the fishways in Iffezheim and Gambsheim on the Upper Rhine and at the monitoring stations in Moselle and Sieg compared to previous years. In 2017, adult salmon were for the first time again observed in the Elzbach, a tributary of the Moselle.



Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Delta Rhine	0	0	0	0	23	11	17	15	5	98	226	133	103	96
Lower Rhine	1	2	10	18	9	7	16	13	52	76	365	96	242	191
Middle Rhine	0	0	1	0	0	1	5	12	5	48	56	31	46	59
Upper Rhine	0	0	0	0	0	9	24	5	7	3	76	61	95	93
High Rhine	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Delta Rhine	63	58	51	110	83	82	76	57	99	86	21	10	4	10
Lower Rhine	135	244	342	556	385	314	398	205	137	169	218	269	154	189
Middle Rhine	42	14	27	46	44	68	27	10	18	15	18	22	15	14
Upper Rhine	73	49	70	93	161	108	57	120	92	36	159	401	241	327
High Rhine	0	0	0	0	0	0	0	0	2	0	0	0	0	0

Figure 8: Number of salmon identified in the Rhine system since 1990.
Restricted operation of the Iffezheim fishway between April 2009 and October 2013. Due to abandonment of fyke-net fishing in the Netherlands in 2011, fewer returning salmon were identified. The number of identified individuals per section of the Rhine represents the sum of several (on the Upper Rhine partly successive) monitoring stations.

Reproduction:
The proofs of reproduction are compiled in Annex 3. The listing points out the direct relationship between the proof of natural reproduction and improvements of river continuity. Today, the main reproduction areas are to be found in the river systems of R. Sieg, Ahr, Saynbach and in the Bruche (Ill river system). In 2007/2008, considerable natural reproduction was also documented for the R. Wisper (Middle Rhine). In the Black Forest rivers Alb, Murg and Kinzig spawning activities of returned salmon have been regularly observed since 2011. Increasingly, stocking exercises are stopped in R. Agger and Naafbach (Sieg system) as, in these rivers, natural reproduction has been observed for some time.
The stock will be supported until the ecological framework conditions will have improved and the number of returnees indicates a stable salmon population. For some river systems on the Lower and Middle Rhine (Sieg, Saynbach, ev. Ahr) it is expected that by now 5 to 20 % of the returnees are descendants of salmon born wild and are thus at

least to be attributed to the first generation of “wild salmon”. However, in most regions, the occurrence of “wild salmon” has been decreasing during the past four or five years.

Figure 9: **Salmon alevin of natural reproduction**

5.2 European eel

For protection purposes and for the future management of the endangered eel populations in Europe, the European Union issued a regulation (EC No. 1100/2007) focussing on a reduction of eel mortality of anthropogenic origin. Based on this regulation, all EU Member States with natural stocks of eel drafted national Eel Management Plans by end 2008 which they handed over to the EU Commission. The ICPR report no. 207 published national measures under the Eel Regulation implemented in the Rhine catchment during 2010-2012. In the following, the state of the stock of eel and the state of implementation of national measures aimed at stabilizing the stocks of eel in the Rhine catchment are summarized.

Stock:

During the past decades, the stocks of the European eel have greatly declined in almost its entire distribution area, including the Rhine and its tributaries. Since the beginning of the 1980s, only a few percent of the long-time average number of glass eel return upstream into the rivers. Among the known causes figure habitat modifications, parasite infections, the construction of hydropower plants for energy production, overfishing of the stock of glass and silver eel and sediment pollution. Furthermore, changes in marine currents transporting eel larvae towards European coasts should be taken into account as one reason for the reduced occurrence of glass eel.

In almost all water bodies of the Rhine catchment where eel occur, migration is impeded by transverse structures. This particularly applies to the Delta Rhine, the southern Upper Rhine and almost all Rhine tributaries. In particular, downstream migrating eels are at risk: Often, they get into the turbines of hydropower plants, intake structures, pumps, etc. Due to the length of their bodies they often collide with moving parts of these constructions and suffer grievous, mostly lethal injuries; the cumulated mortality may be considered substantial if several transverse structures follow one another.

The numbers of glass eel occurring on the Dutch coast again fell back on a low level after having shown a slight upwards trend (Den Oever-Index for the period March to May: 2013: 4.9 %; 2014: 4.6 %; 2015: 0.2 % of the long-standing average).[19] Additionally, the ICES Working Group on Eel (WGEEL) is entering the data from the states in the Rhine catchment into the calculation of the Recruitment Index for glass eel; this index gives evidence of a comparable decline.

The environmental target of the regulation is to secure the downstream migration of at least 40 % of the silver eel biomass into the sea compared to the natural stock. Models for calculating the rate of downstream migration have been developed in the Netherlands, Germany and France. For Germany the calculations for 2011-2013 revealed

[19] ICES. 2016. Report of the Joint EIFAAC/ICES/GFCM Working Group on Eel (WGEEL), 24 November–2 December 2015, Antalya, Turkey. ICES CM 2015/ACOM:18. 130 pp and Country Reports.

that on average 149 t/year of silver eel migrate downstream the Rhine, corresponding to 52 % of the reference value. The implementation reports for the period 2014-2016 will be available as of June 2018.

In France, the stock of silver eel in the Rhine catchment in 2012 was estimated to 7 t.

A monitoring of yellow and silver eel in the rivers Rhine, Moselle, Saar, Lahn, Sarre and Nahe in 2013 based on electrofishing/fyke-net fishing shows that the age structure of stocks is slowly beginning to level out. This could indicate an improvement of the stock which might be a consequence of increased stocking exercises in the Rhine.

Analysis of eel in the Rhine catchment states carried out between 2000 and 2011 along the Rhine and in many tributaries gave evidence of extensive pollution of the fish with dioxins, furanes, dl-PCB and mercury, in some cases also indicator PC or hexachlorobenzene (HCB). In the Delta Rhine, a major decrease in HCB contamination of yellow eel was apparent since the 1970s, from more than 0.1 mg/kg FW to values of about 0.01 mg/kg FW. Fluorosurfactants (PFT) as well as perfluorooctanesulfonic acid (PFOS) also accumulate in eel. So far, little is known about the effect of the different pollutants on the health of the fish; however, a physiological contamination which in particular concerns the long spawning migration is assumed.

Measures:

The obligations resulting from the Eel Regulation have been entered into the fishing laws of all EU states in the Rhine catchment, apart from Luxembourg, where the regulation is directly implementable ex officio. Switzerland is not obliged to implement the EU Eel Regulation. The harmonization of the equivalent regulations on the High Rhine with Baden-Württemberg does however happen within the cooperation in the Fishing Commission for the High Rhine.

Almost everywhere, where it plays a relevant role, commercial fishing and sports angling have been limited by fish protection periods (between 3 months in winter and all year), minimum fish size (50 cm) and/or a ban on professional fishing gear. In the Netherlands, there is a ban on professional fishing of silver eel between September and November. However, illegal fishery is an issue.
Due to pollution of eel with dioxins, there is a ban on professional fishing of eel in the Dutch Rhine. Sports anglers are committed to release any eels caught.

Due to the known pollution, almost no eels are professionally caught in the German part of the Rhine catchment. Figure 10 shows that since 2008, eel catches in the German part of the Rhine catchment have fallen by more than 50 % and reached a stable level compared to the period before implementing the eel management plans (2005-2007).

Due to their mercury content, a ban on selling and eating eel from the Rhine, the Grand Canal d'Alsace, the Ill and its tributaries has been issued in France. At a national level, there were many police actions targeted at illegal fishery.

There is no professional fishing for eel in Luxembourg or Switzerland.

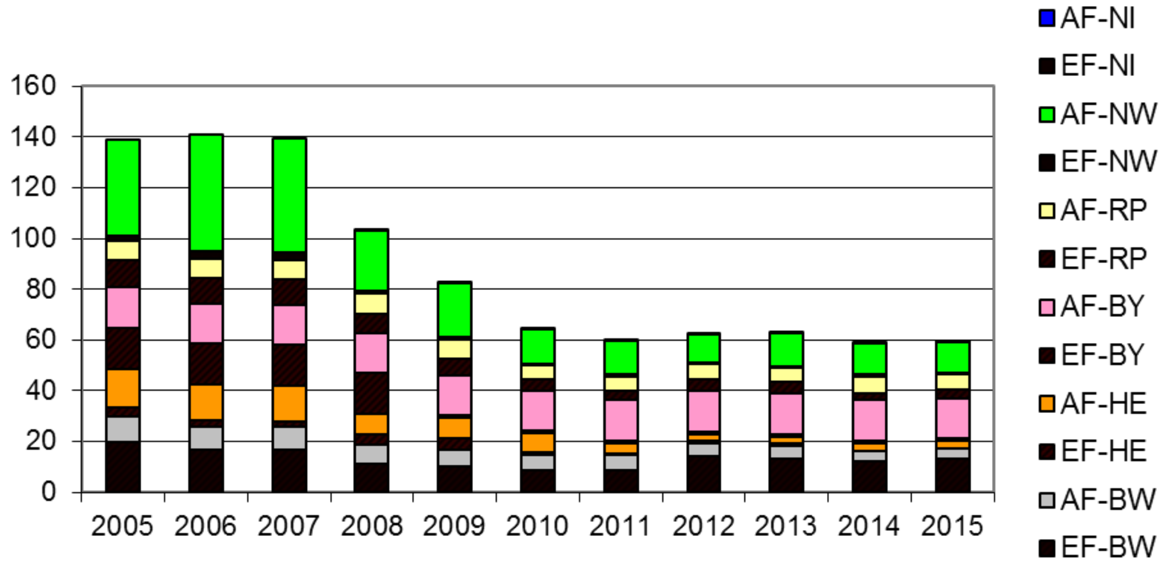


Figure 10: Eel catches (t) of professional fishers (EE) and sports anglers (AF) in the German eel catchment of the Rhine. NI = Lower Saxony, NW = North Rhine Westphalia, RP = Rhineland Palatinate, BY = Bavaria, HE = Hesse, BW = Baden-Württemberg

In the Netherlands and in Germany (except for the High Rhine) different public organisms, professional fishermen and fishing associations carry through stocking exercises. In North Rhine Westphalia, eel is analysed with respect to *Anguillicoloides crassus* before being released. In France, and Luxembourg there is no release of eel in the Rhine catchment.

Within the implementation of the EU WFD, many hydromorphological measures are carried out from which the eel will also profit.

Numerous protection devices for eel at transverse structures (in all Rhine bordering countries) and pumps (in the Netherlands) were implemented by 2015 or will be implemented by 2027. They include upstream migration facilities, screens protecting downstream migrating eel and turbine management during the main eel migration period. Partly, these measures are carried out as a part of licence renewal for existing hydropower plants. Priorities were set for certain waters particularly suitable for eel. In France, the construction of new transverse structures has been interdicted in certain waters. Examples of such measures are:

The hydropower plant in the German-Luxembourgian border river Sûre at Rosport-Ralingen equipped with two vertical Kaplan turbines and a nominal discharge of 70 m^3/s represents the greatest and so to speak only potential danger for eel migrating downstream the Sûre catchment.
The Sûre catchment covers about 4.300 km^2 and almost completely drains into the R. Sûre at Rosport, before this river flows into the Moselle some 15 km further downstream. In order to protect eel migrating downstream towards the sea from injuries induced by turbines, downstream migrating silver eel have been caught in the headwater of the weir in the power canal of the hydropower plant Rosport-Ralingen since 2004. Depending on seasonal discharges, two fishing methods are normally applied between June and September. Fyke-net fishing if discharges are moderate and handle-end fishing if discharges are higher after heavy rainfall. The subsequent transportation of the eel into the Rhine results in comparative high survival rates, as the 10 hydropower plants on the Moselle between Trier and Koblenz (D) are avoided. Depending on the amount of eel caught, the professional fisher commissioned either directly carries the fish from Rosport to Koblenz or the eels are brought to the collecting point for eel from the Moselle-Sarre catchment from where they are carried into the Rhine.

In the power canal of the hydropower plant at the site Rosport-Ralingen between 282 and 960 eel were caught between 2004 and 2015 which were then safely brought into the Middle Rhine.

Since 1995, Rhineland-Palatinate has been carrying out a comprehensive eel protection programme (Aalschutz-Initiative Rheinland-Pfalz/innogy SE) together with Innogy SE, the operator of the hydropower plants (Landesamt für Umwelt Rheinland-Pfalz, 2006). Apart from investigating into physical and intelligent measures aimed at considerably reducing resp. preventing eel mortality in turbines the project consists of an immediate measure described as a bridging technique. During these catch-and-carry measures, 5.34 t of silver eel (in 2016 well 5 t) were caught upstream the power plants in the Moselle and transported into the Rhine. The operation of the 12 hydropower plants on the Moselle adapted to eel migration is triggered, when the number of silver eel caught by professional fishermen between July and December distinctly increases and implies the maximum possible opening of all gaps of all Kaplan turbines (simulation of a situation at full load) between 8 pm and 6 am. Catch-and-carry methods for eel in the Moselle have increased their survival rate from 23 % to 45-47 %. If in addition all turbine operation is adapted to eel requirements without modifying the power plants, a survival rate of 55 % is achievable.
In 2015, silver eels were for the first time caught upstream of power plants on R. Saar and transported into the Rhine within the project in Rhineland-Palatinate.

The Land Hesse has been operating "catch-and-carry" for eel in R. Lahn since 2012. Efforts towards stocking measures were considerably increased in 2016 as now stocking exercises are carried out in the Hessian section of the Rhine and its oxbow lakes on behalf of the Land. When amending the Hessian Fisheries Regulation (HFischV), a ban on stocking eel in stagnant waters permanently blocked for fish migration was decreed for the entire Land.

"Catch-and-carry" is also being operated in Bavaria. Annually some 4 to 6 tons of silver eel are caught in the Main catchment and transported from the Harrbach barrage to the confluence of the river with the Rhine. Thus, eel avoid 18 transverse structures with 17 hydropower plants. Additionally, 4 hydropower plants on R. Main are equipped with eel-migromates and 2 hydropower plants have zigzag pipes with a counting system.

Measures in Bavaria are also described in detail here:
http://www.lfl.bayern.de/ifi/flussfischerei/030519/index.php

In France, the national eel management plan aims at reducing eel mortality due to human interference, but not to fishing by 75 % in 2018. To achieve this, further measures of the Water Framework Directive will be implemented and ecological river continuity is to be restored. During 2010-2015, 4.32 billion € have already been invested in such measures.

There is research on "fish-friendly" turbine management (Germany, Luxembourg, France), on the main migration period and the downstream migration behaviour of eel (Netherlands, Meuse area; Germany, Neckar), on infrasound barriers and reporting systems (Germany), on mortality and migration behaviour of eel at hydropower plants (Germany, France) and on artificial eel breeding (Netherlands).

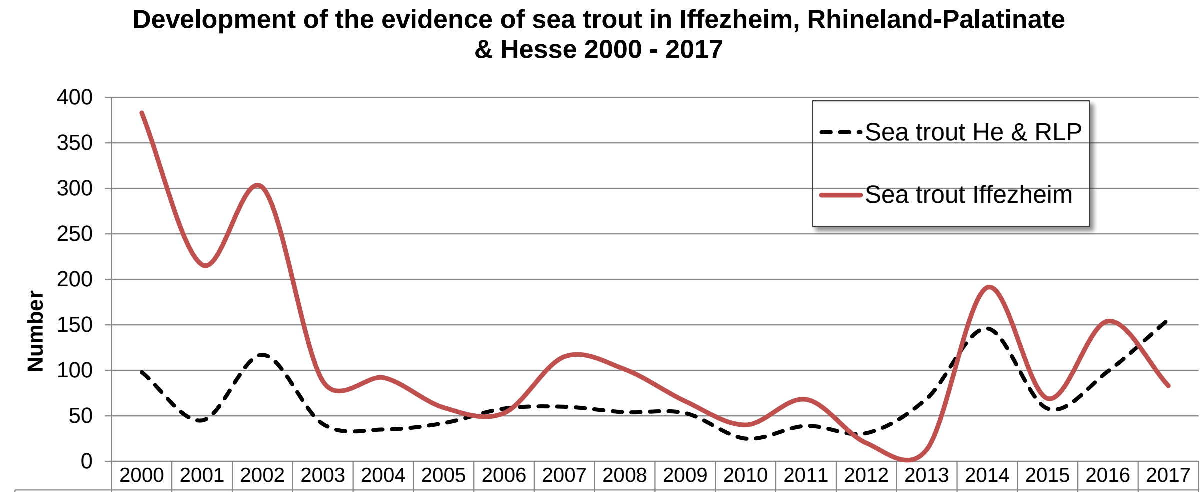
In some German federal states, limited shooting of cormorant has been permitted with a view to protecting the stocks of eel and other fish.

Measures fighting the pollution of eel with PCB: According to the 2nd Management Plan for the Rhine (see ICPR 2015), all measures have been implemented to reduce PCB emissions and no direct PCB inputs are known. Heavily polluted sediments must be cleaned up to the greatest possible extent (see ICPR report no. 175 and 2nd Management Plan for the Rhine, ICPR 2015).

5.3 Sea trout

Returnees:
As for salmon, the numbers of detected individuals distinctly fell during 2007 to 2013. Figure 4 in Annex 7 shows that the numbers of adult sea trout detected in the fishway at Iffezheim and Gambsheim have distinctly increased in 2014 after the fishway at Iffezheim resumed full operation in November 2013. Figure 5 in Annex 7 presents data for the Moselle (Koblenz fishway). Figure 11 compares the development of the number of individuals detected at Iffezheim with those in Hesse and Rhineland-Palatinate.

Reproduction:
There are no comprehensive findings available concerning successful sea trout reproduction as it is not possible to differentiate between young sea trout and the potamodromous “brook trout” and both usually occur together. Since their requirements to spawning habitats largely correspond to those of salmon, the sea trout is almost exposed to the same restrictions with respect to deficient river continuity and quality of habitats. It is to be assumed that reproduction is very successful in those waters where salmon also successfully reproduces.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Sea trout He & RLP	98	45	117	41	35	42	58	60	54	53	25	39	31	69	146	58	99	156
Sea trout Iffezheim	383	216	301	88	92	59	53	115	101	66	40	68	20	13	191	69	154	83

Figure 11: Sea trout detected at Iffezheim (Fishway monitoring, data: Fischereiverwaltung Baden-Württemberg, Association Saumon-Rhin, ASR) and in Hesse & Rhineland-Palatinate (different methods) during 2000 to 2017.

5.4 Sea lamprey

Returnees:
During 2010-2013, a massive fall of returnees was stated at the monitoring stations Iffezheim and Gambsheim. However, the functionality of the Iffezheim fishway was considerably restricted due to construction measures beginning in 2009. Annex 7, Figure 6 shows distinctly higher numbers of detected sea lamprey for 2014 and 2015.

Reproduction:

Proofs of reproduction of sea lamprey exist from all parts of the *accessible* Rhine catchment (apart from the Dutch section). Redds and sometimes even lamprey larvae have among others been detected in the R. Ill system, R. Wieslauter, Murg and Kinzig and in the Middle Rhine rivers Wisper, Saynbach, Nette and Ahr. The Sieg-system as well as the Wupper-Dhünn-system equally range among present reproduction areas. Reproduction of the species has also been detected in the main stream of the Upper Rhine (presumably as far as the Strasbourg barrage). That means that today's stock is reproductive.

5.5 River lamprey

Presumably, the statements concerning the sea lamprey will largely also apply to river lamprey. As redds of river lamprey are smaller and more insignificant, they seem to be more difficult to detect and proofs of reproduction are rarer. On the Upper Rhine, proofs of reproduction exist from the main stream downstream of Iffezheim and from the tributaries Alb and Murg. In the downstream section of R. Murg great numbers of juvenile river lamprey are observed. There are no reliable quantitative data available with respect to the present situation of the stock and in particular any comparison with the decline of the stock of sea lamprey.

5.6 Allis shad and twait shad

Since 2008, and within an EU-LIFE (2007-2010) and a LIFE+ project (2011-2015), comprehensive stocking exercises aimed at reintroducing the allis shad into the Rhine system have been implemented in the Upper and Lower Rhine as well as in the R. Sieg (NRW). Due to these stocking exercises the number of upstream migrating allis shad in the Rhine has distinctly risen (Annex 7, Figure 7). In 2014 and 2015 significant numbers of upstream migrating allis shad (157 and 82) were detected (Figure 12). In the Rhine tributaries Moselle (Koblenz monitoring station), Neckar (functional check at the Ladenburg fishway) and Main (grid system at the hydropower plant Kostheim and tributary Nidda) 50 allis shad were observed during the same period of time. The detection of numerous juvenile individuals in the Upper Rhine far upstream of any stocking exercise locations, in the Middle, Lower and Delta Rhine prove natural reproduction of allis shad during 2013 to 2016. In 2016, 16 allis shad were registered at Iffezheim and one in R. Main, but on the whole the number of individuals observed is distinctly lower than in previous years. This must be seen against the extreme floods of the Rhine in the spring of 2016 which will have had negative effects on the migration and presumably also on successful allis shad reproduction.

An international project financed by state and private means will at first secure the continuation of the most important core measures targeting allis shad.

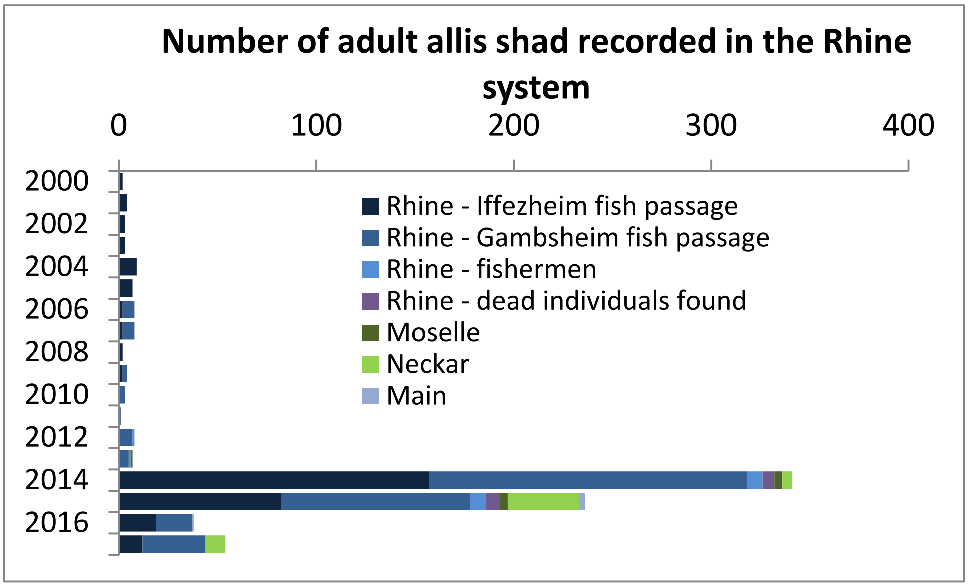


Figure 12: Number of adult allis shad registered in the Rhine system
(Graph: A. Scharbert)

Twait shad

According to Wiegerinck *et al.* (2008) a total of 78 individuals of this species close to the allis shad was registered within the passive fish monitoring in 2006 and 2005 and 2004 376, resp. 332 individuals were detected. In the delta area, there seems to be a small, reproducing stock.

5.7 Lake Constance Lake Trout

In the sub-basin Alpine Rhine/Lake Constance the Lake Constance lake trout (*Salmo trutta lacustris*) is the fish species migrating over the longest distances. In the Lake Constance region, it is therefore also called “inland salmon”. Just as the salmon downstream of the Rhine Falls it has an important role for achieving the water protection targets. The Lake Constance lake trout grows up in Lake Constance until it is mature to spawn, subsequently it migrates into the tributaries to Lake Constance to spawn. This migration may stretch over 130 kilometres into the tributaries to the Alpine Rhine. Due to its complex habitat requirements self-sustaining lake trout populations are only able to settle in obstacle-free water systems with habitats for all stages of development permitting to conclude the entire life cycle of the species.

During the 1970s, and in spite of stocking exercises, the yield of the lake trout continuously sank in Lake Constance (Figure 13). Looking back, the first lake trout programme of the “Lake Trout Working Group” was responsible for the survival of the lake trout in Lake Constance and that it may today again be used for commercial fishery. Saving the last spawning fish, the subsequent stocking measures and the gradual elimination of obstacles to migration in the spawning rivers figured among the decisive measures. In particular the construction of the fishway at the Reichenau (Switzerland) hydropower plant in 2000 represented an important step towards reopening historical spawning waters. In order to sustainably secure the stock of fish, they must again have the possibility to develop self-sustaining populations. The long-term target is to reduce the presently required intensive stocking measures or to even be able to completely stop them. The successful programme aimed at saving Lake Constance lake trout is being coordinated by the working group Migratory Fish of the Internationale Bevollmächtigtenkonferenz für die Bodenseefischerei (IBKF) (International Conference of

Plenipotentiaries for Fishery in Lake Constance). In 2017 and based on findings of the studies carried out during the past years on spreading, development of stock and genetics of the Lake Constance lake trout the IBKF determined guidelines (see IBKF 2017) for the future fisheries management and supporting measures for this endangered fish species. Considerable deficits of habitats continue to exist in the tributaries to Lake Constance, in particular with respect to river continuity.

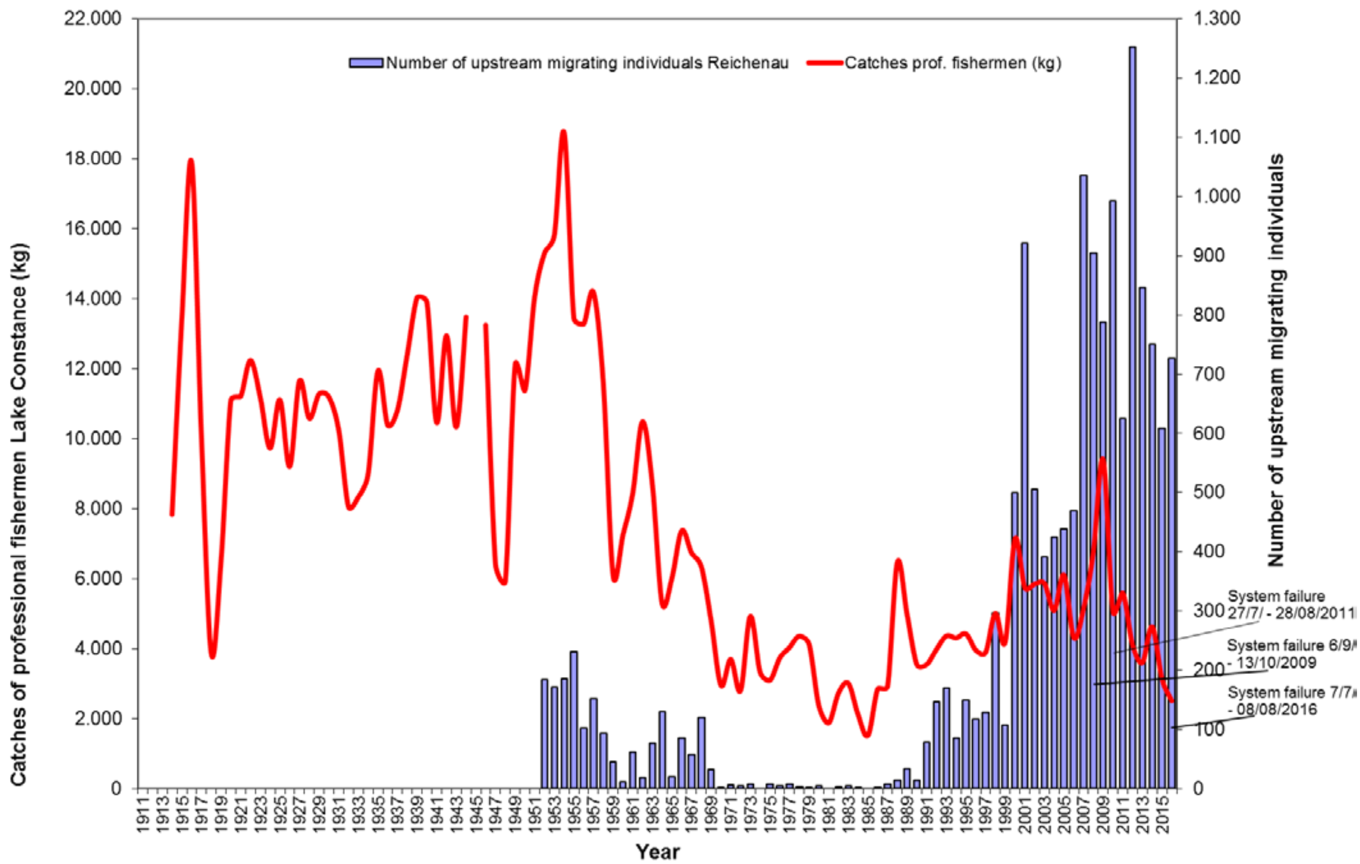


Figure 13: Lake Constance lake trout catches by professional fishermen in Lake Constance-Obersee and number of fish migrating upstream at the Reichenau power plant (Switzerland): Caught broodstock (until 1999), fyke-net control (as of 2000) and video counting (as of 2007). (Chart from IBKF, 2018)

5.8 Houting

The former houting population in the Rhine was considered to have died out; for the Upper Rhine evidence must still be given that the houting used to be found here (regularly). The individuals which, historically, did appear here, may also have belonged to congeneric genus (*Coregonus*) having migrated downstream from the lakes in the Alpine region. Therefore no stocking or restoration programmes are planned for Upper Rhine.

In North Rhine-Westphalia the stock of houting has distinctly increased following stocking exercises (see Wiegerinck et al. 2007) and is successfully reproducing in the lower course of the Rhine and in the delta. In 2011, ten houting were caught during "schokker"-fishing within the framework of scientifically supported monitoring fishing; these were adult individuals mature to spawn. Stocking measures carried out since 1996 in the Rhine were stopped again as early as 2006 and since then, a self-sustaining population has established (Borcherding et al. 2014). During drift net fishing in March 2014 in Rees near the Dutch border houting larvae were detected which equally confirms successful reproduction in the German section of the Rhine. Thus, this long-lost migratory fish species has been successfully reintroduced into the Rhine.

5.9 Information on European sturgeon

In the Rhine catchment, the European sturgeon (Figure 14) died out in the 1940s / 1950s. The reintroduction of the sturgeon into the Rhine catchment is not part of the ICPR Master Plan Migratory Fish.

Worldwide, the sturgeon belongs to the most endangered species. The only river in which the European sturgeon still reproduced until quite recently is the Gironde-Garonne-Dordogne river system in France. The French National Sturgeon Action Plan is concentrating on this river system and does not concern the Rhine catchment[20]. But the ex-situ breeding of sturgeon of the IRSTEA (formerly CEMAGREF) institute since 1981 does support other European sturgeon stocking projects, as that in R. Elbe in Germany[21].

In the Netherlands, the WWF in cooperation with the ARK foundation and Dutch sports anglers released 47 juvenile sturgeon into R. Waal near Nijmegen and near Rotterdam. The fish originated from the French ex-situ hatchery. In 2015, 44 young sturgeon (4 years old) were released in the German-Dutch border area. They were all equipped with transponders. All of them swam downstream and 50 % reached the North Sea. During the next years (life span of the transponder) it will be observed, which habitats in the Rhine delta are used by the species and how they are used.[22] For the years 2017 to 2020 the sturgeon project of WWF, ARK and Sportvisserij Nederland will concentrate on determining the chances of a sturgeon reintroduction programme in the Netherlands. An analysis of suitable habitats will give a survey over possibilities and problems of the potential reintroduction of the species into the river (see Staas, 2017[23]), its estuary and the marine environment.

The ICPR will continue to gather information on this project.

Figure 14: European sturgeon (photo: S. Wieland)

[20] Ministère de l'Ecologie, du Développement durable, des Transports et du Logement 2010
[21] http://www.bfn.de/habitatmare/de/spezielle-projekte-wiederansiedlung-stoer.php
[22] see www.steureninnederland.nl
[23] https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjFtrz4w6XZAhUKjqQKHRRnAi8QFggpMAA&url=https%3A%2F%2Fharingvliet.nu%2Fsites%2Fharingvliet.nu%2Ffiles%2F2017-12%2FSturgeon_reproductive_habitat_Rhine.pdf&usg=AOvVaw0RLNHJOg7U2Wqv9Vk3DlON

6. Recommendations and outlook

Since the Master Plan Migratory Fish Rhine was published in 2009, considerable progress has been achieved with respect to recovering the river continuity and accessibility of habitats. Also, measures fighting bycatches and illegal fishery have been taken and stocking exercises have been implemented. The increasing number of upstream migrating adult salmon, allis shad and other migratory fish species demonstrate the positive effects of measures implemented.
However, the stocks of some migratory fish species are not yet self-sustaining in the entire or parts of the Rhine catchment. They continue to require the stocking of juvenile fish, implementing further hydromorphological measures and habitat improvements, the restoration of up- and downstream river continuity at further transverse structures and fish protection at hydropower plants and pumping stations. Apart from these most important measures the further reduction of the pollutant load, measures aimed at preserving temperatures near to the natural state and aimed at restoring bedload dynamics, the restoration and preservation of a near-natural water balance and local measures impacting predators are of importance. Measures taken in the marine environment may also greatly impact all long-distance migratory fish. So far, the impact of invasive species on fish communities in the Rhine has not been determined.

Since the opening of the fishway at Strasbourg in May 2016, the ecological upstream continuity of the main stream of the Rhine is restored until downstream the Gerstheim barrage. Many smaller tributaries dispose of a great potential of valuable habitats for juvenile fish which may only be exploited once these areas are accessible.
For the next years, further measures aimed at restoring river continuity are planned for numerous transverse structures in the entire Rhine catchment. On the Delta Rhine, the partial opening of the Haringvliet sluices in 2018 and the construction of a fish migration river are planned for the enclosure dam. In the partial catchment area of R. Sieg, at the Moselle barrages and on further tributaries on the Middle Rhine and in the partial catchment of R. Main further measures aimed at river continuity are planned. In the main stream of the Rhine the inauguration of the fishway in Gerstheim is planned for 2018 and in tributaries to the Upper Rhine and the High Rhine river continuity will be restored at further transverse structures in order to restore longitudinal connectivity and to reconnect valuable salmon habitats.
With respect to lacking river continuity in the section of the Upper Rhine upstream of Rhinau until upstream the barrages Vogelgrün/Breisach and solutions envisaged please refer to the activities of the PG ORS.

During the past years, many measures were focussed towards improving upstream migration, now, increasingly, there is a shift towards also improving river continuity for downstream migration. The conference of ministers in 2013 asked the ICPR to intensively work on the joint determination of innovative techniques of downstream migration at transverse structures in order to reduce the losses of salmon, eel and other fish species in the turbines during their downstream migration. The exchange of international experts during a workshop on innovative solutions and challenges when implementing fish protection measures staged in October 2016 will be continued.

Therefore, and taking into account climate change and its expected impacts on the fish fauna, **optimizing and restoring the ecological continuity** remains an important measure (see ICPR report no. 219). The rise in water temperatures and modified bedload dynamics might influence reproduction and development, migration patterns and the sensitivity of fish to diseases (see ICPR report no. 204). In particular, salmonids are adapted to cooler waters and would be driven back or try to migrate to higher ranges in order to avoid critical temperatures. However, a migration to higher regions is only possible, if upstream river sections are accessible and dispose of an adequate structure. Further measures resulting from the European Water Framework Directive and the implementation of nature protection laws such as increasing minimal discharge / minimal water flow, improving water quality and ecological restoration of waters will increase the resilience of fish populations and of water ecosystems facing changing climate conditions (see Baptist et al. 2014).

In order for measures within the Master Plan Migratory Fish Rhine to be successful, new fishways for up- and downstream fish migration are required, but the **functionality of existing fishways must equally be checked** in order to dispose of a basis for eventually required optimisations.

The rate of salmonid returnees can only be increased, if the problem of **bycatches and illegal catches** of salmonids on the coast, in the Rhine delta and along the further course of the river is solved.

The genetic investigation of the DNA of fish is still a comparatively new tool offering various possibilities of supporting the "Master Plan Migratory Fish for the Rhine". ICPR fisheries experts have stated that such analysis is of great interest and that a coordinated genetic investigation of Atlantic salmon in the Rhine catchment would thus make sense. In particular, genetic investigation can in future be used for the **success control of stocking measures** carried out in the Rhine catchment.

The exchange of information on investigations into stocks of migratory fish in different inland waters and in the Atlantic Ocean will increase the understanding of the complex life cycle of migratory fish.

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Glossary

Adult: Adult, mature, a designation of the phase of life after reaching sexual maturity
Allochthone: non-indigenous, alien
Anadromous: migrating from marine waters into freshwater in order to spawn
Autochthonous: indigenous
Benthos: All organisms living in the bottom zone of a water body
Benthic: living on the bottom of a water body
Diadromous: migrating between marine waters and fresh water
Dominance: Predomination of a species in a biocoenosis
Eurytopic: living in most different biotopes. For fish: no particular hydraulic preferences
Eutrophic: nutrient-rich with a high phosphate content and thus high organic production
Fauna: All animal species in an area
Grilse: Salmon returning to spawn after having spent one winter at sea.
Herbivore: Plant eating
Habitat: characteristic living place of a plant, an animal or another organism
Homing: Instinct of certain fish (e.g. adult salmon, sea trout, greyling) to return to their home waters
Hybrid: Individual having developed from crossing different species
Interstitial space: gravel interstice on the river bed
Invasive species: alien species potentially putting local ecosystems, biotopes or species at a risk
Juvenile phase: phase of life of an organism before achieving sexual maturity
Catadromous: migrating from fresh waters into the ocean in order spawn.
Macrophytes: All aquatic plants detectable with the naked eye
Macrozoobenthos: All organisms of the water bottom still detectable with the naked eye
Milter: mature male fish
Mortality: death rate
MSD: Marine Strategy Directive /2008/56/EC)
MSW salmon: „Multi-Sea-Winter" salmon - big returning adult salmon with more than 1 (winter)(s) ocean residence

Neozoa: Invasive species
Pelagial zone: free water zone over the bottom zone (bed zone)
Pelagic: living in free waters
Phytophilic: Preferring plants; for reproduction guilds: Species spawning on plants
Plankton: Organisms floating in the water, which are not able to move against the current
Potamodromous: Migrating exclusively in fresh water
Rheophile: Species preferring the current
Spawner: Sexually mature female fish
Smolt: young silvery salmonid (salmon, sea trout) migrating downstream into the sea mostly at the age of two or three years
Stagnophile: Preferring standing waters
WFD: Water Framework Directive (2000/60/EC)

Annexes

Annex 1: Implemented and planned hydromorphological measures for anadromous migratory fish in the Rhine catchment according to the 2nd River Basin Management Plan Rhine, ICPR 2015 *(State: December 2015)*

State: December 2015					
		Measures implemented by 2015 or implementation started			
		Implementation or begin of work by 2018 planned			
		Implementation by 2027 planned			
	Long term phased implementation planned (see Conference of Ministers, Bonn 2007 & Basel 2013)				
* The costs indicated for ongoing and planned measures are largely based on estimates and only partly concern specific measures for migratory fish.					
The costs of measures aimed at improving habitat quality have been added to those for the modification of transverse structures in the section of the watercourse concerned.					
Country	**Section of the Rhine / tributary system**	**Waters/section, construction/s**	**Improvement upstream migration fish passage: Number of transverse structures**	**Improvement of habitat quality (=x) and further measures**	**Expenses (million Euros)***
NL	Delta Rhine - main stream	Nederrijn/Lek: Construction of 3 fish ladders (Driel: 2001, Amerongen and Hagestein: 2004)	3		9,2
		Nederrijn/Lek: Construction of a fish guidance system at the hydro power plant Amerongen (	1		# (see below)
		Afsluitdijk: Implementation of a fish-friendly management of tidal gates and locks (including construction of a freshwater discharge system) at Den Oever and Kornwerderzand (2015)	4		6,9
		Afsluitdijk: Construction of a fish ladder at Den Oever (2015)	1		
		Afsluitdijk: Construction of a fish ladder at Kornwerderzand, possibly as fish migration river (2016-2021)	1		55,0
		Haringvliet (Maas river system): partial opening of the Haringvliet locks (2018)	1		80,0
	Delta Rhine - tributaries	Overijsselse Vecht: Construction of fish ladders (6 of 6: 1987-1994)	6		2,5
	Delta Rhine - Canals	Amsterdam-Rijnkanaal: Implementation of fish-friendly lock management (2010-2015)	2		# (see below)
		Amsterdam-Rijnkanaal: Implementation of fish-friendly lock management (2016-2021)	2		# (see below)
		Nordzeekanaal: Optimization of the fish passage Oranjesluizen (2016-2021)	2		# (see below)
	Delta Rhine - lateral connection of the main stream with regional waters	In the Dutch part of the Delta Rhine work has been carried out at about 90 locations since 2010 (including the above mentioned locations #): Most locations concern measures taken at tributaries (among others at locks and pump stations) in order to restore and improve lateral connections between regional waters and the main stream. Between 2010 and 2015 some 40 measures were implemented. The rest will be carried through after 2015.		x	23,0
				x	(Including #)
				x	
Sum Delta Rhine incl. branches of the Rhine, IJssel, Lake IJssel & Haringvliet (Meuse)			**23**		**176,6**
D-NW	Kalflack	Fishway from the Lower Rhine into the Kalflack at the scooping-bucket elevator at Rhine km 852.4 (at the Emmerich bridge over the Rhine)	1		1,3
	Wupper	Wupper: Upstream continuity in water body for migratory fish from the confluence until km 72.3 is granted. Downstream migration: Need for remediation at approx. 5 locations; tributaries: Morsbach, Gelpe, Eschbach, Wiembach, Murbach	8	Structural improvement	1,5
		Dhünn: River continuity of the water body for migratory fish achieved	4	Structural improvement	0,8
	Sieg	Rheinische Sieg; monitoring station; pilot fish protection installation Unkelmühle: Accomplishment 2012	5	Structural improvement	10,5
		Bröl	2	Structural improvement	0,15
		Agger with Sülz and Naaf	2		0,6
D-RP		Sieg, middle section	6		1
		Sieg, middle section: Weir Hösch, Freusburger Mühle, weir Scheuerfeld (RWE), weir Euteneuen	2		1
		Nister, downstream region (23 km)	8		1,2
		Nister, downstream region (23 km)	1		
		Nister, upstream region (22.5 km)	4		
D-NW		Sieg, upstream region in North Rhine-Westphalia	9		
		Ferndorf, upstream tributary of R. Sieg	25		
Sum Lower Rhine and tributaries			**77**		**18,05**

Country	Section of the Rhine / tributary system	Waters / section, construction / s	Improvement upstream migration fish passage: Number	Improvement of habitat quality (=x) and further measures	Expenses (million Euros)*
D-RP	Ahr	Ahr (70 km), lower course	46		4
		Ahr (70 km), lower course	2		
		Ahr, upstream	3	x	
	Nette	Nette, downstream region (6.6 km)	3		0,17
		Nette, upstream	9		0,75
		Nette, upstream section (50 km)	14		
	Saynbach	Saynbach-Brexbach	12	x	1
	Moselle	Moselle, Koblenz (fish passage and visitors' centre in service)	1		5,18
		Moselle, downstream (Koblenz to Enkirch)*****	6		20
		Moselle, upstream (Zeltingen to Trier)	4		
		Elzbach, downstream	1		0,07
		Elzbach, upstream	12		
Lux		Sûre / Rosport	1		1,22
		Sauer, Erpeldange	1		0,11
		Sauer, Bourscheid	1		0,2
		Sauer, Dirbach	1		0,3
D-RP	Lahn	Lahn, lower section (Lahnstein until border RP/HE)	4		3,1
		Mühlbach, downstream region (6 km)	4		0,3
			2		
		Aar, downstream region (13 km)	10		0,9
D-HE		Lahn, border RP/HE until downstream the mouth of R. Dill	5	x	2,1
			1		
			2		
		Lahn, upstream mouth of R. Dill until border HE/NW	9	x	57,1
			3		
			19		
			26	x	
		Elbbach (downstream, 10 km to Hadamar)	6		1,1
		Elbbach, upstream to mouth of R. Lasterbach	9	x	1,5
		Dill (as far as Dillenburg-Niederscheld)	11	x	2,33
		Dill	5	x	2
		Dill	14	x	4,9
		Weil in the district Limburg-Weilburg until Utenhof	5		0,81
		Weil	2		0,24
		Weil	1	x	0,85
		Weil	1	x	3,3
D-RP	Nahe	Nahe, downstream, 5 km undisrupted	8		
		Nahe, upstream (105 km)	14		
		Nahe, remaining obstacles	11		5,1
D-HE	Wisper	Wisper, downstream and middle section	1		0,19
			1	x	0,3
Sum Middle Rhine and tributaries including Moselle			**291**		**119,12**

Country	Section of the Rhine / tributary system	Waters / section, construction / s	Improvement upstream migration fish passage: Number of transverse	Improvement of habitat quality (=x) and further measures	Expenses (million Euros)*
		Main: Kostheim	1		0,97
		Main: Kostheim (improvement fish passage, second entrance)	1		0,3
		Main: Kostheim downstream migration	1		4,00
		Main: Structural improvement measures (Flörsheim)		x	2
		Main: Eddersheim	1		2,6
		Main: Griesheim, Offenbach, Mühlheim, Krotzenburg	4		23
		Schwarzbach (Taunus / Main) near Hattersheim, remove lining	0	x	0,032
		Schwarzbach near Hattersheim, enhancement restriction	4	x	0,103
		Schwarzbach near Hattersheim, removal of consolidation	0	x	0,1
		Schwarzbach near Hattersheim, enhancement restriction	0	x	0,035
		Schwarzbach near Hattersheim, removal of consolidation	0	x	0,245
		Schwarzbach near Hattersheim (Bonnemühle)	1		0,008
		Schwarzbach near Hattersheim (outdoor pool)	1		0,081
		Schwarzbach / Eppstein - green belt	0	x	0,198
		Schwarzbach / Eppstein Rühl	1		0,1
		Schwarzbach / Eppstein Rühl II/Nottarp	1		0,1
DE-HE	Main & tributaries	Schwarzbach / Eppstein Rühl cascade drop	1		0,04
		Schwarzbach / Hofheim (Obermühle)	1		0,14
		Schwarzbach / Eppstein, enhancement location of restriction	0	x	0,036
		Schwarzbach / Eppstein, enhancement location of restriction	0	x	0,035
		Schwarzbach / Eppstein, green belt	0	x	0,07
		Schwarzbach / Eppstein, green belt structure	0	x	0
		Schwarzbach / Lorsbach (Fabricasa)	1		0,06
		Schwarzbach / Eppstein (Schwarzmühle)	1		0,001
		Schwarzbach / Eppstein, enhancement location of restriction	1	x	0,576
		Schwarzbach / Eppstein (Wiesenmühle)	1		0,13
			16	x	3
		Nidda (with Usa and Nidder)	13	x	16,2
			35	x	10
			18		1,9
		Kinzig (with Bracht, Salz, Bieber and Schwarzbach/Kinzig (= upstream Kinzig)	5		1,1
			4	x	0,9
			32	x	3,6
DE-BW		Weschnitz	2	x	0,77
	Weschnitz		5	x	2,13
DE-HE		Weschnitz	6	x	35,7
D-RP		(Wies)Lauter Bienwaldmühle	1		0,25
		(Wies)Lauter, weir Scheibenhardt	1		0,38
F		(Wies)Lauter, Lauterbourg mill	1		0,16
D-RP	(Wies) Lauter	(Wies)Lauter, Berizzi mill	1		0,17
		(Wies)Lauter downstream	2		
F		(Wies)Lauter, French section near Wissembourg	3	Inventory	n. s.
		(Wies)Lauter, upstream section upstream of Wissembourg	1		0,42

D-BW	Alb/Moosalb	Alb downstream	3	x	2,45
				x	1,80
			2	x	0,38
		Alb upstream to mouth of R. Maisenbach in Marxzell	4		0,62
			1		0,03
			15	x	1,40
		Moosalb	1		0,15
	Murg/Oos system	Murg, downstream region (20 km)	1	x	9,50
			1		0,15
		Murg, upstream region until the mouth of the R. Forbach at Baiersbronn	7		1,20
			8		0,36
			13	x	6,23
		Reichenbach	1		0,15
		Oos system	4	x	5,31
			1		0,15
			3	x	2,56
F / D-BW	Rhine	Northern Upper Rhine: downstream of Iffezheim		x	1,80
				x	13,65
		Southern Upper Rhine: upstream of Iffezheim, Gambsheim	2	Telemetric study	20
		Strasbourg power plant	1		15
		Agricultural weir in the Gerstheim loop of the Rhine to connect the Rhine with the alluvial waters of the water body OR2 (Rhin 2) (target date according to conference of Rhine	1		
		Gerstheim power plant: Construction of the fish passage	1		15
		2 agricultural weirs in the Rhinau loop of the Rhine open the access to the Elz-Dreisam-system and to connect the Rhine with the alluvial waters of the water body OR2 (Rhin 2) (target date according to conference of Rhine ministers Bonn 2007)	2		
		Rhinau power plant	1		
		Marckolsheim power plant	1		
		Hydro power plant at the agricultural weir Breisach (adaptation measures so that the fish	1		
		Vogelgrün power plant	1	Research	
		Old Rhine: Interreg project "Feasibility study concerning the revitalisation of the Old Bed of		Feasibility study	
		Old Rhine: Renewal of the concession Kembs: Restoration of controlled erosion		Alluvial habitats	
		Kembs (renewal of concession): Construction of a new fish passage	1	Compensatory measures	8
D-BW	Rench	Rench (river continuity for salmon along 25 km)	15	x	7,5
			2	x	
			11	x	
F	Ill	Ill to mouth of R. Doller	1	x	
			1		
			27	x	
		Bruche, Giessen, Liepvrette, Fecht, Weiss, Doller	7	x	
			4		
			99		
D-BW	Kinzig	Kinzig (Baden-Württemberg)	36	x	39,5
		(continuity for salmon)	15	x	
		Tributaries Schiltach, Gutach, Wolfach, Nordrach, Erlenbach	17	x	
	Elz-Dreisam system	Old Elz & continuous branch of the old Rhine	8		25,0
			1		
			6		
		Leopodskanal	3		
		(continuity for salmon)			
		Elz upstream of Leopoldskanal	14	x	
		(river continuity for salmon up to river-km 85)	8	x	
		Tributary: Wilde Gutach	24		
		Dreisam	13	x	
		(river continuity for salmon up to river-km 21)	1		
		Tributaries: Wagensteig, Brugga, Osterbach	16	x	
Sum Upper Rhine & tributaries including Main			**574**		**289,53**

Country	Section of the Rhine / tributary system	Waters/section, construction/s	upstream migration fish passage: Number	habitat quality (=x) and further measures	Expenses (million Euros)*
CH/DE-BW	High Rhine	Birsfelden power plant	1		
		Augst-Wyhlen power plant	1	x	
		Rheinfelden power plant: Compensatory measures within new concession:	1	x	
		Ryburg-Schwörstadt power plant: bypass river for salmon, improvement of fishladder	1		
		Säckingen power plant	1	x	
		Laufenburg power plant	1	x	
		Albbruck-Dogern power plant: Nature-near bypass river with "collection gallery"; new	1		
		Reckingen power plant	1	x	
		Eglisau power plant: within the new concession 2 fishways at the weir and the lock	1	x	
		Mouth R. Glatt: Construction of fishways in the Glattstollen as compensatory measure within	2		
		Rheinau power plant: Improvement of fish ladders at the auxiliary weirs or dismantling;	3	x	
CH	Wiese	Wiese, downstream: Elaboration of pre-project for fish ladder at "Schliesse" (km 3.5) and	1		
DE-BW		Wiese, middle section and upstream	15	Structural improvement	9,00
		Tributaries: Kleine Wiese, Steinenbach; Kohlgartenwiese	18	Structural improvement	
			11	Structural improvement	
CH	Birs	Birs: downstream section: improved fish migration and revitalisation; replacement of 5 drop structures by block ramps (number: 1 + x)	7	x	
		Birs, upstream: improved fish migration (number: 1 + x)	2		
	Ergolz	Ergolz	1+n/s		
	Biber	Removal of several obstacles to river continuity and restoration of fish passability (2 + 4)	6	Connection	
Sum High Rhine & tributaries			**74**		**9,00**
D-BW	Tributaries to Lake Constance	Old Rhine, Höchst to outlet into Lake Constance	2	x	
		Bregenzerach: improve fish passage and ramps	4	Feasibility study	
		Upper and Lower Argen, lowermost hydropower plants	2		
		Upper and Lower Argen, upstream hydropower plant	n. s.		
		Schussen, gauging station Lochbrücke / Gerbertshaus	1		
		Schussen, hydropower plant Berg (accessibility Wolfegger Ach and Ettishofer Ach)	1		
		Seefelder Aach, hydropower plant Mühlhofen, improve river continuity	1		
		Stockacher Aach	21	x	1,3
		(river continuity for lake trout up to river-km 14)	2		
		Tributary: Mahlspürer Aach	3		
D-BY/AT		Leiblach and Rickenbach: Reconstruction of at least 3 transverse structures	3		1,5
D-BY		Oberreitnauer Ach (reconstruction transverse structures)	1		0,14
			2	x	
CH	Alpine Rhine	Fish passage power plant Reichenau	1		
		Lake Constance to mouth of R. Ill		Development concept	
AT/FL/CH		Confluence Posterior Rhine		Development concept, international flood	
AT		Spirsbach	1	x	0,5
FL		Liechtenstein inland canal	1	x	
AT	Ill	Hochwuhr river km 8.0, fishway power plant with video surveillance since October 2010	1		
		weir Dabalada, km 20,0	1		1
Sum Lake Constance, Alpine Rhine & tributaries (Lake Constance sea trout)			**48**		**4,44**
Water bodies not focussed on as migration route and habitat for anadromous fish resp. Not designated as programme waters					
D-BY	Main & tributaries	Main: from Aschaffenburg upstream to Gemünden***	11		
D-BW		Tauber	n. s.		
D-BY		Kahl, Aschaff, Elsava, Mömling, Gersprenz, Lohr, Mud, Erf****	n. s.	x	
		Sinn (and Kleine Sinn) and Fränkische Saale (with Schondra and Thulba)****	n. s.	x	
D-BW	Neckar**	Neckar: lowermost transverse structure near Ladenburg	1		0,49
		Neckar: Kochendorff, Lauffen (planning permission procedure; beginning of consgtruction work presumably by 2021)	2		5,4
		Neckar: Wieblingen/Heidelberg, Horkheim/Heilbronn and Gundelsheim (fish passages planned)	3	x	
D-HE		Neckar: Hessian section in the lower reaches	2	x	4,7
D-BW		Neckar: remaining sections (impoundments listed in the action and prioity concept to achieve the continuity of the federal waterway Neckar)	19	x	
Entire Rhine catchment			**1125**		**627,33**

** The R. Neckar and its tributaries are neither central migration routes nor habitats for anadromous fish species. When planning and implementing measures, long distance anadromous migratory fish species such as allice shad and the eel as a catadromous migratory fish species will be taken in to account.
*** In the Master Plan Migratory Fish Rhine of 2009, this river section is not indicated as programme water. If measures are planned or taken to restore river continuity, their definition will also take into consideration the diadromous fish species concerned. When updating the Master Plan it will be examined whether the river section will be included in the programme waters.
**** In the Master Plan Migratory Fish Rhine of 2009, these rivers are not indicated as programme waters. However, measures aimed at restoring river continuity and at improving habitats will take into account the requirements of diadromous fish species.
*****For the fish passage Lehmen the beginning of work is planned for 2018.

Annex 2: Stocking exercises in the Rhine system 2013 - 2017

Stocking exercises with big salmonids in the Rhine system 2013					
Country / Water body	**Stocking**				Sums / smolt equivalent
Switzerland	Kind and stage	Number	Origin	Marking	**34.600**
Rhine	L b (La)	5.000	Allier		
Birs	L b (La)	7.000	Allier		
Ergolz	L b (La)	1.000	Allier		
Riehen Tych	L b (La)	600	Allier		
Wiese	L b (La)	3.000	Allier		
Arisdörferbach	L b (La)	2.000	Allier		
Möhlinbach	L b (La)	6.500	Allier		
Etzgerbach	L b (La)	5.000	Allier		
Bachtalbach	L b (La)	500	Allier		
Inland canal Klingnau	L b (La)	500	Allier		
Magdenerbach	L b (La)	3.500	Allier		
France					**357.220**
Rhine (Old Bed of the Rhine)	La	47.000	Allier		5875
	L0	46.500	Rhine		1535
	La	37.800	Allier		4725
Doller	La	20.000	Rhine		2500
	La	11.750	Allier		1469
Thur	La	31.350	Allier		3919
Lauch	La	10.760	Rhine		1345
Fecht and tributaries	La	42.500	Rhine	650 a/c	5313
Ill	La	2.500	Rhine		313
Giessen and tributaries	La	34.900	Rhine	400 a/c	4363
Bruche	La	29.040	Allier	2120 a/c	3630
	La	32.120	Rhine		4015
Moselle	La	3.000	Ätran		375
Blies	La	3.000	Allier		375
Saar (Moselle system)	La	5.000	EFH Ätran		
Luxembourg					**10.022**
Sure (Moselle)	Ls	10.022	Denmark	a/c + wt	
Germany, Baden-Württemberg					**225.130**
Alb	L a	18.760	Loire-Allier	no	
Murg	L a	47.000	Loire-Allier	no	
Murg	L s	3.470	Loire-Allier	no	
Oos, Oosbach	L a	3.000	Loire-Allier	no	
Rench	L a	10.250	Loire-Allier	no	
Kinzig and tributaries Erlenbach, Gutach, Wolf	L a	70.700	Loire-Allier	no	
	L a	25.900	Rhine	no	
	L s	4.300	Loire-Allier	no	
Elz	L a	29.250	Loire-Allier	no	
Dreisam	L a	3.000	Loire-Allier	no	
Wiese	L a	9.500	Loire-Allier	no	
Germany, Hesse					
Nidda *	Mf p	10.000	Rhine	a/c	**10.000**
Lahn, Dill, Weil	L 1	1.400	EFH Ätran	a/c	**52.100,00**
Kinzig (Main)	L p	1.000	EFH Ätran		
Schwarzbach (Main)	L p	20.000	EFH Ätran		
Weschnitz (first stocking!)	L p	4.500	EFH Ätran		
Wisper	L s	3.200	EFH Ätran	a/c	
	L p	22.000	EFH Ätran		
Germany, Rhineland Palatinate					**191.050**
Ahr	L p	75.000	EFH Ätran		
Ahr	L s	4.200		a/c	
Lahn, Mühlbach	L s	5.000	EFH Ätran	a/c	
	L p	0	EFH Ätran		
Moselle, Elzbach	L p	11.000	EFH Ätran		
Moselle, Elzbach	L s	4.200	EFH Ätran	a/c	
Saynbach	L s 1	2.850	EFH Ätran	a/c	
Nister, Kleine Nister (Sieg)	L p	4.000	KFS Sieg		
Nister, Kleine Nister (Sieg)	L p	4.000	EFH Ätran		
Nister (Sieg)	L p	23.500	KFS		
	L p	23.000	EFH Ätran		
	L s	3.300	EFH Ätran	a/c	
Wisserbach (Sieg)	L p	0			
	L s	1.000			
Wieslauter	L b	30.000	EFH Ätran	a/c	
Germany, North Rhine Westphalia					**966.930**
Sieg and tributaries	Lb (L0)	89.510	Sieg	no	
	Lb (La)	200.000	Ätran	no	
	Lb (La)	340.331	Sieg	no	
	Lp (0+)	9.518	Sieg	a/c	
	Lp (0+)	112.000	Ätran	partly a/c	
	Lp (1+)	20.000	Ätran	a/c	
	Lp (1+)	10.687	Sieg	no	
	Ls (L1)	12.697	Sieg	no	
	Ls (L2)	40	Sieg	Transponder	
Wupper and small tributaries	Lb (L0)	63.500	Sieg	no	
	Lb (La)	47.300	Sieg / 3000 Wupper	no	
	Ls (L2)	40	Sieg	Transponder	
Dhünn and small tributaries	Lb (L0)	61.267	Sieg	no	
	Ls (L2)	40	Sieg	Transponder	
cwt = coded wire tags; a/c = adipose clipping; EFH = parent fish keeping; KFS = Monitoring and catching station; L e = salmon spawn; L b = Salmon fry; L0 unfed fry; La = fed fry; L p = Salmon parr (= one summer old, half year = 0+); L ps = Salmon pre-smolt; L s = Salmon smolt; L 1 = one year old salmo L 2 = two years old salmon; Mf p = Sea trout parr; k. A. = not specified by deadline					
Sum stocking stages		**1.847.052**			

Stocking exercises with big salmonids in the Rhine system 2014					
Country / Water body	**Stocking**				Sums / smolt equivalent
Switzerland	Kind and stage	Number	Origin	Marking	**35.500**
Rhine	L b (La)	8.000	Petite Camargue/Rhine F2	Genetics	
Birs	L b (La)	3.000	Petite Camargue/Rhine F2	Genetics	
Ergolz	L b (La)	2.000	Petite Camargue/Rhine F2	Genetics	
Riehen Tych	L b (La)	1.000	Petite Camargue/Rhine F2	Genetics	
Wiese	L b (La)	3.000	Petite Camargue/Rhine F2	Genetics	
Arisdörferbach	L b (La)	2.500	Petite Camargue/Rhine F2	Genetics	
Möhlinbach	L b (La)	6.500	Petite Camargue/Rhine F2	Genetics	
Etzgerbach	L b (La)	4.000	Petite Camargue/Rhine F2	Genetics	
Bachtalbach	L b (La)	1.000	Petite Camargue/Rhine F2	Genetics	
Inland canal Klingnau	L b (La)	1.000	Petite Camargue/Rhine F2	Genetics	
Magdenerbach	L b (La)	3.500	Petite Camargue/Rhine F2	Genetics	
France					**438.210**
Rhine (Old Bed of the Rhine)	L0	77.000	Rhine		3850
	L0	175.200	Allier		8760
Doller	La	24.850	Rhine		2485
Thur	La	26.350	Rhine		2635
Lauch	La	10.760	Rhine		1076
Fecht and tributaries	La	37.500	Rhine	650 a/c	3750
Ill	La	2.840	Rhine		284
Giessen and tributaries	La	32.900	Rhine	400 a/c	3290
Bruche	La	42.470	Rhine	2120 a/c	4247
	La				
Moselle	La	5.340	Ätran		534
Blies	La	3.000	Rhine		300
Saar (Moselle system)					
Luxembourg		0			**0**
Sure (Moselle)		0			
Germany, Baden-Württemberg					**381.750**
Alb	L a	62.270	Allier		
Murg	L a	84.600	Allier		
Oos, Oosbach	L a	2.700	Allier		
Rench	L a	10.000	Allier		
Kinzig and tributaries Erlenbach, Gutach, Wolf	L a	103.150	EFH Rhine		
	L a	49.000	urnee Rhine x EFH Returnee Rhine		
	L p	8.000	urnee Rhine x EFH Returnee Rhine		
	L p	1.530	Allier		
	L p s	700	EFH Rhine		
Elz	L 0	8.000	Allier		
Elz	L p s	26.900	urnee Rhine x EFH Returnee Rhine		
Dreisam	L p s	5.000	Allier		
Wiese	L a	8.900	Allier		
Wiese	L p s	11.000	Allier		
Germany, Hesse					
Nidda *	Mf p	3.800	Wupper	a/c	**3.800**
Lahn, Dill, Weil	L s 2	410	EFH Ätran		**42.410,00**
Kinzig (Main)	L p	1.000	EFH Ätran		
Schwarzbach (Main)	L p	19.000	EFH Ätran		
Weschnitz		0			
Wisper	L p	20.000	EFH Ätran		
	L s 1	2.000	EFH Ätran	a/c	
Germany, Rhineland Palatinate					**218.070**
Ahr	L p	47.000	EFH Ätran		
Ahr					
Lahn, Mühlbach	L p	1.200	EFH Ätran		
	L s 2	2.340	EFH Ätran		
Moselle, Elzbach	L p	15.000	EFH Ätran		
Moselle, Elzbach	L s 1	1.730	EFH Ätran	a/c	
Saynbach	L s 1	3.460	EFH Ätran	a/c	
Nister, Kleine Nister (Sieg)	L p	5.000	EFH Ätran		
Nister (Sieg)	L 1	8.570	EFH Ätran		
Nister (Sieg)	L p	15.000	KFS		
	L p	40.000	EFH Ätran		
	L s 1	3.000	EFH Ätran	a/c	
Wisserbach (Sieg)		0			
		0			
Nahe (first stocking!)	L p	2.000	EFH Ätran		
Nahe (first stocking!)	L s 1	5.770	EFH Ätran	a/c	
Guldenbach (Nahe) (first stocking!)	L p	13.000	EFH Ätran		
Speyerbach (first stocking!)	L b	15.000	EFH Allier		
Wieslauter	L b	40.000	EFH Allier		
Germany, North Rhine Westphalia					**862.627**
Sieg and tributaries	La	66.071	Returnee to R. Sieg / EFH		9911
	La	483.053	Returnee to R. Sieg / EFH; Returnee to R. Gundenau / EFH		82119
	Lp	100.366	Returnee to R. Sieg / EFH; Returnee to R. Gundenau / EFH	a/c	9090
	L1	33.191	Returnee to R. Sieg / EFH		6638
	L2 (Smolt)	890	Returnee to R. Sieg / EFH	Heliogen blue / NEDAP	223
Wupper and small tributaries	L2 (Smolt)	1.056	Returnee to R. Sieg / EFH	HDX / NEDAP	264
	L0	86.000	EFH		4300
	La	52.000	EFH		7800
Dhünn and small tributaries	La	40.000	Returnee to R. Sieg / EFH		6000
cwt = coded wire tags; a/c = adipose clipping; EFH = parent fish keeping;					
KFS = Monitoring and catching station; L e = salmon spawn; L b = Salmon fry; L0 0 unfed fry; La = fed fry;					
L p = Salmon parr (= one summer old, half year = 0+); L ps = Salmon pre-smolt; L s = Salmon smolt; L 1 = one year old salmon;					
L 2 = two years old salmon; Mf p = Sea trout parr; k. A. = not specified by deadline					
Sum stocking stages		**1.982.367**			

Stocking exercises with big salmonids in the Rhine system 2015					
Country / Water body	**Stocking**				
	Kind and stage	Number	Origin	Marking	smolt equivalent
Switzerland					
Wiese	Lp	2600	Petite Camargue/Rhine group 9	Genetics	433
Rhine	Lp	0		Genetics	0
Riehenteich	Lp	600	Petite Camargue/Rhine group 8	Genetics	100
St. Alban-Teich	Lp	0		Genetics	0
Birs (lowermost section)	Lp	1.500	Petite Camargue/Rhine group 8	Genetics	250
Arisdörferbach	Lp	2.500	Petite Camargue/Rhine group 7	Genetics	417
Birs	Lp	500	Petite Camargue/Rhine group 8	Genetics	83
Ergolz	Lp	1.000	Petite Camargue/Rhine group 8	Genetics	167
Magdenerbach	Lp	2.000	Petite Camargue/Rhine group 10	Genetics	333
Möhlinbach (Bachtele, Möhlin)	Lp	500	Petite Camargue/Rhine group 6	Genetics	83
Möhlinbach (Möhlin / Zeiningen)	Lp	1.500	Petite Camargue/Rhine group 6	Genetics	250
Möhlinbach (Zuzgen, Hellikon)	Lp	2.300	Petite Camargue/Rhine group 6	Genetics	383
Etzgerbach	Lp	2.000	Petite Camargue/Rhine group 10	Genetics	333
Rhine	Lp	1.000	Petite Camargue/Rhine group 10	Genetics	167
Old Rhine	Lp	1.500	Petite Camargue/Rhine group 10	Genetics	250
Bachtalbach	Lp	500	Petite Camargue/Rhine group 10	Genetics	83
Percolating canal Klingnau	Lp	500	Petite Camargue/Rhine group 10	Genetics	83
Total		**20.500**			**3.417**
France					
Bruche	La	42.120	Rhine	Genetics	4.212
Mossig	La	400	Rhine	Genetics	40
Giessen and tributaries	La	8.200	Rhine	Genetics	820
Lièpvrette	La	26.700	Rhine	Genetics	2.670
Ill	La	2.320	Rhine	Genetics	232
Fecht	La	26.700	Allier/Rhine	Genetics	2.670
Weiss	La	5.800	Rhine	Genetics	580
Béhine	La	1.000	Rhine	Genetics	100
Lauch	La	6.760	Rhine	Genetics	676
Thur	La	16.350	Rhine	Genetics	1.635
Doller	La	26.750	Allier/Rhine	Genetics	2.675
	L0	145.000	Allier	Genetics	7.250
Rhine (Old Bed of the Rhine)	La	8.800	Allier	Genetics	880
				Genetics	
Moselle	Le	2.100	Ätran	Genetics	
	L0	2.550	Ätran	Genetics	
Blies	La	3.000	Allier	Genetics	300
Saar (Moselle system)					
Total		**324.550**			**24.740**
Luxembourg					
Sure (Moselle)					
Total		**0**			
Germany, Baden-Württemberg					
Alb	Lp	19510		Genetics	3.252
Alb	La	50000		Genetics	1.250
Murg	Lp	41500		Genetics	6.917
Murg	La	10000		Genetics	500
Oos, Oosbach	Lp	5000		Genetics	834
Rench	Lp	10500		Genetics	1.750
				Genetics	
Kinzig and tributaries	Lp	71780		Genetics	11.963
Erlenbach, Gutach, Wolf	La	75100		Genetics	3.755
				Genetics	
				Genetics	
Elz	Lp	27200		Genetics	4.533
Dreisam	Lp	5600		Genetics	933
Wiese	La	9600		Genetics	480
Wiese	Lp	11100		Genetics	1.850
Total		**336.890**			**38.017**
Germany, Hesse					
Nidda *	Mf s	2.640	Wupper	a/c	
Lahn, Dill, Weil, Elbbach	L s	4.385	Ätran (DCV)	a/c	
Lahn, Dill, Weil, Elbbach	L p	6.000	Ätran (EFH)		
Lahnsystem total					2.296
Kinzig (Main)	L p	2.000	Ätran (EFH)		
Schwarzbach (Main)	L p	19.300	Ätran (EFH)		
Weschnitz					
Wisper	L p	9.000	Ätran (EFH)		1.500
Total		**43.325**			**3.796**
Germany, Rhineland Palatinate					
Ahr	L p	50.000	Ätran (EFH)		8.333
Lahn, Mühlbach		0			
		0			
Moselle, Elzbach	L p	21.500	Ätran (EFH)		3.983
Saynbach	L s	1.200	Ätran (EFH)	a/c	
Saynbach	L s	4.040	Ätran (DCV)	a/c	
Saynbachsystem total					1.310
Nister, Kleine Nister (Sieg)					
Nister (Sieg)	L s	9.100	Ätran (DCV)	a/c	
Nister (Sieg)	L p	28.490	Ätran (KFS)		
	L p	48.510	Ätran (EFH)		
Wisserbach (Sieg)		0			
		0			
Siegsystem total					15.100
Nahe	L s	8.762	Ätran (DCV)	a/c	
Guldenbach (Nahe)	L p	9.250	Ätran (EFH)		
Speyerbach	La	30.000	Allier		
Wieslauter	La	35.000	Allier		
Total		**245.852**			**28.726**
Germany, North Rhine Westphalia					
Sieg and tributaries	La	85.554	Sieg-Returnees		13.237
	La	105.985	Gundenau-Returnees / EFH		18.017
	La	143.037	Sieg-Returnees / EFH		23.965
	L1p	2.950	Sieg-Returnees / EFH		590
	L1 (Smolt)	6.880	Sieg-Returnees / EFH		1.720
	L2 (Smolt)	67	Sieg-Returnees / EFH	Heliogen blue / NEDAP	17
Wupper and small tributaries	L2 (Smolt)	567	Sieg-Returnees / EFH	HDX / NEDAP	142
	L0	45.601	Sieg-Returnees / EFH		2.280
	La	45.000	Sieg-Returnees / EFH		2.250
Dhünn and small tributaries	L1p	10.000	Sieg-Returnees / EFH		2.000
	L2 (Smolt)	66	Sieg-Returnees / EFH	NEDAP Transponder	17
Total		**445.707**			**64.234**
Sum stocking stages		**1.416.824**			

cwt = coded wire tags; a/c = adipose clipping; EFH = brood stock keeping; DCV= Danish Center for Vildlaks
KFS = Monitoring and catching station; L e = salmon spawn; L b = Salmon fry; L0 0 unfed fry; La = fed fry;
L p = Salmon parr (= one summer old, half year = 0+); L ps = Salmon pre-smolt; L s = Salmon smolt; L 1 = one year old salmon
L 2 = two years old salmon; Mf p = Sea trout parr; k. A. = not specified by deadline

Stocking exercises with big salmonids in the Rhine system 2016

Country / Water body	Kind and stage	Number	Origin	Marking	smolt equivalent
Switzerland					
Wiese	Lp	3000	Petite Camargue R22, B2, B3, B4, B5	Genetics	
Rhine	Lp	3.800	Petite Camargue B9, B10, B11, B13	Genetics	
Riehenteich	Lp	1.000	Petite Camargue B9, B10, B11, B13	Genetics	
St. Alban-Teich				Genetics	
Birs (lowermost section)	Lp	2.000	Petite Camargue R22, B2, B3, B4, B5	Genetics	
Arisdörferbach	Lp	3.500	Petite Camargue R23	Genetics	
Birs	Lp	1.200	Petite Camargue R23	Genetics	
Ergolz	Lp	2.500	Petite Camargue R23	Genetics	
Magdenerbach	Lp	4.000	Petite Camargue R20	Genetics	
Möhlinbach (Bachtele, Möhlin)	Lp	500	Petite Camargue B6B7	Genetics	
Möhlinbach (Möhlin / Zeiningen)	Lp	1.000	Petite Camargue B6B7	Genetics	
Möhlinbach (Zuzgen, Hellikon)	Lp	1.300	Petite Camargue B6B7	Genetics	
Möhlinbach	Le	6.100	Petite Camargue B8	Genetics	
Möhlinbach	Lb	6.000	Petite Camargue B9, B10	Genetics	
Etzgerbach	Lp	4.600	Petite Camargue R20	Genetics	
Rhine	Lp	1.200	Petite Camargue R21	Genetics	
Old Rhine	Lp	3.200	Petite Camargue R21	Genetics	
Bachtalbach	Lp	1.000	Petite Camargue R20	Genetics	
Percolating canal Klingnau	Lp	1.000	Petite Camargue R20	Genetics	
Total		**46.900**			
France					
Rhine (Old Bed of the Rhine)	L0	195.000	Allier		9750
Doller	La	34.950	Rhin		3495
Thur	La	12.000	Allier		1200
Lauch	La	5.000	Allier		500
Fecht and tributaries	La	38.700	Allier		3870
	La	14.000	Rhin		1400
Ill	La	2.500	Rhin		250
Giessen and tributaries	La	26.250	Rhin		2625
Bruche	La	56.250	Rhin		5625
Moselle	L0	5.150	Allier		258
	La	5.350	Allier		535
Blies	La	4.490	Allier		449
Saar (Moselle system)					
Total		**399.640**			**29.957**
Luxembourg					
Sure (Moselle)					
Total		**0**			
Germany, Baden-Württemberg					
Alb	L p	17805	Loire-Allier		1.016
Murg	L p	68500	Loire-Allier		11.417
Oos, Oosbach					
Rench	L a	10300	Parent fish Rhine		258
Rench	L p	8000	Parent fish Rhine		1.333
Kinzig and tributaries Erlenbach, Gutach, Wolf, Schiltach	L a	82550	Parent fish Rhine		2.064
	L p	66750	Loire-Allier		3.338
	L p	68780	Parent fish Rhine		11.464
	L s	250	Parent fish Rhine		63
Elz	L 0	11000	Parent fish Rhine		275
Elz	L p	20600	Parent fish Rhine		3.433
Dreisam	L p	10000	Parent fish Rhine		1.667
Wiese	L p	21000	Parent fish Rhine		3.500
Total		**385.535**			**39.828**
Germany, Hesse					
Nidda *	Mf p	3.500	Rhine, Wupper	a/c	**700**
Lahn, Dill, Weil, Elbbach	L p	6.000	EFH		
Lahn, Dill, Weil, Elbbach					
Lahnsystem total					1.200
Kinzig (Main)	L p	600	EFH		200
Schwarzbach (Main)	L 1	4.270	EFH	a/c	1.025
Weschnitz					
Wisper	L p	25.250	EFH		5.050
Total		**39.620**			**8.175**
Germany, Rhineland Palatinate					
Ahr	L s	5.000	EFH		
Ahr	L p	61.500	EFH		11.500
Lahn, Mühlbach					0
Moselle, Elzbach	L p	23.250	EFH		
Saynbach	L 1	4.270	EFH	a/c	
Saynbach					
Saynbachsystem total					1.025
Nister, Kleine Nister (Sieg)	L p	58.770	KFS		
Nister, Kleine Nister (Sieg)	L p	34.450	EFH		
Nister (Sieg)	L s	2.000	EFH		
Wisserbach (Sieg)	L p	4.930	KFS		
Heller (Sieg)	L p	3.850	KFS		
Siegsystem total					17.500
Nahe	L s	4.650	EFH		
Guldenbach (Nahe) & Nahe	L p	32.500	EFH		6.580
Speyerbach	La	30.000	EFH Obenheim		3.000
Wieslauter	La	35.000	EFH Obenheim		3.500
Total		**300.170**			**43.105**
Germany, North Rhine Westphalia					
Sieg and tributaries	La	504.938	eg-returnee, Ätran / returnee from Guden	without	84.043
	Ls	5.630	Sieg-returnee	without	1.407
	L1	11.600	Sieg-returnee	without	2.320
	L2	200	Sieg-returnee	NEDAP Transponde	50
Wupper and small tributaries	L0	51.000	Sieg-returnee	without	2.550
	La	82.500	Sieg-returnee	without	12.375
Dhünn and small tributaries	La	80.000	Sieg-returnee	without	12.000
Total		**735.868**			**114.745**

cwt = coded wire tags; a/c = adipose clipping; EFH = brood stock keeping; DCV= Danish Center for Vildlaks
KFS = Monitoring and catching station; L e = salmon spawn; L b = Salmon fry; L0 0 unfed fry; La = fed fry;
L p = Salmon parr (= one summer old, half year = 0+); L ps = Salmon pre-smolt; L s = Salmon smolt; L 1 = one year old salmon;
L 2 = two years old salmon; Mf p = Sea trout parr; k. A. = not specified by deadline

Sum stocking stages	**1.907.733**

Stocking exercises with big salmonids in the Rhine system 2017					
Country / Water body	**Stocking**				
	Kind and stage	Number	Origin	Marking	smolt equivalent
Switzerland					
Wiese	Lp	3500	Petite Camargue B1K3	Genetics	
Rhine					
Riehenteich	Lp	1.000	Petite Camargue K1K2K4K4a	Genetics	
Birs	Lp	4.000	Petite Camargue K1K2K4K4a	Genetics	
Arisdörferbach	Lp	1.500	Petite Camargue F1 wild	Genetics	
Hintere Frenke	Lp	2.500	Petite Camargue K1K2K4K4a	Genetics	
Ergolz	Lp	3.500	Petite Camargue K7C1	Genetics	
Fluebach Harbotswil	Lp	1.300	Petite Camargue K7C1	Genetics	
Magdenerbach	Lp	3.900	Petite Camargue K5	Genetics	
Möhlinbach (Bachtele, Möhlin)	Lp	600	Petite Camargue B7B8	Genetics	
Möhlinbach (Möhlin / Zeiningen)	Lp	2.000	Petite Camargue B7B8	Genetics	
Möhlinbach (Zuzgen, Hellikon)	Lp	3.500	Petite Camargue B7B8	Genetics	
Etzgerbach	Lp	4.500	Petite Camargue K5	Genetics	
Rhine	Lp	1.000	Petite Camargue B2K6	Genetics	
Old Rhine	Lp	2.500	Petite Camargue B2K6	Genetics	
Bachtalbach	Lp	1.000	Petite Camargue B2K6	Genetics	
Percolating canal Klingnau	Lp	1.000	Petite Camargue B2K6	Genetics	
Surb	Lp	1.000	Petite Camargue B2K6	Genetics	
Bünz	Lp	1.000	Petite Camargue B2K6	Genetics	
Total		**39.300**			
France					
	L0	269147	Allier		13457
Rhine (Old Bed of the Rhine)	L0	142.000	Rhine		7100
	La	31.500	Rhine		3150
Doller	L0	5.000	Rhine		250
	La	21.900	Rhine		2190
Thur	L0	2.500	Rhine		125
	La	12.000	Rhine		1200
Lauch	L0	2.500	Rhine		125
	La	5.000	Rhine		500
Fecht and tributaries	L0	10.000	Rhine		500
	La	39.000	Rhine		3900
Ill	L0	4.200	Rhine		210
	La	17.500	Rhine		1750
Giessen and tributaries	L0	10.000	Rhine		500
Giessen and tributaries	La	28.472	Rhine		2847
	L0	10.500	Rhine		525
Bruche	La	32.000	Rhine		3200
	La	25.000	Rhine, wild (F1)		2500
	Le	2.100	Allier		76
Moselle	L0	3.500	Allier		175
	La	3.580	Allier		358
Blies	La	3.150	Rhine		315
Saar (Moselle system)	La	2.550	Rhine		255
Total		**683.099**			**45.208**
Luxembourg					
Sure (Moselle)					
Total		**0**			
Germany, Baden-Württemberg					
Alb	L p	13050	Allier		2.175
Murg	L p	67000	Rhine, Allier		11.167
Oos, Oosbach		0			0
Rench	L e	5000	EFH Rhine		83
Rench	L a	15000	EFH Rhine		750
Kinzig and tributaries Erlenbach, Gutach, Wolf, Schiltach	L e	10000	EFH Rhine		166
	L a	49850	EFH Rhine		1.246
	L a	59000	EFH Rhine		2.950
	L p	33500	EFH Rhine		5.583
	L ps	4000	EFH Rhine		800
Elz	L 0	7600	Allier		190
Elz	L p	15000	Allier		2.500
Dreisam	L p	10000	Allier		1.667
Wiese	L a	2000	Allier		100
Wiese	L p	11000	Allier		1.833
Total		**302.000**			**31.210**
Germany, Hesse					
Nidda	Mf p	4.000	Wupper		**5**
Lahn, Dill, Weil, Elbbach	L p	8.000	EFH		5
Lahn, Dill, Weil, Elbbach	L 1	2.500	EFH		5
Lahnsystem total					
Kinzig (Main)	L p	180	EFH		5
Schwarzbach (Main)	L p	4.400	EFH		5
Weschnitz					
Wisper	L p	6.400	EFH		5
Total		**25.480**			**30**
Germany, Rhineland Palatinate					
Ahr	La	71.000	EFH		6
Moselle, Elzbach	L p	10.500	EFH		5
Saynbach		0			
Saynbach		0			
Saynbachsystem total					
Nister, Kleine Nister (Sieg)	L p	2.660	KFS		6
Nister, Kleine Nister (Sieg)					
Nister (Sieg)	L p	18.130	KFS		6
Wisserbach (Sieg)	L p	2.000	EFH		6
Heller (Sieg)					
Siegsystem total					
Nahe	L p	14.500	EFH		6
Guldenbach (Nahe) & Nahe	L p	40.000	EFH		6
Speyerbach	La	30.000	EFH		20
Speyerbach	L s	1.200	EFH	PIT-Tags	4
Wieslauter	La	38.000	EFH		20
Total		**227.990**			**85**
Germany, North Rhine Westphalia					
Sieg and tributaries	La	257.043	Sieg-returnee / WLZ, EFH Albaum, returnée Ätran-Gudenau / EFH DCV		43.678
Wupper and small tributaries	La	14.824	Returnee to R. Sieg / EFH Albaum		2.520
	La	3.500	Returnee to R. Sieg / EFH Albaum (Breeding: Hatchery Wupper)		350
	La	89.881	Returnee to R. Sieg / EFH Albaum / EFH Haspe (Breeding: EFH Haspe		13.862
Dhünn and small tributaries	La	38.788	Returnee to R. Sieg / EFH Albaum		6.594
	L p	5.285	Returnee to R. Sieg / EFH Albaum		951
Total		**409.321**			**67.955**
cwt = coded wire tags; a/c = adipose clipping; EFH = brood stock keeping; DCV= Danish Center for Vildlaks					
KFS = Monitoring and catching station; L e = salmon spawn; L b = Salmon fry; L0 0 unfed fry; La = fed fry;					
L p = Salmon parr (= one summer old, half year = 0+); L ps = Salmon pre-smolt; L s = Salmon smolt; L 1 = one year old salmon;					
L 2 = two years old salmon; Mf p = Sea trout parr; k. A. = not specified by deadline					
Sum stocking stages		**1.687.190**			

Annex 3: Natural reproduction of Atlantic salmon and sea trout in the waters of the Rhine catchment 1994-2017

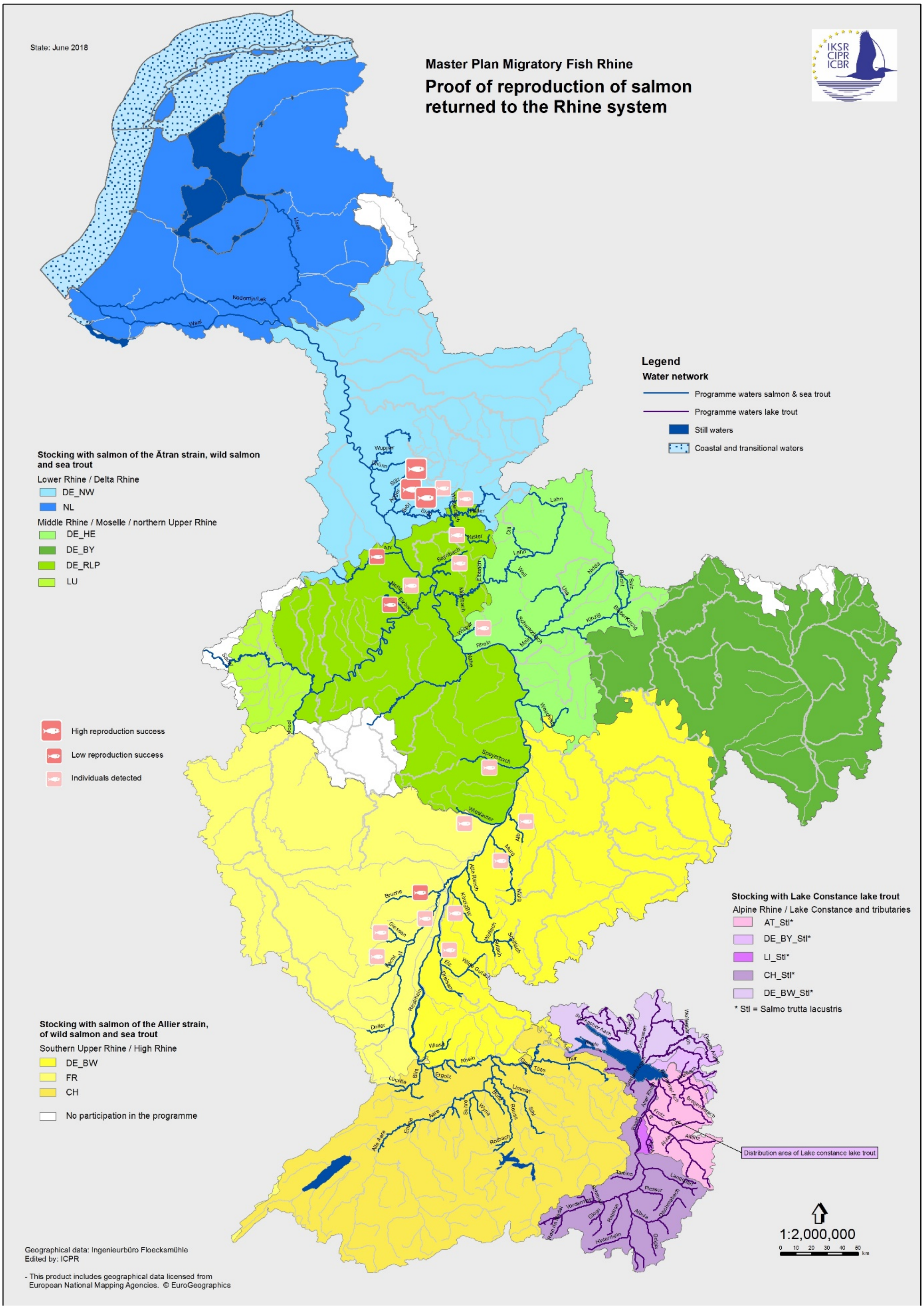
Proof of reproduction of salmon returned to the Rhine system

				Year of spawning proof (reproduction during the preceding autumn/winter)																							
Country	System	Project water - Selection of the most important tributaries (* no stocking)	First salmon stocking	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
D	Wupper-Dhünn	Wupper		/	/	/	/	/	/	/	/	0	/	/	/	/	/	(X)	/	/	/	/	/		/	/	/
		Dhünn	1993	/	/	/	/	/	/	/	/	0	/	/	X	X	/	/	/	/	/	/	/		/	/	/
		Eifgenbach		/	/	/	/	/	/	/	/	/	/	/	/	0	/	/	/	/	/	/	/		/	/	/
D	Sieg	Sieg NRW	Salmon stocking exercises in the Sieg river system since 1988, since 1998 in addition to classical umber and barbel regions also in selected smaller and medium sized brooks	X	/	/	/	/	/	/	X	0	XX	/	/	/	/	/	/	/	/	XX	/	XX	0	0	0
		Agger (lower 30 km)		X	/	/	/	/	/	/	0	0	XXX	XXX	XXX	XX	XXXX	XXXX	XXXX	/	/	XXX	XXX	XXX	XXX	XXX	XX
		Naafbach		/	/	/	/	/	/	/	XX	0	/	XXX	XXX	XXX	XXXX	XXXX	XXXX	/	/	XXX	XXX	XXX	XXXX	XXX	XXX
		Pleisbach		/	/	/	/	/	/	/	0	/	/	0	/	/	X	/	X	/	/	/	/		/	/	/
		Hanfbach		/	/	/	/	/	/	/	/	0	/	0	X	/	/	/	/	/	/	/	/		/	/	/
		Bröl		X	/	/	X	/	/	/	0	0	XX	XX	0	XX	XXX	/	XXX	/	/	/	XX	XXX	XXX	XX	XXX
		Homburger Bröl		/	/	/	/	/	/	/	0	0	/	XX	XXX	XX	X	/	/	/	/	/	/	0	XX	XX	0
		Waldbröl		/	/	/	/	/	/	/	0	0	/	0	0	XXX	XXX	/	0	/	/	/	/	XXX	0	0	0
		Derenbach		/	/	/	/	/	/	/	/	/	/	/	/	0	/	/	/	/	/	/	/		/	/	/
		Steinchesbach		/	/	/	/	/	/	/	/	/	/	/	/	0	/	/	/	/	/	/	/		/	/	/
		Krabach		/	/	/	/	/	/	/	/	/	/	/	X	/	/	/	/	/	/	/	/		/	/	/
		Gierzhagener Bach		/	/	/	/	/	/	/	/	0	/	/	/	/	X	/	/	/	/	/	/		/	/	/
		Irsenbach		/	/	/	/	/	/	/	/	0	/	/	/	/	/	/	/	/	/	/	/		/	/	/
		Sülz		/	/	/	/	/	/	/	0	0	/	/	/	XX	/	/	/	/	/	XXX	/	XXX	XXXX	XXX	XXX
		Schlingenbach		/	/	/	/	/	/	/	/	0	/	/	/	/	X	XXXX	XXX	/	/	XXX	0	0	0	0	0
		middle Sieg RLP	1994	/	/	/	/	/	/	/	X	0	0	0	X	X	X	XXXX	X	0	?	?	?	?	0	0	?
		Nister system	1991	/	/	/	/	/	XX	0	X	X	X	X	X	XXX	XX	XXXX	X	X	X	X	X	X	X	X	X
		Wisserbach	1991	/	/	/	/	/	/	XXX	XX	XX	0	X	XX	XXX	XX	XXXX	0	X	0	0	0	0	XX	0	0
		Elbbach	1995	/	/	/	/	/	/	/	/	0	X	0	/	/	XX	XX	0	0	0	/	/	/	/	/	/
		Heller-Daade	1998	/	/	/	/	/	/	/	/	0	0	/	/	/	X	X	x	0	0	0	0	0	0	0	0
		Asdorf	1997	/	/	/	/	/	/	/	/	0	0	/	/	/	/	/	/	0	/	/	/	0	0	0	0
D	Ahr	Ahr	1995	/	/	/	/	/	/	X	0	0	X	X	0	0	0	?	0	XX	XX	0	XX	XX	XXX	X	XXX
D	Nette	Nette *	-	/	/	/	/	/	/	/	X	0	XX	X	X	X	0	X	0	X	0	X	0	XX	XX	0	XX
D	Saynbach	Saynbach	1994	/	/	/	/	/	/	XX	XX	XX	XXX	XXXX	XXXX	XX	XXXX	XXXX	XX	XX	XXX	X	X	XX	XX	XX	0
		Brexbach	1994	/	/	/	/	/	/	XXXX	XX	X	X	0	0	0	0	XXX	XX	XX	0	0	0	0	0	0	0
D	Moselle	Elzbach	2005	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	XX	XX	XX
		Kyll	1996	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
		Prüm system	1996	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Lux/D		Sûre	1992	/	/	/	/	/	/	/	/	/	0	/	/	/	/	/	/	/	/	/	/	/	/	/	/
		Our	1992	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
D	Lahn	Mühlbach	1994	/	/	/	/	/	/	(X)	0	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
		Weil	1995	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	0	/	/	/
		Dill	1995	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
D	Nahe	Nahe	2004 / 2013	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	0	0	0	0
D	Wisper	Wisper	1999	/	/	/	/	/	/	/	/	0	XX	XX	0	0	XX	XXXX	0	X	XX	0	0	XX	0	XXX	0
D	Main	Schwarzbach	2009	/	/	/	/	/	/	/	/	/	/	/	/	/	/	0	0	0	0	0	0	0	X	0	X
		Kinzig system (Hesse)	2001	/	/	/	/	/	/	/	/	/	/	/	/	0	/	/	/	/	/	/	?	0	/	/	/
D	Alb	Alb	2001	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	X	X	X	X	X	X	/
D	Speyerbach	Speyerbach/Rehbach	2013	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	X	XX
D/F	(Wies)Lauter	(Wies)Lauter	1991	/	/	/	/	/	/	/	/	/	/	/	/	/	/	X	X	X	X	X	X	X	X	X	X
D	Murg	Murg	2001	/	/	/	/	/	/	/	/	/	/	/	X	X	X	/	/	/	X	X	X	X	X	/	/
F / D	Rhine	Rhine downstream Iffezh	-	/	/	/	/	/	/	/	/	/	/	X	/	/	/	/	/	/	/	/	/	/	/	/	/
D	Rench	Rench	2001	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
F	Ill	Ill	1995	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	X	X	X	0	0	/	X	X
		Bruche	1991	/	X	X	X	X	(X)	X	X	X	X	X	X	X	X	X	XX	XX	XX	XX	XX	XX	XX	XX	XX
		Giessen	1992	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	0	0	/	0	/	X	0
		Lièpvrette	1995	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	0	0	/	/	/	/	0
		Fecht	1991	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	X	X	X	0	X	X	X	0
		Weiss	1991	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	0	0	/	0	0	/	0
		Doller	1993	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
D	Kinzig	Kinzig (Baden-Württ.)	2001	/	/	/	/	/	/	/	/	/	/	X	/	/	/	/	/	X	X	X	/	X	X	X	X
D	Elz + Dreisam	Elz	2005	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	X	/
		Dreisam	2008	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
F / D	Rhine	Old branch of the Rhine	1991	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
CH	Wiese	Wiese	1984	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
CH	Birs	Birs	1995	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
CH	Ergolz	Ergolz	1995	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
				1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017

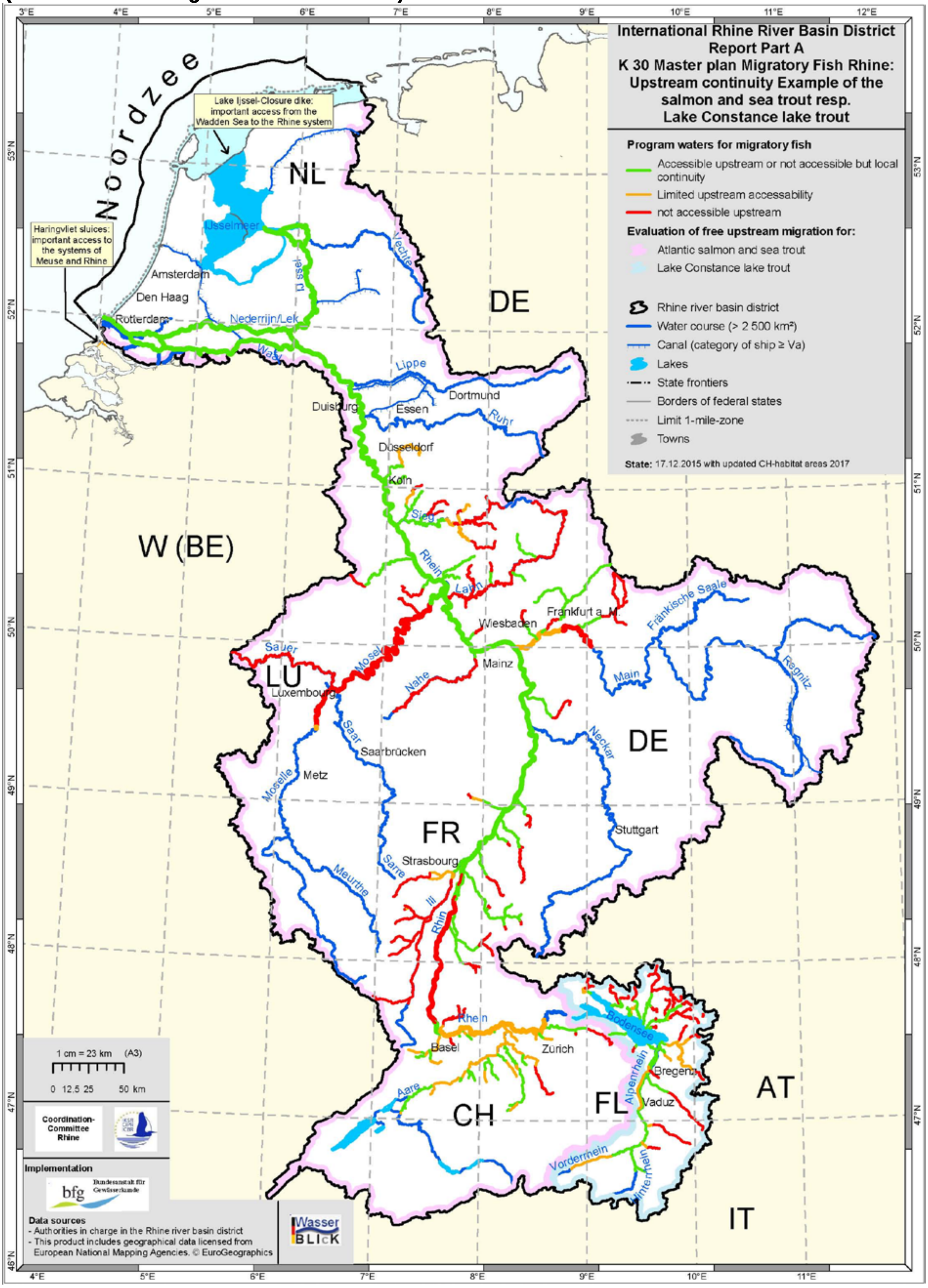
quality proof / individuals detected / samples taken from individual locatio	X
qualitative evidence / returnees released upstream of obstacle	(X)
little success of reproduction (1 to ≤ 5 parr/100 m2)	XX
considerable success of reproduction (> 5 - 50 parr/100 m2)	XXX
extremely high rate of success of reproduction (> 50 parr/100 m2)	XXXX
investigations carried through, no evidence	0
no investigation	/
evidence uncertain	?

spawning grounds (largely) accessible
spawning grounds partially accessible/accessible to a limited extent
spawning habitats not accessible/accessible in exceptional cases

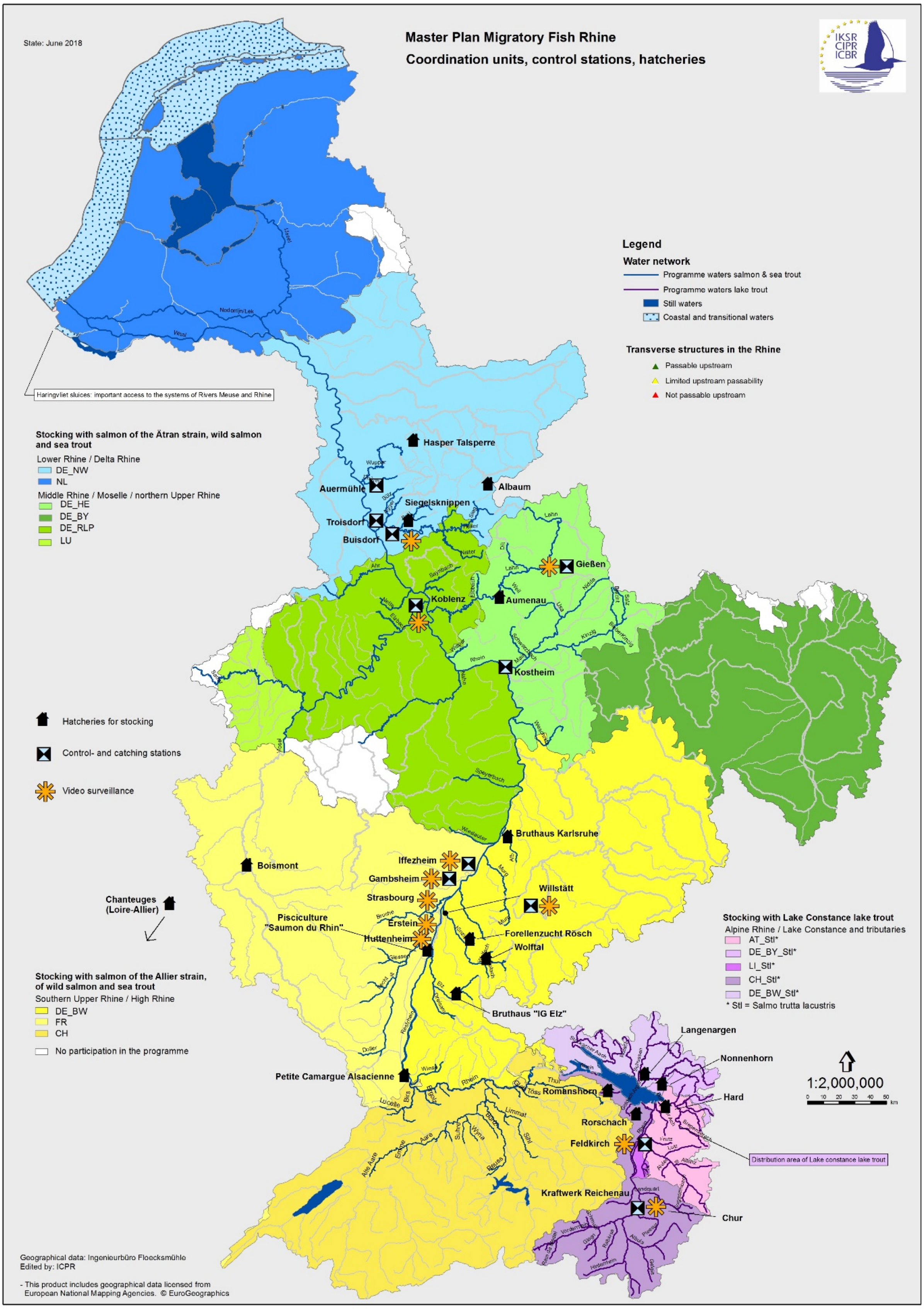
Annex 4: Map Proof of reproduction (average 2015-2017) including stocking exercises



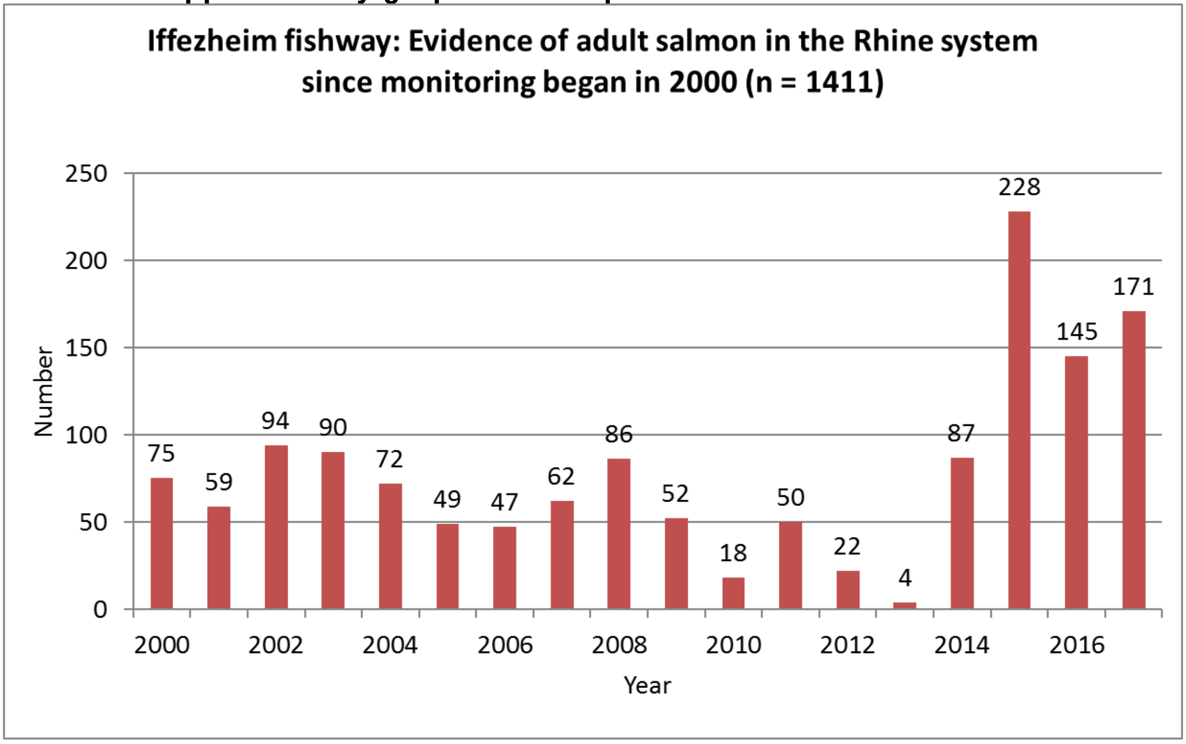
Annex 5: Map Upstream river continuity in programme waters for migratory fish: example of the salmon and the sea trout resp. Lake Constance lake trout (K30 from Management Plan 2015)



Annex 6: Map Monitoring stations and hatcheries



Annex 7: Supplementary graphs for Chapter 5



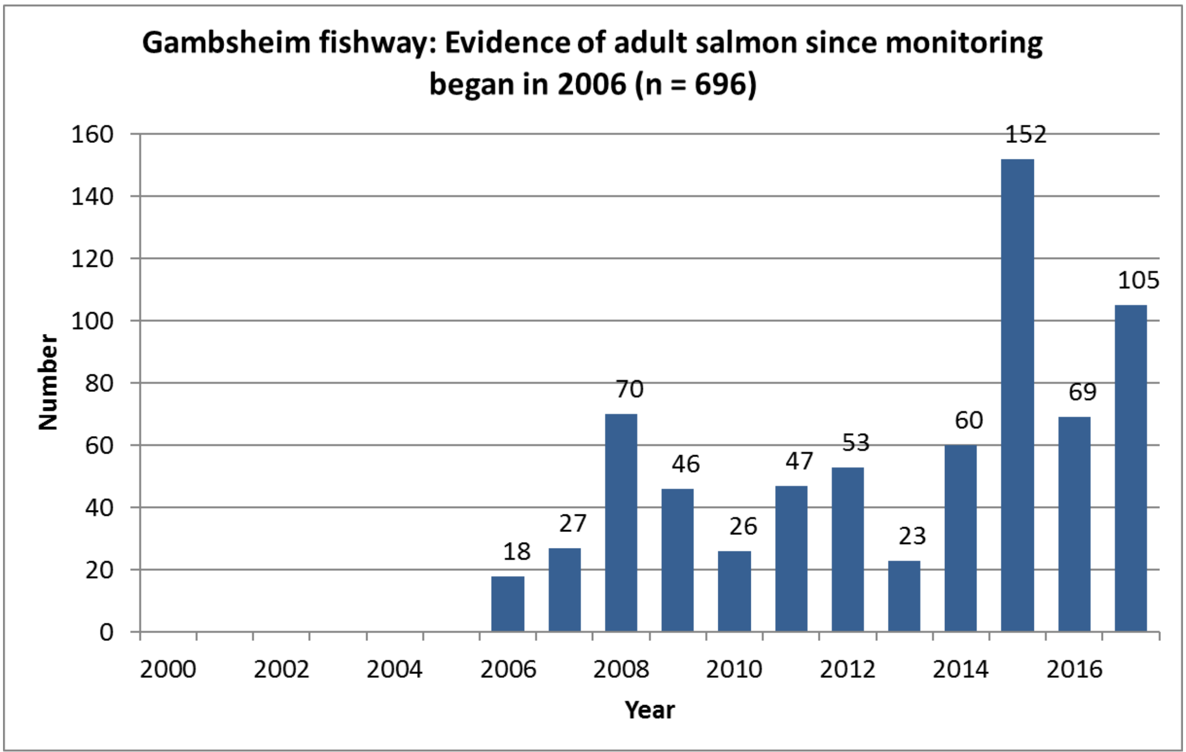


Figure 1: Evidence of salmon at the monitoring stations in Iffezheim (as of 2000) and Gambsheim (as of 2006). Data: Fischereiverwaltung Baden-Württemberg, Association Saumon-Rhin (ASR). Restricted operation of the Iffezheim fishway between April 2009 and October 2013.

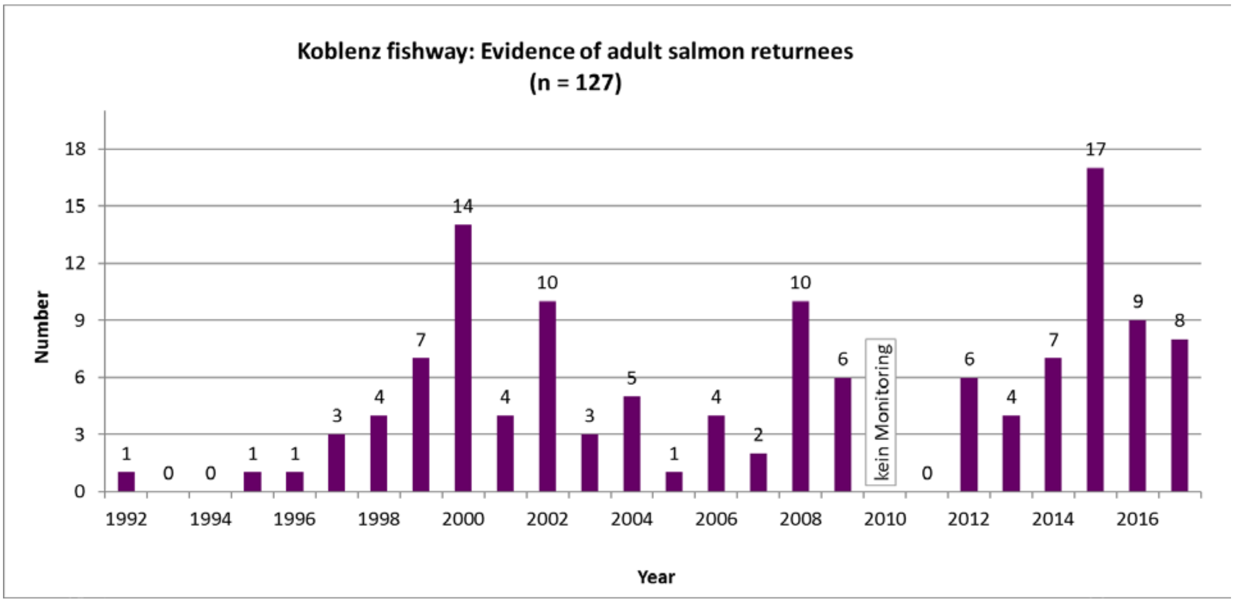


Figure 2: Evidence of salmon at the monitoring station Koblenz/Moselle (as of 1992 until 2009 "outdated" fishway; no recording in 2010 due to construction work).

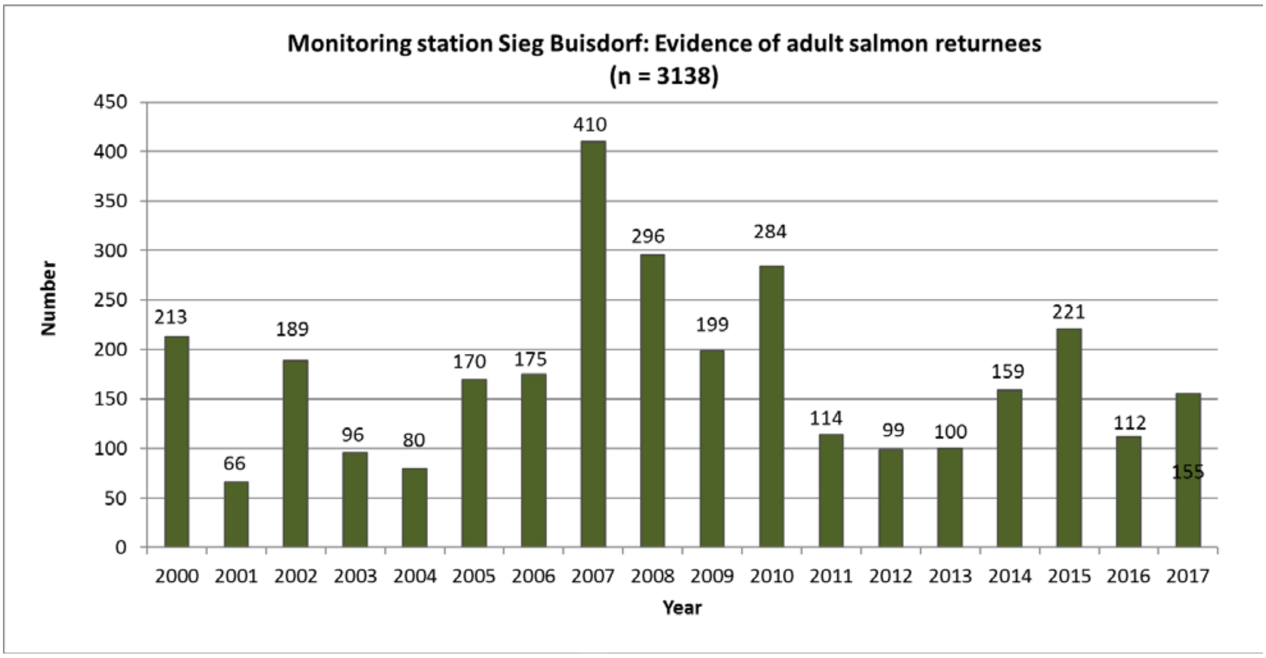
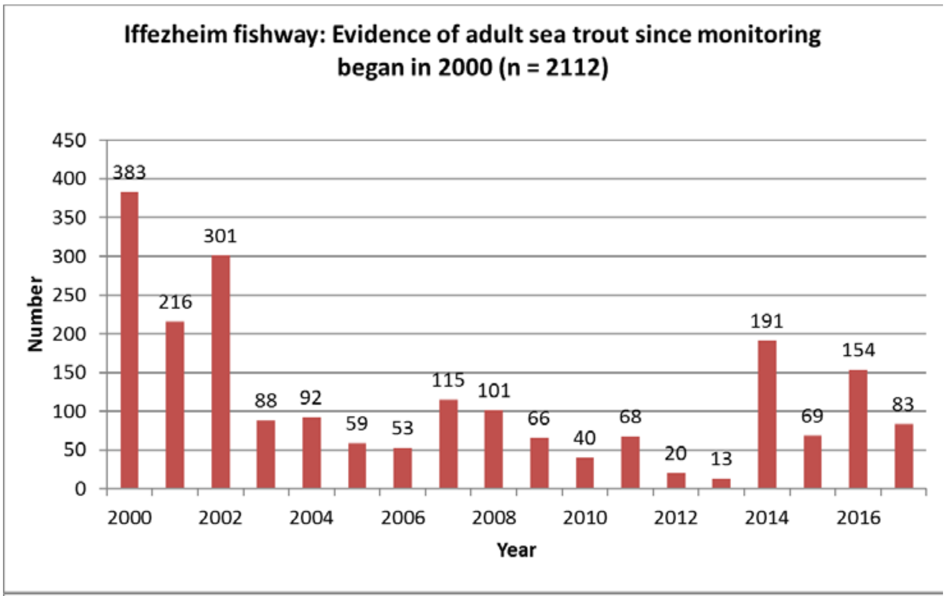


Figure 3: Evidence of salmon in the Buisdorf monitoring station on R. Sieg (as of 2000)



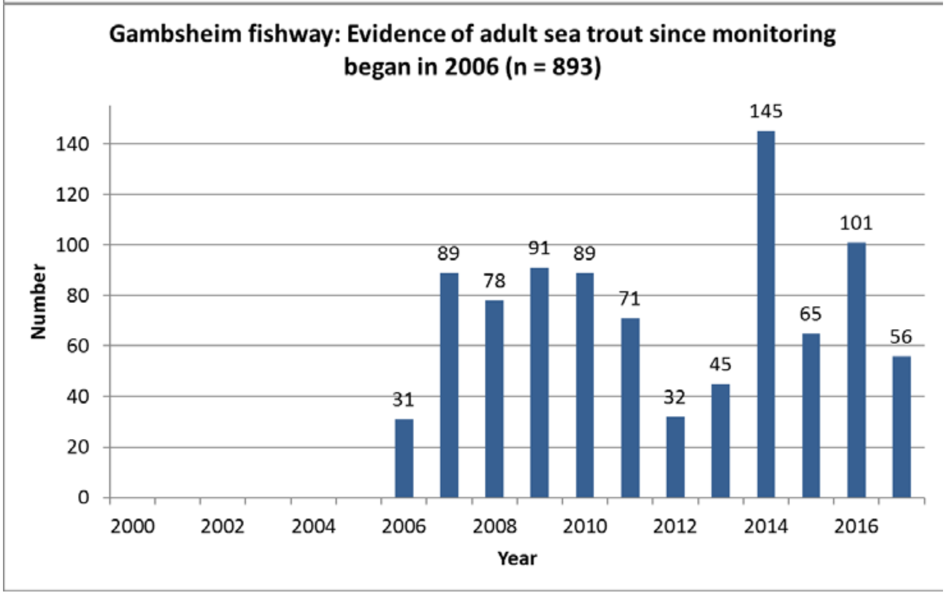


Figure 4: Evidence of sea trout in Iffezheim (starting 2000) and Gambsheim (starting 2006). Data: Fischereiverwaltung Baden-Württemberg, Association Saumon-Rhin (ASR). Restricted operation of the Iffezheim fishway between April 2009 and October 2013.

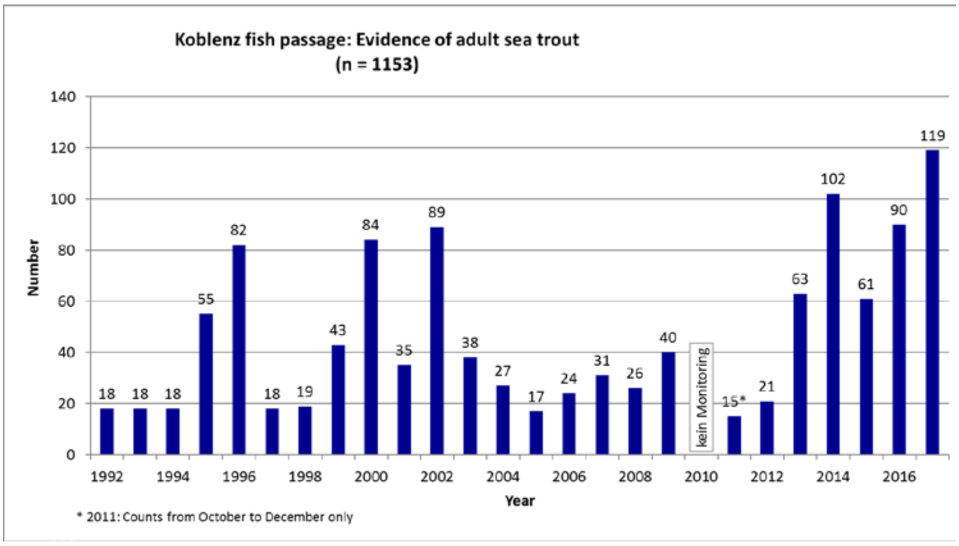


Figure 5: Evidence of sea trout in the Moselle, Koblenz fishway 1992 - 2017 (data: Bundesanstalt für Gewässerkunde- BfG).

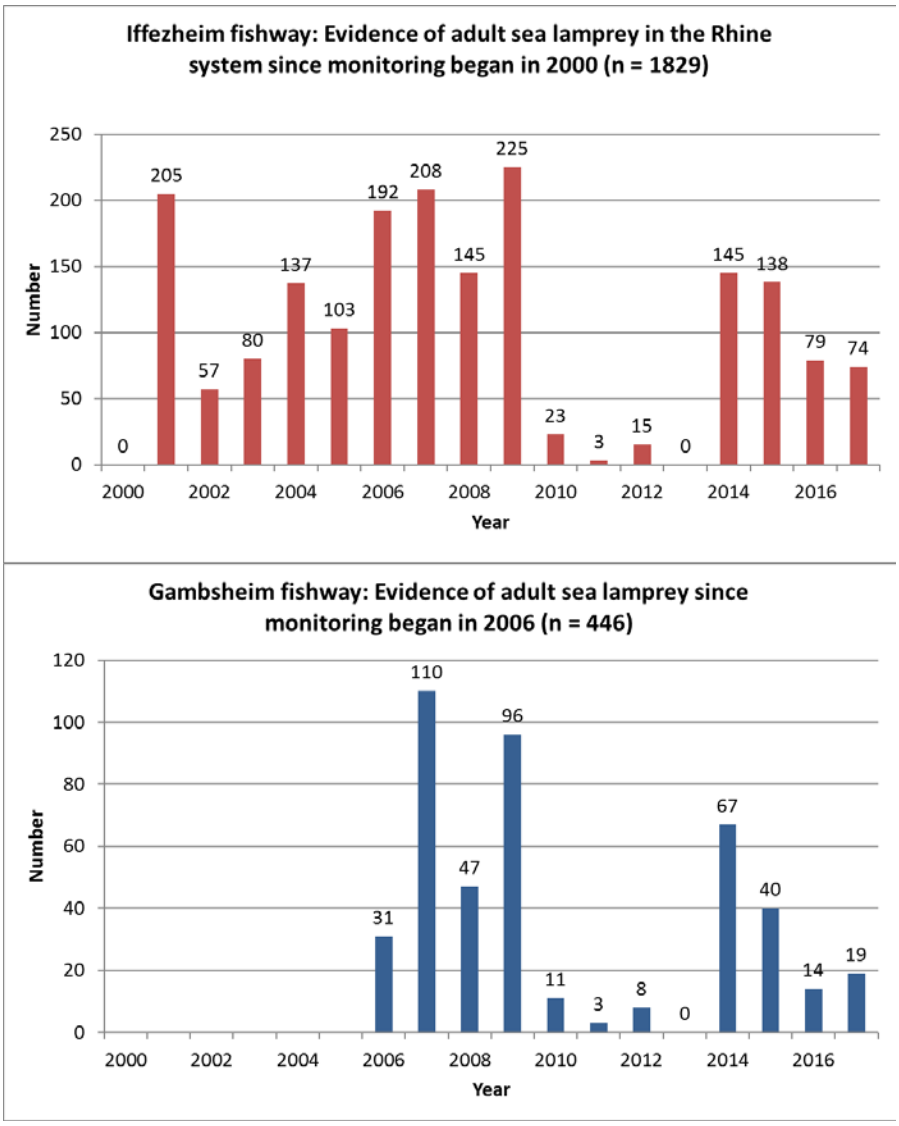


Figure 6: Evidence of sea lamprey in Iffezheim (starting 2000) and Gambsheim (starting 2006). Data: Fischereiverwaltung Baden-Württemberg, Association Saumon-Rhin (ASR). Restricted operation of the Iffezheim fishway between April 2009 and October 2013.

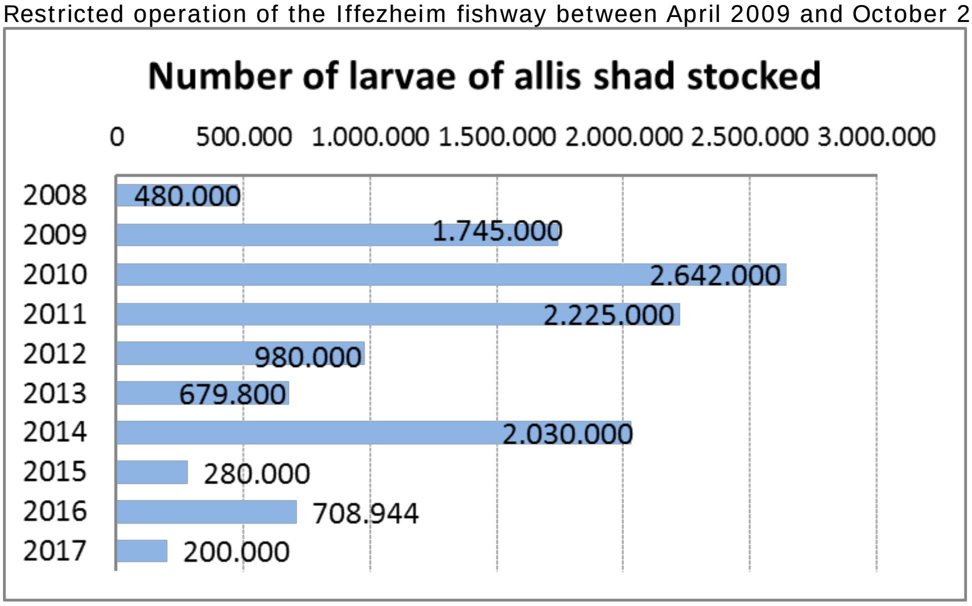


Figure 7: Number of larvae of allis shad stocked (Graph: A. Scharbert)