



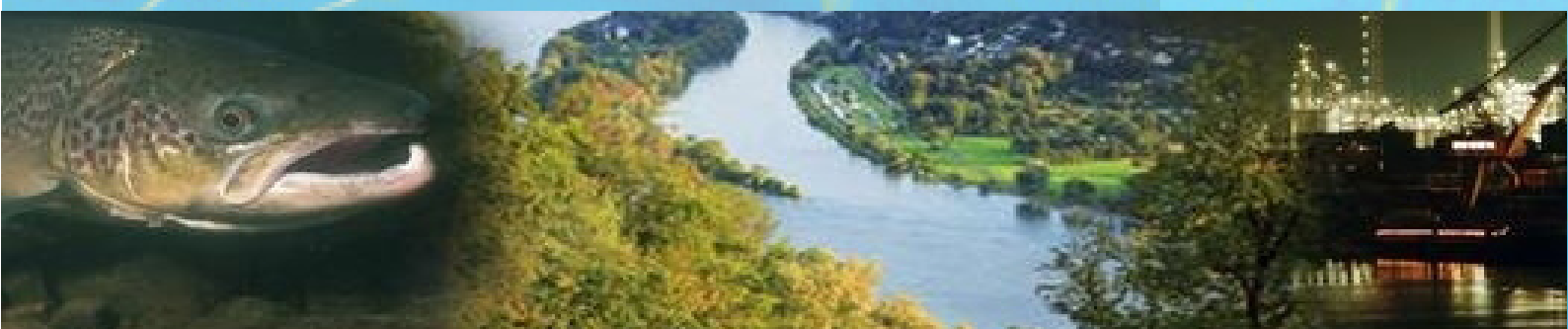
# Master Plan Migratory Fish Rhine

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# Master Plan Migratory Fish Rhine

## 1. Initial conditions

The **Master Plan Migratory Fish Rhine** is supposed to indicate, how self sustaining, stable populations of migratory fish can again be settled in the Rhine catchment as far as the Basel area within both reasonable time and costs. On 18 October 2007, the Conference of Rhine Ministers confirmed its intent to gradually restore river continuity in the Rhine as far as Basel and in the waters under the salmon programme. As a symbol, salmon represents many other migratory fish species, such as sea trout, sea lamprey and allice shad, while the lake trout is to be considered as indicator species for the Alpine Rhine and Lake Constance. Furthermore, measures aimed at reintroducing salmon and sea trout have positive effects on the incidence of many more animal and plant species and are suitable for improving the entire ecology of the Rhine. Basically, improving river continuity is part of the requirements for watercourses, including heavily modified water bodies. Thus, achieving the objective of the European Water Framework Directive (EC-WFD) is being substantially supported.

The protection regulations for migratory fish species and their habitats in annex II (particular protection areas for species), annex IV (strict protection) and annex V (management measures concerning uses) of the Habitats Directive<sup>1</sup> were taken into account when deciding on measures (Chapters 3 and 4). Additionally, following the EU regulation no. 1100/2007, the EU Rhine bordering countries with natural eel stocks have drafted national plans for managing stocks of eel; these plans are summarized in Chapter 5.

Additionally, the Master Plan represents an important part of the planned „Habitat Patch Connectivity along the Rhine“.

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) represents a basis for an integrated approach towards sustainable ecosystem improvement.

This analysis proposes solutions and lists the following most important measures:

- Restoration of up- and downstream river continuity;
- Diminish pressure due to fishery;
- Development of the quantitative and qualitative aspects of spawning and juvenile habitats.

*From a technical point of view, the results of this analysis complete the important proposals for measures aimed at an ecological improvement of the Rhine watershed with respect to the reintroduction of migratory fish. The effects of the measures proposed have been 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 indications in literature.*

*With the comprehensive in depth analysis of the BFS consultancy, the states, regions and federal states in the Rhine catchment have received a basis in order to decide, which*

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<sup>1</sup> Directive 92/43/EEC

*proposals for measures are of priority importance for the objective “restoration of migratory fish”.*

*These measures selected on a national level (see Chapter 4 and table in Annex) will be part of the programmes of measures according to the EU WFD and the programme „Rhine 2020”/“Salmon 2020” (phased implementation until 2015, resp. 2020/2027) and of the “Sea Trout Programme”.*

*Based on achievements so far, the „Master Plan” defines priorities for a phased implementation of measures, lists orders of magnitude for costs and indicates further required investigations.*

*Survey maps represent*

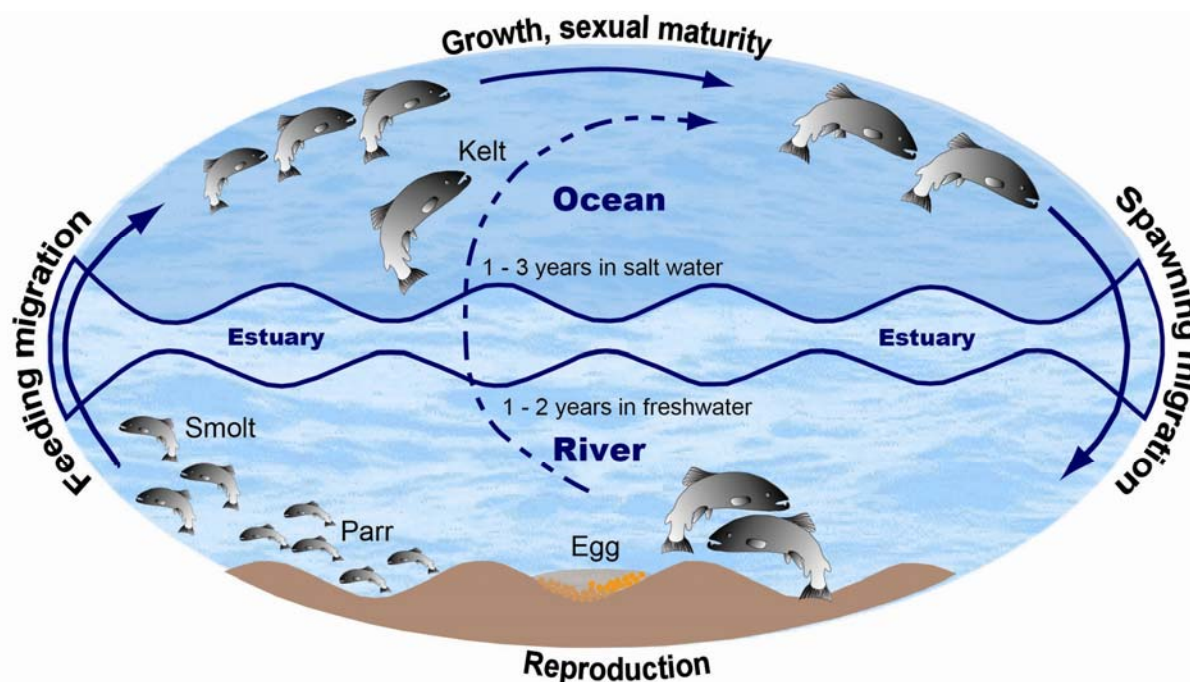
- *The historical distribution of salmon in the Rhine catchment (map MP-K 1)*
- *Potential habitats existing for salmon and sea or lake trout and which waters already grant river continuity (map MP-K 2)*
- *Where eel occurs in the Rhine catchment, where its stocks are being supported by stocking measures and where its migration is impeded by transverse structures (map MP-K 3)<sup>2</sup>.*

## **2. Background**

In the river Rhine and the rivers in its catchment there is great need for action to restore and improve river continuity for salmon, sea trout, sea lamprey and other anadromous migratory fish species (spawning in freshwater) and for the catadromous eel (spawning in the sea). During their life cycle, these long distance migratory fish migrate from the sea into freshwater or from freshwater into the sea. Fig. 1 represents the salmon life cycle. Apart from the Haringvliet sluices in the Rhine delta, hydropower plants and weirs represent significant obstacles for these fish species. Furthermore, due to a multitude of obstacles, numerous spawning and juvenile waters in the tributaries are today not accessible at all or only accessible to a very limited extent.

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<sup>2</sup> In the 1st management plan for the IRBD Rhine, part A these maps are listed as K 14.1, K 14.2 and K 14.3.



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

The map of historically proven salmon waters (MP-K 1) shows that, formerly, the Rhine catchment belonged to the very important European salmon habitats. 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 fish could migrate downstream into the North Sea and the Atlantic Ocean almost without surmounting any obstacles and returned to their home waters when 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.

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. Partly, redds and juvenile fish habitats for migratory fish have been destroyed or are no longer accessible.

Following several, mostly irreversible modifications of the river system only parts of the former area may today be made accessible.

### 3. Already implemented measures for anadromous migratory fish

The ICPR is coordinating the implementation of the „Salmon 2000“ programme since 1987 aimed at re-settling salmon, sea trout and other anadromous migratory fish species in the Rhine system. The programme „Rhine 2020“ and the implementation of the European Water Framework Directive (EU-WFD) represent a continuation of these efforts.

Thanks to the great efforts of the past and to great investments, the water quality of the Rhine and of most of its tributaries has been improved to such an extent that the basis for the existence of migratory fish has largely been restored. Recent investigations into stocks of fish reveal that all fish species formerly present in the Rhine – except for the sturgeon – have returned, even though some ubiquists are predominant and migratory fish, in particular salmon, are comparatively seldom (see ICPR report no. 173). Sea and river lamprey have also drawn their profit from improved water quality and have returned to the Rhine without human interference. They do not require any supporting measures but will profit from the restoration of river continuity.

Waters in the Rhine catchment with good spawning and juvenile habitats for migratory fish have been identified as re-settling programme waters; these are the waters measures concentrate on (see map MP-K 2).

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 spawning grounds and juvenile habitats in the Rhine tributaries. In the main stream, the two impoundments at Iffezheim and Gamsheim have each received fish passages (costs approx. 20 million €) and in the Rhine delta (Nederrijn/Lek) three barrages have been equipped with bypasses (approx. 7 million €). Present obstacles in the tributaries have equally been equipped with fish passages or obstacles have been removed (approx. 23 million €) so that it may be assumed that, since 1990, total investments amount to more than 50 million €. This sum equally includes costs for salmon stocking measures.

Thanks to measures implemented so far, more than 5,000 salmon returned to the Rhine catchment by end 2008. Nevertheless, salmon populations are today not self sustained. Further efforts aimed at their re-settling are required (see annexed table 2).

## **4. Measures planned for anadromous migratory fish in the different sections of the Rhine**

The natural living conditions in the Rhine change from its mouth up to the source areas in the Alps. Therefore and in order to achieve a targeted implementation of the proposals of measures presented by the Master Plan and matching to these conditions, the main stream and its tributaries have been sub-divided into sections.

In the programme waters, a total of more than 1000 ha of spawning and juvenile habitats could be opened in the Rhine catchment area.

As a matter of principle, the restoration of river continuity concerns the up- and downstream migration of fish. However, few technical measures are known with respect to the question of how to protect downstream migrating fish at hydropower plants. Therefore, in a first approach, measures aimed at improving upstream migration will be considered for the main stream of the Rhine. For smaller rivers, including some tributaries of the Rhine, functioning fish protection devices already exist, so that downstream migration through these waters will be included in the Master Plan.

The following measures are part of the management plan of the different EU states and federal states in the Rhine catchment as stated in the Water Framework Directive. Initially, it has been checked, where which measures are required and may achieve the objective. Priority measures will be chosen based on aspects of efficiency (proportionality), technical feasibility and financing possibilities and a timetable will be established for their implementation until 2015, 2021 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 is being drafted for all federal waterways aimed at improving river continuity. Presently, concrete implementation steps are being coordinated by federal administrations in charge, the federal administration for waterways and navigation and the power plant operators. In future, the federal administration for waterways and navigation will legally be in charge of measures aimed at improving the river continuity at impoundments for the navigable part of the rivers Moselle, Main, Neckar and Lahn.

In order to achieve the targets of the programme Rhine 2020 and to implement the decisions of the Conference of Rhine Ministers in 2007, the already known further investment requirement on the Upper Rhine amounts to some 100 million €, that for adapting the regulation of the Haringvliet sluices amounts to some 36 million €. As far as known today, costs for further measures required until 2015 or 2027 along the tributaries are listed in the annexed table.

### **4.1 River Continuity and Habitats**

#### **4.1.1 Delta Rhine**

##### **Measures until 2015**

Upstream migration of migratory fish into the Rhine system mainly passes by the Nieuwe Waterweg into the R. Waal leading 2/3 of the runoff of the Rhine into the North Sea. The R. Waal is the most important unhindered migratory route for up- and downstream migration into the Rhine system.



Today, upstream migration through the sluices of the Haringvliet and the Waal is only possible to a limited extent.

Only 1/9 of the runoff of the Rhine passes by the R. IJssel. Even though the closure embankment of the Lake IJssel is of little importance, upstream migration will also be improved at this location.

Between 2001 and 2004, by-passes / fish passages were built at the three weirs in R. Lek / Nederrijn: Hagestein, Maurik/Amerongen and Driel (costs: 7 million €).

Until 2010, the improvement of river continuity concentrated on partly opening the Haringvliet sluices with a fish-friendly sluice regime (expenses: 36 million €).

Additionally, the closure embankment of Lake IJssel will be made easier to pass by constructing 3 fish passages and making the regime of the sluiceway and sluices easier to pass for fish (costs about 2.5 to 5 million €). The indicated costs do not include any compensatory measures due to saltwater penetrating inland.

#### 4.1.2 Lower Rhine

There are no transverse constructions 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 until 2015

According to present knowledge, the programme waters **Wupper** (with its tributary **Dhünn**) and **Sieg** (with its tributaries **Agger** and **Bröl**) dispose of more than 200 ha juvenile habitats apt for salmon. This surface would be sufficient for the reproduction of some 2,500 adult salmon. At the time being, some 30 % of spawning and juvenile habitats are easily accessible for returning salmon. Presently, these surfaces are used for stocking measures and salmon are already reproducing successfully. *The R. Sieg is the first water body in the Rhine catchment, where natural salmon reproduction has been proved.*

A number of fishways have already been installed in the lower **Wupper** (costs: more than 1 million €). Opening further potential habitats in the systems of Wupper and Dhünn is being strived for.

In the Northrhine-Westphalian part of the **Sieg river system**, 4 major transverse structures in the main course of the R. Sieg and 1 weir in the R. Agger have been equipped with rough ramps during the past 20 years. Total costs amounted to some 2.5 million €. Thus, river continuity has been established as far as the section of the Sieg in Rhineland Palatinate. During the past years, further measures, such as the construction of monitoring stations (salmon counting) and strengthening of existing fishways (Buisdorf and Troisdorf) have been carried out on the rivers Sieg and Agger (costs: about 1 million €).

In the **Bröl** river catchment, an overall concept was developed as part of a pilot project aimed at removing existing deficits concerning the quality of salmon waters due to topsoil runoff, erosion, discharge of precipitation water, etc. (costs: approx. 12 million €). The concept indicates input pathways and sources of contamination as well as improvement measures for the Bröl river system. Implementation began in 2009.

In the section of the Sieg located in Rhineland Palatinate, 5 of 9 existing weirs have been made passable during the past 15 years. Costs amounted to approx. 1 million €. In 2010 the Höschwehr in Wissen will be dismantled and plans will be drafted for re-designing the weir at Freusburger Mühle. Irrespective of the federal state, RWE is planning to modify the fish passage at the Scheuerfeld weir. No solution is presently proposed for the Eutenneuen weir. The phasing out of the water rights in 2017 is being waited for.

Additionally, within re-naturation measures an improvement of habitat structures is being planned along some river sections in the R. Sieg system.

In the Sieg tributary **Nister**, 8 weirs have been modified during the past years for an equivalent of about 640,000 €. Due to these measures, today already 23 km of the R. Nister are unobstructed. The planned modification of four more weirs will add a further section of 22.5 km of undisrupted river.

#### 4.1.3 Middle Rhine

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

#### Measures in the tributaries to the Middle Rhine until 2015

Following vast re-naturation 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 49 transverse structures and river bottom sills have so far been modified or dismantled (costs approx. 3 million €). Thus, along its first 70 km, the R. Ahr is undisrupted. 3 further transverse structures are still to be modified and measures to improve habitat conditions are planned.

The R. **Nette** is directly flowing into the Middle Rhine and is continuous along 6.6 km in upstream direction. 7 of the 24 existing transverse structures have so far been modified to grant river continuity (costs: 445,000 €). 3 more weirs are presently being modified (costs: 205,000 €). On the medium term, the entire river is supposed to become undisrupted along 50 km in upstream direction.

After concluding modification works at the Isenburg waterfalls, the last of the 12 transverse structures on the R. **Saynbach** was made passable in 2008. During the past 15 years, measures amounting to about 0.5 million € have been implemented within the programme "Salmon 2000".

The most important tributary of the Middle Rhine, the **Moselle**, is 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. Connecting waters do, themselves, not dispose of any spawning or juvenile habitats for migratory fish. Due to their linking function, their importance is comparable to that of other programme waters.

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 (upstream direction from the confluence). In co-operation with Luxemburg, a long term project is being implemented to re-open habitats in R. **Sauer** (70 ha).

The costs for the 6 first fish migration constructions run up to approx. 20 million €. On the occasion of the total renovation of the hydropower plant Rosport (Luxemburg), river continuity of the R. Sauer will be improved at this migration obstacle (beginning of construction: 2011; costs: 1.6 million €). In order to open spawning and juvenile habitats in the upper Sauer, 3 more weirs will be made passable as of 2009; the first weir is already being modified (costs: 0,54 million €).

In the **Elzbach**, a tributary to the Moselle, 1 of 13 existing obstacles to migration has been modified; further measures are being planned.

From the outlet at Lahnstein upstream to the mouth of the Ohm the R. **Lahn** is an important linking water body to tributaries presenting spawning and juvenile habitats; in the hyporhithal further upstream the Lahn itself disposes of such habitats. In its lower section until Diez river continuity of the Lahn is not yet given (19 impoundments, continuity at the Diez weir is already granted).

In the Hessian part of the R. Lahn, so far 360,000 € have been invested in the section between Limburg and Wetzlar (mouth of river Dill). In this river section, there are 4 fish passages, which are yet to be optimized for long distance migratory fish. Conversion measures are being planned (cost estimation: approx. 700.000 €)

During the past years, the continuity of the R. Lahn was re-established in the sections between the mouth of R. Dill and R. Ohm up to the spawning grounds and juvenile habitats in the hyporhithal and this section was successively made accessible (modification of 7 weirs and drop structures; costs: approx. 1.4 million €). For the medium term, the restoration of the R. Lahn continuity upstream the mouth of R. Ohm is being planned.

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 make a further surface of 4.3 ha of spawning and juvenile habitats accessible.

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 fish passages). In order to make the entire grayling region up to the mouth of the **Lasterbach** near Heuchelheim accessible, 7 more obstacles must be made passable.

Since 1995, about 3 million € have been invested in the R. **Dill** catchment to restore ecological river continuity. Apart from two medium-sized obstacles to be modified in the near future, 32.5 km of R. Dill upstream its outlet into R. Lahn are already accessible for the fish fauna. On the medium term, accessibility of the grayling region for migratory fish as far as the outlet of the **Aubach** upstream of Haiger will be given, once 3 weirs will have been modified.

Investments in the R. **Weil** with approx. 18.5 km of spawning and juvenile habitats and which pours into the R. Lahn amount to some 670,000 €. On the medium term, the last approx. 5 km of the grayling region will equally be made accessible by modifying a weir.

R. **Wisper** has a direct outlet into the Rhine and has been designated as spawning and juvenile water along 14 km of its downstream and middle stream section. With a view to creating river continuity, all in all three weirs were modified in this section and measures aiming at structural improvement were carried out in its outlet (total costs: 185,000 €). In order to make further suitable sections located in the upstream region accessible, at least one more weir must be modified, entailing costs of approx. 100,000 €.

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. On the medium term, measures are planned at 14 weirs. Today, river continuity is granted along the first 5 km upstream the outlet near Bingen.

#### 4.1.4 Upper Rhine

The Rhine is freely flowing downstream of the Iffezheim impoundment (Rhine-km 700). Upstream of Iffezheim until Basel there are 10 barrages with hydropower generation, 4 of which are located in the Grand Canal d'Alsace. On the two lowermost of these impoundments in Iffezheim and Gamsheim fish passages for upstream migration were put into service in 2000, resp. 2006. As a consequence, upstream tributaries up to the R. **Kinzig** in Baden-Württemberg are again accessible. With a view to implementing the programme "Rhine 2020" and the Water Framework Directive, a „Feasibility Study for Restoring Ecological Continuity of the Upper Rhine for the Fish Fauna"<sup>3</sup> proposes basic solutions for the four upriver impoundments with hydropower generation located at **Strasbourg, Gerstheim, Rhinau and Marckolsheim** and for the sills in the loops of the Rhine .

#### Measures in the main stream until 2015

The next important measures along the Upper Rhine aim at opening the access to the **Elz-Dreisam** catchment (with 59 ha spawning and juvenile habitat) for anadromous migratory fish. The „Comprehensive Fish-Ecological Analysis" (ICPR report no. 167, chapter 5) presents the requirements to achieve this aim. According to this analysis, on French territory, fish passages must be built at the two barrages in Strasbourg and Gerstheim as well as at the agricultural weirs in the loops Gerstheim and Rheinau. According to national plans, fish will be able to pass the Strasbourg barrage by 2015; work on the Gerstheim barrage will begin before 2015. Measures aimed at achieving passableness of the agricultural weirs in the Gerstheim and Rhinau loops will be co-ordinated on a bilateral basis as they concern French as well as German territory. These measures will open a further section for river continuity into the tributaries and towards Basel. The total costs for this section are estimated to approx. 39 million €.

At each of the hydropower plants at the Iffezheim and Gamsheim impoundments, a 5th turbine is being integrated. Once this work will have been concluded (i.e. after 2011), telemetric studies are planned to examine the traceability of existing fish passages. This efficiency control will allow assessment of the respective measures implemented and further implementation steps may be planned.

At the cultural weirs at Kehl and Breisach, fish protection and downstream fish migration installations were built as part of the construction of small hydropower plants and **performance of the existing fish passages has been improved.**

The new concession for the Kembs power plant includes the obligation to construct a new fish passage at the bypass weir of the Märkt power plant towards the Grand Canal d'Alsace and to increase minimum discharge into the old bed of the Rhine. The French concession provides for increased residual flow with seasonal variations. The basic flow from November to March has been fixed to 52 m<sup>3</sup>/s (decree no. 2009-721 of 17 June 2009). The concession includes a review clause with respect to a possible increase of the residual flow as of 2020. The Swiss concession has not yet been granted. Additionally, further hydro-morphological processes will again be made possible on the French bank (sediment yield due to controlled gravel input). An Interreg project, in which technical institutes from Alsace (F) and Baden-Württemberg (D) participate, will support the pilot project. On the German bank, measures aimed at flood protection are planned which, during the years to come, will sustainably improve the ecological quality of water

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<sup>3</sup> Abstract: ICPR report no. 158 available at [www.iksr.org](http://www.iksr.org)

and floodplain habitats in this important section of the river between Kembs and Breisach (50 km).

These measures are expected to considerably enhance the entire ecosystem of the old bed of the Rhine (among others: reactivation of 88 ha of spawning and juvenile habitats).

### Measures in the main stream after 2015

According to the Feasibility Study, costs for restoring the migration routes further upstream towards Basel concern the hydropower plants Rhinau and Marckolsheim as well as the mobile weirs in the loops of the Rhine and are estimated to approx. further 40 million €.

The technical solution for the impoundment Vogelgrün/Breisach is particularly demanding. According to engineering opinion and due to the given spatial difficulties, given the present state of the art the only efficient solution which may be implemented on the short term is the construction of an installation to catch and regularly transport fish to a location in the Old Bed of the Rhine, where they will be released again. Construction costs are estimated to approx. 10 million €. However, this transport will only be maintained until it may be replaced by other technical solutions. From their stocking location in the Old bed of the Rhine migratory fish may reach the Basel area, since the Märkt weir in the old bed of the Rhine already grants river continuity and will receive a new fish passage within the new concession.

Due to this diversion of fish it will be possible to abandon the restoration of river continuity further upstream in the Grand Canal d'Alsace at the impoundments Vogelgrün, Fessenheim, Ottmarshiem and Kembs. Thus the old bed of the Rhine and its 88 ha spawning and juvenile habitats and the High Rhine in the Basel area (and the tributaries Wiese, 24 ha, Birs, 17 ha and Ergolz, 3 ha) will again be accessible (costs: approx. 40 million €).

With respect to the renewal of the concession for the Kembs hydropower plant, a success control will analyse by 2020, whether further habitat improvement measures are required in the old bed of the Rhine; in particular, a further increase of the minimum flow will be considered.

Eventually, partial adaptations will have to be carried out at the power plants, in particular aiming the protection of downstream migrating fish.

### Measures in the tributaries to the Upper Rhine until 2015

From its outlet into the Rhine at Mainz / Wiesbaden as far as Bamberg the R. **Main** is being used as federal waterway. Impoundments in the Main as well as further transverse structures in the Main tributaries block the access to spawning and juvenile habitats. The following potential salmon waters exist: the Hessian tributaries to the Main, **Schwarzbach, Nidda** (with **Usa** and **Nidder**) and **Kinzig** (with **Bracht, Salz** and **Bieber**), the Bavarian Main with its tributaries **Kahl, Aschaff, Elsava, Mömling, Haslochbach, Hafenlor, Gersprenz, Lohr** (with **Aubach**), **Mud, Erf, Sinn** (with **Kleine Sinn**) and **Fränkische Saale** (with **Schondra** and **Thulba**; presently, there are little chances of success for further tributaries of the Schondra) and **Tauber** in Baden-Württemberg.

In 2007, conversion of the lowermost impoundment in the Main near Kostheim began. Achievement is planned for end 2009. The impoundment will be equipped with one of the most modern fishways in Germany. Only the Eddersheim barrage must yet be modified in order to open up the Schwarzbach river system; preliminary designs for constructing a vertical slot fish passage exist. Their implementation is planned to be achieved by 2015.

In the catchment of the Schwarzbach the Land Hesse is supporting a project aimed at improving spawning habitats; measures will be implemented under the management of a sewage board with technical assistance of the authorities in charge.

Detailed technical solutions for fishways are being drafted for the next four impoundments upstream the R. Main (Griesheim, Offenbach, Mühlheim and Krotzenburg). Additionally, spawning and juvenile habitats in further tributaries of the Hessian Main will be determined and the required measures for their accessibility will be investigated.

Based on these analyses, possibilities with respect to restoring river continuity at barrages upstream the Bavarian Main, in a first step until Gemünden, will be investigated and checked. That is where the Fränkische Saale and its tributary Sinn flow into the Main. These rivers used to belong to the most important salmon waters in the Main system. In cooperation with operators of hydropower plants and the federal administration for waterways and navigation the Bavarian State Authority for Environment is drafting a "Strategic Overall Concept River Continuity Bavaria" equally including the entire Bavarian section of the Main and potentially important waters for migratory fish. It will be presented in 2010. Accessibility of spawning and juvenile habitats of diadromous fish species in the R. Main system plays an important part in this concept.

### **Neckar**

The lowermost 203 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 neither central migration routes nor habitats for anadromous fish species. Since middle-distance migratory fish such as nase and barbell are typical fish species in the R. Neckar and its catchment area, measures aimed at restoring river continuity are considered to be an important part towards achieving the "good ecological status" or potential. In addition, measures aimed at improving the aquatic habitats are required.

The lower, navigable section of the R. Neckar from the outlet into the Rhine near Mannheim to the mouth of the R. **Enz** has a much higher fish-ecological potential than the following section. River continuity will be entirely restored for this reason. The objective further upstream is to restore longer continuous sections of the Neckar in order to open up access to habitats and tributaries.

The lowermost transverse structure at Ladenburg has already been equipped with a fish passage. When determining the order of construction for the required fish passages in the river section between the outlet of the R. Neckar into the Rhine and the outlet of the R. Enz into the R. Neckar, the construction programme for prolonging the sluices will be taken into account. This also applies to the construction of the three fish passages required in the river section between the mouth of the R. Enz and the end of the federal waterway at Plochingen. Construction of the first two facilities (Kochendorf and Lauffen) will presumably begin before 2015.

The 63 km long R. **Lauter (Wieslauter)** is partly a French-German transboundary water body pouring directly into the Upper Rhine. Along the lower section of the Lauter, river continuity until the mouth of the Neuburger Altrhein has already been restored at two transverse structures. There are plans for two more transverse structures on German territory to restore river continuity until 2015. Investments in these two installations and bypasses will amount to approx. 0.75 million €.

An inventory of salmon and juvenile habitats is planned for the French part of the R. Lauter for 2010; until 2015, 3 more transverse structures near Wissembourg will be redesigned. On the long term, one further transverse structure in the German upper section of the R. Lauter in the Pfälzerwald will be redesigned.

Until 2015 river continuity of the **III** (4 transverse structures until the mouth of the Doller) including the tributaries **Bruche, Giessen, Liepvrette, Fecht, Weiß and Doller** (72 ha of spawning and juvenile habitats in all, 66 transverse structures) will be restored.

R. **Alb** and its tributary **Moosalb** all in all present approx. 10 ha suitable spawning and juvenile habitats. The redesigning of 23 transverse structures aims at restoring river continuity until the mouth of the **Maisenbach** in Marxzell along 36 km by 2021.

The **Murg** is one of the important programme waters in Baden-Württemberg and presents a high potential for reintroducing anadromous migratory fish. The first priority for their reintroduction concerns the river section as far as Forbach (36 ha), the second priority concerns that up to the upper section near Baiersbronn (approx. 12 ha). All in all, 39 obstacles to migration are to be redesigned 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.

In the rivers **Rench (11 ha) and Kinzig (68 ha)** all in all 79 ha of juvenile habitats will again be made accessible. In this connection, 5 transverse structures have already been redesigned in R. Rench and 18 in R. Kinzig to achieve river continuity and further 21 (Rench) resp. 117 (Kinzig) will step by step be redesigned until 2027. In parallel, structural improvement measures will be implemented in all river sections.

In the programme waters of the **Elz-Dreisam river system**, considerable potential surfaces (59 ha spawning and juvenile habitats) may again be made accessible. Therefore, river continuity within this system will be restored along 109 km (costs: 25.8 million €). Apart from measures aimed at structural improvements in all sections of the system, twelve transverse structures have already been redesigned and the same is planned for 18 further structures by 2015. Thus, river continuity will be given along the lowermost 90 km of the system. The remaining 37 transverse structures will step by step be modified until 2027. A prerequisite for accessing the Elz-Dreisam system is to restore river continuity at the hydropower plants Strasbourg and Gerstheim as well as at the agricultural weirs in the Rhinau loop of the Rhine (s. above).

#### 4.1.5 High Rhine

On the High Rhine, the following hydropower plants are equipped with largely functioning fish passages: Birsfelden, Augst-Wyhlen, Rheinfelden, Ryburg-Schwörstadt, Bad Säckingen, Laufenburg, Albbruck-Dogern, Eglisau, Reckingen and Schaffhausen. Only the Rheinau power plant downstream of the Rhine Falls at Schaffhausen is not yet equipped with any fish passage.

#### Measures until 2015

Until 2010, the river continuity at the hydropower plants Rheinfelden (bypass and fish passage), Albbruck-Dogern (bypass and redesign fish passage) and Eglisau (fish lift and fish passage) on the **High Rhine** will be improved. By 2012, the Ryburg-Schwörstadt power plant will be equipped with a by-pass. The fish passage at the Rheinau power plant is part of an ongoing procedure.

Additionally, within the implementation of the Water Framework Directive, the following existing fishways in the area of operation High Rhine will be improved: Birsfelden, Säckingen, Laufenburg and Reckingen.

The Swiss parliament is discussing a counterproposal to the popular initiative "Living Water", aimed at accelerated renaturation of brooks and rivers, and filed by the Commission for Environment, Spatial Planning and Energy of the Council of States. The legal basis is being prepared to enhance the revitalisation of waters, to reduce the negative impact of discharge fluctuations downstream of power stations with reservoirs,

to reactivate the bed-load balance and to restore fish migration at power plants. At the same time, a basis will be created to secure the financing of measures. The following approach is planned in order to implement this regulation:

- The Cantons plan the revitalisation of waters and implement corresponding measures according to their priorities.
- The Cantons plan restoration measures in the fields of hydropeaking, bed-load balance and fish migration and present their plans to the federal government by the end of 2014.
- The operators of installations concerned will implement these measures according to the schedule valid for the canton, at the latest 20 years after the new regulations come into effect.

A prerequisite for accessing the **Wiese** river system is that river continuity in the Upper Rhine and at a weir which has not yet been re-designed in the Swiss lower section of the Wiese will be restored; this weir will be redesigned by 2015. In this Swiss river section, about 2ha are suitable for juvenile fish habitats. In the middle and upper river sections in Baden-Württemberg river continuity has already been restored at 4 transverse structures and the structure of the water body has been improved; according to plans, 31 transverse structures will step by step be redesigned and further habitat improvement measures will be implemented. All in all, 22 ha of juvenile habitats are planned to be made accessible.

In the **Birs** river, many revitalisation measures have been implemented and a majority of obstacles has been dismantled; two fishways remain to be improved. Locally, some 17 ha of juvenile fish habitats have been redeveloped and are accessible to migratory fish once river continuity of the Rhine will be granted as far as Basel. The reintroduction has already been successful in the lower and medium part of the Rhine district presenting a similar habitat potential as the Birs.

In order to access to the R. **Ergolz**, the uppermost Rhine tributary in the Basel area, salmon will have to surmount two more impoundments on the High Rhine. Today, a little more than 3 ha juvenile habitats are located in this river.

With a view to opening the access to spawning and juvenile habitats which, due to the backwaters of hydraulic structures in the High Rhine are not even accessible for the fish fauna typical of the water body, the tributaries **Hasel**, **Hauensteiner Alb** and **Hauensteiner Murg** as well as the rivers **Wutach** and **Biber** will be connected with the High Rhine.

#### **Measures after 2015**

Eventually, partial adaptations will have to be carried out, in particular aiming the protection of downstream migrating fish.

#### **4.1.6 Lake Constance / inlets to Lake Constance / Alpine Rhine**

Upstream the natural area of salmon expansion, in the river basin of the Alpine Rhine/Lake Constance, the Lake Constance lake trout (*Salmo trutta lacustris*) is the only migratory fish. All in all, compared to its historic distribution, the habitat of the lake trout has been heavily reduced.

In Lake Constance with its water bodies "Obersee" (Upper Lake) and "Untersee" (Lower Lake) today presenting a good chemical and ecological status, the free water constitutes the preferred habitat of the lake trout. Here it grows up until it is mature to spawn and migrates upstream to the Alpine Rhine and its tributaries to spawn (potadromous pattern of life).



For the lake trout, the continuity of the Alpine Rhine is provided from the outlet into 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 fish passage 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.

Due to the operation of storage power plants for the production of power peaks, the runoff patterns of the Alpine Rhine have been heavily modified. Almost every day, discharge fluctuations between 60m<sup>3</sup>/s during low water periods and 200m<sup>3</sup>/s during hydropeaking runoff are registered in the lower river section (river km 65-94). Given these circumstances, the river bed may hardly be used as spawning and juvenile habitat for fish. Additionally, the density of fish feeding animals has been considerably reduced. Therefore, for the sea trout, the Alpine Rhine is mainly important as linking water body. During recent investigations, specimens of sedentary sea trout were detected in the Alpine Rhine.

The tributaries to the Alpine Rhine and of waters directly pouring into Lake Constance may only be used to a limited extent for the lake trout, as, in many places, transverse structures are already located in the outlet area and the waters are impacted from a morphological and hydrological point of view.

### Measures until 2015

The successful measures carried out within the „Lake Trout Programme“ of the „Internationale Bevollmächtigtenkonferenz für die Bodenseefischerei (IBKF) (International Conference of Plenipotentiaries for Fishery in Lake Constance) prove that a coordinated programme may contribute to achieving the objectives.

An international programme of measures will now assign an important role to the lake trout to achieve water protection targets in the entire area of operation Alpine Rhine / Lake Constance. The basic report, „Habitat for the Lake Constance lake trout“, commissioned by the IBKF includes a framework programme integrating and co-ordinating all programmes of measures aimed at enhancing the sea trout and other migratory fish species as well as programmes with similar water protection and water development objectives based on a common (transboundary) objective.

The measures the report proposes for the tributaries will be implemented according to national priorities from 2015 on.

On the river **III**, 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 outlet up to the Bregenzerach canyon. To this end, measures must be implemented at existing ramps and at an existing technical fishway.

River continuity of the **Spirsbach (Spiersbach)**, a torrent partly flowing in parallel to the Alpine Rhine is granted, since its outlet into the Rhine was redesigned in 2008. Now further river sections are to be enhanced as habitat so as to fulfil the function of a spawning and juvenile habitat.

At the time being, measures aimed at ecologically enhancing the **Old Rhine** are being implemented, beginning at the outlet into Lake Constance.

Technical feasibility, financing and ecological effects of measures concerning the **Dornbirnerach**, the **Schwarzach**, the **Bregenzerach**, the **Frutz**, the **Ehbach** and the **III** are presently being investigated.

Between 1980 and 2000, all transverse structures were eliminated in the **Liechtensteiner Binnenkanal**. Further measures aimed at improving spawning and juvenile habitats and at restoring morphological variety are planned in the tributaries and the Binnenkanal itself.

The river continuity of the **Vereinigte Argen** is already given. At the time being, river continuity is being restored at the first hydropower plant in the **Upper Argen**. Plans are being established for the structures further upstream so that, by 2015, fish from Lake Constance should be able to access the Wangen area. The planning assessment procedure for redesigning the lowermost obstacle in the **Lower Argen** is ongoing. After the implementation of measures, river continuity would be restored along 15 km. The owners of the hydropower plants further upstream seem to be willing to enter into negotiations so that river continuity upstream as far as the Gottrazhofen reservoir seems to be achievable by 2015.

The river **Schussen** is accessible to lake trout along 30 km, as the gauging station Lochbrücke/Gebertshaus is already passable to a limited extent; further improvements are planned. This means that 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. First negotiations with the operator of the power plant have been conducted.

In the **Seefelder Aach**, the hydropower plant in Mühlhofen is the only remaining obstacle before the flood storage basin Hohenbodman at river kilometre 30. The outlet gauge is accessible to a limited extent. Further improvements are possible.

5 transverse structures have already been modified in the **Stockacher Aach**, so that river continuity has been achieved as far upstream as Wahlwies. If the drop structures at Wahlwies were redesigned, the further course of the Aach itself and the **Krebsbach** would be re-connected. 10 more transverse structures are to be redesigned. River continuity of the **Radolfzeller Aach** is given along 10 km upstream from its outlet; 8 transverse structures have already been redesigned, until 2027 10 more will follow. In both tributaries to Lake Constance measures aimed at improving spawning and juvenile habitats are planned by 2015.

The Bavarian lake trout waters R. **Leiblach** and **Oberreitnauer Ach** have already been redesigned and largely permit unhindered migration. Apart from the lake trout, these rivers are spawning waters of the soufie (a heavily endangered fish species listed in annex II of the Habitats Directive). Modifications of rest of the constructions and habitat improvement measures will be achieved by 2015.

### Measures after 2015

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 outlet 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 bottom and thus the groundwater level;
- Restore river continuity and networking 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.

## 4.2 Pressure from fisheries

In the entire Rhine catchment and in the Dutch coastal area, catching and possessing salmon and sea trout is forbidden by law. Nevertheless, from today's point of view, fishery must be considered as a limiting factor for big salmonids and allice shad, as implementation is deficient. For sea lamprey, negative effects can be excluded as this species is of no 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), to accidental catches (including inadvertent by-catches) and to poaching. In particular, there are no reliable data on targeted illegal catches. Information, intensified controls and the consequent use of penal law should considerably reduce salmonid mortality due to fishery. The ICPR has drafted the following recommendations aimed at improving legal compliance and thus reducing by-catches and illegal catches of salmon by professional and leisure anglers:

### 1. Supplementary and improved investigations

Supplementary investigations with other methods and instruments within professional fishing may give an improved view of the real causes for disappearing salmon and fish mortality.

### 2. Adequate regulations

- a. As far as salmonids are concerned, regulations for catches and sale as well as obligations to put 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. Interdictions will be practicable (see example given under 4c).

### 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;
  - The interdictions applied to catching and selling salmons. Fines and other eventual penalties will 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, to take as few salmonids as possible 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 stocking purposes).

### 4. Well passable constructions and other obstacles

- a. Well passable 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 passableness, it is recommended to strive for an optimal synergy with measures resulting from the Eel Regulations.
- c. The creation of a zone with a 300 m perimeter around smaller and 500 m around bigger weirs, sluices, fishways and natural sills (in up- and downstream direction) is recommended, as many salmonids are liable to aggregate in these river sections during their migration. Complete interdiction of fishery is easier to implement in these areas around constructions than the specific ban on catching certain salmon species without putting them back again.

## 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 put these fishes 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 by-catches. 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

In future, experts will annually exchange information within the ICPR on the implementation of these recommendations in the Rhine bordering countries and report on their effectiveness in practice.

## 4.3 Further action / outlook

The following proposals are submitted with a view to granting the success of the migratory fish programme and to prove cost efficiency of measures:

1. With respect to downstream migration in the main stream, a programme should be brought on the way targeted at enhancing knowledge about effective measures to modify power plant constructions in great rivers.
2. The cumulating effects during up- and downstream migration of migratory fish should be demonstrated.
3. In order judge the effectiveness of measures for the entire Rhine catchment, individual success control measures should be carried through in the outlets of the most important Rhine tributaries or in fishways at great impoundments; in these locations, the rate of returning adult fish should particularly be assessed.

Experience drawn from migratory fish programmes in different river districts should be exchanged.

## 5. Threat posed to eel and eel protection in the Rhine catchment

### 5.1 Initial conditions

Contrary to other migratory fish, the eel does not reproduce in fresh water but in the sea (Caribbean Sea, presumably Sargasso Sea). From there, the eel spawn drifts with the Gulf Stream across the Atlantic Ocean; the glass eels then develop in the European coastal waters, before they migrate upstream into the rivers, brooks and still waters, where they partly spend more than 10 years before returning into the sea as adults to spawn and die. Figure 2 illustrates the life cycle of the eel.

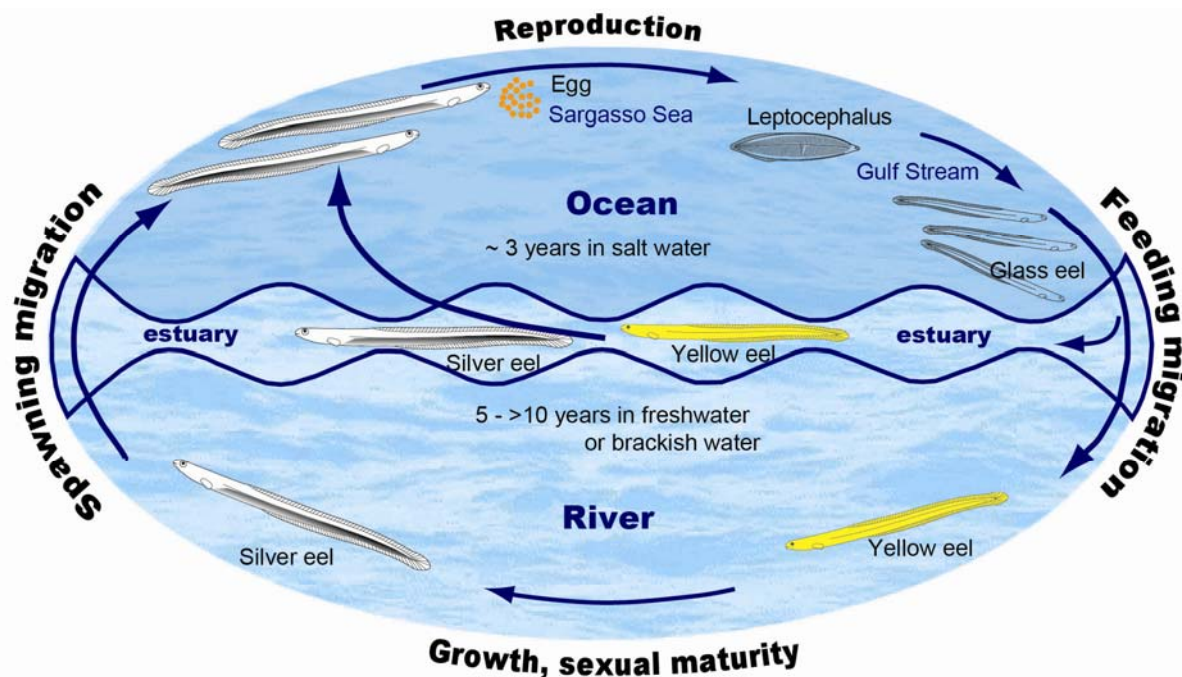


Fig. 2: Eel life cycle. Source: Bundesanstalt für Gewässerkunde (BfG)

For professional fishery, the eel represents an important source of income almost everywhere in the Rhine, in particular on the North Sea coast, in the Delta Rhine and in Lake Constance. Luxemburg is the only country without professional fishery. Angling for eel exists in all Rhine bordering countries.

During the past years, the stock of eel has considerably declined. Since the beginning of the 1980s, only a few percent of the long-time average of glass eel numbers migrating upstream into the rivers return. There are many reasons for this decline:

- Commercial fishing of glass eel in river estuaries;
- Commercial fishing for yellow eel, silver eel;
- Losses due to piscivorous birds;
- Transverse structures impeding access to habitats;
- Loss of downstream migrating silver eel at hydropower stations, pumps, etc.;
- Eventually parasites (*Anguillicola crassus*) and illness (eel herpes);
- Heat waves in summer coinciding with low water periods as in 2003 when a mass die-off of eel was locally observed;
- Certain toxins, as PCB resembling dioxins mobilised from historic sediment pollution: It has been proven that these substances accumulate in the fat of the eel and may contribute to a permanent physiological pressure on fish;
- Changes in the marine environment (climate change): They may possibly have a negative impact on the populations of the European eel.

The sum of these factors leads to the fact that today comparatively few specimens again reach the open sea.

The map MP-K3 shows that eel is present almost everywhere in the Rhine catchment; thus, most waters are suitable as eel habitat: There is enough food and demands of eel with respect to habitat structures and water quality are low.

The eel is particularly wide spread in waters near the coast and in lowland waters. For natural reasons, the eel is only sparsely spread in mountain ranges above 800 m.

Therefore, measures aimed at eel protection should above all concentrate on the lowlands and central high hills below 800 m altitude, even though measures can also make sense for partial populations in higher mountain ranges. Apart from the High Rhine the stocks of eel are being supported by stocking measures in the entire German territory and in Lake Constance (agreements with Switzerland exist). The other Rhine bordering countries do not stock eel, however, in these regions eels settle which originate from stocking measures in Germany. Some Rhine bordering countries dispose of quantitative indications concerning the density of the eel population; compared to waters in mountain regions they confirm a higher density of eel near the coast.

Map MP-K 3 illustrates how eel migration – in particular downstream migration through the Delta Rhine, in the southern Upper Rhine and almost all Rhine tributaries – is affected by transverse structures. Eels migrating downstream are in particular danger, as they move along the river bed: They are often caught in the turbines of power plants, intake constructions, pumps, etc. Due to the length of their bodies they suffer from grievous, mostly lethal injuries; the cumulated mortality may be considered substantial if several transverse structures follow one another. Besides the risks already mentioned this additionally reduces the rate of returning eel. A consequence of the sum of risks is that the life cycle of the eel is interrupted even before the eels have returned to their spawning grounds in the Caribbean Sea. Therefore, the eel in the European coastal and inland waters must be protected by a comprehensive programme.

## 5.2 Eel protection measures

For protection purposes and future management of the endangered eel populations in Europe, the EU issued a regulation (EC No. 1100/2007) focussing on a reduction of eel mortality of anthropogenic origin. This regulation lists possible measures aimed at protecting the eel, such as restricting fishery and restoring or improving up- and downstream river continuity. According to 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 environmental objective set by the EC eel regulation is to secure 40 % survival as compared to the natural stock. These eel management plans are supposed to secure that, if the downstream migrating stock of eel falls below this survival rate, it will be supported.

In particular, the national eel management plans of the Rhine-bordering countries provide for the following measures aimed at stabilising the stock of eel in the Rhine catchment area:

### 1. Improvement of up- and, above all, downstream river continuity

It is particularly important to improve the protection of downstream migrating silver eel at hydropower plants in order to enable a sufficient number of eels to reach the sea. In many places, bypasses and / or eel ducts or protection devices are planned which will avoid eel to get into turbines or pumps.

In the Netherlands, 255 instream barriers to eel migration have already been removed. Further **reconstruction measures** are planned at numerous **impoundments, pumps and hydropower plants**: 136 by 2010, 538 by 2015, 249 by 2027; the approach for 608 instream barriers in the Delta Rhine is not yet clear. By 2027, 48 transverse structures in eel waters in France (Lauter, Ill and tributaries) will be made passable. In Germany, discussions are going on with the operators of hydropower plants.

If, for technical reasons, effective fish protection cannot be achieved, **turbine management** constitutes an appropriate measure. During the main eel migration period individual turbines are turned off in order to reduce the risk of mortality when passing by the hydropower plant. In Germany and in France negotiations on this aspect are going on with the operators of hydropower plants.

In Germany, the **construction of new hydropower plants** in eel waters will, if possible, only be permitted **in connection with functional fishways for up- and downstream migration**. However, at present we only dispose of limited technical solutions aimed at reducing the mortality of silver eel at great hydropower plants. On the R. Moselle and its tributary Sauer **catching and transporting** eel during their downstream migration have proved successful as a provisional solution. The fish are caught upstream the impoundment and set back into the unobstructed lower section of the Rhine in order to continue their migration into the sea. As part of this measure and within a German-Dutch research project, silver eel were equipped with a **transponder** during 2004 to 2007; the project will be continued. In France, detailed knowledge on the behaviour and mortality of eel at hydropower plants is expected to result from a **telemetry study**.

Additionally, research programmes are going on in Germany and France concerning the **optimization of downstream fish passages** in order to minimize injuries to eel in the turbines (infrasound barriers, turbine management, fish-friendly turbines, etc.). Within this framework, **registration systems for the main migration** (e.g. sounder, reports by professional fishermen) are being looked into.



## **2. Limitation of fishery**

Closed seasons, minimal size, ban on fishing at night, ban on certain kinds of fishing gear are measures which may limit the fishing on eel by professional and leisure fishermen.

In France, the closed season for the yellow eel will gradually be extended to the period 16 September to 14 April (in 2011) (today: 1st November to 30 March); there is already a year-round ban on fishing silver eel.

In the German part of the main stream of the Rhine the closed season for downstream migrating silver eel covers the period 1st October to 1st March; in Hesse, this closed season also applies to all backwaters of the Rhine. Existing fishing regulations, such as the general ban on fishing upstream migrating eel, the ban on electro-fishing of eel in Northrhine-Westphalia, limitations on fishing at night in Baden Württemberg and minimal mesh width remain valid; the minimum size for eel was increased to 50 cm.

As of 2010, there is a ban on fishing eel between 1st September and 1st December applying to professional fishermen in the Netherlands; along the coast, there is a ban on leisure fishing with professional fishing gear. Additionally, areas with a general ban on fishing have been defined; a research project aims at making artificial eel reproduction possible.

## **3. Stocking**

For several decades (Lake Constance: since more than 120 years) different state authorities and fisheries associations have been carrying out eel stocking measures in the entire German Rhine catchment area apart from the High Rhine. Within the eel management plan, these stocking measures will be maintained under all circumstances and will partly be reinforced (750,000 glass eel and 1.1 million pre-fed eel fry annually on about 50,000 ha). No stocking measures are planned in the French Moselle-Saar area because of the many obstacles to migration, while 9 areas have already been designated as apt for stocking measures in the Rhine and its tributaries. These areas are located downstream and right upstream the Iffezheim impoundment, so that little mortality is expected for downstream migrating eel. A national French guidance plan for eel stocking measures is presently being drafted.

## **4. Hydro-morphological measures**

When developing the shipping lane for navigation purposes, blocks with a side length  $\geq 30$  cm will be used for river bank stabilization without interlocking; eels prefer the interstices as habitats.

## **5. Limitation of predation**

In Germany, cormorants may be shot to a limited extent, in order to protect eels and other fish species (salmon, sea trout).

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For further literature please see the comprehensive bibliography in 2. (Comprehensive fish-ecological analysis)

### **National eel management plans (for the Rhine catchment):**

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- Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen: Aalbewirtschaftungsplan – Flussgebietseinheit Rhein. December 2008
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**References for Map MP-K 1:**

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**Annex****Table 1: Implemented and planned hydro-morphological measures in the programme waters for anadromous migratory fish in the Rhine catchment****Maps****MP-K 1 Historically proven distribution of salmon and sea trout and of the Lake Constance lake trout in the Rhine catchment area****MP-K 2 Master Plan Migratory Fish Rhine – example: Salmon and Sea Trout, Lake Constance Lake Trout**

Transverse structures in the Rhine, passableness of programme waters, potential spawning and juvenile fish habitats

**MP-K 3 Eel in the Rhine Catchment**

Present eel distribution, interference with eel migration (up- and downstream) resulting from transverse structures, hydropower plants, pumps, etc.<sup>4</sup>

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<sup>4</sup> In the 1st management plan for the IRBD Rhine, part A these maps are listed as K 14.1, K 14.2 and K 14.3.

Annex: Table 1

Master Plan Migratory Fish Rhine							
Implemented and planned hydro-morphological measures in programme waters for anadromous migratory fish in the Rhine catchment							
		Implementation accomplished (state 2009)		Measures implemented, ongoing and planned until 2015			
		Ongoing implementation (state 2009)					
		Implementation planned by 2015					
		Begin of work planned before 2015					
		Implementation by 2027 planned		Non-binding forecast			
		Long term phased implementation planned (see Conference of Ministers, Bonn)					
* The costs indicated for ongoing and planned measures are largely based on estimates and only partly concern specific measures for migratory fish.							
Expenses for accomplished and on-going measures aimed at improving habitat quality are not separately listed but added to measures planned by 2015.							
Country	Section of the Rhine / tributary system	Waters/section, construction/s	Transformation transverse structure (number)	Improvement of habitat quality (=x) and further measures	Expenses (million Euros)*		
NL	Delta Rhine	Lek/ Nederrijn: Hagestein, Amerongen, Driel	3		7		
		Haringvliet, sluice	1		36		
		Lake IJssel, closure embankment (expenses: 2,5 - 5 million €)	1		5		
D-NW	Wupper-Dhünn	Wupper and tributary Dhünn, total system	8	Structural improvement	1		
D-NW	Sieg	Rhenish Sieg and Agger (lowermost 30 km): Monitoring station exists already	5	Structural improvement	10,5		
		Bröl (pilot project): including storm water treatment	2	Structural improvement	12		
D-RP	Sieg	Sieg, middle section	5		1		
		Sieg, middle section: Weir Hösch, Freusburger Mühle, weir Scheuerfeld (RWE)	3				
		Nister, downstream region (23 km)	8		0,64		
		Nister, upstream region (22.5 km)	4				
D-RP	Ahr	Ahr, downstream region (70 km)	46		3		
		Ahr, upstream	3	x			
D-RP	Nette	Nette, downstream region (6.6 km)	7		0,45		
		Nette, upstream	3		0,21		
		Nette, upstream section (50 km)	14				
D-RP	Saynbach	Saynbach-Brexbach	12	x	0,5		
D-RP	Moselle	Moselle, downstream (Koblenz to Enkirch)	6		20		
		Moselle, upstream (Zeltingen to Trier)	4				
		Elzbach, downstream	1				
		Elzbach, upstream	12				
Lux		Sauer, Rosport (construction beginning: 2011)	1		1,6		
		Sauer, upstream (the lowermost weir is already under transformation)	3		0,54		
D-RP	Lahn	Lahn, downstream (Lahnstein to Diez)	1				
D-HE	Lahn	Lahn, Wetzlar (mouth r. Dill) to Limburg	2	x	2,1		
		Lahn, upstream mouth of R. Dill	19	x	29		
		Lahn, upstream mouth of R. Dill	26	x	28,1		
D-RP	Lahn	Mühlbach, downstream region (6 km)	2		0,18		
D-HE	Lahn	Elbbach (downstream, 10 km to Hadamar)	6		1,1		
		Elbbach, upstream to mouth of R. Lasterbach	9	x	1,5		
		Dill	5	x	2		
		Dill	14	x	4,9		
		Weil	2		0,24		
		Weil	1	x	0,85		
D-RP	Nahe	Nahe, downstream, 5 km undisrupted	8				
		Nahe, upstream (105 km)	14				
		Nahe, remaining obstacles	11				
D-HE	Wisper	Wisper, downstream and middle section	1		0,19		
		Wisper, downstream and middle section	1	x	0,3		
D-HE	R. Main	Main: Kostheim	1		0,97		
		Main: Eddersheim	1		2,6		
		Main: Griesheim, Offenbach, Mühlheim, Krotzenburg	4		10,95		
		Main: Measures for structural improvement		x	94,43		
		Schwarzbach near Hattersheim (mouth)	1	x	1,9		
		Schwarzbach (Eppstein)	1	x	0,02		
		Schwarzbach (Eppstein)	3	x	3,5		
		Nidda (with Usa and Nidder)	17	x	18		
		Nidda (with Usa and Nidder)	35	x	10		
		Kinzig (with Bracht, Salz, Bieber and Schwarzbach/Kinzig (= upstream Kinzig))	3		0,09		
		Kinzig (with Bracht, Salz, Bieber and Schwarzbach/Kinzig (= upstream Kinzig))	11	x	2,4		
		Kinzig (with Bracht, Salz, Bieber and Schwarzbach/Kinzig (= upstream Kinzig))	32	x	3,6		
		D-BY		Main upstream Aschaffenburg to Gemünden	11		
		D-BW		Tauber	n.s.		
D-BY		Kahl, Aschaff, Elsava, Mömling, Haslochbach, Hafenlohr, Gersprenz, Lohr, Mud, Erf		x			
		Sinn (and Kleine Sinn) and Fränkische Saale (with Schondra and Thulba)		x			
Entire Bavarian Main with tributaries			Total concept for continuity				
D-HE	Weschnitz	Weschnitz	6	x	35,7		
D-BW	Neckar **	Neckar: lowermost transverse structure near Ladenburg	1				
		Neckar: Kochendorf, Lauffen	2		(5,4)		
D-BW	Neckar	Neckar downstream to mouth of R. Enz	9	x	(13,5)		
D-HE	Neckar	Neckar: Hessian part downstream	2	x	(4,7)		
D-BW	Neckar	Neckar: Mouth R. Enz to Plochingen	3	x	(4,8)		

(Fortsetzung nächste Seite)

Table „Master Plan Migratory Fish Rhine“ continued					
Country	Section of the Rhine / tributary system	Waters/section, construction/s	Transformation transverse structure (number)	Improvement of habitat quality (=x) and further measures	
D-BW	Rhine	northern Upper Rhine downstream of Iffezheim		x	12,2
D-BW	Alb	Alb downstream	4	x	1,5
		Alb upstream to mouth of R. Maisenbach in Marxzell	19	x	2,1
F	(Wies)Lauter	(Wies)Lauter, Lauterbourg mill	1		0,16
D-RP		(Wies)Lauter, Berizzi mill	1		0,17
		(Wies)Lauter downstream	2		0,42
F		(Wies)Lauter, French section near Wissembourg	3	Inventory	
D-RP		(Wies)Lauter, upstream section upstream of Wissembourg	1		
D-BW	Murg	Murg, downstream region (20 km)	1	x	4,9
		Murg, middle and upstream section to mouth of Elbbach in Baiersbronn	39	x	8,5
F / D-BW	Rhine	southern Upper Rhine: Iffezheim and Gamsheim	2		
		Optimize fish passages Iffezheim, Gamsheim	Telemetric study		
		southern Upper Rhine: Strasbourg	1 + x		20
		Dreisam***	1 + x		20
		southern Upper Rhine: Rhinau, Marckolsheim including loops and mobile weirs***	2 + 4		38
		southern Upper Rhine: Vogelgrün	1		10
		southern Upper Rhine: Vogelgrün		Research	
		Old Rhine: Interreg project "Feasibility study on restoring the dynamics of the Old Rhine", implementation eventually by lowering the river forelands on the right bank of the Rhine		Only feasibility study	3
F		Old Rhine (renewal of the concession Kembs): Restoration of controlled erosion of the left bank of the Rhine between Kembs and Breisach (if feasibility is proven)		Alluvial habitats	
		southern Upper Rhine, Kembs (renewal of concession): Construction of a new fish passage	1		
		southern Upper Rhine, Kembs: potential extension of the reproduction surface for salmonids by increasing the residual flow in the Old Rhine and construction of a 7 km long bypass on the Kembs island		Compensatory measures	
D-BW	Rench	Rench	5	Structural improvement	5
			2	Structural improvement	
			19	Structural improvement	
F	Ill	Ill to mouth of R. Doller	4	x	
		Bruche, Giessen, Liepvrette, Fecht, Weiss, Doller	66	x	
D-BW	Kinzig	Kinzig (Baden-Württemberg)	18	Structural improvement	26
			83	Structural improvement	
			34	Structural improvement	
D-BW	Elz-Dreisam	Elz and Dreisam, downstream	12	Structural improvement	25,8
		Elz and Dreisam, to km 90	18	Structural improvement	
		Elz and Dreisam, upstream	37	Structural improvement	
D/CH	High Rhine	High Rhine: improve existing fish passages	4		
CH		High Rhine, Rheinau: Construction of a new fish passage (procedure ongoing)	1		
CH	Wiese	Wiese, downstream	1		9
D-BW		Wiese, middle section and upstream	4	Structural improvement	
			16	Structural improvement	
			15	Structural improvement	
CH	Birs	Birs: Downstream: improved fish migration and revitalisation	several	x	
		Birs, upstream: improved fish migration	2		
	Ergolz	Ergolz	n.s.		
D-BW	High Rhine tributaries	Hasel, Hauensteiner Alb, Hauensteiner Murg, Wutach, Biber		Connection	
AT	Tributaries to Lake Constance (Lake trout)	Old Rhine, Höchst to outlet into Lake Constance		x	
		Bregenzerach: improve fish passage and ramps (existing)	4	Feasibility study	
		Upper and Lower Argen, lowermost hydropower plants	2		
		Upper and Lower Argen, upstream hydropower plan	n.s.		
		Schussen, flood measuring post 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	5	x	
			5		
			6		
	Radolfzeller Aach	8	x		
	4				
	6				
D-BY		Leiblach, Oberreitnauer Ach	n.s.		
		Leiblach, Oberreitnauer Ach: remaining constructions	n.s.	x	
CH	Alpine Rhine (Lake trout)	Fish passage power plant Reichenau	1		Development concept
		Lake Constance to mouth of R. Ill			
AT/FL/CH		Confluence Posterior Rhine/Anterior Rhine to outlet into Lake Constance			Development concept
AT	Alpine Rhine - tributaries (Lake trout)	Ill: 1 weir, make 2 water fall structures surmountable	3	x	
		Dornbirner Ach, Schwarzach, Frutz, Ehbach, Ill	Feasibility study	Feasibility study	
AT/FL		Spirsbach	1	x	
FL		Liechtenstein inland canal	1	x	
<b>Entire Rhine catchment</b>			<b>881</b>		<b>528,34</b>

\*\* The R. Neckar and its tributaries are not central migration routes and habitats for anadromous fish species.

\*\*\* Upper Rhine upstream Strasbourg (F): Apart from the big barrages in the main stream, a number of cultural weirs must be made surmountable in coordination with Baden-Württemberg (indicated by '+x')

# Historically proven distribution of salmon, sea trout and Lake Constance lake trout in the Rhine catchment

Former Zuiderzee around 1900 (without closure embankment)

## Legend

### Waters

- Historically proven salmon and sea trout waters
- Historically proven Lake Constance lake trout waters

### Network of water bodies

- Network of the Rhine
- Alpine lakes
- Coastal and transitional waters

Distribution area of Atlantic salmon and sea trout

### Distribution area

- Atlantic salmon and sea trout
- Lake Constance lake trout



1:2.000.000

0 10 20 30 40 50 km

Distribution area of Lake Constance lake trout

Sources:  
See bibliography  
in the Master Plan Migratory Fish Rhine

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# Master Plan Migratory Fish Rhine

## Example: Salmon and sea trout, Lake Constance lake trout



### Legend

#### Transverse structures in the Rhine

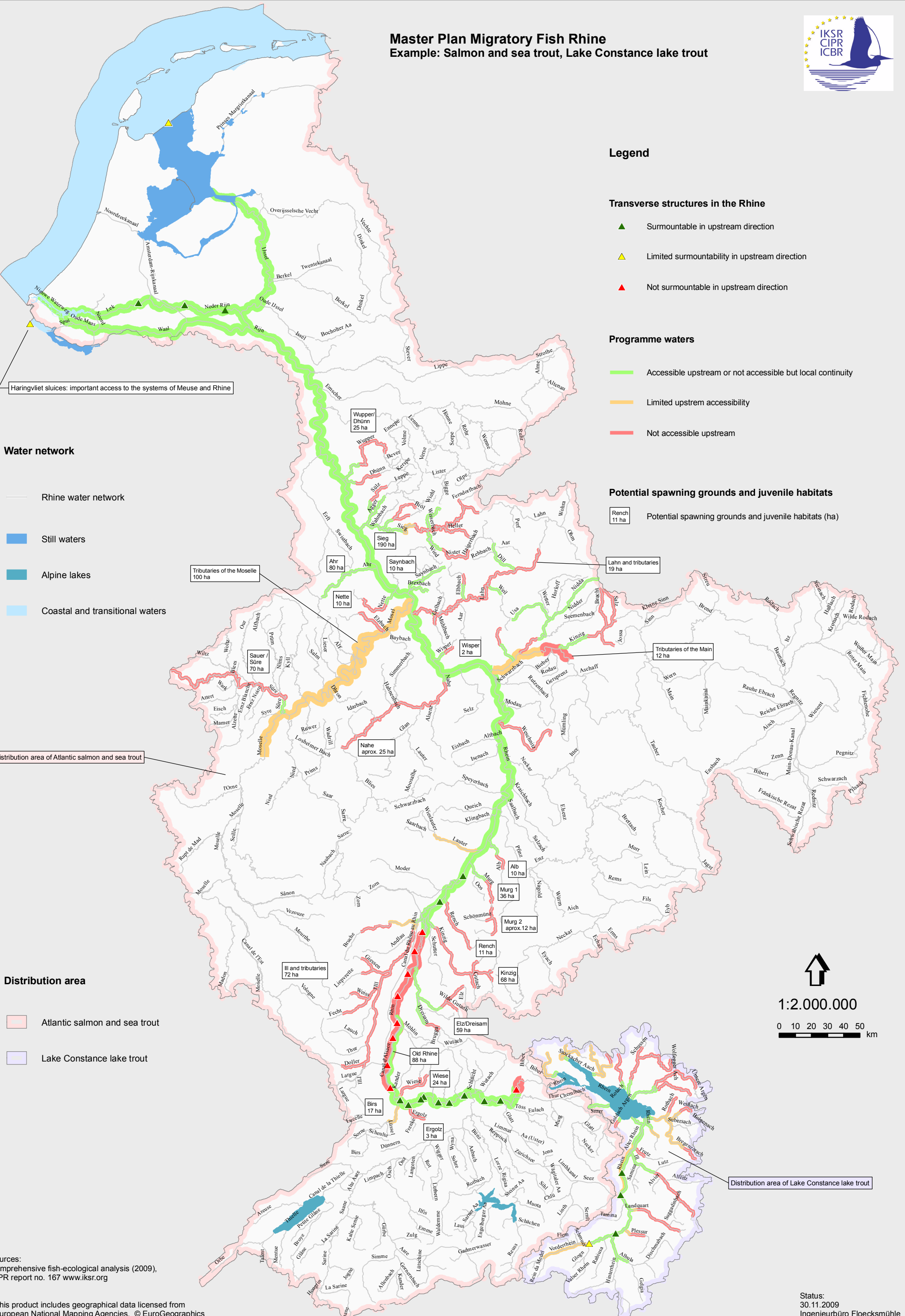
- ▲ Surmountable in upstream direction
- ▲ Limited surmountability in upstream direction
- ▲ Not surmountable in upstream direction

#### Programme waters

- Accessible upstream or not accessible but local continuity
- Limited upstream accessibility
- Not accessible upstream

#### Potential spawning grounds and juvenile habitats

- Potential spawning grounds and juvenile habitats (ha)



Sources:  
Comprehensive fish-ecological analysis (2009),  
ICPR report no. 167 www.iksr.org

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# The eel in the Rhine catchment



## Legend

### Present distribution of the eel

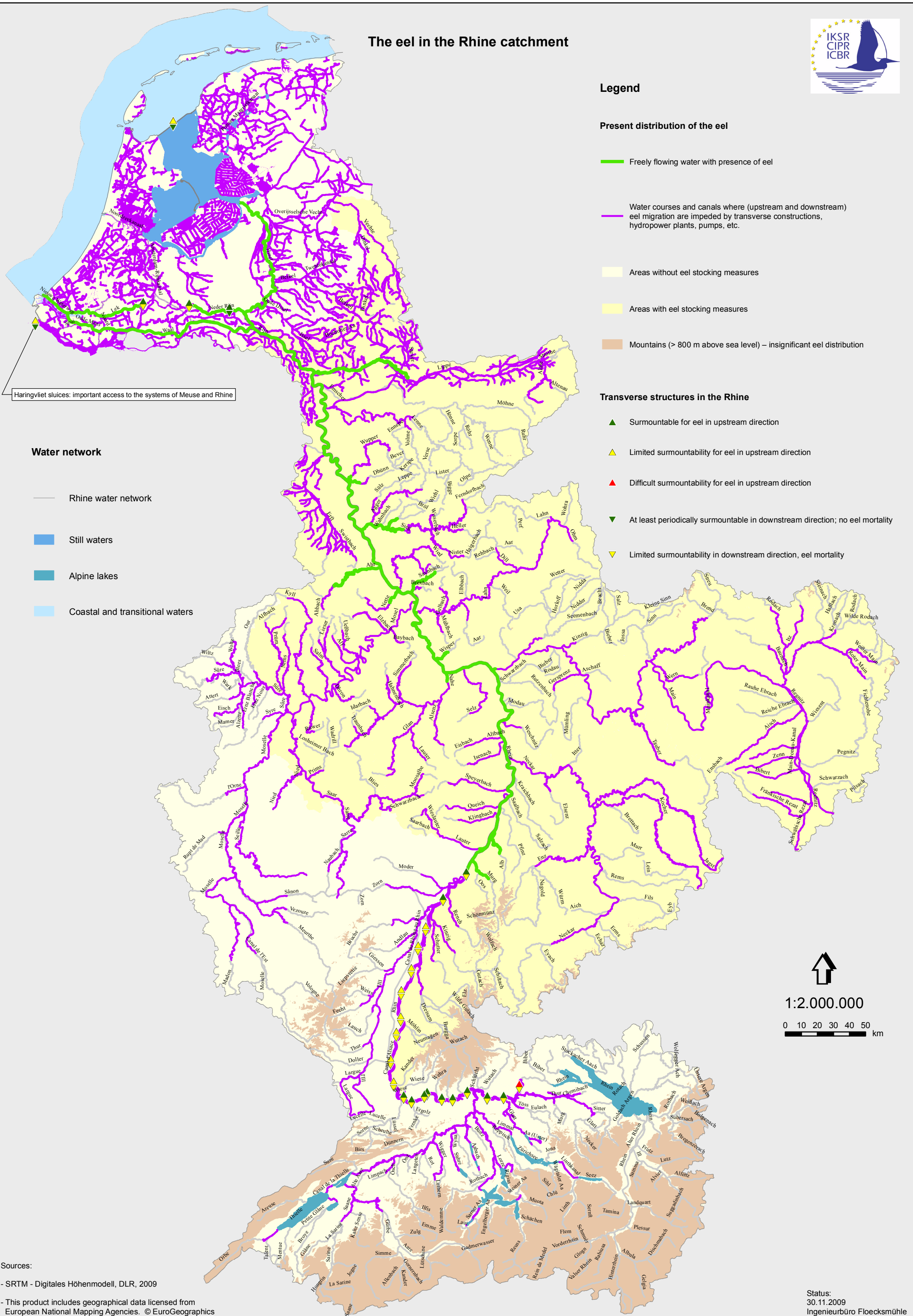
- Freely flowing water with presence of eel
- Water courses and canals where (upstream and downstream) eel migration are impeded by transverse constructions, hydropower plants, pumps, etc.
- Areas without eel stocking measures
- Areas with eel stocking measures
- Mountains (> 800 m above sea level) – insignificant eel distribution

### Transverse structures in the Rhine

- ▲ Surmountable for eel in upstream direction
- ▲ Limited surmountability for eel in upstream direction
- ▲ Difficult surmountability for eel in upstream direction
- ▼ At least periodically surmountable in downstream direction; no eel mortality
- ▼ Limited surmountability in downstream direction, eel mortality

## Water network

- Rhine water network
- Still waters
- Alpine lakes
- Coastal and transitional waters



Haringvliet sluices: important access to the systems of Meuse and Rhine



1:2.000.000

0 10 20 30 40 50 km

Sources:  
 - SRTM - Digitales Höhenmodell, DLR, 2009  
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