Agenda Item 5.2
For Information

**Council**

**CNL(15)42**

***Restoration of upstream and downstream connectivity on the River Rhine (Tabled by EU-Germany)***

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## *Restoration of upstream and downstream connectivity on the River Rhine*

Federal Office for Agriculture and Food, Germany May 2015

This paper provides a short outline of current developments regarding the restoration of upstream and downstream connectivity on the River Rhine with particular focus on the reintroduction programme for Atlantic salmon. In this context, the paper deals with information about the 'Master Plan Migratory Fish Rhine' and facts concerning bottlenecks in up- and downstream connectivity and the planned measures for the coming years to improve fish migration in the River Rhine and its tributaries.

### Background

By the end of the nineteenth century there were still hundreds of thousands of Atlantic salmon migrating upstream in the river Rhine to their spawning grounds. Historical data indicates a catch of almost 250,000 salmon in 1885. After that peak, the catches declined, until the complete extinction of the Rhine salmon. The last salmon was caught in the Rhine in 1958. The extinction of Rhine salmon is closely correlated with the construction of obstacles to migration; other contributory factors were deterioration of water quality and overexploitation of the remaining salmon stocks.

In 1986, a Swiss warehouse storing chemical pesticides burned down. The so called 'Sandoz disaster' practically wiped out the life in the main stem of the Rhine. Just one year later, Ministers from countries bordering the Rhine agreed the Rhine Action Plan. The Ministers adopted the salmon as a symbol of a healthy Rhine.

When starting the ambitious programme for the ecological rehabilitation of the Rhine, the Member States of the International Commission for the Protection of the River Rhine (ICPR) agreed that migratory fish species, such as the Atlantic salmon, should again colonize the river and its tributaries (Ingendahl *et al*., 2007). To achieve that goal a restocking programme was started in several areas of the Rhine basin, especially in Germany, France and Switzerland. Since 1990, adult salmon have been regularly recorded in an increasing number of tributaries of the River Rhine and at fish counting stations in the Upper Rhine.

### ICPR programmes for salmon and migratory fish

For the benefit of the Rhine and of all waters flowing into the Rhine, the members of the ICPR (Switzerland, France, Germany, Luxemburg, the Netherlands and the European Union) successfully co-operate with Austria, Liechtenstein and the Belgian region of Wallonia as well as Italy. Nine states and regions in the Rhine watershed closely cooperate in order to harmonise the many user interests and protection in the Rhine area.

One of the issues in the ICPR is the ecological river restoration, for which the Atlantic salmon has become a key species. In this context the 'Master Plan Migratory Fish Rhine' (ICPR, 2009a) indicates how self-sustaining, stable populations of migratory fish can be reintroduced to the

Rhine catchment within a reasonable period of time and at reasonable cost. The salmon serves as a symbol representing many other migratory fish species (such as sea trout, sea lamprey, allis shad and eel). Furthermore, measures aimed at reintroducing migratory fish have positive effects on the incidence of many more species of fauna and flora and are appropriate for improving the entire ecology of the Rhine. This considerably supports the main objective of the European Water Framework Directive (WFD) to achieve a 'good status' or a 'good potential' of water bodies.

An important step in improving river continuity was the Fifteenth Conference of Rhine Ministers held in 2013 (ICPR, 2013). This Conference adopted a precise schedule for restoring the continuity of the Rhine for fish migration.

In order to achieve the objectives of the programme 'Rhine 2020' and of the 'Master Plan Migratory Fish Rhine' in the main stream of the Rhine, Ministers acknowledged *inter alia* that:

- salmon stocking can be reduced step by step in parts of the River Sieg system, a tributary in the lower reaches of the Rhine, even though such stocking measures remain absolutely essential in the long term in the upper reaches of the Rhine, in order to increase the number of returnees and to enhance the slowly recovering natural reproduction;
- the restoration of migration routes represents an important management aspect for the implementation of the WFD and Swiss law on water protection;
- migratory fish also play a role in the implementation of the European Marine Strategy Directive;
- for juvenile salmon, downstream migration in the turbine areas is critical because of the great danger of injuries, particularly where there are successive hydropower plants. For 2014 - 2016, the ICPR has the mission to work intensively on the joint determination of innovative techniques of downstream migration at transverse structures; and
- due to ongoing measures, river continuity upstream as far as Basel is becoming more and more realistic and plannable. This will open the access to the existing spawning grounds of migratory fish in the rivers Birs, Wiese, Ergolz and Aare (CH) by 2020.

In order to achieve the objectives of the programme 'Rhine 2020' and of the 'Master Plan Migratory Fish Rhine' in the main stem of the Rhine, Ministers acknowledged that:

- the Haringvliet sluices on the North Sea coast will be partly opened in 2018;
- the fish pass at the Strasbourg impoundment will be operational in 2015;
- construction work on the fish pass at the Gerstheim impoundment will start in 2015 in order to reconnect the Elz-Dreisam area with the Rhine;
- the experience and assessment of the effectiveness of the existing fish passes built in the river system, to date, will contribute to improving the technical solutions still to be constructed;
- the transfer of fish into the old bed of the Rhine in the region around the impoundment Vogelgrün/Breisach is a technical challenge. With respect to the upstream migration through the Upper Rhine as far as Basel, the ICPR facilitated an exchange of experts in 2014, taking into account the results of studies to date, in order to contribute to finding the optimal technical solution; and

- an efficient fish pass system must be planned and implemented at the impoundments Rhinau, Marckolsheim and Vogelgrün on the Upper Rhine, so that by 2020 fish may reach the old bed of the Rhine and Basel.

Concerning the Rhine tributaries, the Ministers agreed on the following:

- by constructing fish passes at the impoundments, the continuity of the River Moselle as far as Schengen (tri-border region France-Luxembourg-Germany) must be successively restored;
- fish passability must be restored at all existing transverse structures in all programme waters of the 'Master Plan Migratory Fish Rhine';
- as a matter of principle, no new migration obstacles may be constructed in the programme waters and, as far as possible, no obstacles to migration may be constructed in the remaining free-flowing stretches in order to conserve these stretches as spawning grounds and juvenile habitats; and
- the measures in the 'Master Plan Migratory Fish Rhine' should be extended to several tributaries of the High Rhine and the Aare (Switzerland) which, according to an inventory established in 2012, present more than 200 hectares of additional habitat for juvenile salmon.

**Upstream connectivity in the River Rhine**

In total, more than 1,200 hectares of spawning and juvenile salmon habitats are available in the Rhine catchment area. By 2012, about 256 hectares had been made accessible. That means that for the entire catchment area, more than one fifth of the potential productive habitat is accessible.

The current habitat availability and accessibility to upstream migrating fish is shown in Figure 1 for individual sections of the River Rhine. In the Lower Rhine, Middle Rhine and Upper Rhine (downstream of Strasbourg) 45%, 69% and 25% of the spawning habitat, respectively, is accessible to salmon. The important salmon habitats in the Upper Rhine (upstream of Strasbourg) and in the River Moselle, the second largest tributary of the Rhine, are still not accessible to salmon. It is a big challenge for the coming years to open these areas to migratory fish.

Up to 2013, almost 500 barrage weirs were made passable for fish by building fish ladders or by removing the barriers. The most commonly used facilities are different types of pool passes.

Special action needs to be taken at the main 'front door' of the Rhine and Meuse rivers, the Haringvliet, that are currently closed from the sea by a dam that only allows downstream migration of fish. In 2018, the dam will be partially opened, in order to facilitate upstream migration of fish.

In the Upper Rhine, five barrages still have to be provided with fish passes in order to meet the Rhine objective of 'passability' to Basel by 2020. This year, the fish pass at the Strasbourg impoundment will be operational and construction work on the fish pass at the Gerstheim impoundment will commence. With the help of these two new fish passes, the Elz-Dreisam area will be reconnected to the Rhine. The experience and assessment of the effectiveness of the fish passes constructed in the river system to date will contribute to improving the technical

solutions where there are still barriers to fish migration. The transfer of fish into the old bed of the Rhine in the region around the impoundment Vogelgrün/Breisach is a technical challenge. An efficient fish pass system at the impoundments Rhinau, Marckolsheim and Vogelgrün on the Upper Rhine still must be planned and implemented.

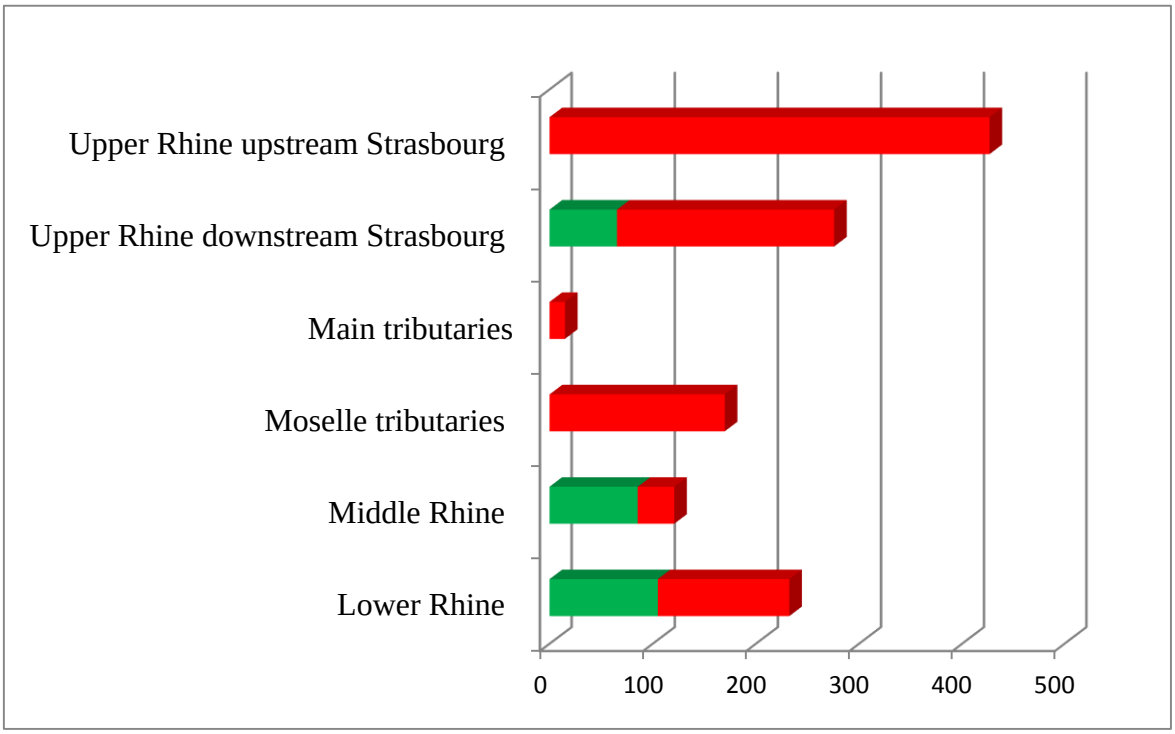


*Figure 1. Accessible (green) and non-accessible (red) spawning and juvenile habitat surfaces (ha) for Atlantic Salmon in the Rhine system divided in different river sections in 2012*

**Downstream connectivity in the River Rhine**

Passage of fish migrating downstream through turbines at hydropower plants causes damage, the extent of which depends on the fish species concerned, the size of the fish and the technical specification of the plant (ICPR, 2009b). In the Rhine and those tributaries with numerous hydropower plants, damage to fish is cumulative during their downstream migration. For salmon, in particular, this mortality poses a threat to the survival of the population, as this species returns to its natal stream and losses of the partial population must almost exclusively be balanced by the reproducing population upstream of the hydropower plant. In order to be able to build a self- sustaining population, at least 1% of the downstream migrating smolts are required to return as adults to the spawning grounds. A higher return rate is possible and is for the goal.

In order to comply with the objectives established by the Rhine Ministers, the ICPR started with an overview of the bottlenecks for downstream migrating fish, and all Rhine countries collected data. Within the River Rhine catchment, 552 bottlenecks were identified. Only a few obstacles have special facilities installed to protect downstream migrating fish against passage through the turbines. When passing the hydropower installation, fish can be damaged by turbine blades or guiding vanes, by the differences in pressure, and by high flow rates and turbulence. Apart

from this ‘direct’ damage, ‘indirect’ effects can also occur, e.g. a higher predation rate after passing a hydropower installation.

The Kaplan turbine is the dominant type in use in the Rhine system, particularly in the main stem of the river. Other types in use are Francis turbines and Banki-Mitchell turbines. In the smaller, recently constructed hydropower stations, the Archimedes screw is sometimes used. The mortality rate of fish varies from under 5% to over 90% for Francis turbines. On average, fish mortality is lower in Kaplan turbines, ranging from under 5% to approximately 20%. A study conducted for the Archimedes screw in the Netherlands showed no fish mortality at all, while another study found a mortality of 5%.

The most important protective measure is to prevent fish from passing through the turbines by using screens. Recently, studies aimed at determining best practice solutions for downstream migrating salmon at hydropower plants have been conducted in the Rhine catchment with the first results expected in 2016.

**Conclusions**

As a consequence of the improvements in water quality and river continuity in the River Rhine, the Atlantic salmon could be reintroduced. With the growing numbers of fish migrating up the river, it became clear that both upstream and downstream migration of fish had to be facilitated. Hydropower installations represent a serious threat, not only for migrating salmon smolts, but also for eels.

Recently, several developments have focused on smaller hydropower installations ($\leq 50 m^3/s$). The effectiveness of measures implemented must be confirmed on site. For larger installations, new developments are urgently needed.

In addition to the importance of up- and downstream river connectivity, many other issues need to be addressed such as water quality, genetics, stocking and habitat restoration as well as illegal catches of salmon. Much has been achieved to restore the connectivity of the River Rhine, but the issue remains the biggest challenge regarding restoration and protection of migratory fish species.

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