Critical review on the re-introduction of flagship species

The reintroduction of salmon, wolves and bears has been in the news, but do they represent a true restoration of biodiversity? The authors discuss the advantages and limits to such projects, using as an example the re-introduction of salmon in the Rhine river.

Re-introduction is the planned release of endangered or very rare species into the wild. The individuals that are released into an area where the species is extinct are from captivity or relocated from other areas where the species still survives. Re-introduction projects are performed with mammals (beaver, wolf, otter, etc.), birds (white-tailed eagle, peregrine falcon, griffon vulture, etc.), but also with butterfly and fish species. Some projects are highly successful (beaver, lynx), whereas other projects are still ongoing. Many species in such re-introduction projects are well-known to the public and representative of the environment in which they are liberated. They represent a key species for a specific ecosystem or an environmental cause and their function as so-called "flagship species" is believed to enhance public awareness and support.

Migratory-fish species change from freshwater to sea and vice-versa during their life cycle. They migrate in some cases over thousands of kilometres. Often, they are large, have represented a valuable resource for local fisheries over the last centuries and are well known to many people. These key characteristics qualify them to be chosen as flagship species. Especially salmon is famous for its dynamic migration skills. Mysteriously, the fish fight their way back to the spawning grounds where they were born, leaping at obstructions like dams or water falls. In more recent times, salmon angling, especially fly fishing, was a popular sport for wealthy people who could afford the high cost associated with such a luxurious activity. Therefore Atlantic salmon benefits from a highly positive image and its presence is recognised as an indicator of a healthy environment, good water quality and moderate summer water temperature.

In the Rhine river, like in other European rivers (Elbe, Thames or Weser), salmon was extinct by the middle of the 1900s due to overfishing, water pollution and dam construction. In 1986, a fire in the Sandoz factory on the Rhine river in Switzerland led to major water pollution and a massive fish kill. Surprisingly, this Sandoz pollution revealed that a fast recolonisation of the Rhine river by many river fish species had occurred due to improved water quality in the early 1980s. After this accident, a public discussion on the ecological status of the river immediately followed and the Member States of the International Commission for the Protection of the Rhine river (ICPR) started an ambitious project to ecologically restore the river and its flood plain (Rhine Action Plan 2000). The goal of the plan was to enhance habitat quality and connectivity of the river and its flood plain enough that sensitive (fish) species such as Atlantic salmon could return. The Rhine Action Plan was called "Salmon 2000" for short and in this manner, salmon, extinct from the Rhine, was designed as the flagship species by the ICPR.

This paper gives an overview on the achievements of the re-introduction more than 20 years after the start of programme. The Salmon project will be compared to the re-introduction of Allis shad and North-Sea houting, two other migratory-fish species which are currently being re-introduced in the Rhine. The success of all three projects will be discussed especially in relation with the choice of salmon as the flagship species for the Rhine Action Plan (see box 1), more than 20 years ago.

❶ Male Atlantic salmon ascending the River Sieg, Germany, shortly before the spawning period.

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Cases studies of fish re-introduction in the Rhine river

Atlantic salmon (see photo ❶ and box ❶)

More than 100 years ago, the Rhine river was one of the most important salmon rivers in Europe. In 1885, about 250 000 adult salmon were caught and the species was the most valuable freshwater fish for commercial fishermen in the Netherlands and Germany. At the end of the 1800s and the beginning of the 1900s, salmon declined dramatically in Western Europe and by the late 1950s, Atlantic salmon was extinct in the Rhine river. Water pollution, construction of dams, habitat loss and overfishing are the major causes for the loss of migratory-fish species from the Rhine.

The importance of salmon in the Rhine river was demonstrated by an international treaty agreed on as early as 1855, called the "Lachsvertrag", whereby the Netherlands, Germany and Switzerland agreed upon the protection of the species. In the beginning of the 1900s, several million young salmon (fry) were released in the upper part of the river without stopping the complete decline of salmon. As natural recolonisation of the river by salmon seemed highly unlikely due to the extinction of the species in a wide range of neighbouring river systems, a re-introduction was started and the first juveniles were released in 1988. In 1990, the first adult salmon was caught in the Sieg river and in 1994, the first natural reproduction was observed in the Bröl river, a tributary of the Sieg.

Despite these initial encouraging results, the number of recorded salmon in the Rhine remained relatively low in the following years. Only since 2000, when perma-

❶ SPECIAL INFORMATIONS

Criteria for the choice of flagship species

1) Emotional requirements. Large, beautiful, impressive migratory skills, distinctiveness, commercial impact, well known to the general public, even after a long period of extinction.
2) Ecological requirements. Flagship species should match well with the objectives of the restoration project, e.g. be a useful component in river restoration, in the action taken to restore the river, improve habitat quality and ecological connectivity.
3) Regional requirements. The species should be a factor in the history of the region, it should still be known to the local population and its past presence should be commemorated in the region.

Salmon is a good example for the emotional requirements as it is a famous, well known fish species. Its ecological criteria align well with the goal of river restoration, but it needs very high-quality habitats and good connectivity to the sea. Salmon is still known in the Rhine area and especially anglers contribute actively to its restoration.
The success of the salmon programme can be seen in the tributaries of the Rhine where juveniles are stocked and adult fish return to spawn.

Allis shad is still known in local areas along the Rhine (in Cologne, the migration of shad is commemorated every year by the population) and it meets ecological requirements in these parts of the Rhine basin. It is less demanding than salmon, but good water quality and migration from the sea to freshwater need to be enhanced.
Regional visibility will be increased when the first adults are expected to return in 2013 (see text for further details).

The North Sea houting is probably not a candidate capable of meeting high emotional requirements, because it is fairly unknown and not as impressive as salmon. Ecological conditions have already been met due to the improvement in water quality and the houting is therefore a good indicator of the success of river restoration. The regional requirement is probably not met far beyond the Netherlands as the species is established in the Rhine delta.

nent control stations (see photo ❷) were installed at fish passages in the Rhine at Iffezheim (first dam about 800 kilometres upstream of the sea) and some of the tributaries, number of recorded salmon increased to 300 and up to 800 individuals per year (see fig. ❶). The number of released young salmon from 1998 to 2009 varied between 1 and 3 million juveniles per year (see fig. ❷). But the relation between the number of young salmon released and returning adult salmon is too low to establish a self-sustaining salmon population.

The reasons for the lack of adult returns are not fully understood. But many of the large tributaries (Moselle, Lahn, Main and Neckar) and the Upper Rhine are still blocked by dams and a high percentage of former important habitats are still not accessible. The Rhine delta is partly dammed to protect the Netherlands against sea flooding, which hampers the free migration of migratory fish between freshwater and the North Sea. Additionally, although salmon is a protected species, bycatch in commercial and recreational fisheries occurs, further reducing the number of adult salmon coming back to spawn in the rivers of their release.

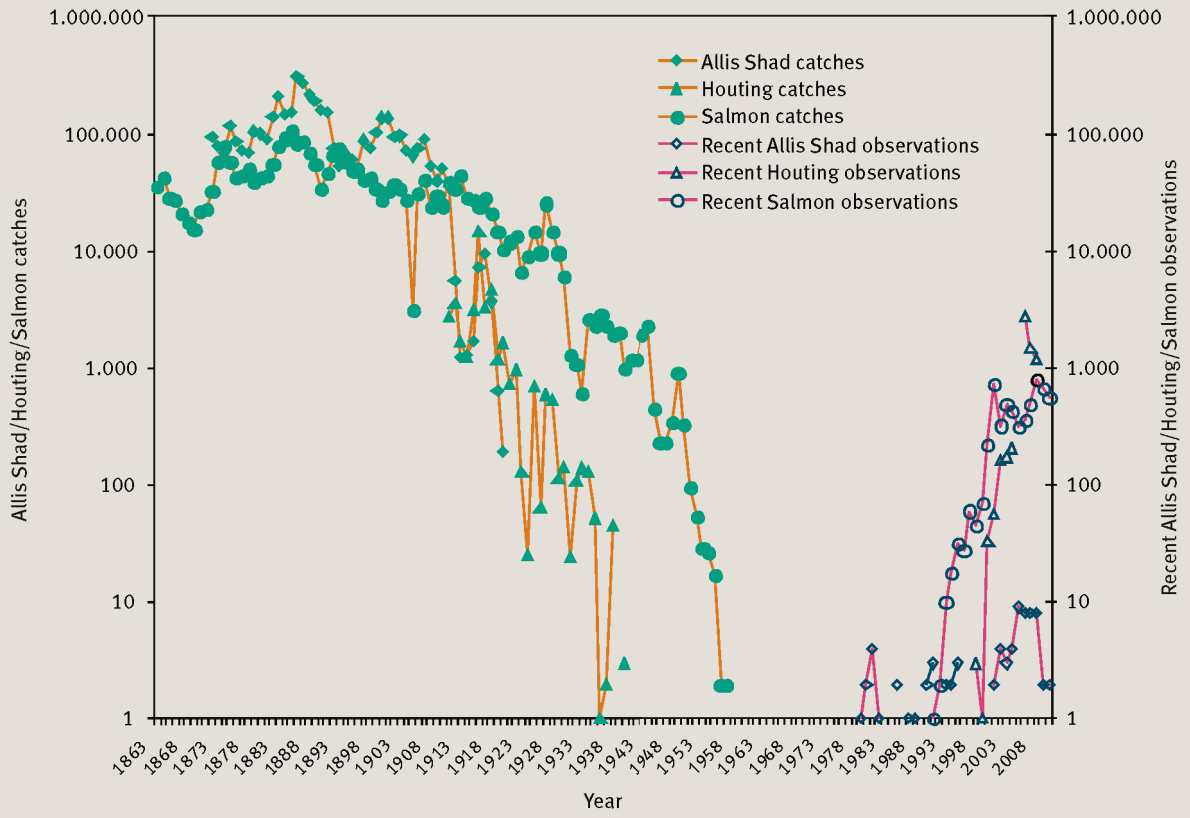
Acknowledging that river restoration and salmon re-introduction are long-term tasks, the ICPR has prolonged the Rhine Action Plan until 2020. River restoration is now integrated in the efforts of EU Member States to reach the good ecological status of their waters, the goal of the Water framework directive. A special master plan aiming at the protection and development of migratory

❷ Salmon monitoring station operating on the R. Sieg, Germany.

fish, especially salmon, was set up recently in order to reach the initial goal of a self-sustaining salmon population within the next 10 to 20 years. Action will be taken to open up more salmon habitat in the tributaries and to protect downstream migrating juveniles from losses in the turbines of hydropower plants. By the end of 2010, the Netherlands plan to open the Haringvliet dam in the delta to enhance fish migration and to reduce accidental bycatch of salmon.

Stocking of young salmon needs to be continued for at least another 10 to 20 years. Support has been provided

❶ **Number of Allis Shad, Houting and Salmon catches in the Netherlands (historical data) and recent observations of these fish species in the River Rhine.**



not only by the state agencies responsible for the re-introduction of salmon, but also by fisheries and angling associations along the Rhine river. Nevertheless, many problems still remain to be solved before a viable salmon population has been re-established. The re-introduction of a migratory-fish species with a highly complex life cycle is a demanding, long-term task for every contributing organisation. The quality of the environment, especially rivers, was largely changed in the Rhine basin since salmon went extinct. The re-establishment of a salmon population will probably be limited only to those parts of the Rhine basin where high-quality habitat accessible for migratory fish can be preserved. Because large parts of former habitats are definitively lost, salmon will never again be as abundant as reported at the end of the 1800s.

Allis shad (see box ❶)

Besides salmon, Allis shad was the most abundant migratory fish in the Rhine river system. At the end of 1800s, several hundred thousand shads migrated into the river every year. Allis shad is, like salmon, a long-distance anadromous fish which belongs to the herring family. In former times, Allis shad migrated more than 800 kilometres upstream the river to spawn in fast-flowing gravel sections. However, in contrast to salmon, Allis shad spawned in the main river stem and the major tributaries and did not migrate into the smaller headwaters of the tributaries. Allis shad migration occurred between April and June and the Allis shad fishery ensured the income of the Rhine fishermen before the salmon runs started later in the year.

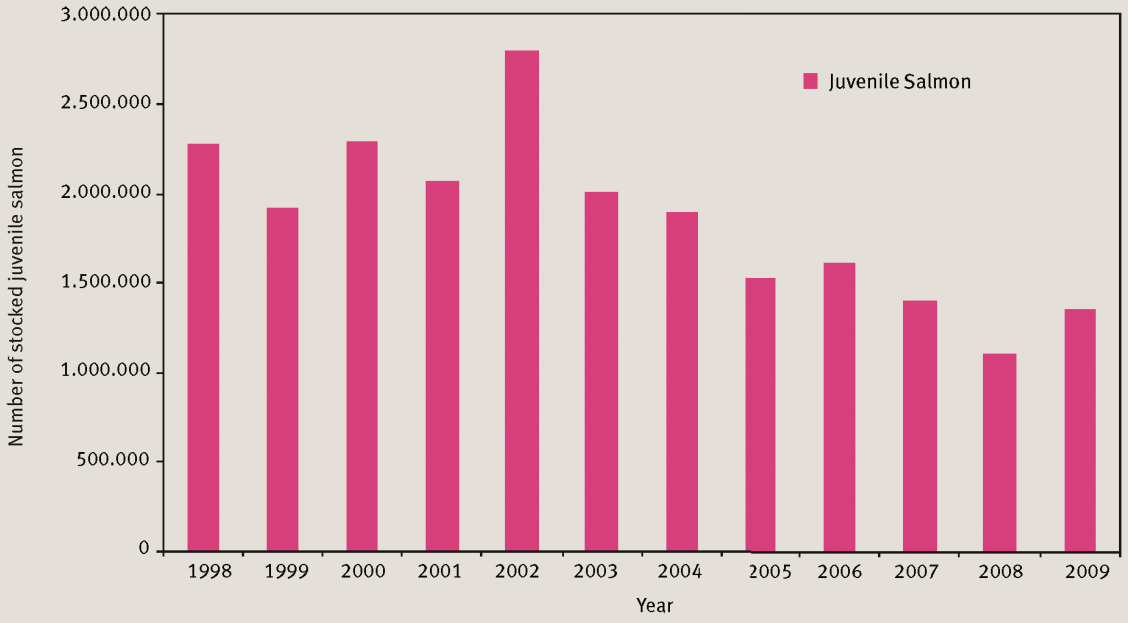
At the beginning of the 1900s, the Rhine shad population collapsed and the last shads were caught in the early 1960s. However, this breakdown was not confined to the Rhine river. At the end of the 1800s, the geographic range of the Allis shad ran from the North Sea to the coasts of Morocco and into the Mediterranean region. Only half a century later, Allis shad populations were found only in river systems flowing to the French and Portuguese Atlantic coasts (Bagliniere *et al.* 2003).

Since there was no sign of natural recovery at the beginning of this century, the German Federal State North Rhine-Westphalia started a feasibility study for the re-introduction of Allis shad. The study included habitat and genetic analyses, but also rearing and marking trials in France and Germany. Potential spawning habitats are still available in the Rhine, e.g. in the inner bends of the river and the single shads which were caught in the Rhine during recent years are most likely straying from French populations. This could be confirmed because they were assigned to samples from French populations using genetic markers.

However, the biggest challenge for a re-introduction of Allis shad was the development of mass production and mass marking techniques, given that early attempts to supplement the declining shad population in the Rhine failed in the beginning of the 1900s. In a joint French-German research project between Cemagref and the State Agency for Nature in North Rhine-Westphalia, mass production techniques of the closely related American shad were successfully adapted to Allis shad. This led to the European Life project for the re-introduction of Allis shad to the Rhine river system which started in 2007 (LIFE 06 NAT/D/00005). Together with the two French partners Cemagref and Migado and co-financing from Germany and the Netherlands, around 4.7 million juveniles have already been produced and stocked in the Rhine during the last three years.

The donor population for the Rhine is coming from the Gironde river system. Unfortunately, this population has suffered a strong decline since 2006 and a fishing moratorium was established in 2008. The reasons for this breakdown are not clearly understood yet, but is seems to be a combination of overfishing, climatic factors and also structural problems in the river system. As a consequence, combined efforts to conserve and restore Allis shad populations in the Gironde and Rhine have been developed and will be implemented in a European Life+ project in the period 2011-2015.

❷ Number of juvenile salmon stocked in the River Rhine since 1998.



The general life cycle of Allis shad is 5 years, thus we expect the first Allis shad returning to the Rhine river from 2013 onwards. We are expecting a faster response to our stocking efforts because Allis shad has, in comparison to salmon, several advantages for restoration projects, i.e. 1) high fecundity (200 000 eggs/kg female), 2) fast egg development (average time between spawning and hatching is only 5 days) and 3) spawning takes place in the main river and is not restricted to headwaters. Due to the high fecundity, fast recolonisation was observed, e.g. in French rivers where migration barriers were removed (installation of a fish lift in Golfech, on the Garonne river).

However, the Allis shad re-introduction project would not have been possible without the salmon restoration programme. Without the initial success of the salmon programme in recent years and the increased awareness of the public and the politicians, it would have been difficult to find money for shad restoration in the Rhine. Co-financing of the European Life project is coming from the environmental ministries, but also from anglers and the environment foundation of a supermarket chain. Today in Germany, very few people at former hot spots for commercial shad fishing still know that Allis shad was once a key species for the Rhine fisheries. The success of the salmon programme with increasing numbers of salmon coming back to the river cleared the way for Allis shad restoration in the Rhine.

North-Sea houting (see box ❶)

The North-Sea houting is an anadromous, coregonid fish species that previously colonised the Wadden sea area of the North Sea and spawned in the adjacent river systems such as the Rhine and the Elbe. In the beginning of the 1900s, it was regularly caught by commercial fishermen in the Rhine delta in the Netherlands. The mean annual harvest was between 1 and 10 tons and therefore the fish was of minor economic importance in comparison to salmon and Allis shad. From 1930 onward, catches dropped and the species was extinct in the middle of the 1900s.

In 1996, the first juvenile houting were stocked in the Lower Rhine area of North Rhine-Westphalia. Stocking was performed until 2006 and more than 2 million juveniles were released. Stocked fish started to feed immediately after release and drifted downstream with the flow of the river (Borcherding et al. 2006). In 1997, three sub-adult houting were caught in Lake Ijsselmeer, a former estuary closed off from the sea by dam construction in 1932. The number of adult houting reported from Lake Ijsselmeer increased steadily in the years after release and reached more than 2 700 adult fish in 2005. This strong increase indicated that stocked larvae survived in high numbers and finally reached maturation.

After the release of tagged larvae, only a minor proportion of juveniles caught in the Rhine delta showed the marking. This strongly indicates significant natural reproduction of North-Sea houting in the Rhine delta. Tagging of adult houting caught in Lake Ijsselmeer with radio transmitters showed migration of mature fish out of Lake Ijsselmeer into the Ijssel river. Some individuals started a spawning migration into the German stretch of the Rhine and its tributary, the Lippe river, where initial stocking was performed. Interestingly, after tagging, only a few individuals left Lake Ijsselmeer via the sluices at the dam to enter the North Sea. From the analysis (using microchemistry techniques) of scales of mature houting, it can be concluded that at least some fish never left freshwater before reproduction. Therefore part of the new houting population of the Rhine may complete its life cycle in freshwater without migrating to the sea.

This new feature, different than the Danish donor stock, may be decisive for the successful re-establishment of houting in the Rhine river. At least a part of the houting population avoids a risky migration from freshwater to the Sea and back to freshwater again. In the highly dammed Rhine delta, this strategy may be more successful than strict anadromy where important losses during migration are not sufficiently counterbalanced by the energetic advantage of a sea migration (Limburg & Waldman, 2009). Monitoring will show if the houting can maintain its population without further stocking. In spring 2009, houting was present at a fairly high density of 3 to 5 adult fish per hectare in Lake Ijsselmeer.

Despite this great success, public awareness of houting is very low in comparison to Allis shad and salmon. This is clearly shown by comparing the hits in an internet platform when typing Rhine and the name of all three migratory-fish species separately (see Table ❶). Unfortunately, the rather small-scale houting project was not linked to a public-information campaign. In the case of Allis shad, public information is a crucial part of the European Life project. If increasing numbers of shads return to the Rhine in coming years, the public of the Rhine neighbouring states will be informed about the success of the project.

❶ Number of counts and related documents in the Internet regarding the R. Rhine and different migratory fish species.

Number of counts in the Internet			
(in german) Rhine	Allis Shad 9.140	Houting 1.140	Salmon 59.700

Conclusion

Migratory-fish species represent a good indicator for river quality and connectivity in large river basins because they migrate from freshwater to the sea and vice-versa. This specific life trait makes them natural candidates for the choice of a flagship species in river restoration projects. Especially salmon is well known to the public and famous for its long journey to the headwater of rivers. After the Sandoz accident in 1986, this species was selected to represent the ambitious ICPR river-restoration programme, under the name “Salmon 2000”.

In Europe, rivers have been heavily modified by human activities over more than 250 years. Habitats for sensitive fish species have been lost in a large part of the Rhine basin. Spawning areas in the headwaters are blocked by numerous weirs and dams which are not easy to pass even when fish ladders are available. Therefore the salmon population still depends on massive stocking even 20 years after the start of the re-introduction. Questions have been raised about the long-term success of the pro-

ject and a master plan for migratory fish has been set up, prolonging the salmon project another 10 years to 2020. Nevertheless, the re-introduction of salmon and the first returning adults observed in the Rhine have been widely recognised as a sign of the ecological recovery of the river. It served as a starting point for other projects on Allis shad and North-Sea houting. Unfortunately, both species are much less known to the public than salmon. The two species spawn in the main river, their habitats are not blocked by dams and their fecundity is higher than salmon. Their less demanding habitat and migratory requirements contribute to a higher probability for a successful re-introduction. In the case of Allis shad, the first returning adults are expected only in 2013. The re-introduction of the houting is already a success story as increasing numbers of adults are observed in the Lower Rhine even after the end of stocking and considerable natural reproduction is observed.

When looking for a flagship species, project managers should carefully look at the ecological requirements of the potential species. Within the migratory-fish group, salmon may be the most demanding choice in terms of habitat quality and access. Therefore it may be a wise strategy in restoration projects to select several species or species with lower sensitivity to environmental changes in order to increase the probability of success. However, in the case of the Rhine river, the choice was made 20 years ago on the basis of limited knowledge (de Groot, 1992). It is obvious that salmon is the only one of the three species capable of arousing public concern and interest in all Rhine countries from the delta to the Swiss mountains. Probably only the salmon's positive image is powerful enough to incite all the different countries along the Rhine to work together toward a common goal of river restoration.

With the help of this flagship species, other migratory-fish species may be re-established in different parts of the Rhine basin. The future houting population will be restricted to the Lower Rhine area and its success will probably be more known in the Netherlands than on the Upper Rhine in France and Switzerland. Allis shad will be a candidate for the recovery of a fish species in the Middle Rhine area in Germany. In some places, the memory of this valuable food resource is still present (e.g. in the old town of Düsseldorf or Cologne where the history of Allis shad catches is still celebrated every year). Therefore an opportunity to arouse interest in the fate of Allis shad still exists on a more regional scale. ■

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