Landesamt für Natur,
Umwelt und Verbraucherschutz
Nordrhein-Westfalen

Conservation and restoration of the Allis shad in the Gironde and Rhine watersheds

LANUV-Fachbericht 70

LIFE09 NAT/DE/000008

www.lanuv.nrw.de

Conservation and restoration of the Allis shad in the Gironde and Rhine watersheds
LANUV-Fachbericht 70

Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen

Recklinghausen 2016

IMPRESS

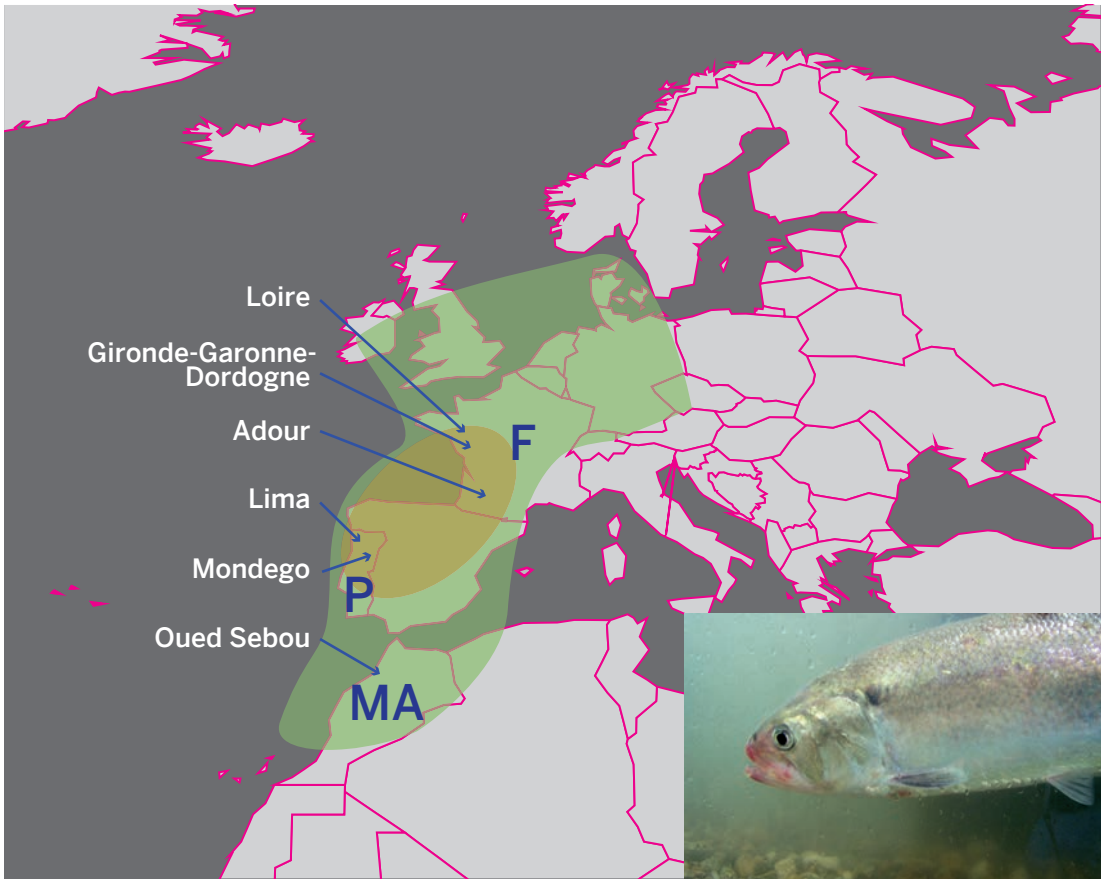
Coordinating beneficiary	North Rhine-Westphalia State Agency for Nature, Environment and Consumer Protection (LANUV) Leibnizstraße 10, 45659 Recklinghausen Telefon +49 2361 305-0, Telefax +49 2361 305-3215, E-Mail: poststelle@lanuv.nrw.de
Project management	North Rhine-Westphalia State Agency for Nature, Environment and Consumer Protection (LANUV) Department 26 Fish Ecology, Heinsberger Straße 53, 57399 Kirchhundem-Albaum, Contact: Daniel Fey
Office Allis shad project	Rhenish Fisheries Federation from 1880, Wahnbachtalstraße 13a, 53721 Siegburg, Contact: Dr. Andreas Scharbert Aquazoo-Löbbecke Museum Düsseldorf, Kaiserswerther Straße 380, 40200 Düsseldorf
Co-Financiers	• European Union (Funding instrument Life+) • Agence de l'eau Adour-Garonne • Bezirksregierung Düsseldorf • Conseil régional d'Aquitaine • Électricité de France • Hessian Ministry of the Environment, Climate Protection, Agriculture and Consumer Protection • HIT environmental foundation • Rhine Fishing Cooperative North Rhine-Westphalia • Sportvisserij Nederland • Federation of hessian fishermen
External Funding	Hermann Hoffmann Group
Cover photo	Association MIGADO
Figures	Andreas Scharbert (7 bottom left, 9 bottom, 14 Centre, top right, 17 top right, bottom left, 18 bottom, 19 top, bottom, 22 bottom), Association MIGADO (4 detail, 5 bottom left), Bundesanstalt für Gewässerkunde (18 centre left), Bordes (6 bottom left, top right, 8 top left), Büro für Fischereibiologie und Ökologie (20 top right), Egbert Korte (15 bottom right, 18 centre right), Epidor (5 top right, 7 top, centre left, right, 8 bottom left, right, 12 top, 22 top), Hanns Hönigs (21 bottom left), Irstea (4 map), Jens Breer (20 bottom left, bottom right), LANUV (13 Map), M.M. Foto-Team Deutz (21 top right, top left), Marion Wille (23 bottom left), Matthias Hundt (16, 17 top left), Peter Beeck (11 top, 12 centre, bottom), Philippe Jatteau (23 top), Roland Paschmann (21 bottom right), Sméag (9 Map, Centre, 10 Map, bottom), Stefan Staas (14 top left, 27 bottom, 15 top, 18 top, 23 bottom right), Thomas Höferer (20 bottom left), Walter Fricke (15 bottom left, 17 bottom right)
Layout	LANUV
ISSN	1864-3930 (Print), 2197-7690 (Internet), LANUV-Fachberichte

Informationsdienste	Informationen und Daten aus NRW zu Natur, Umwelt und Verbraucherschutz unter • www.lanuv.nrw.de Aktuelle Luftqualitätswerte zusätzlich im • WDR-Videotext Tafeln 177 bis 179
Bereitschaftsdienst	Nachrichtenbereitschaftszentrale des LANUV (24-Std.-Dienst): Telefon 0201 714488

Content

Introduction

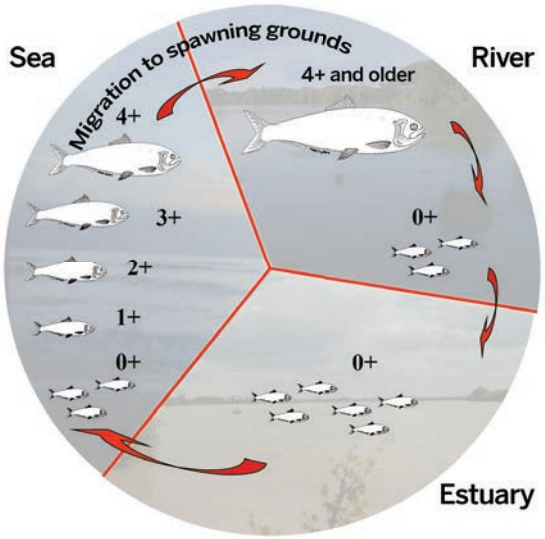
The allis shad is one of Europe's most vulnerable species. At the beginning of the twentieth century, it could be found in large shoals in almost all of the major river systems which flow into the Atlantic, the North Sea and partly those flowing into the Mediterranean Sea.
The distribution area stretched from North Africa to southern Scandinavia. Due to often rigorous overfishing, coupled with increasing environmental degradation through water pollution, development and the progressive construction of weirs and dams, which block access to their spawning grounds, this species has died out in large parts of Europe within the span of only a few decades. Vital remaining stocks of this species have survived in some western French, Portuguese rivers and one Moroccan river system. The allis shad in these waters are still commercially important today and feed many fishing enterprises. Until 2007, this was also true for the hitherto largest remaining stock of allis shad in the French Gironde-Garonne-Dordogne system, also known as the donor population selected for the first stocking project of allis shad to date, the LIFE project „Re-introduction of shad to the Rhine System" (LIFE06 NAT / D / 000005).
While an average of about half a million allis shad still migrated to spawn in the Garonne and Dordogne in the 1990s, the stock collapsed dramatically early in the new millennium. Since then the population has been reduced to less than one percent of that number. The identification of the reasons for this development, in addition to the continuation and documentation of the success of stocking activities in the Rhine, is the aim of the Life+ project „Conservation and Restoration of the Allis shad in the Rhine and Gironde Watersheds". The project has two distinct and yet inseparable pilot measures in order to protect the stocks of Alosa Alosa: the aim of preserving the reintroduction of the species in its former area of distribution and the investigation of the reasons for the decline of the largest remaining population with the aim of maintaining and improving the stock situation of allis shad in Europe.
The measures are jointly coordinated by the LANUV and the Rhenish Fisheries Federation from 1880 and implemented in cooperation with partners in the French Aquitaine, the Netherlands and in the German federal states North Rhine-Westphalia and Hesse.



Map of the original (green) and current (brown) population range in Europe. Main rivers having accomodated populations of allis shad are listed.

The collapse of allis shad populations in the Gironde region

As late as the turn of the millennium, around half a million adult allis shad migrated to the Garonne and the Dordogne in order to spawn. At that time the delicious allis shad still constituted the most economically important target species of the numerous fishing companies in the Gironde region, which used about half of the stock. The year 2003 seems to have been a turning point for the allis shad stock – indeed still a few hundred thousand adult allis shad migrated to the rivers at that time, but unlike previous years, a far lower number of migrating juvenile fish could be found in the Gironde estuary for the first time in 2003.
In order to be able to understand this development, it is necessary to take a look at the complex life cycle of the species under the microscope.



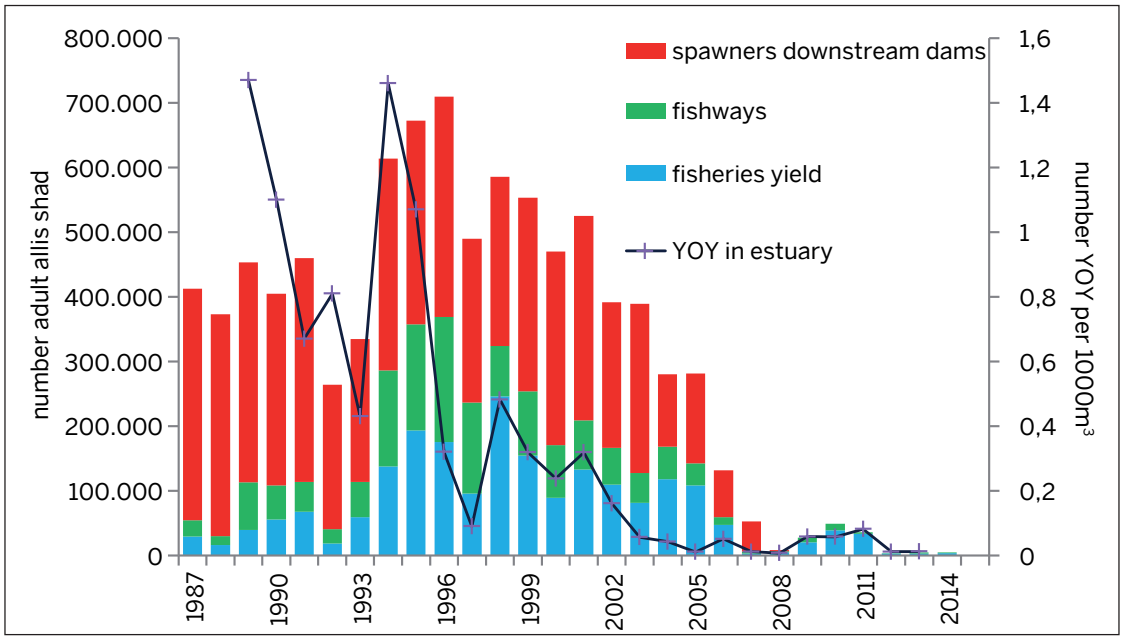
Scheme of the allis shad life cycle

The spawning act of allis shad, the so-called bull, takes place during the night on the surface of the water in certain river stretches

The fertilised eggs are deposited in gravel gaps

How can the decline of the allis shad population be explained against the background of biology and the way of life of the allis shad?

The allis shad is an anadromous migratory fish, which belongs to the same family as the herring and herring-type fish (Clupeidae), and spend most of their lives in the sea. Mature allis shad migrate to spawn in the middle reaches of rivers (barbel region). When the water temperature rises above 11°C, the allis shad gather together in the estuaries and migrate up the rivers. The fish spawn in the spring, when the water temperature rises above 15°C, from April to July and especially in the month of May (this is the reason for the German name of ‚May fish'!). Spawning areas are moderately flowing gritty river sections, such as those found on the inner bend banks, overflown gravel banks or at the mouths of tributaries. The peculiar spawning takes place at night directly on the water surface. The allis shad beat their tail fins in circular swimming movements on the surface of the water. The vociferous splashing can be heard from a long distance. The fertilised eggs sink to the bottom and are deposited in gaps in the gravel substrate. It takes about four to five days for the eggs to hatch. Afterwards, the young fish remain in the rivers for a few weeks or months and migrate to the brackish areas of the estuaries in late summer / autumn. They migrate into the sea from these areas no later than winter, where they grow to maturity in three to seven years and complete the life cycle with a renewed migration to the rivers.
The decline in the young-of-the-year fish population (fish that are hatched in the same year) observed in the Gironde estuary in autumn 2003, which was finally reflected from three years later on in a similarly dramatic decline of the stock of sexually mature allis shad from this generation returning from the sea. The decline in stocks in the Gironde-Garonne-Dordogne system can most probably be explained by an insufficient spawning success since that time or the increased mortality of juvenile fish prior to their arrival in the estuaries.



The number of allis shad caught by fishermen, the number counted in the fishways at the dams and on the spawning grounds downstream of the dams in the rivers Garonne and Dordogne and the number of the YOY allis shad sampled in monitoring studies in the Gironde estuary

Fisheries for the delicious allis shad were economically important in the Gironde basin until approximately one decade ago. Since 2008 a moratorium to save the population is in force.

Limited functionality of fishways

One possible explanation for reduced spawning success might be the lack of suitability of the fishways on the dams of the Garonne and Dordogne. Due to the fact that only a small proportion of the allis shad population is able to overcome the dam structures in order to reach the major spawning areas of the rivers, the shads are forced to reproduce in the inferior spawning areas which lie below the dams in the lower reaches. As the gravel and the bed load are trapped in the barrage sections and are not transported further downhill, significantly less favourable reproduction conditions for allis shad can be found in the lower reaches because their eggs cannot deposit in these essential gaps between pieces of gravel, where they can develop until the larvae hatch. There were indeed possible deficits in the fishways when the stock was still vigourous, however, it could be observed that the number of allis shad negotiating the fishways decreased with the size of the stock, so that fewer and fewer fish were spawning on the more effective productive spawning grounds in the middle reaches of the rivers. Studies on the use of existing fishways by allis shad, which were caught on the fishways and provided with radio telemetric transmitters before being released again downstream, point to significant deficiencies in terms of discoverability and attractiveness of the three fishways investigated. Only one of the 222 allis shad equipped with transmitters managed to negotiate one of the fish ladders. The fishway concerned, the slot pass at the weir in Bergerac on the Dordogne, was easier to evaluate than the fish lifts in

Tuilières and Golfech, also with respect to other parameters such as the number of entry attempts and the residence time of the allis shad in the fishway.

Inserting a radio-transmitter into the shad's gorge

Recovery of a tagged allis shad from the narcosis prior to release

A shoal of allis shad in search of the downstream entrance of the fishway at the Bergerac dam on the Dordogne

Searching for tagged allis shad in the river course

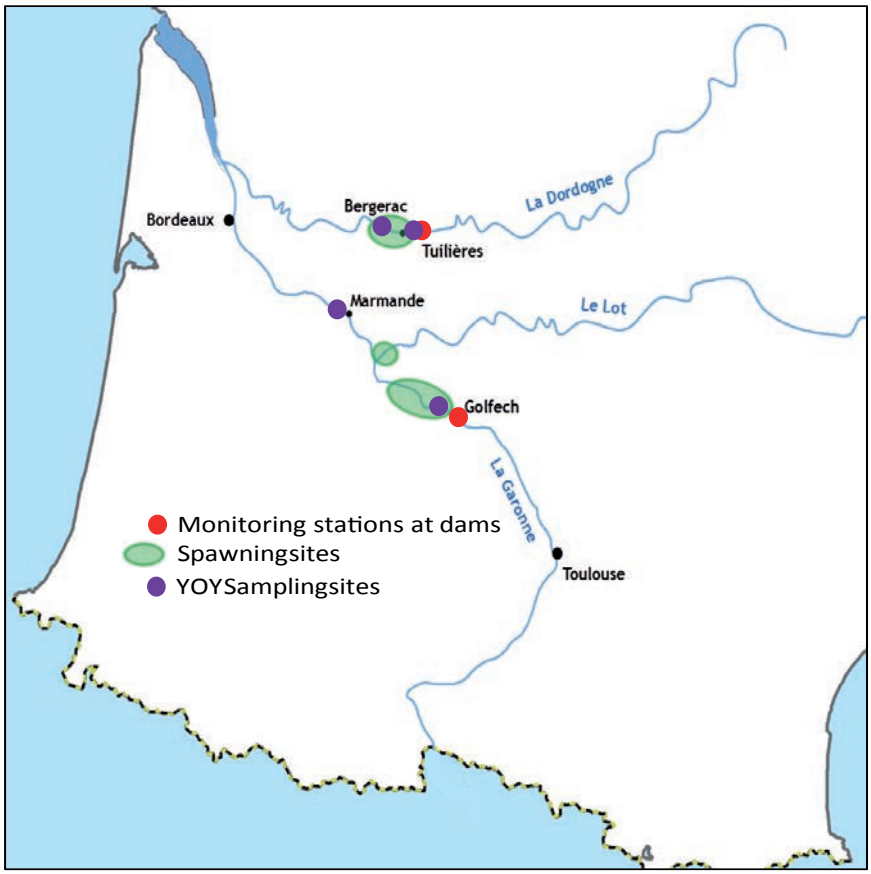
Overall, the suitability of the investigated fishways relevant for the allis shad in the Gironde region seem very limited. Similar problems also appear in the more modern and significantly larger fish migration facilities at rivers used by shad (here concerning the American allis shad) on the US east coast, as were revealed by a joint evaluation of the functional checks by American, Canadian and French fishway experts from the Life+ project team. The optimisation of fishways for the allis shad therefore has a key function for the (re)development of spawning areas and the conservation

of the allis shad. Based on these findings, the functioning of the existing fish migration facilities should be improved in the coming years and additional fishways should be constructed on the dam structures in Garonne and Dordogne where possible.

Although the three dams on the river Dordogne in Tuilières (upper left), Mauzac (lower left) and Bergerac (right) are equipped with fish ways, only a minor part of the allis shad population is able to pass the dams. The same applies to the dam at Golfech on the Garonne river.

Condition of juvenile fish populations in the rivers

Another possible hypothesis for the collapse of the allis shad population, which has been explored within the framework of the Life+ project and could explain the decline of juvenile fish stocks in the Gironde estuary in autumn since 2003, is the deterioration of living conditions in the rivers and increased mortality of juvenile fish during the first weeks of life. This could be caused by, for example, changes in the conditions of the physical habitat, such as the composition of the soil substrates or food availability. A complicating factor when investigating this issue is that it was not possible to sample the juvenile stages of allis shad in the past, or even to quantify their populations, which is due particularly to their pelagic way of life. Scientists repeatedly succeeded in finding evidence of juvenile allis shad with specially designed push and drift-nets. River sections below spawning grounds in the Garonne and the Dordogne were examined in a study. Due to the continuing decline in the number of mature allis shad returning from the sea at the start of the investigations, which sank to an all-time-low in the years 2012 to 2015, the natural breeding volume was so low that in total only a few juvenile fish were detected, and a quantification of stocks and comparative analysis of the influence of conditions for growing to maturity on population density was not possible. In this respect, the small number of detected juvenile allis shad reflects the dramatic population trends and their limited self-renewal to a large extent.



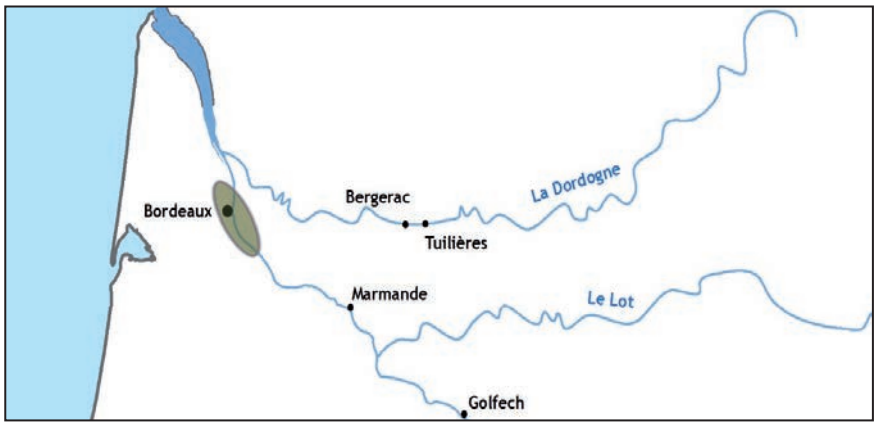
Map of the Gironde-Garonne-Dordogne basin with the location of the current spawning sites (green) and the YOY sampling sites (purple)

Boat equipped with push nets for the sampling of YOY allis shad and the push net (see construction in detail)

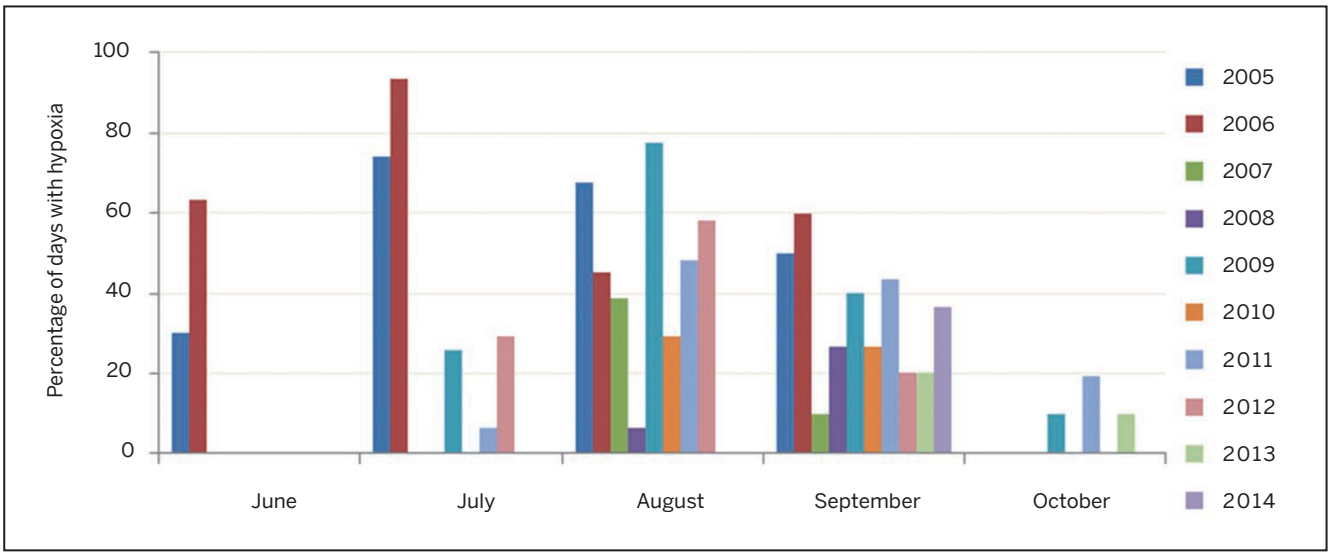
Juvenile fish monitoring via push nets in a river section below an allis shad spawning ground in the river Garonne

Danger in the lower reaches of rivers

Another factor of great importance for the insufficient self-renewal of the stock is recruitment, which has emerged as a consequence only in recent years:
Because of the extreme heat wave and the record low water levels in 2003, the so-called Bouchon Vaseux (silt plug) formed from suspended fine sediments in the tidal-influenced lower reaches of the river. Due to the retention of the outflow in reservoirs and dams, there were hardly any floods in the rivers which could flush this mud cloud out into the open sea. Because of the constant supply of fine sediments from farmland in the catchment area, especially cornfields, the Bouchon Vaseaux survives and regenerates itself, and it represents an increasing problem for the communities in the area of the tidal-influenced lower river reaches.
A particular problem here is the accumulation of oxygen-consuming particles, which means that there is a lack of oxygen in the Bouchon Vaseux area in summer and autumn, i.e. during the periods in which the juvenile allis shad are undertaking their migration to the sea through the lower river reaches. It seems reasonable to suppose that only a few of the juveniles migrating through the zone of the Bouchon Vaseux survive the journey unscathed and therefore the recruitment is also diminished. While the investigation of this factor is not the subject of the Life+ project, it is, however, likely to be of great importance for the allis shad population in the Gironde region and should become a stronger focus of future action, especially as a similar problem has also been occuring in other European river estuaries.



Location of the mud plug (Bouchon vaseux) in the tidal influenced downstream part of the river Garonne around the city of Bordeaux



Percentage of days per month and year in which hypoxia (< 5mg O_2 /l) occurred in the mud plug section of the Garonne. Particularly in August and September, when the YOY shads must pass through the Bouchon vaseux to reach the estuary, they encounter critical conditions.

Fine suspended solids accumulate in the lower and tidal influenced Garonne and constitute the so called Bouchon vaseux, the mud plug

Continuation and review of the success of the resettlement activities in the Rhine system

With the LIFE project „The re-introduction of allis shad in the Rhine", the foundations and infrastructure for Europe's first project for the re-introduction of allis shad in its former distribution area have been created with the help of the development of mass breeding, transportation and stocking techniques and the construction of an allis shad farm in Aquitaine. From 2008 to 2010 about five million allis shad larvae bred in France were released into the Rhine system for the first time (see LANUV Technical Report 28). The stock fish were taken from the Gironde-Garonne-Dordogne population. Allis shad which are ready to spawn are caught during the spawning migration in the Garonne and Dordogne, and brought to reproduce in the breeding facility near Bruch in the Aquitaine. The aim to make adult fish return from the stocking programme and founding a population the restocking measures are continued as part of the Life+ project from 2011 onwards. by Other key measures in the Rhine catchment area were studies on the behaviour of young allis shad after restocking, the search for the first adult allis shad from the restocking of the first Life project, which should return as of 2013, as well as exploring the possibility of raising allis shad in breeding stocks to sexual maturity in order to be able to increasingly draw on ‚ex situ' stocks in future restocking programmes and therefore become more independent of the offspring from wild stock.

Breeding and stocking of allis shad

Allis shad breeding is carried out at the breeding facility in Bruch in the Aquitaine. The French project partner association MIGADO, which also conceived and built the breeding facility for the preceding LIFE Allis shad project, is responsible for catching the parent fish in the Garonne and Dordogne and the work involved in the breeding and transportion of the allis shad larvae.

The breeding techniques have been optimised to the extent that around 80 parent fish need to be taken from the Garonne and Dordogne in order to breed two million allis shad larvae for stocking in the Rhine. This number corresponds to approximately one percent of the size of the spawning stock and has no impact on the natural population size in the Gironde region. After being caught, the parent fish are administered a hormone which which speeds up the maturing and the fish are soon able to spawn independently after their arrival at the fish farm and transfer into a spawning pool. The fertilised eggs are incubated for a few days in breeding jars before the allis shad larvae hatch from the eggs. Soon after hatching, the larvae are transferred into a solution containing with the fluorescent substance oxytetracycline, which is incorporated in bony structures such as otoliths and makes it possible later on to identify the fish which have come from the breeding facility. The larvae are then transported to Germany at the age of 5 to 20 days to be released in waters in the Rhine system. A total of around 6.2 million allis shad larvae were produced and transferred into the Rhine system between 2011 and 2015. In the years

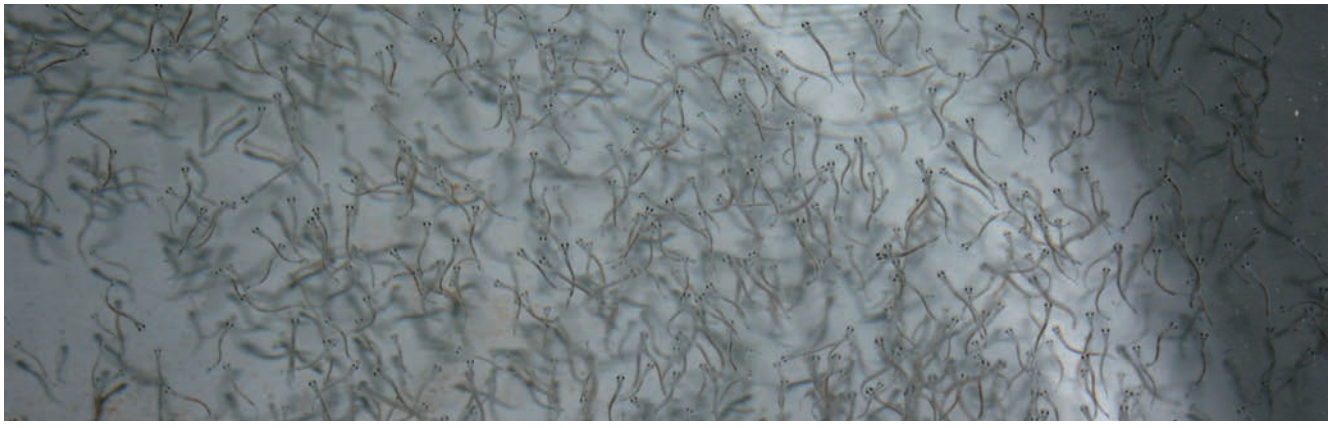
in which damp, cool weather and flood conditions prevailed in the Gironde region, the breeding success was significantly lower than in friendly hydro-climatic conditions. In addition, as due to the stock situation only a limited number of parent fish could be taken, the stock shortage was under a million in three of these years.

As the stock was dependent on the conditions in the Rhine basin (water level and flow, presence of competitors and potential predators etc.), certain waters were selected in order to guarantee the optimal chances of survival for the young allis shad larvae. Based on the experience of the first stocking year, after transportation to the river the allis shad were kept in circular tanks and fed until the evening in order to facilitate adaptation to the new habitat and guarantee higher survival rates.

After trapping in the fishways, the parent fish are injected with a hormone to induce spawning prior to the transport into the hatchery

The allis shad hatchery in Bruch in the Aquitaine

Adult allis shad in the hatchery



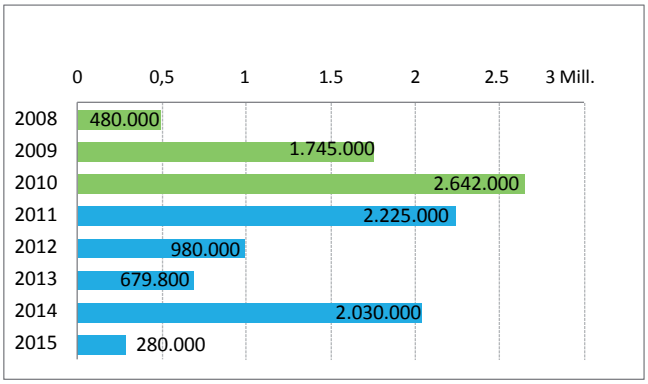
Freshly hatched allis shad larvae in the hatchery in Bruch

Map of stocking locations in the Life+ project duration in the Rhine basin

Delivery of allis shad larvae at a stocking location

After delivery in the morning the allis shad larvae are kept in round tanks and fed to recover from the transport before they are released in the dark

Allis shad larvae ready to be released. The guts of the yet transparent larvae appear red due to just having been fed.



Number of allis shad larvae released in the Rhine basin in the Life (green bars) and Life+ (blue bars) project

Feeding of the allis shad larvae in the tanks

Monitoring of juvenile fish after restocking

The studies on the behaviour and habitat use of the young allis shad following stocking are aimed at evaluating the stocking strategy and assessing the survival rates and optimisation of the stocking programme.
Similarly to the search, which was carried out at the same time, and previous studies of the juvenile fish in the river habitats in the Gironde region, it could be seen how difficult it is to track the juvenile stages of allis shad by monitoring the restocked waters. Despite intensive studies, which were carried out immediately after restocking and in the vicinity of the stocking locations using fine-meshed drift, push and seine nets, they did not provide any new insights on the behavior of allis shad larvae, which apparently spread in small shoals and created ‚niche partioning' after restocking or natural hatching. It is difficult to find evidence of them, especially given their small number in comparison to the immense habitat area. This appears to apply to an even greater extent to the juvenile stages, which were searched for in the weeks following restocking using push, drift and fixed nets in accordance with the expected size of the fish, as well as electro-fishing from the area of the restocking locations up to several kilometres around them. Despite the considerable amount of work and time spent, there was no success in recapturing the allis shad. Nevertheless, evidence finds of juvenile allis shad in the by-catches of an anchored stow-net in the mid and lower Rhine and in the cooling water intakes of power plants along the Rhine showed that the juveniles were able to find good growing conditions in the Rhine system and migrate to the sea in autumn.

Fishing for shad larvae with drift-nets in the river Sieg

Searching for juvenile allis shad with floating gill-nets in the river Lippe

Searching for juvenile allis shad by means of electric fishing in the Oxbow Erfelden

Sampling the Oxbow Erfelden with a push-net

Pilot facilities for ex situ stock

In order to guarantee stocking measures for Alosa alosa in future regardless of the exploration of the wild stock, the pilot facilities have been put into operation for ex situ stocks. In these pilot facilities, the aim is to grow allis shad larvae from the breeding facility in Bruch to juveniles and finally to adult, sexually mature fish, in order to use these as future breeding stock for the production of stocking fish. The success of this method is not certain due to the complex life cycle of the species and their stay at sea over several years. Part of the study, which is implemented at two sites in Aßlar (Germany) and in La Rochelle (France), is to investigate the importance of food composition, salinity and water temperature as well as the influence of the circadian rhythm on the growth and development of sexual maturity.
The growth of the allis shad in the pilot facilities has been encouraging. The fish in Aßlar reached a total length of 20 cm in their first year and the two-year old allis shad had already grown to 33 cm. At the La Rochelle site, the development of sexual maturity under farm conditions is being followed by accompanying histological and physiological studies. It appears that the sexual organs of the allis shad in the farm have been developing normally. The first males were sexually mature at the age of four, with a length of 32 cm. Despite this satisfying result, there still remains a lot of work to be done for the development of efficient breeding in ex situ stocks. So far, it is unclear whether the fish living under farm conditions have high fecundity (number of eggs per individual) and how large the stocks would need to be in order to produce the required number of allis shad larvae for stocking.
Furthermore, it needs to be clarified whether the complex mechanism of the development of maturity can be simulated under farm conditions. Problems are still posed regarding the function of the biofilters in recirculating systems with changing salinity values, and the nutrient supply to the demanding allis shad under farm conditions. A study conducted by scientists at the University of Giessen on the nutrition optimization of juvenile allis shad showed that the phenomenon of jaw deformity and extreme nervousness of the fish repeatedly observed in the past can be prevented by an appropriate diet with probiotic bacteria and certain essential fatty acids, resulting in a generally better constitution of the juvenile allis shad.

Juvenile allis shad in a tank in the pilot facility at the Aquarium La Rochelle

Young-of-the-year juvenile allis shad from an ex situ stock

Two year old allis shad from the Aßlar ex situ stock

Three year old allis shad in the Aquarium la Rochelle

Recirculation system in the Aßlar pilot facility

Searching for the first returnees in the Rhine

After it had been found that the juvenile fish in the Rhine had grown and continued to the next stage of their life cycle by migrating to the sea, the burning question remained as to whether these fish would return from the sea to the Rhine after reaching sexual maturity and whether it would be possible to detect the fish in the large river area. On the assumption that about one in 250 stocked allis shad larvae survived the subsequent stages of the life cycle and will return to the Rhine as an adult allis shad, and that about 40 percent of the fish become sexually mature in their fourth and fifth year of life, there was hope that as of the year 2013 (the initial stocking of allis shad in the Rhine took place in 2008), the first returnees could be recorded in the Rhine, in fishways in the Upper Rhine or in the larger tributaries, and that their number would continue to increase between 2014 and 2016.

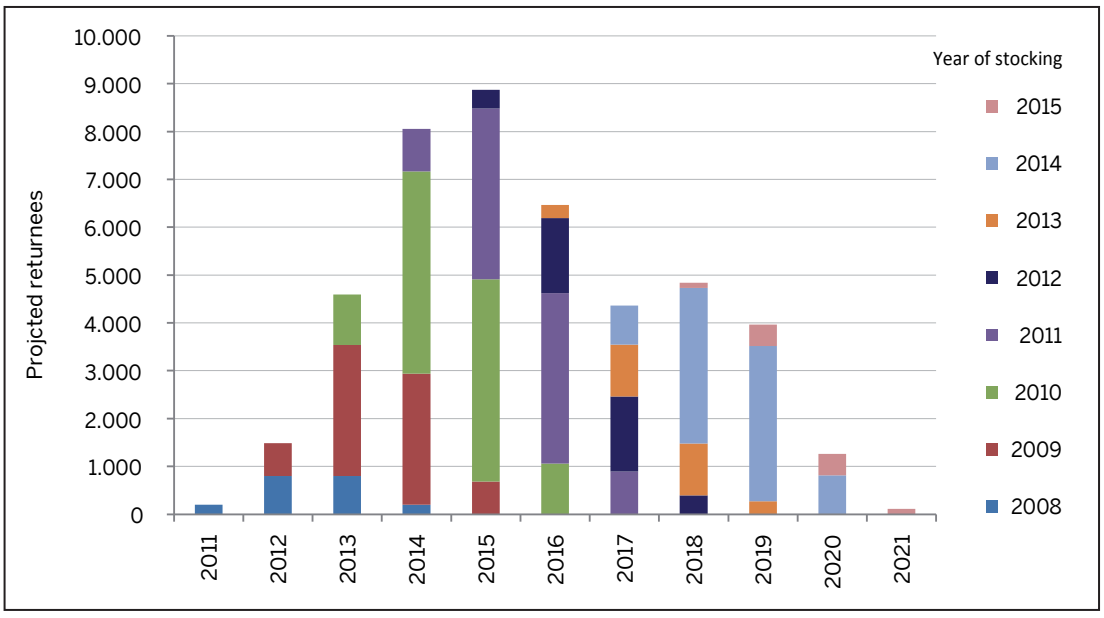
In fact, an allis shad was observed in a fishway in the Moselle in July 2013 – which was the first allis shad to be seen in the Moselle for 60 years. In the Rhine itself, the search for returnees was more difficult due to maintenance work at the fishway in Iffezheim, which meant that the facility was out of operation during the migration season, and due to a long-lasting flood. However, sensational evidence was found by chance: while monitoring the amount of fish at an extraction point of cooling water from the Upper Rhine, three juvenile allis shad were discovered in September of the same year for the first time. When examining the otoliths, no traces of the oxytetracycline used for marking of the fish were found, meaning that the animals did not originate from the stocking of the LIFE+ project, but were the descendants of allis shad reproducing naturally in the Rhine - the first record of a natural reproduction of allis shad since the extinction of the stock around a hundred years ago. The capture of a demonstrably spawned female allis shad by a professional fisherman in the same section of the Upper Rhine near Karlsruhe in autumn underlines the fact that allis shad do actually spawn in the Rhine. In 2014, when a larger number of allis shad were to be expected due to the intensification of stocking five years earlier, the search for shad was to be intensified.

Anchored stow-net near Rees at the Lower Rhine

Young-of-the-year juvenile allis shad caught with an anchored stow-net in the Lower Rhine

The first allis shad seen in the river Mosel for 60 years. It was discovered by a VAKI fish counter while climbing the fishway in Koblenz in July 2013.

French fishermen fishing for adult allis shads with floating gill-nets in the Lower Rhine



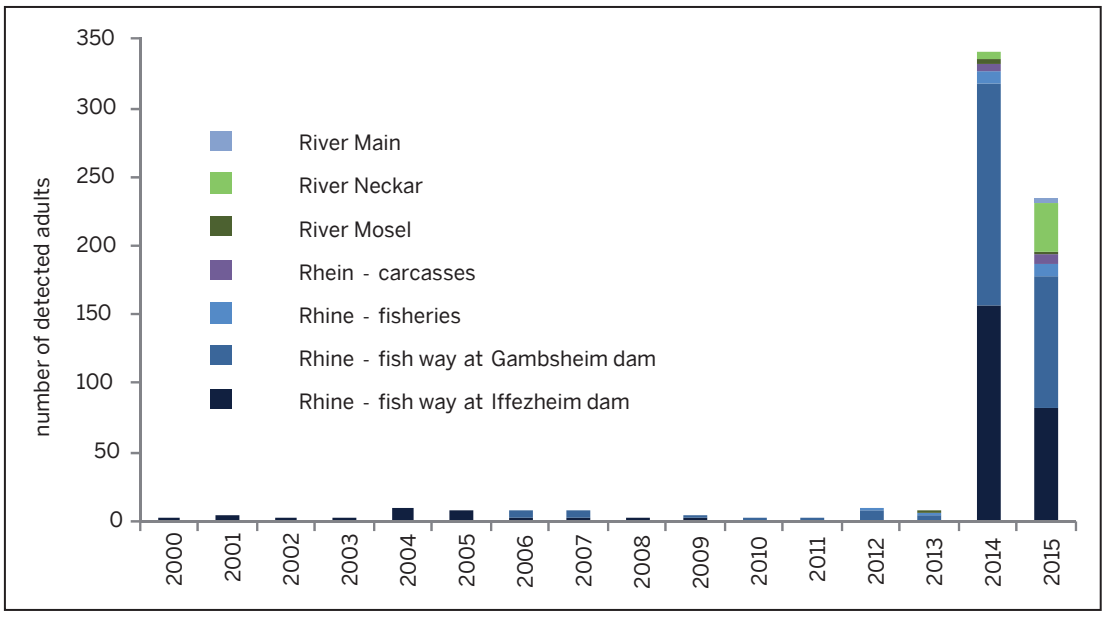
Estimated number of adult allis returning from the stocking measures based on the numbers of released larvae and an assumed survival rate of 0.4 percent

Resounding success of the reintroduction activities in the Rhine

Like the juveniles, due to their pelagic lifestyle, adult allis shad are also difficult to track, which means that the monitoring of adult allis shad in a big river like the Rhine presents a significant challenge. The otherwise positive fact that the Rhine is free-flowing for the first 700 kilometres and, unlike the other major rivers in Europe, no interfering dam structures exist which restrict fish migration, in this case makes the search for allis shad difficult because of the large river area. For the search for returnees professional fishermen from the Garonne were hired, who had lived from fishing allis shad until the imposition of the fishing prohibition and therefore knew the migration habits of the species and had mastered the fishing technique of drift net fishing. They therefore succeeded in finding evidence of three adult allis shad in the Lower Rhine at Rees during the monitoring investigation – the first adult allis shad in North Rhine Westphalia which could be identified as returnees from the stocking of the LIFE project by means of the marking of the otolith. This was only to be the beginning of the sensational return of allis shad in the Rhine during 2014. 318 allis shad alone were recorded in the fishways at the barrages of Iffezheim and Gambsheim, whereby both the timing in which the fish were registered at the two successive locations and the differing length distributions suggest that the majority of the fish observed in Gambsheim had migrated over the shipping locks of the Iffezheim barrage and had not been registered in the fishway.

More allis shad were found in the bycatches of professional fishermen in the Upper Rhine or were registered in fishways in the larger tributaries such as Moselle and Neckar, or took the bait of surprised anglers fishing in the Nidda, Lippe and Sieg. Numerous carcasses found in the Rhein indicated that the fish had spawned naturally in the

Fishway with monitoring station at the Gambsheim dam, the second obstacle for migrating fish in the Rhine



Number of adult allis shad observations in the Rhine between 2000 and 2015

current. Overall an incredible number of 341 adult allis shad were registered in the Rhine system in 2014. Notwithstanding a somewhat lower number of allis shad, which probably were not able to find entry into the fishways due to a long-lasting flood on the Upper Rhine, the wave of returning allis shad (a total of 231) continued in the Rhine in 2015. Numerous carcasses of adult allis shad which died due to spawning activity, are a clear indication that there are several active spawning grounds in the free-flowing stretch of the Rhine. The discovery of numerous juvenile fish which were not all proven as originating from the stocking, but from the natural reproduction of the Rhine returnees, demonstrates that the natural build-up of the stock recurring had begun. When searching for spawning areas of allis shad in the Rhine – due to their characteristic flapping of tail fins on the water surface, the spawning activities of allis shad are audible from a long distance – spawning shad in a characteristic habitat in the Middle Rhine could be heard near Koblenz and thus an active spawning ground was identified.

Curious discovery from an angler on the bank at the middle Rhine near Coblenz: big pike perch suffocated after preying an allis shad of 48 centimetres

Allis shad passing through the fishway at the Iffezheim dam on the Upper Rhine

Potential spawning habitat in a side channel of the middle Rhine

Perfect conditions for shads to spawn and for the monitoring of spawning activities – a mild night in early June at the middle Rhine near Coblenz

Transfer of knowledge and public perception

An important objective of the LIFE+ project is to distribute the project's contents, findings and achievements at different levels and to make this information available to both those involved in science, planning and management as well as the general public.

The project has the aim, in addition to the technical issues, to connect with the once great cultural and culinary importance of allis shad along the Rhine and, along with associations such as ‚Poller Maigeloog' dedicated to preserving traditional customs, to revive allis shad festivals.

Together with a group of pupils the Minister of Environment of North Rhine Westphalia, the state-secretary in the hessian Ministry of Environment and the mayoress of Cologne released allis shad larvae at the allis shad festival in Cologne-Poll

Parallel to these events, a classroom programme is being conducted in which children learn about the allis shad as an example of the habits of migratory fish, the wildlife of the Rhine and the function of the current as a habitat and migration path, and to release a new generation of allis shad into the Rhine together with politicians and officials. These events, which are carried out annually at different locations along the Rhine in North Rhine-Westphalia, as well as the opening of the pilot facilities for keeping parent allis shad, generated great media interest. Some television reports of the LIFE+ allis shad project can be found on the allis shad YouTube channel along with video documentation of the project.
In exhibitions organised by the project at the Aquarium La Rochelle in France and the Aquazoo Löbbecke Museum in Düsseldorf, hundreds of thousands of visitors can enjoy a unique opportunity to see live allis shad and to learn about the type of conservation and stocking measures taking place under the LIFE+ project.
Being the only project in Europe which is dedicated specifically to the conservation of the species Alosa alosa, the Life+ project is closely linked to national and international institutions and communicates its goals and achievements in conferences and symposia.
At an international symposium in Bergerac, allis shad experts from France, Germany, Portugal, the United Kingdom and North America discussed possible ways in which the critical situation of the allis shad stock in the Gironde region and further allis shad rivers could be overcome in the remaining distribution area of the species, and what lessons can be drawn from the positive re-introduction of allis shad in the Rhine.

In the allis shad school class programme children discover practical knowledge about the allis shad and other communities in the river, particularly these of migratory fish

Photo above: International allis shad symposium in Bergerac.
Photo below: Debriefing with international shad experts at the allis shad symposium about the ways out of the crisis of the allis shad population in Europe and particularly the Gironde basin.

Excursion to shad spawning grounds with a Gabarre, a historical boat, on the Dodogne as part of the allis shad symposium

Aquarium exhibition at the Aquazoo Löbbecke Museum in Düsseldorf

Exhibition at the im Aquarium La Rochelle

Allis shad in the exhibition at the Aquazoo Löbbecke Museum

Press conference in the context of a release event at the river Lippe

Conclusion and outlook

The results of studies on the situation of the allis shad and its habitats in the French Gironde region demonstrate the dramatic development of the allis shad stock and shortfall bottlenecks of their migration and reproduction. An independent recovery of the population is not expected due to the alarmingly low levels of the stock of spawning fish on the one hand and also the limited availability of high quality spawning grounds for allis shad. This means that concrete measures must be taken in order to secure the recovery and medium-term increase of the population and to improve the reproductive success of the population. This requires that access to high quality spawning areas must be procured for a larger part of the stock than previously, which presupposes on the one hand the optimisation of the fishways across dam structures or the construction of additional and more appropriate fish migration facilities.

In addition, measures aimed at improving spawning habitats in the lower reaches of rivers would be desirable, in particular regarding the presence of gritty river bed substrate to ensure that developing allis shad eggs are deposited in the gravel gap system and therefore a higher percentage of these eggs will be able to hatch into larvae. Furthermore, measures should urgently be reviewed and then taken that would lead to an improvement in the oxygen saturation in the lower reaches of rivers and ensure the survival of juvenile allis shad migrating to the Gironde estuary.

As a consequence of the successful restocking in the Rhine system it stands to reason that a scientifically oriented stocking programme in the rivers Garonne and Dordogne could also be started: by stocking the rivers with marked allis shad larvae, monitoring investigations could take place to estimate the survival of juveniles in the rivers and to identify deficiencies. With a similar success in stocking to the Rhine system, the spawning stock would also increase in the future as a consequence. In combination with the improvement of the conditions for natural reproduction as described above, a recovery of the stock seems conceivable, and in the best case, renewed fishing

activity could be possible under the umbrella of a management plan.
The positive development in the Rhine system can be attributed to the success of the actions taken so far by LIFE and LIFE+. The return of allis shad from the stocking of previous years and their natural reproduction in the Rhine impressively demonstrates that the ambitious goals of this unprecedented pilot project have been achieved and that this can act as a model for future reintroduction projects. For the Rhine this means that the assessable development until the end of the project shows that building a native allis shad population began by recruiting juvenile fish from independently spawning returnees and thus the basic requirement is provided for sustainable population development. This sensational finding against the backdrop of a threatened stock situation across Europe must not hide the fact that only the first steps have been taken with regard to the development of an allis shad stock which can survive in the Rhine independently in the Rhine. Therefore the stocking must be maintained over the next few years to ensure that the base population is large enough to provide a sustainable population development. The breeding of stock fish in the future, if possible, should take place among returnees which are already better adapted to the Rhine river system. They would be caught in the fishways in the Upper Rhine region and taken to a breeding facility to be created there along the lines of an allis shad farm, where they can be reproduced. Simultaneously, a monitoring procedure must be established that makes it possible to follow and assess the further development of allis shad and its recruitment in the Rhine, and for which pilot studies have shown that keeping allis shad in ex-situ stocks is possible. The experiences will be incorporated into optimised systems, which will make it possible to collect stock fish from such parent fish in the future.
These measures should ideally be implemented together with the proposed stocking and monitoring activities in the Gironde region and thereby help to develop management plans which will be transferable to other river systems and which will contribute to recovery across Europe.

The LIFE+ Project "Conservation and restoration of the Allis shad in the Gironde and Rhine watersheds" (LIFE09 NAT/DE/000008) was supported by:

Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen

Hessisches Ministerium für Umwelt, Klimaschutz, Landwirtschaft und Verbraucherschutz

Bezirksregierung Düsseldorf

Aquazoo Löbbecke Museum Landeshauptstadt Düsseldorf

What's Life+?
Life+ is a promotion program of the European Union aiming on supporting Environmental and Nature conservation projects within the community. By means of Life+ Biodiversity and Nature conservation projects like the "Alosa alosa" project are supported, which serve the maintenance and the reestablishment of wild populations of the endangered allis shad as a part of the Natura 2000 network.

Further information under **www.alosa-alosa.eu** and **www.lifealose2015.com**

Landesamt für Natur, Umwelt
und Verbraucherschutz
Nordrhein-Westfalen
Leibnizstraße 10
45659 Recklinghausen
Telefon 02361 305-0
poststelle@lanuv.nrw.de

www.lanuv.nrw.de