Technical publication on Allis shad stocking and monitoring measures within the Framework of the LIFE Allis shad project

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Introduction

The LIFE Allis shad project's main objectives are besides the development of mass rearing techniques the stocking of up to 5 Mio Allis shad to the Rhine System. Monitoring investigations are mandatory for measuring the efficiency and assessing the success of re-introduction programs in the sense of the IUCN. In the opposite to many other fish species and as result from experiences made in reintroduction programs for the American shad (*Alosa sapidissima*) in the US, keeping bred YOY shads until an advanced age (i.e. at least until having reached the early juvenile stage) is problematic with regard to adequate feeding, handling and most often accompanied with increased mortalities, so that stocking at the larval stage, just a few days after hatching from their eggs, has turned out to be more efficient. In general the availability of habitats that match the specific requirements of YOY fish, or even particular developmental stages, is commonly considered as being essential for YOY survival, recruitment and population maintenance. On the contrary scarcities of specific habitats are often followed by retarded growth, increased predation mortality, reduced survival, and thus considered as a major threat for the populations of many fish species, particularly when habitat requirements are emphasized. Identifying the habitats most beneficial with regard to forage, growth and survival is a prerequisite for the identification of suitable sites for stocking and optimizing stocking operations in order to minimize mortality and increase the project's success. To our knowledge the nursery habitats and their significance on the shad juvenile's survival has never been addressed before. Regular monitoring investigations carried out in the Gironde estuary and studies on otolith chemistry draw a quite precise picture of appearance of the juveniles from the rivers Garonne and Dordogne at the Gironde in late summer and on the duration of the estuarine phase, however nothing is known about the period from the spawning of the adults until the juveniles appearance at the estuary. Consequently nothing is known about YOY Allis shad habitat preferences or even requirements. To close this gap of knowledge and to identify suitable habitats for the larvae and getting ideas on post-stocking behavior is a key task for making the re-introduction program to become successful. This is particularly true, since particularly at early developmental stages natural mortality-rates are significantly increased.

When spawning Allis shad release their sexual products in the open water and do not, unlike most other freshwater fish, attach their eggs to certain substrates. Nevertheless, spawning is restricted to particular habitats, mostly at stretches at the tradition from pools to faster flowing riffles with gravel substrate. Most likely this active site selection aims on the opportunity of eggs to be kept in gravel interstices where the current and thus oxygen supply and embryogenesis is enhanced. However, eggs are displaced with the current and hatching of larva is most probably not restricted to specific habitats but at random. This is notable, because in freshwater fish spawning habitats are often similar to the required habitats of early larva stages. Thus no conclusions can be drawn from spawning habitats to preferred or even required habitats of the early YOY.

Although YOY fish communities and habitat requirements of YOY fish had become a focus of fish biological research in the 1990ies, at this time Allis shad had already become absent from almost all rivers in those studies had been conducted. On the other hand, the remaining populations, e.g. in the Gironde tributaries, didn't suffer any notable decrease so far and where thus not subject of research on the fresh water phase of juvenile Allis shad. The few studies on habitat utilization of YOY fish of several species carried out in late summer in the Garonne river and its floodplain, do not contain any information on YOY Allis shad. This might indicate that these had already emigrated from the river at this time or did not utilize habitats close the bank, which have been predominantly sampled in these studies.

The present reports objective is to summarize the results the stocking operations and monitoring investigations parallel carried out in order to closing the gap of knowledge on habitat requirements of larval Allis shad and to optimize stocking operations. Conclusions will be drawn on the suitability of the different methods used for detecting Allis shads so far and finally how the results with regard to habitat utilization could be interpreted

Material and Methods

Criteria of stocking site selection

The identification and quantification of potential stocking sites in the Rhine watershed was subject to a separate study which was carried out in advance to the first stocking measures. From preselected sites, potential habitats were shortlisted in cooperation with the stocking teams, whose assignation implied that these had a long experience with the particular ecology and habitat requirements of YOY fish. Due to negative experiences at the very first socking the actual stocking sites were selected after criteria which were considered to entail a low risk of predation, enable shad larvae to cope with the new environment and to start foraging quickly.

In the light of the expected requirements of shad larvae after stocking, the sites preferably selected for the release, were mainly characterized by relatively high natural dynamics, which involve heterogeneous, but predominantly weak to moderate currents, and varying depths. Investigations on the role of substrate grain sizes on habitat utilization pointed to marked preferences of larvae for gravel and pebbles, thus sites with a predominantly coarse substrate were preferred upon fine grained bottom substrates. Despite the lower than expected negative influence of wash on larval survival caused by ships, it was taken care, that potential stocking sites were not influenced by shipping, in order to minimize potential risks of mortality or even damage. For the same reasons, larvae were released at microhabitats, in which the abundance of other species' YOY fish, which have been observed to cause high predatory pressure, was apparently low. A further important criterion was a good accessibility for the stocking team and the transportation van, respectively, as well as suitable conditions to carry out the related monitoring investigations, i.e. to install the monitoring facilities.

The final decision upon at which sites larvae were released was, depending on current and discharge conditions, made immediately prior to stocking in order to guarantee the highest possible survival of larvae and to be able to conduct the accompanying investigations on post-stocking behavior of the shad larvae. Such monitoring investigations are prerequisite for the optimization of subsequent stockings.

Stocking sites

In order to increase the chance of attracting adults to return to the water or perhaps the river stretch where they have once been stocked in the future years, two sites which met the criteria listed above well, were selected to be stocked each year.

In Hessen this was the oxbow Erfelden, which is connected to the Rhine at its up- and downstream end. The oxbow is almost 17 km long and covers an area of about 163 ha. The discharge and the current within the oxbow depends on the Rhine's discharge, however, despite increased discharge, only week currents occurred when stocking was carried out in 2008, 2009 and 2010, respectively. The depth at average conditions ranges between 1 and 2.5 meters. The predominating substrate in habitats with current is sand and gravel, whereas mud prevails in the more lentic areas. Although the oxbow is characterized by an only moderate structural complexity, hydraulic engineering measures have been realized only close to the mouth to the Rhine and the banks are largely naturally vegetated with reeds and willows. Areas with woody debris are present as are unpaved undercut banks with steep slopes and shallow inner bend banks with week slopes. Due to the permanent augmentation of nutrient rich River water and the reduced current within the oxbow, productivity of phyto- and zooplankton is sharply increased compared to the lotic sites in the River itself, thus providing suitable and rich food resources for YOY fish.

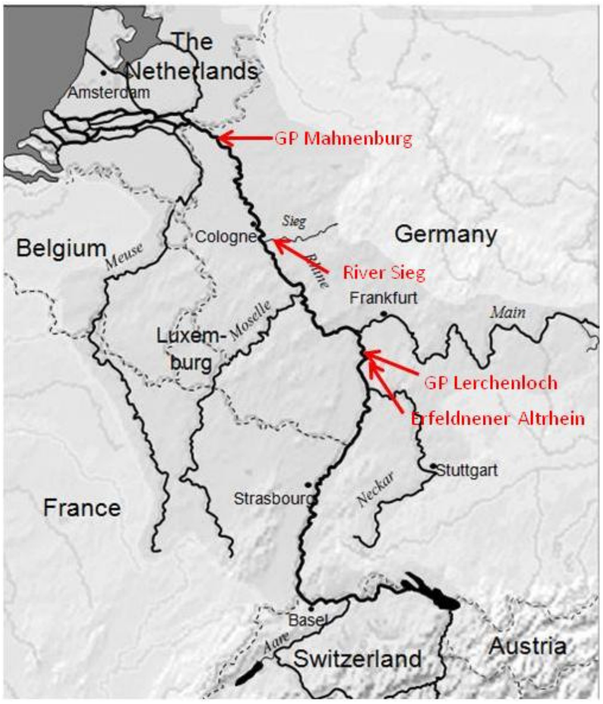

Fig.1 Location of the different stocking sites in the Rhine system

Due to its historical tradition as a spawning site of Allis shad, the still nature-like Character and the likeness with active shad rivers in France as well as the positive trends and recruitment proofed for the populations of other anadromous fish species (Atlantic salmon, River and Sea Lamprey) in the recent years, the lower River Sieg in North Rhine-Westphalia was selected to be stocked over the entire project duration. Below the lowest weir at St. Augustin-Buisdorf, which is equipped with a modern fish-pass and monitoring facilities being well suited to detect potential adult returners, the

River Sieg is free-flowing and entirely passable for migratory fish. The stretch below Buisdorf until the mouth into the Rhine is approximately 15 km long. The mean discharge is 53 m^3 sec^{-1}. Although the banks are reinforced with basaltic blocks in some sections, the River Sieg is characterized by an overall comparably low anthropogenic modification. With exception of single stretched segments with bottom sills, pools alternate with riffle sections. The substrate is predominated by pebble and gravel. The banks are largely covered with willows and scrubland vegetation.

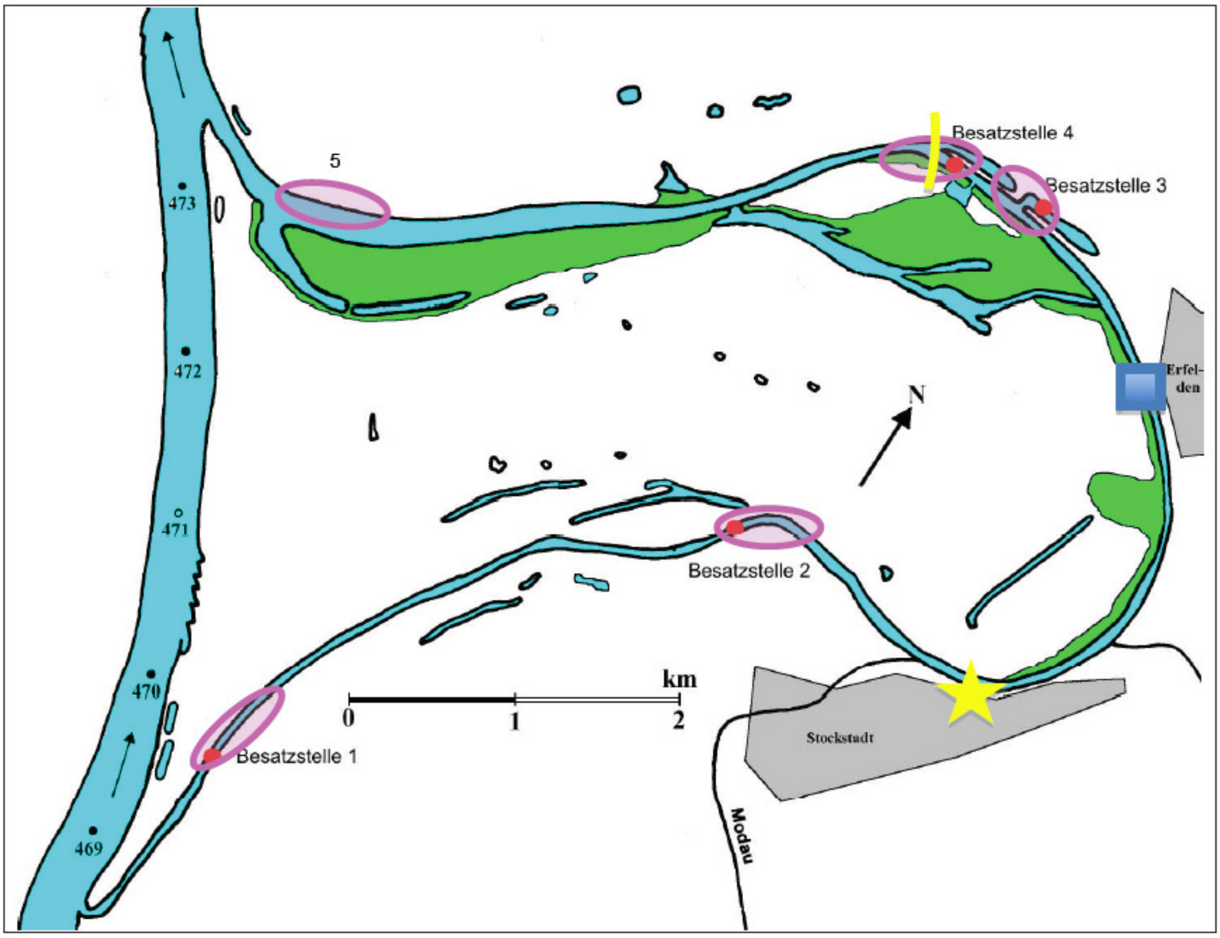

Fig. 2 Map of the Erfeldener Altrhein. Red point denote stocking sites and pink ovals the sites sampled with beach seine nets and dip nets in 2008. The yellow star denotes to the release site of shads for drifting observations and the yellow marl until the shads could be traced in the drift.

Fig. 3: Riffle section in the River Sieg downstream of the site where the larvae were released.

Both waters provide various habitats which are considered to allow Allis shad larvae to niche, feed and should thus guarantee a good survival.

The additionally stocked stagnant water bodies connected to the Rhine were a gravel-pit in Hessian Upper Rhine section, the so-called “Lerchenloch”, and the “Mahnenburg”, a connected gravel-pit in the Lower Rhine section in North Rhine-Westphalia.

Transport and stocking operations

The transport of larvae from the fish farm in Bruch, southwest of France, to the Rhine area in North Rhine-Westphalia and Hessen, respectively, was done in transportation bags, which were filled to one third with water and to two thirds with atmospheric oxygen. The number of larvae per bag ranged from 7 to 15.000, depending on their size. It has turned out beneficial to put an additional bag around the actual transport bags in order to maintain pressure stable. The bags are stored between ice packs and transported in vans, which can cover the distance between the Aquitaine region and North Rhine-Westphalia and Hessen cheaply and within a relatively short time. Because of the lower temperatures and traffic volume, it has turned out to be beneficial if the larvae are transported during the night, usually arriving in Germany early in the morning. So far single transports comprised up to one hundred bags and 1.2 Mio larvae, respectively. Meeting points with the responsible stocking teams were arranged in advance in order to reload the bags and to approach the preselected stocking sites without further delay. Under these conditions transportation mortality was estimated to be much smaller than 5 %.

Fig. 4: Transportation van with plastic bags (left), shad larvae in a transportation bag.

Methods for assessing stocking efficiency and post-stocking behavior of Allis shad larvae

The accompanying investigations aimed on gathering information on the post-stocking behavior of larvae and to draw conclusions on habitat suitability and how stocking can be further optimized in the future. Thus the sampling methods and the gears used need to be appropriate to provide information on whether the larvae niche in habitats immediate to where they were released or migrate downstream even with regard to the tiny size of the larvae.

For screening particular habitats for the presence of larvae small meshed (≤ 1 mm) dip-nets and beach-seine nets (10 x 1.5 m) were used. Dip-nets (diameter 0.7 m) were used to sample the stocking habitats and nearby sections, including lotic habitats on a random basis by taking many small samples. Beach seines were predominantly used to sample lentic habitats. The catch was transferred into water-filled basins and inspected in order to identify Allis shad larvae amongst other YOY fish. In the case of Allis shad records, abundance was to be quantified by means of point-abundance-sampling by electro fishing, as described by Scholten (2003, see there for details regarding methodology and gear specifications). Electric fishing using direct current devices was, due to the expectable larger size, even used to sample habitats in larger time distance to the stocking, when YOY Allis shad are to be expected to have grown so far that they can be recorded by electric fishing.

Flowing water was sampled with fine-meshed (0.8 mm) drift-nets (0.5 x 1.0 x 1.5 m, height x width x depth) which were exposed to lotic habitats, preferably riffles. The nets were attached to metal frames which were fixed to a thick rope which was, being attached to a large willow tree at one and a heavy iron anchor at the opposite bank site, stretched across the entire river bed. To facilitate identification of larvae and to avoid bias caused by clogging of the nets and backwash effects, it turned out to be necessary to empty the nets at least every 2 to 3 hours, after which the net content already amounts to ≥ 5 kg per net. This was done by transferring the content completely into water-filled tubs. The majority of the content consists of plant material (leafs, seeds), detritus, invertebrates and their carcasses respectively. Smaller portions were inspected for fish larvae in the field, which were fixed and stored in a 5% Formalin solution and identified by means of a dissecting microscope in the laboratory. Night samples and even samples containing large amounts of organic matter were completely stored in Formalin solution and the search for and the identification of larvae was done in the laboratory.

At least when the water was not too turbid, direct observations of Allis shad larvae are considered to allow drawbacks and qualitative information on their behavior after stocking. Visual observation was done from above the surface, by tracking drifting larvae with the current at day- and night-time (in the latter case by means of an artificial source of light), or from below the surface by diving or snorkeling and observing their position in the water column. Diving observation were only conducted in stagnant habitats.

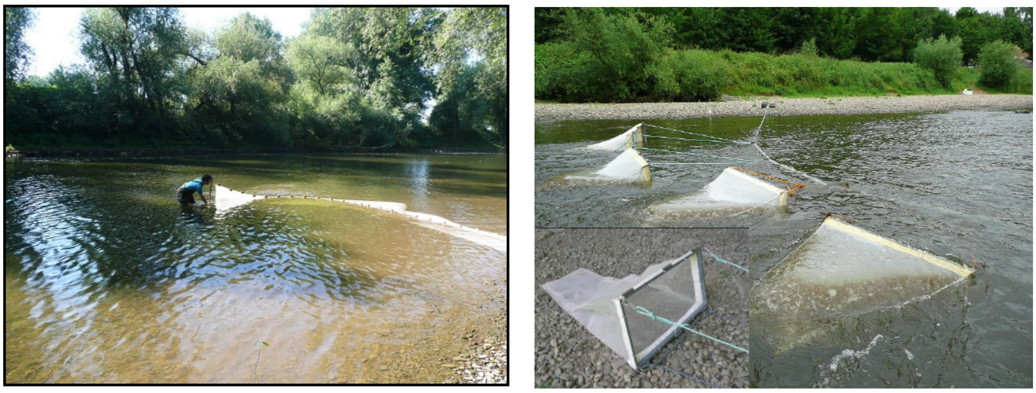

Fig. 5: Beach seine nets (left) and drift nets (right)

Fig. 6: Diving observations conducted in gravel pit lakes connected to the Rhine

Fig. 7: Drifting observations (left) and observation on post-stocking behavior (right)

Monitoring of shad habitat utilization throughout the summer, seaward migration and estuarine phase

Historical data from the Rhine, as well as current studies in the Gironde area, indicate that YOY shads stay in freshwater habitats for elongated periods before they successively migrate to the estuary in late summer and autumn. Studies on habitat utilization the weeks or months after stocking and the seaward migration on the Rhine require fixed permanently operating sampling devices or at least an increased sampling effort. Hence such measures could not be financed from the project. Information on the presence in the compared to the Rhine shallow tributaries like the river Sieg can be gained through regular electric fishing surveys as they are conducted in connection with external monitoring, e.g. on behalf of the EU water frame work directive. In the Rhine, where the main channels depth exceeds 10 meter and averages still more than 3 meters electric fishing surveys are restricted to the areas close to the bank.

The discovery of juvenile shads by professional fishermen seems most promising. In the German and the Dutch section of the river Rhine still some professional fishermen go out their daily business. Most of them are supervised by authorities (e.g. the Rhine fisheries cooperative North Rhine-Westphalia, the IMARES institute in the Netherlands) and many additionally work on a collaborative basis with research institutes, so that exceptional records are announced immediately and the data in general is forwarded to involved organisations on a regularly basis. These fishermen often use traditional gears and methods (fyke-nets, trawling, stow-nets, gill and drift nets), which are different from those of the standard monitoring measures and thus better suited to detect individuals that prefer offshore habitats.

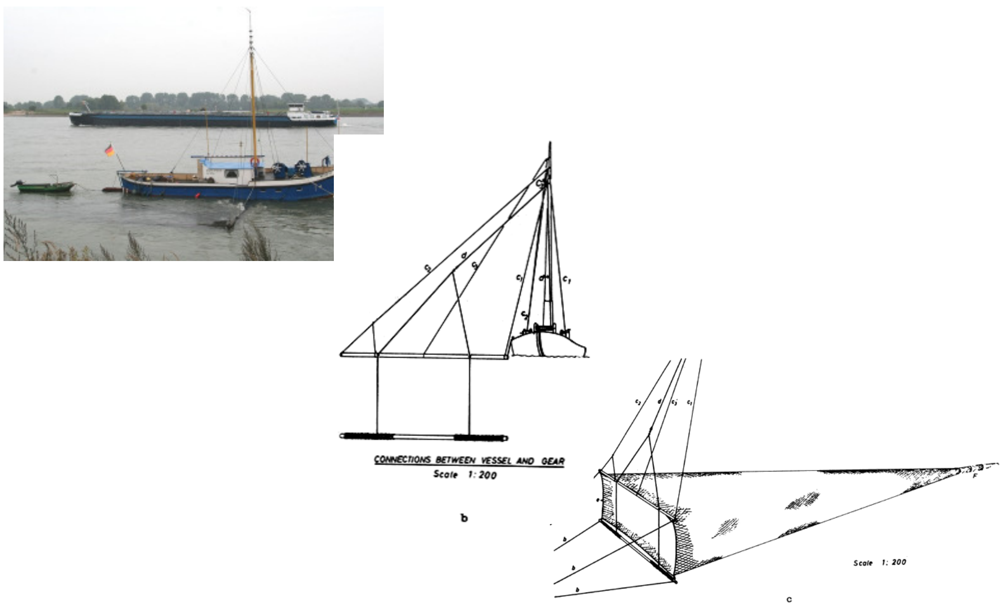

Fig. 8: Anchored stow-nets are frequently used by professional fishermen to catching silver eels and well suited to monitoring fish on their downstream migration

Although even in the Dutch Delta Rhine section some fishermen are still working, the fishing effort in the last years was reduced due to restrictions imposed with regards to the protection of silver eels, the target species of fyke- and stow-net fisheries. The same applies for monitoring schemes carried out in the framework of monitoring investigations conducted by the Dutch authorities, which imply hauls with large trawl-nets, which are considered to be well suited to representatively cover the large Delta branches and lakes and thus to detect juvenile Allis shad when being conducted during the estuarine phase of the juvenile shads. An agreement was made that the Dutch authorities will be informed as soon as the first downstream migrating fish are detected in the German section in order to provide them with the opportunity to intensify and to specify their efforts. In the recent years the first juveniles of North-Sea houting coming from a re-introduction program similar to the LIFE Allis shad project, and even the first adults some years later were detected by professional fishermen. The same applies to the closely related Twaite shad, for which data on the positive population trend was supplied by professional fishermen, who forwarded these information to the respective authorities.

A determination sheet was prepared and distributed in order to enable fishermen to distinguish even juvenile stages of Allis shad from other clupeid fishes and particularly the closely related Twaite shad. Since records of juvenile Allis shad were due to fishing effort and temporal probability expected to come from the Delta area, this determination sheet was produced in Dutch language.

Besides information expected to coming from the stow- and fyke-net fisheries, additional seining and trawling surveys in the Delta region were sub-contracted to specialized fishermen and biologists in order to obtain information on the presence and distribution of juvenile shads in the Estuary in autumn. The open water area has been monitored using a seine net (total length 225 meter and a height of 7 meter), consisting of two long wings and a bag. Two long ropes (100 meter) extended from the wings of the seine were used to encircle a large area. Due to the small mesh-size (40 mm at the start and 14 mm at the end of the seine) the applied seine was useable for the monitoring juvenile shads (size approximately 10 cm total length). The fish population directly at the shore of the research areas has been sampled using an electric fishing gear (using two anodes).

Results and Discussion

Stocking observations

After the long transport the larvae need to get acclimatized to the ambient temperatures of the water in which they are to be stocked. To this end the transport bags were always situated into the water in shaded areas for at least an hour until the temperature inside the bags was adjusted to the ambient water temperature. Since the release of larvae during daytime, particularly when conducted in areas close to the bank, turned out to involve the risk of immediate and intensive predation exerted by other YOY fish, this stocking strategy was not further pursued after the experiences made in 2008. In the light of the notably lower abundance of YOY fish in open water areas, the release of Allis shad larvae from the stocking bags (after temperature adjustment) was however continued, when such habitats were accessible for the stocking team (e.g. when a boat was present) and especially when large amounts of larvae were to stock. Besides a lower expectable predatory pressure acting on the larvae, open water stocking in stagnant or slow flowing waters implies the advantage that shad larvae are provided with the opportunity to feed on abundant zooplankton organisms in the open water areas and serving as an appropriate prey resource.

Since the larvae do not comprise sufficient energetic storages, providing them access to nutrition after the starvation as a consequence of the long transport it was taken care to facilitate the larvae to get used to the new environment and to reduce mortality. Hence it was tested to keep the larvae under ambient conditions and feeding them before releasing them after dusk by keeping the larvae in large round channel tanks (approximately 200,000 larvae per tank, per m^3, respectively) supplied with river water and fed with Nauplii of *Artemia salina* and a particular dry feed called *Caviar*. Tanks were shaded to avoid the larvae's exposition to strong sun-light. The releasing was facilitated using a coarse tube (diameter 2 inch) situated at the bottom for draining the container and siphoning the larvae without the need to handle them directly. By this larvae could be transferred to open water habitats.

Fig. 9: Transferring shad larvae from the transportation bags to round channel tanks supplied with river water (left). Larvae forage Artemia nauplii as indicated by the colored content of their guts.

Surveys on the immediate behavior of larvae after releasing them from the transportation bags were regularly conducted. Unless the water is not very turbid it is possible to trace single larvae when wearing polarization glasses. These observations gave indications on a strong predation pressure exerted on the shad larvae when a) stocking is conducted during day-time and b) YOY fish with a size advantage are highly abundant in the respective habitats. Sampling YOY schoals which were observed to attack shad larvae close to the surface by means of dip-nets revealed, that amongst these were mainly YOY of typically non-predatory species, like *Rutilus rutilus*, *Leuciscus leuciscus* and *L. cephalus*. These observations finally led to the modification of the stocking operations, i.e. to delay them into the period after dusk. Stocking observations furthermore gave indications, that Allis shad larvae actively move away from the surface at daylight (a similar behavior was observed for shad larvae kept in round channel tanks), so that these kind of survey is feasible only for the immediately following period after release.

Based on the experiences that the release of larvae during day-time could result in an increased predation through river-born YOY fish, even when these have only slight size advantages, the release of shad larvae from the tanks should whenever possible be carried out after the onset of dusk.

Suitability of methods for monitoring

Dip nets

Despite many thousand YOY fish of several species were caught, no Allis shad were recorded, by means of dip-net sampling. This method was only applied in 2008, when the amount of stocked larvae was considerably lower than in the following years, and it was categorically less likely to recapture shad larvae. Further explanations are that the larvae moved downstream and did not occur in the sampled area any more. With regard to the numbers of other YOY fish sampled by means of dip nets and the fact that these were much higher abundant than the shad larvae even when still residing in the sampled area It however should be taken into account that dip-netting might provide records for shad larvae only when these are highly abundant

Beach seine nets

Despite the lower number of hauls carried out by seining compared to dip-netting the sampled area was multiple, as was the number of fish recorded. However, the species composition and furthermore the relative abundance of the several species was rather similar. However, as with regard to dip-net sampling no Allis shad larvae were detected. Since this method was applied in 2008 exclusively, the reasons for the missing detection of shad larvae is most probably the same as stated for dip-netting.

Electric fishing

Electric fishing was only applied in the “Erfeldener Althrein” in Hessen two weeks after the release of shad larvae. No shads could be detected by means of electric fishing. However, this could be due to the large area of the respective water body and comparably low number of shads stocked to it. Furthermore the method has its disadvantages when sampling deep open water areas. Finally the size of the shads attained at this time might have been too small to be affected by the current field around the anode. Electric fishing conducted in less depth and more heterogeneous habitats in late summer, particularly in narrower river beds, could be well suited to detect shads before emigrating to the Estuary. Based on the observations made by Boisneau in the Loire river that indicate to diurnal habitat utilization patterns and altering open water and bank habitat preferences, electric fishing after onset of dark could be worth trying.

Drift nets

Drift nets exposed in the current and few hundred meters downstream of the release sites detected peaks of drifting shad larvae during the night. A first batch of about 580,000 larvae had been released until 2:30 when the drift-nets (n = 4) were already installed. The largest amount (1055) of larvae was detected the first hour after release. Subsequent periods yielded only some single larvae (three hours after release 17, seven hours after release 11 larvae, respectively) despite approximately 90,000 larvae kept and fed in round channel tanks were released at 6:00 a clock in the morning. During daylight and for a first sample at the onset of dusk the evening after release no further shad larvae were detected. The proportion of the shad larvae relative to cyprinids was with 17.6% quite low and drift peaks were parallel to that of cyprinid larvae. No differences with regard to catching efficiency was detected between the several drift nets, indicating that shad larvae drift occurs dispersed across the entire width of the channel.

Drift nets situated in a larger distance of 3 to 12 km downstream of the release site did not detect drifting shad larvae neither in experiments carried out in the Erfeldener Altrhein nor in the River Sieg, despite shad larvae should have passed this position when moving with the current. Although drift-net studies turned out to provide reliable and quantitative data, the disadvantage is the high maintenance effort due to clogging of the nets. On these grounds it would be desirable to empty the nets every one to two hours, which would however require increased man-power.

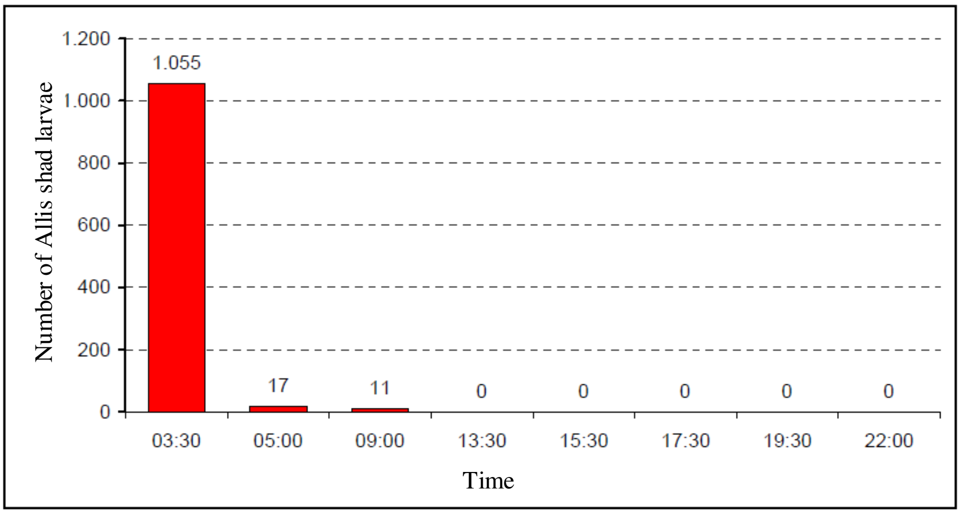

Fig. 10: Number of Allis shad larvae detected in the drift in the period following stocking during the 2009 drifting experiments at the river Sieg. Stocking time of the first batch (580,000) was 2:30. An additional batch of larvae kept and fed in round channel tanks was released at 6:00 o clock

Observations from boats drifting with the current

Pursuing shad larvae from a boat drifting with the current is enhanced when using spotlights in which beams larvae can be observed well. Doing so it was possible to trace shad larvae, which swam normally immediately below the surface while foraging, up to three kilometers from the site they were released. The size of schools, however decreased with increasing distance to the stocking site and no shad larvae could be seen three kilometers downstream.

Observations on swimming and drifting larvae were already proofed to be suitable to provide valuable information on the post-stocking behavior of North Sea houting (Borcherding et al 2004) and could be easily realized unless the water is not too turbid or illumination is impaired. However the outcome is difficult to quantify. Nevertheless, the observations support the results of the drift-net studies and indicate that shad larvae leave the drift and niche in river habitats with increasing distance to the stocking site.

Diving observations

Diving observations were conducted parallel to the release of larvae in the connected gravel-pits with the assistance of professionally equipped divers. Obtaining quantitative data in such habitats is difficult due their large open water area and their high depth, and with regard to tiny size of the larvae. Unless the turbidity is not increased larvae could be observed for the immediate period following releasing, however due their nearly translucent character they could not be traced over a longer period. The observations accordingly indicated, that the larvae actively orientate away from the surface layers and away from the bank into the pelagic area. They could be traced until a depth of approximately 1.5 meters before getting invisible to the diver. These observations are identical to the observations made with shad in round channel tanks during daylight and observations made in mesocosms.

Stow-net fisheries

These methods is frequently used by professional fishermen targeting on silver eel in the German and Dutch section of the Rhine and other large North Sea tributaries. Furthermore stow-nets were already proven to be able to detect other species, including juveniles of potamodromous and diadromous species like salmon and houting and to provide sound data on seaward run peaks. Actually it was a professional fisherman who proofed the first juvenile Allis shad from the stocking measures of the LIFE project migrating downstream to the delta in autumn of 2010 by means of an anchored stow-net. Between the beginning of September and the end of October a total of 30 juvenile Allis shads (a sub-sample of 11 shads were proven to origin from the stocking after the OTC marks in their otoliths) was caught in total, and these attained a mean total length of 124 cm. Despite the stow-net due to its marginal width (10 meters) probably detected only a small fraction of the Allis shad passing the location (width of the Rhine ~ 600 meters in respective period) it is impossible to calculate a reliable projection of the actual number so far. However, these findings demonstrate that the shads apparently survive and grow well and moreover perform migratory patterns as their ancestors. Despite the juveniles on their sea run were recorded over an extended period no obvious relationship to nor river discharge, neither to water temperature could be identified.

Apparently stow-net fisheries are well suited to detect juvenile shads (and juveniles of other species) on their downstream migration. Due to the high effort of maintenance stow-net fisheries most probably can only be conducted and regularly controlled by means of (semi-) professional fishermen. It is desirable to assess the proportion of fish detected to the actual total amount passing the location where the stow-nets are situated undetected, e.g. by means of mark and recapture assessments.

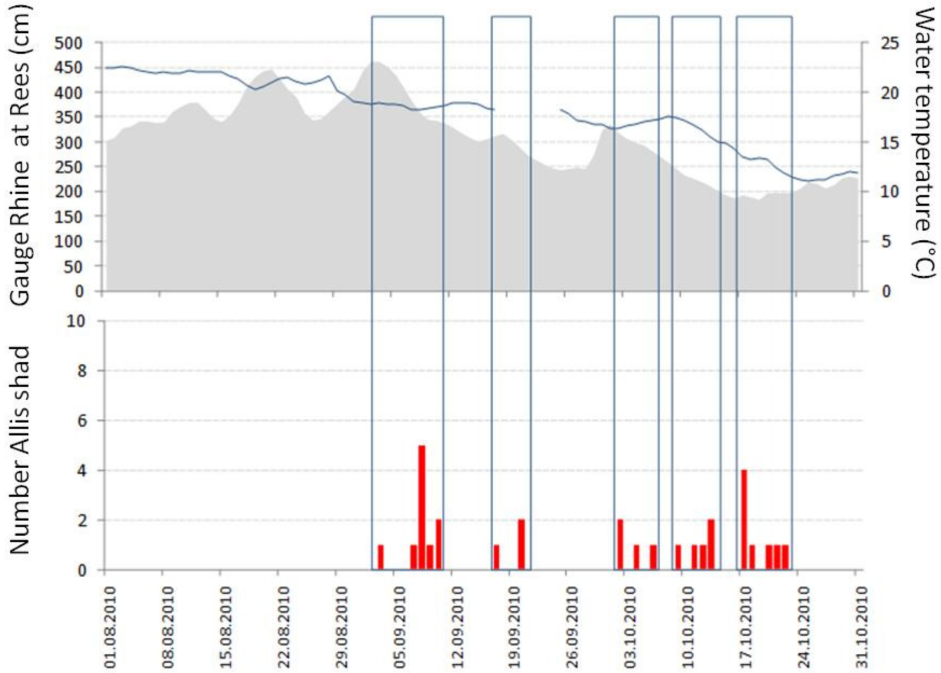

Fig. 11: Number of juvenile Allis shad larvae detected by means of an anchored stow-net on the lower Rhine in the autumn of 2010. No apparent relationship to discharge or temperature was identifiable for migration patterns

Seine fishing

A survey with large seine nets in the Delta Rhine area was conducted with the help of professional fisherman disposing on the required equipment, vessel and skilled personal. Unfortunately this investigation could only be realised at the beginning of December 2010 after the temperatures had decreased to a degree, that fishing became nearly impossible. No Allis shad could be recorded between the 7^{th} and 16^{th} December (afterwards the investigation was ceased because it does not seem reasonable to proceed and it became increasingly hazardous for the fishing team), which could be most probably explained with the extremely low temperatures and the emigration of the shads to the North Sea. However the catch of more 22 juvenile and adults houting in this study and regular records of Twaite shad in the Delta area by means of seining, indicate, that his method is theoretically well suited to sample shads in the large Delta branches. However this method implies high costs with regard the equipment and personal.

Conclusions on post stocking habitat utilization and survival

The studies carried out so far indicate that shad larvae drift downstream during night-time and leave the immediate area where they were released. This conclusion can be drawn after a) the missing records of shad larvae in the vicinity of the release sites the days following stocking, b) records of drifting larvae close to the stocking site in the night and early morning hours and the lack of such observations for the day-time, c) tracking of larvae from a boat drifting with current and d) no records of larvae by means of drift-nets with increasing distance to the release site. The latter observation fits well with the visual observation that the drifting larvae's schoal size decreases continuously with increasing distance to the stocking site and that no drifting larvae could be pursued after 3 km drifting. In this light it is not confusingly that the first juvenile shads on the lower Rhine, hundreds of kilometers downstream of the release sites, were recorded months later and provides indications that the shad stayed the period in between close to the release sites or at least in the Rhine before starting their seaward migration.

Only assessments on the survival for the period immediately after releasing could be obtained.