RUSSIAN ACADEMY OF SCIENCES
BIOLOGICAL SCIENCES
A.N. SEVERTSOV INSTITUTE OF ECOLOGY AND EVOLUTION
(IPEE RAS)

MINISTRY OF NATURAL RESOURCES
OF THE KRASNODAR TERRITORY
CENTRE OF THE STURGEON CONSERVATION
"KUBANBIORESURSY"

REPORT ON THE INTERNATIONAL WORKSHOP

BIOLOGICAL AND HYDRAULIC BASIS OF FISH FREE PASSAGE IN REGULATED RIVERS

2013 September 16-21
Moscow – Krasnodar
Russia

Content

Workshop description

During the Workshop, experts and specialists on fish passage and protection from Russia (Inst. of Ecology & Evolution, Rus.Ac.Sci.; Moscow State University, Hydroproject, "Kubanbioresursy"; Inst. of Biology of Inland Waters, Rus.Ac.Sci.; Fed.St.Un.Ent. Caspian Fisheries Res. Inst.) and European research and consulting institutions from Austria, Germany, The Netherlands, and FAO will exchange knowledge and experience. Key topics and latest achievements in the fields of biology and hydraulics underlying development and design of fish passes will be discussed. Approaches to development of fish passes for different fish species under progressing deterioration of riverine conditions will be considered. Most of the large rivers of Europe and European Russia are regulated. This factor together with shipping, anthropogenic pollution, significant changes of the water level negatively influenced populations of commercial fish, sturgeons and salmonids in particular. These anadromous fishes have to migrate upstream to the spawning grounds located at many hundreds of kilometers.

Development of methods and constructions ensuring free passage of migrating spawners through dams and methods preventing mass mortality of down-stream migrants are major tasks among measures of conservation and restoration of few existing populations. Efficiency of these measures depends on coordinated efforts of biologists, who study behavior of migrants, and specialists in hydraulics, who provide optimal parameters of water flow facilitating fish migrations, as well as on efforts of specialists in fisheries, management and protection of fish resources.

1st day, 16.09.2013

Welcome

Prof. D.S Pavlov welcomed the workshop participants, and thanked especially Herman Wanningen and Dr. Andreas Zitek for initiating the workshop. He pointed out, that this was the first visit of a European expert group (delegation) on fish passage to Russia. He also thanked the other participants for travelling to Moscow from different parts of the country for participating and contributing to the workshop.

It was also reported, that the first fish pass in Russia has been built in 1876, and that in further developments the laboratory of fish behavior of the Rus.Ac.Sci. contributed most to the development of the parameters for the construction of fish passes in the past.

In 1967 the first meeting of Russian experts on fish passage issues took place in Moscow, followed by a second meeting in 1978, where also proceedings were published.

In the recent past, the research on fish migrations was practically stopped, and the protection of inland fisheries from poaching was very poor. This led to a significant decrease of sturgeon stocks in whole Russia.

Pavlov D.S. «Biological basis of development and application of fish pass facilities: rheoreaction, migration, and management of fish behaviour»

In his presentation, **Mr. D.S. Pavlov** reported on the **«Biological basis of development and application of fish pass facilities: rheoreaction, migration, and management of fish behaviour»**. He described the natural migrations of fish in river systems that can be also described as "migratory rings". These migrations of different fish species in up- and downstream direction can take place over different spatial and temporal scales, including long distance migrations between marine and freshwater habitats. Different fish species hereby might show very different migration (life) histories. The different migration patterns evolutionarily developed as a central basis for successful reproduction and maintenance of sustainable populations. In regulated rivers these patterns are negatively affected, e.g. by artificial connectivity interruptions in rivers like dams and weirs, which might lead to sever impacts on fish populations.

Then he focused on the biological basis for constructing efficient fish passes, especially with regard to attraction flow velocities (threshold velocities for orientation and attraction), velocities that can be maintained for a specific time and maximum velocities (critical velocities) that can be overcome by different fish species. Hereby he pointed out that different environmental parameters like illumination but also temperature can affect the swimming capabilities (the critical velocities) of fish. Threshold velocities and critical velocities were shown to increase with fish length. An important point was, that pelagic fish typically have a low threshold velocity and high critical velocity, and that this is different for bottom oriented fish like sturgeon, with higher threshold velocity and lower critical flow velocity. This knowledge is very important for the design of sufficient attraction and maximum velocities at fish pass entrances.

Then he presented studies on rheoreaction of fish to different flow velocity conditions, which also represents an important contribution to the design of fish passes, especially for directing fish to and through a fish pass.

Fish passage can be also affected by turbulence in nearby channels, and velocities for attraction can be defined in a relatively narrow range. It was also presented, that different species were documented during different times of the day at the fish passage at the Krasnodarsky dam.

Another important point, that was mentioned, was the horizontal distribution of fish during their spawning migrations in rivers. This is important for defining the location of a fish pass entrance with regard to the bathymetry and the migration routes of fish below a dam. Examples of migration routes of *A. stellatus* below the Federovskaya dam at Kuban river were presented to highlight this issue. Similar data were presented for *A. güldenstaedtii* at the Volgograd hydropower station (Volga river). The principle of different approach zones for different fish species was highlighted at the example of the Kochetovskaya hydraulic project with regard to the situation of the fish lock entrance. Fish guidance was also planned to be achieved by an electrical fence. Different generalized schemes for hydraulic attraction of fish were presented, based on threshold velocities, critical velocities and velocities used for attraction. It seemed to be important, that fish were able to recognize the relative difference between the attraction flow and the coming flow from lateral spill. This may lead to situations, where the critical flow velocities of fish are exceeded by the spill, and the attraction flow is below the velocity of the spill. In other cases the flow velocity of the attraction flow might be higher than that of spill.
Then flow velocities recommended for the attraction flow were presented (for *A. güldenstaedtii, A. stellatus* and *Huso huso*=0.7-09. m/s; Salmo salar=0.9-1.2 m/s; Alosa sp.=0.7-1 m/s; potamodromous species like *A. brama, St. luciperca, V. vimba* etc.=0.7-1 m/s). Finally he presented the principle of a mobile, floating fish pass, with different inclinations of the structure for guiding fish from the river bottom into the pass. The optimum flow velocity for attraction was described as being 0.8 times the critical velocity.

Selected key information:

- **Understanding and controlling rheoreaction of fish is of central importance for the design of fish passes, especially for the design of adequate attraction at the fish pass entrance.**
- **It is necessary to meet the hydraulic requirements for fish to be attracted to the fish entrance, including turbulence, flow velocity etc.**
- **Flow velocities for attraction flow for *A. güldenstaedtii, A. stellatus* and *Huso huso*=0.7-09. m/s; Salmo salar=0.9-1.2 m/s; Alosa sp.=0.7-1 m/s; potamodromous species like *A. brama, St. luciperca, V. vimba* etc.=0.7-1 m/s**
- **Sturgeons are bottom oriented tactile fish, with high threshold velocities, and relatively low critical velocities, which makes the range of adequate flow velocities for attraction narrower than for e.g. pelagic fish.**
- **Sturgeons are nocturnal migrants and migrate near the bottom layer of the flow; this means that probably this bottom layer of the flow is most relevant for their attraction.**
- **Most individuals of *A. güldenstaedtii* and *A. stellatus* were found to migrate at the deeper sections of the river near the lateral shorelines at the left and right side of the river; it seems that they orient towards the shoreline, and then choose a deeper part next to the obliquely inclined lateral sections of the river bed for their migration; the inclined lateral river bottom and the middle of the river were less used as migration routes.**

- **Sturgeons seem to approach the weirs according to the local bottom relief preferring deeper sections; this opens ways to guide sturgeons also by manipulating the bottom topography of the river bed.**
- **Sturgeons might be able to use fish ladders, but it might be better to construct fish locks and lifts at higher dams.**

Wanningen H. «From sea to source: an overview of principles and practice for the restoration of fish migration highways»

H. Wanningen from Wanningen Water Consult gave a presentation on the book **«From sea to source: an overview of principles and practice for the restoration of fish migration highways»**. He started pointing out the problems that exist with regard to fish migration especially in the North Sea and the Netherlands, and mentioned the different legislative regulations that exist in Europe linked to the re-establishment of connectivity n rivers (EU-Water Framework Directive, Eel regulation, Natura2000). He pointed out the preference for nature-like solutions in the Netherlands, and that only in cases where this type of fish pass cannot be established, technical solutions are used. He also pointed out the educational work that is performed to inform already children about the importance of free fish passage. Then he went in detail into the content of the "From Sea to Source" book that is freely available from ***www.fromseatosource.com***. Then he pointed out, that in 2015 it is planned to have fish passage conference organized in Europe, based on the principles of the American fish pass conference. He finally reported on his aims, of linking all initiatives dealing with fish migration issues worldwide.

Selected key information:

- **Dams and weirs should be remove, when not in use any more.**
- **Education and involvement of the public is seen as cetral to draw more and more attention to the migration needs of fish and the necessity of river connectivity.**
- **A fish pass conference is planned for 2015 in Europe, based on the principles of the American fish pass conference.**

Mikheev V.N. «Behaviour of migrating fish in regulated rivers: modifications at different spatio-temporal scales»

Mikheev V.N. in his presentation reported on the **«Behaviour of migrating fish in regulated rivers: modifications at different spatio-temporal scales».** He pointed out that behavior of fish is the key intermediate variable between environmental changes and fish wellbeing, either in natural or regulated rivers. Habitat heterogeneity and ontogenetic changes during the development of fish are the main triggers affecting fish migrations. Major environmental and biotic factors affecting fish behavior are topography, flow regime, structure of habitats, diversity and abundance of animals and plants, food availability and risk of parasitism. Typical behaviors of fish are migration (including locomotion and orientation), foraging, antipredatory defense and parasite avoidance , mainly with regard to reproduction, foraging, defense or social interaction. The potential effect of lack of prey on fish migrations was highlighted at the example of 0+ pikeperch from a reservoir, leading to a massive fish kill due to turbine passage at the Tsimlyanskoe Reservoir. Similar data on downstream migration of 0+ pikeperch caused by

shortage of prey was presented from Rositsa River (Danube, Bulgaria). The higher the availability of prey fish was, the lower was the downstream drift of young pike-perch.
In principle, not only major obstacles (dams, turbines, rapids), which fish have to overcome when migrating to the "points of destination" (spawning and nursery grounds), are important, but also other fish-unfriendly factors in regulated rivers like large 3-dimensional uniform water bodies with no landmarks and shelters, with water food resources being dispersed in the open areas and also an increased high risk of predation and parasitism in shallow-water areas. To study and use fish behaviour as an instrument for management and control in regulated rivers, a multi-scale approach is needed, including different levels of the hierarchy: river basins, rivers and reservoirs, ecological zones within a water body, and hydraulically modified water masses adjacent to water intakes. This principle was highlighted with regard to the guidance of fish during their downstream migration, which could already start far away from a dam by guiding fish by currents and devices to specific areas for safe downstream migration. Fish can be protected from injuries caused by turbine passage by being diverted form turbines already far away or directly in front of the turbine, or by the use of fish friendly turbines. Fish migrations and spatial distribution can be strategically modified in order to prevent fish contacts with unfriendly habitats/zones. Modifications hereby can include abiotic and biotic measures operating at different levels of spatio-temporal hierarchy. Hereby as an example different reaction of different fish species to visual bottom structures was shown. The conclusions were, that deteriorated conditions of regulated rivers (fish unfriendly) can be improved via changes of habitats at different spatial scales by modifying water flow structure and topography close by turbine intakes and other water abstraction sites, by introducing more habitat complexity in the open water habitats and channel-like parts of the river, by meliorating tributaries of the water reservoirs, which can be useful for both adults (spawning grounds) and juveniles (parasite free areas, high habitat complexity). It was also pointed out that conditions for orientation and locomotion for upstream and downstream migrants within very large lake-like water volumes are difficult, and that more studies are needed to develop "marked routes" and "resting areas".

Selected key information:

- **Behavior of fish is influence by a variety of factors, like food availability, presence of predators, seasonality of water temperature, ontogeny, river bed structure and visual clues, and parasites.**
- **Deteriorated conditions of regulated rivers (fish unfriendly) can be improved via changes of habitats at different spatial scales by modifying water flow structure and topography**
- **Conditions for orientation and locomotion for upstream and downstream migrants within very large lake-like water volumes are difficult.**
- **During their downstream migration, fish migration routes can be controlled not only directly in front of a weir or turbine but also already much further upstream.**
- **Knowing the spatial distribution of fish in the river and their reaction to flow velocities and orientation in the water column opens ways to specifically influence downstream migration routes already much more upstream, which might be suited to lead fish to specific areas in the impoundment, where there safe downstream migration can be assured.**

- **More studies are needed to better understand fish migration in large reservoirs.**

Kostin V.V., Pavlov D.S. «Down-stream migration of fish through dams with different types of the water intakes»

Mr. V.V. Kostin reported on **«Downstream migration of fish through dams with different types of the water intakes».** The presentation started with a quantification of downstream migrants per year at different reservoirs, with *Perca fluviatilis, Stizosdedion lucioperca, Osmerus eperlanus eperlanus, Abramis brama, Alburnus. alburnus, Alosa kessleri, Coregonus sardinalla* and *Coregonus peled* being the most abundant species documented during downstream migration at the various reservoirs. He presented the concept of EZWI (Ecological zones of water intakes), that links the presence of fish at water intakes, the ontogenetic shifts in downstream migration routes and that not all fish present in the water intake migrate downstream. The ecological zones in a reservoir to be considered are the littoral zone, the sub-littoral zone, the epipelagic zone, the bathypelagic zone, all in the water column, and the benthal littoral, sub-littoral and bathyal zones. According to the use of these zones during their ontogeny, fish species can be classified in 4 groups – monozonal pelagic, monozonal littoral, monozonal benthal, polyzonal permanent, and polyzonal temporary. Then, a procedure was presented, how to estimate the ecological zones that are affected by a water intake. Hereby, the water intake affects different percentages of each ecological zone can be situated in a way, to not affect sensitive and highly relevant ecological zones in the reservoir. The situation of the EZWI proved to affect species-specific structure of migrants, age and size structure of migrants, seasonal dynamics of fish migration, daily dynamics of fish migration, the fish migration index, but not the total number of migrants. The major factor affecting the total amount of fish migrating downstream from a reservoir was found to be the water exchange rate of the reservoir. The higher the exchange rate was, the higher was the amount of fish migrating downstream.

Selected key information:

- **The ecological zones of an impoundment can be used to construct a EZWI.**
- **knowing the species existing upstream of a dam, one can select optimum sites war for water intakes and develop optimized seasonal water intake schemes based on the ontogenetic needs with regard to habitat use and migratory routes of fish during their life cycle.**

Mochek A.D., Borisenko E.S. «Hydroacoustic methods of studying of fish distribution in river systems»

Mr. A.D Mochek gave a presentation about **«Hydroacoustic methods of studying of fish distribution in river systems».** He started with a description of the complex migration patterns fish are performing between different habitats in rivers (daily and seasonal). He the presented hydroacoustic devices used for studying fish migrations below barriers, e.g. hydroacoustic flouting devices arranged in a certain way below weirs. He also presented a study, where the efficiency of a sonar system was compared to a trap system to assess downstream migration of juvenile sockeye salmon. He also showed a case study, where a Didson was used to assess the number of migrating anadromous steelhead (*Parasalmo mykiss*).

Selected key information:

- **Hydroacoustic devices are well suited to observe fish behavior below dams, and can be arranged to cover large river widths using floating devices.**
- **Different designs of hydrosonar systems were presented (Askar, Pankor, mulitbeam scanner Netkor)**

Gerasimov Yu. V. «Fish passage or fish protection? Current data on fish passing through the dams of three Volga River reservoirs»

Mr. Yu. V. Gerasimov gave a presentation **entitled «Fish passage or fish protection? Current data on fish passing through the dams of three Volga River reservoirs»**. He gave an overview about the methods, how to assess the conditions in large reservoirs, e.g. flow velocity patterns and directions of flow in different vertical depth layers. These directions of flow also could be influenced by wind in very large reservoirs. The he reported on the spatial distribution of the fish, especially of larvae, in different reservoirs, and the downstream migrations during several years. This was related to data gathered from total ichthyological biomass in the reservoir.

The he reported also on the fish densities in the tailwater of the dam in relation to the operation of the hydropower dam. Fish increased significantly in dependence of the operation of the hydropower turbine. But it was stated that it were fish that came from downstream and wanted to go upstream. Some pictures of injured fish were shown, with the injuries most probably stemming from gill net fishing.

The following conclusions were drawn:

A decrease in fish abundance, along with the drastic changes in species composition and spatial structure of pelagic aggregations of fish in the Rybinsk and Cheboksary reservoirs have altered both the qualitative and quantitative characteristics of fish downstream migration through the hydrostation dams.

- An overall decrease in fish stocks observed in recent years leads to under-utilization of food and other resources, thus reducing the rate of externally induced migrations of juvenile and adult fish in both the reservoirs studied.
- The results of the research prove the environmental capacity associated with the level of resource limitation in the reservoir to determine the presence and intensity of the downstream migration.
- Therefore, the “surplus” fish who cannot find the required environmental conditions in the reservoir (or at their native river stretches) have to migrate downstream and leave the reservoir. To block this movement mechanically is to doom these fish (along with their competitors) to resource constraint existence. The artificial expansion of environmental capacity leads to a subsequent resource increase and, as a result, intensifies the downward migration again.
- The free and nontraumatic passage of fish and other organisms through the flow tract of the hydraulic turbines would correspond to the ecological requirements of preservation and reproduction of aquatic bioresources, as the downstream migration of fish through the hydrostation dams represents a natural mechanism of population survival and dispersal.
- The current requirements of the Water Code by no means could solve the problem of conservation of hydrobiont populations, but nonetheless they are the SOLE permissive

rule available now to regulate the impact of hydrostation dams and other water intake structures on the aquatic bioresources.

Selected key information:

- **In large reservoirs it is important to study the seasonal habitat use of different age classes of fish in relation to flow velocities and temperatures in different vertical water layers.**
- **Wind can induce significant flows influencing the dispersal of larvae.**
- **Fish communities in large reservoirs might undergo a succession, where species composition and abundances might change significantly.**
- **In the beginning reservoirs might produce a high a amount of fish and biomass, with significantly decreasing productivity and habitat quality during their aging.**
- **Resource limitation e.g. food, leads to increased downstream migrations from reservoirs.**
- **Safe downstream migration of fish through turbines should be achieved, as downstream dispersal represents a natural phenomenon targeting at maximizing survival and population size.**

2nd day, 17.09.2013

Marmulla G. «European Inland Water Fisheries Advisory Commission (EIFAC, FAO) directions of activities related to migrating fish»

G. Marmulla gave a presentation on **«European Inland Water Fisheries Advisory Commission (EIFAC, FAO) directions of activities related to migrating fish»**. He briefly introduced the FAO, EIFAAC, described the most important aspects of the FAO and EIFAAC work related to fisheries and environmental aspects, described the importance of biodiversity and its main threats in freshwater systems and summarized the FAO's work in the field of fish passage.

With regard to the protection and restoration of fish passage he stated, that any obstruction (weirs, dams etc.) regardless of its height can constitute a barrier to migration, and that always upstream and downstream passage has to be considered. To protect fish migration, the construction of new cross-river obstructions should be avoided and with regard to restoration of fish migration, first the possibility of the decommission (removal) an obstacle should be considered, and as a second option, the construction of a fish passage facility should be considered.

He then reported on the extensive work conducted by FAO with regard to fish passage (guidelines for building fish passes, initatives etc.). But he also stated, that having the knowledge on how to design fish and construct fish passes must not be taken as a justification to construct new dams and weirs. Fish passes always can only support natural fish migrations to a certain degree, and in most cases cannot fully restore natural connectivity of river systems. The closing remarks about the efforts of FAO taken to improve inland fisheries were

- FAO promotes the concept of sustainability in the use of resources
- Sustainable development does not only mean improved fisheries management in *sensu strictu* but also sound ecosystem management
- Management advise on best practices can be based on existing agreed principles, e.g. the CCRF and the Technical Guidelines
- FAO strongly advocates to apply a basin approach
- Avoiding or mitigating negative impacts is very much a question of negotiations and consultations with other stakeholders in the basin
- FAO advocates the rehabilitation of the aquatic environment as a proper tool for management of inland waters for fish and fisheries
- where appropriate, FAO advocates the re-opening of obstructed fish passage for upstream and downstream migration, aiming at improved fish stocks and improved biodiversity
- Develop suitable, adapted technologies (based on information exchange)
- Call for working together: involve biologists, engineers, administrators and managers

Selected key information:

- **FAO strongly advocates to apply a basin approach**
- **FAO promotes the concept of sustainability in the use of resources**
- **FAO and EIFAAC supports many activites related to free fish passage in rivers, e.g. by the production of technical guidance documents, the organization and financial support of courses etc.**

- **Dams should be removed when they are out of use, because connectivity and habitats can be restored.**
- **Biologists, engineers, administrators and managers need to work together to develop sustainable technologies and solutions for a sustainable development and management of freshwater fisheries.**

Skorobogatov M.A. «Development, classification and practical use of fish passes on the rivers of Russia»

Mr. M.A. Skorobogatov reported on the **«Development, classification and practical use of fish passes on the rivers of Russia»**. He presented a classification of different fish pass constructions suitable for fish passing (fish get over the dam on their own when passing from the downstream to upstream using constructed by- canals, steep channel, pool fishways etc.) and fish lifting (where fish are forced from the downstream to upstream by being locked or transported in special containers). Then he described different fish passes existing at Volga, Don, Kuban Tuloma and Peche Rivers, also describing the numbers of selected fish species (sturgeon, herring, salmon) that passed these dams over the last 30-50 years.
It was concluded that sturgeon migration that was documented strongly decreased in the early nineties, with only single sturgeons migrating though fish ladders being documented in 2012.

Selected key information:

- **Documented sturgeon migrations significantly decreasded in the eraly nineties in the Don River and Kuban River.**
- **For designing efficient fish pass entrances, it is important to consider the bathymetry and flow velocity patterns below a weir (which might change seasonally).**
- **It is important to adequately design flow velocities and turbulences in fish chambers used to accumulate fish in fish locks and fish lifts.**

Schollema P. «Close-to-nature and technical fish passes: design and overall assessment»

Mr. P. Schollema gave a presentation on «Close-to-nature and technical fish passes: design and overall assessment». He especially reported on the situation in the Netherlands, including the re-establishment of fish migration form coastal areas into freshwater rivers. He presented different types of solutions, including pumping stations and tidal barriers, dam and weir removal, nature like bypass and technical bypass systems. The situation is especially problematic at coastal areas, where the mixture of salt- and freshwater needs to be considered for re-establishing connectivity for fish at river mouths to the sea. Furthermore, fish have to be lifted at several occasions above dams, as the Netherlands are partly situated below sea water level. Finally monitoring and education of people, especially young people, was seen as important components for an integrated management of fish passage in river systems.

Selected key information:

- **Significant reduction of glass eels entering the Netherlands from the sea.**
- **Rehabilitating fish migrations at coastal areas at tidal barriers and pumping stations is a complex issue, where water movement in two directions has to be considered, as well as the specific mixture zone between fresh- and seawater.**

- **Human induced changes in water temperature might represent a so called "soft barrier" for fish migrations that might cause delays in fish migration (as proved for the downstream migration of eels).**
- **Different types of fish passes (technical and nature-like) exist to improve connectivity at man-made barriers in rivers.**
- **Monitoring and education are seen as key activities for improving knowledge and public awareness.**
-

Zitek A. «EIFAAC guideline for the design of nature-like fish passes»

Mr. A. Zitek gave a presentation divided into two parts. The first part was dealing with the **«EIFAAC guideline for the design of nature-like fish passes».** He coordinates this project within the frame of EIFAAC, with major contributions delivered by Michel Larinier and Rolf Gebler. The targets of the guidelines are the development of a common definition for nature-like fish passes, of a common typology and terminology and of a common design approach. By using a selected set of hydraulic parameters describing each type of facility, guidance for planning and constructing nature-like fish passes according to the specific local needs will be given. He the introduced the definition of nature-like fish passes, that are constructed wholly or mainly from natural materials, are mimicking variable morphological and hydraulic conditions of natural rivers and also provide habitat. A two-part typology was introduced, depending on the location and size of the structure relative to the obstruction and the method of dissipating energy and constraining velocities. With regard to their position in relation to the weir, fish passes could be full width or partial width facilities, or by-passing water courses. With regard to the type of energy dissipation, regular boulder structures, pool type structures and pool/riffle structures were described including the major hydraulic parameters that are needed to be considered for their design.

In general it was stated, that the efficiency of a fish pass basically depends on two factors the entrance efficiency and passage efficiency.

Before describing the selected types of nature like fish passes in more detail it was pointed out, that the parameters that are used for the hydraulic design of these structures stem from empirical data gained during monitoring of fish migrations, stemming mainly from Austria, Germany, France and Russia. However, for sturgeon fish species, information on potential adequate designs are lacking, why this meeting was also conducted to discuss the state of the art of knowledge in Russia.

For the design of a fish pass (maximum flow velocities, maximum turbulence, pools size, slow width, minimum depth etc.) always the maximum size, swimming capacities and behavior of naturally expected indigenous fish species should be considered. Rivers sections are typically inhabited by specific fish communities, but may also be passed by different diadromous fish species. It is important ot consider especially the biggest species, the weakeast swimmer and species with special requirements. E.g. many species bottom oriented in rivers which especially points towards a good bottom connection of all transverse structures that need to be passed by fish during their upstream migration.

Selected key information:

- **A publication on the design of nature-like fish passes will be made available in 2014.**

- **Nature-like fish passes are constructed wholly or mainly from natural materials, are mimicking variable morphological and hydraulic conditions of natural rivers and also provide habitat.**
- **A two part typology was developed, depending on the location and size of the structure relative to the obstruction (full width, particle width, bypassing) and the method of dissipating energy and constraining velocities (dispersed boulders, pool type, pool/riffle type).**
    - **These types can exist in various combinations, considering different discharges of the river and changing up- and downstream water levels.**
- **Biologically the design of the hydraulic parameters in Europe aims at addressing all indigenous species (juvenile to adult) to be expected in the river network and takes into account the weakest swimmer (e.g. for defining maximum flow velocities, max. turbulence etc.), the largest fish (e.g. for defining pool sizes, slot widths, minimum depths) and fish with specific behavior (schooling etc.).**
- **Crucial parameters that are known to influence the efficiency of a fish pass are the right location of the entrance into the fish pass, the flow (amount and velocity) for guiding and attracting fish to the fish pass entrance and the possibility for fish to completely pass the construction without being injured or exhausted.**

Zitek A. «Re-establishing sustainable sturgeon fisheries across Europe»

In the second part of his presentation, Mr. Zitek introduced a currently ongoing pre-study for a potential new FAO program **"Re-establishing sustainable sturgeon fisheries across Europe"**. The project mainly can be seen as gap analysis of current and past sturgeon programs with regard to the question of how sustainable sturgeon fisheries can be re-established in Europe, and what is needed for this effort.

The project aims at identifying major components of the program with a ranking for immediate priority action (with limited funding available) and a road map including habitat availability, river connectivity, water use, decreasing fishing pressure, aquaculture, restocking, public work, etc. It also aims at the identification and involvement of potential key partners/stakeholders to discuss the direction and feasibility, estimating the timeframe needed and the potential costs involved. The major gaps identified so far were,

- Lack of knowledge on design for fish passes for up- and downstream migration of European sturgeons
- Lack of knowledge on diverse life histories
- Judgment of habitat availability in European river network – how much is still available/ needed?
- Political will/involvement of different governments, and future directions?

Finally, the participants of the workshop were addressed and invited to contribute to this study with feedback and the development of the priority list from their point of view.

Selected key information:

- **A gap analysis of current and past sturgeon programs with regard to the question of how sustainable sturgeon fisheries can be re-established in Europe, and what is needed for this effort.**

- **major components of the program with a ranking for immediate priority action (with limited funding available) and a road map will be developed.**
- **potential key partners/stakeholders will be identified and addressed, to discuss the direction and feasibility of a project aiming at the re-establishment of sustainable sturgeon fisheries in Europe.**
- **Gaps identified so far were:**
    - **Lack of knowledge on design for fish passes for up- and downstream migration of European sturgeons**
    - **Lack of knowledge on diverse life histories of different sturgeon species and their consideration in planning strategies.**
    - **Judgment of habitat availability in European river network.**
    - **Political will/involvement of different governments.**

Tchaikovsky, A., Zitek, A. «Advanced analytical methods for caviar provenancing»

In addition, the idea of **developing methods for advanced analytical methods for caviar provenancing** was presented by **Ms. Anastassyia Tchaikovsky**. She pointed out, how improved technologies for determining if caviar stems from wild and illegal catches or aquaculture could support the conservation and rehabilitation of natural sturgeon populations. She presented a pilot study, currently being organized within the frame of her PhD where DNA analysis combined with (natural and non-toxic) Sr isotopes and elemental patterns will be used to differentiate between caviar samples from different species and local origin. She shortly described the major analytical steps involved in the analysis of Sr isotopes by multi- collector inductively coupled plasma mass spectrometry (MC-ICPMS).

Selected key information:

- **A pilot study between the VIRIS laboratory for Analytical Ecogeochemistry at the University of Natural Resources and Life Sciences Vienna, BOKU-UFT, Austria and the University of Padua, Italy will be conducted with regard to caviar authentication by combining the analyses of Sr isotopes, elemental patterns and genetics.**
- **The project aims at the development of methods that could be then applied on an international level to control illegal trade of wrongly labeled sturgeon caviar.**

Ivanov A.V., Filippov G.G. «Biopermeability" of dams – necessity and doubts»

Mr. A.V. Ivanov gave a presentation about **«Biopermeability" of dams – necessity and doubts»** from the viewpoint of the JSC "Institute Hydroproject". In his presentation he was drawing the attention on the different habitats used by fish during their life cycle in the area up- and downstream of a dam. He presented a project, where up- and downstream migration was established by a specific symmetric arrangement of different elements for guiding and blocking fish.

Selected key information:

- **It is important to guide fish in upstream and downstream direction towards the entrance of the fish passage solutions in an adequate manner and/or to block them from turbine passage.**

- **To increase the efficiency of connectivity measures, it is important to consider the availability of habitats needed during the seasonally changing needs of the different fish species.**

Gebler R. «Fishways at large hydro-power plants in Central Europe – current design and operating»

Mr. R. Gebler gave a presentation on **«Fishways at large hydro-power plants in Central Europe – current design and operating».** He presented many examples of different types of fish passes that have been built in Europe at large hydro-power plants (definition of large hydropower plants?). Very commonly used is the vertical slot fish pass. Less common is the use of bypassing water courses, and rare is the use of fish locks or fish lifts.

He then described the general hydraulic functionality of vertical slot fish passes, showing many examples of existing solutions at different sites, mainly in Germany. He then introduced examples of bypassing water courses. The largest bypassing water course that was presented is situated at the hydropower plant in Rheinfelden, River Rhine, and receives a discharge from 10-35 m^3/s representing the largest nature-like bypass channel existing in Europe so far. He also presented monitoring results of fish passage for this nature-like bypass channel compared to monitoring data of other existing fish passes along the river Rhine. Compared to all other fish passes, at the nature-like bypass channel in Rheinfelden, the highest amount of fish and the highest amount of species was documented so far. But it also has to be mentioned, that rheophilic fish like barbel following the main current from the turbines to the weir preferred the passage over a vertical slot fish pass with the entrance directly situated below the weir.

Selected key information:

- **A classification of different types of fishways was presented:**
  - **Rock ramps (typically full width facilities),**
  - **fish ramps (partical width facilities),**
  - **fish pass (a chute separated from the river)**
  - **a fish bypass (a bypassing water course)**
  - **Specific facilities like fish locks, fish lifts and trap & carry**
- **Typical solutions for rehabilitating connectivity for fish at large hydropower plants were presented:**
  - **Vertical slot fish pass**
  - **Nature-like bypass channels**
  - **Fish locks and fish lifts**
- **It is important to consider the ecological and biological needs of the different fish species expected in the river system for the hydraulic design of fish passes.**
- **In large river systems it might be necessary to provide multiple entrances for different types of species at different locations to maximize the benefit for different age classes and species, as was especially shown on the example of Rheinfelden at the river Rhine, were a nature like bypass channel and a vertical slot directly at the weir proved to attract a different set of species and age classes.**

3rd day, 18.09.2013

Chebanov M.S. «The conservation strategy for the sturgeons listed in the Krasnodar Territory Red Data Book in regulated rivers»

The presentation of **Mr. M.S. Chebanov «The conservation strategy for the sturgeons listed in the Krasnodar Territory Red Data Book in regulated rivers»** was quickly introduced by Mr. V. Mikheev. **Mr. M.S. Chebanov** gave his presentation in detail during the final day of the excursion to Krasnodar to the workshop participants that participated the excursion. The presentation started with a statement, that "*after 30 years after critical modification of hydrological regime and only hatchery sturgeon stock enhancement in the Sea of Azov basin it is urgent to develop new strategies for restoration of natural propagation and control reproduction of sturgeon. It is essential because all previous measures on conservation of sturgeon populations and mitigation of effect of water flow regulation have not been efficient.* Furthermore in the beginning of the presentation, the current status of the different sturgeon species in Russia and their current conservation status were described. A major part of the presentation was dedicated to past and current sturgeon migrations and management strategies at the Kuban river. The attention was drawn towards the seasonal dynamics of upstream migration of sturgeons that are mainly influenced by their stage of gonadal maturity. Before the river flow was regulated stellate sturgeon showed considerable diversity in the state of gonads, size and oocyte nucleus polarization. Females caught during the migration period were found to have gonad from III-IV stages to IV complete stage of gonad maturity. In the last 17 years females with gonads even at IV incomplete stage have been absent. Only completely ripe females have been captured in the period of spawning run in river mouth. After 2006 sturgeon breeders have not been practically encountered in the river, so it not possible to provide data on seasonal migration dynamics. The natural migration at the Kuban River was mainly described by data gathered at the fish lift at the Krasnodar dam and the fish lock at the Fedorovskaya Dam. Then the severe loss of spawning grounds due to the loss of connectivity and siltation was described.

Then some considerations were given for the optimum design of attraction flow for sturgeon, and an updated list of measures for sturgeon conservation was presented including fish passes efficiency increasing methods, the elaboration of a new design for the "out-of-the-riverbed" spawning ground with a controlled hydrological regime in order to preserve natural spawning of sturgeons in the Kuban river), melioration in the river mouth, conservation sturgeon culture (hatchery stock enhancement optimization, living gene bank formation) and establishing of landlocked sturgeon population in the upper Kuban river reaches.

Then a set of measures and approaches for improving aquaculture based rehabilitation efforts were presented, including the selection of appropriate spawners by genetic fingerprinting, by keeping up the variability of spawning behavior via the control of the developmental gonadal status e.g. by water temperature in hatcheries and the adequate training of juveniles before releasing them to natural rivers. The implementation of both federal and regional program of sturgeon culture development proved to be a specific feature of the past years in the Russia. The program for sturgeon gene pool conservation has been elaborated in Krasnodar territory. The strategy for conserving sturgeons also involves participation of sturgeon farms of various type of ownership in target federal and regional programs of gene pool conservation, Creation of ichthyo reserves and ichthyo parks, and the development of recreational areas (eco-tourism, agro- (aqua)

tourism). A database system of broodstock certification and registration allows coordination of conservation efforts across different aquaculture farms. New methods, e.g. the determination of sex and gonadal status by ultrasound strongly support these efforts.

Finally, some important research questions that could be targeted within a suggested joint project of Institute of Ecology and Evolution and State Regional Centre "Kubanbioresursy" "Study of pre-spawning and after-spawning behavioral patterns of mature farmed anadromous sturgeons" were presented. The study will use radio-telemetry to track fish migrations, and will allow to determine the distribution and movements patterns of these mature farmed fishes and identify important habitat areas (i.e. spawning). The species studied could be *Acipenser gueldenstaedtii* and *A.stellatus*.

The primary objectives of telemetry studies will be to determine:

(1) movement patterns of males and females near spawning cites and dam,
(2) movement rates,
(3) temperature occupancy, velocity of flow area,
(4) temperature, substrate, depth.
(5) possibility to natural spawning of hatchery produced and rearing only in freshwater breeders.

Selected key information:

- **During last 30 years after critical modification of hydrological regime and only hatchery sturgeon stock enhancement in the Sea of Azov basin it is urgent to develop new strategy for restoration of natural propagation and control reproduction of sturgeon.**
- **five sturgeon species inhabited in the Kuban river**
- **Natural reproduction has not been observed here more than 30 years**
- **After the construction of dams (lower Fedorovskaya and upper Krasnodar) all natural spawning grounds became unavailable for sturgeon breeders.**
- **Due to flow regulation it came to changes in seasonal dynamics of anadromous migration of A. stellatus in different periods of flow regulation in the Kuban River**
- **Ratio of females of A. stellatus with different stages of gonadal maturity in the spawning migration period in the Kuban River mouth significantly changed to 100 % being in stage IV of development – there is no need for these fish to conduct further migrations.**
- **The main factors, that have led to sharp decline in abundance of sturgeons in the Black and Azov seas as well as in the Caspian sea during past 10 years have been poaching and uncontrolled by-catch of immature specimens at commercial fishing.**
- **A set of measures for sturgeon conservation was presented:**
  - **Increasing efficiency of fish passes**
  - **Elaboration of a new design for the "out-of-the-riverbed" spawning ground with a controlled hydrological regime in order to preserve natural spawning of sturgeons in the Kuban river)**
  - **Melioration in the river mouth**
  - **Conservation sturgeon culture:**
    - **Hatchery stock enhancement optimization**

    - **Living gene bank building**
    - **Establishing of landlocked sturgeon population in the upper Kuban river reaches**
- **Application of non-traumatic ultrasound methods of sexing, staging and diagnostics of internal organs and systems**
- **Tagging of released individuals is applied.**
- **Genetic passports with individual sets of alleles and microsatellite loci of nuclear DNA, are allowing optimal selection of breeders for mating and avoid inbreeding and conserve rare alleles.**
- **Training of fish to adopt to natural conditions before releasing them from artificial reproduction is crucial for stocking success.**
- **A strategy for conserving sturgeons also involves participation of sturgeon farms of various type of ownership in target federal and regional programs of gene pool conservation, creation of ichthyo reserves and ichthyo parks, and the development of recreational areas (eco-tourism, agro- (aqua) tourism).**
- **Future telemetry studies on behavior and habitat use of sturgeons below dams and during their migrations need to involve fish from aquaculture (as no natural population is exiting any more) of different maturity, and different training etc.**

Khodorevskaya R.P., Ruban G.I. «Current state of sturgeon populations in the Volga-Caspian Basin»

Mr. Ruban G.I. gave a presentation on the **«Current state of sturgeon populations in the Volga-Caspian Basin»**. He started with a description of the sturgeon catches of Russian fisherman (in the Volga?) since 1900. A severe decline from a maximum of about 32000 tons captured sturgeons to about very low numbers nowadays was reported. Next he showed a map on the upstream boundaries of the spawning ranges of sturgeon species and races in the Volga prior to damming. Then he described the amount of different sturgeon species released between 1950 and 2012. In 2010-2011 mainly the Russian sturgeon was released (22.4 Mio. Individuals). Then he presented the water divider dam at the Volga as major obstacle to fish migration at the Volga river delta. Then it was said, that since 2003 the Russian Federation insists upon cessation of commercial sturgeon fishing in the Caspian Sea. This proposal is based on recent catastrophic state of natural sturgeon populations caused by drastic reduction of recruitment by natural and artificial reproduction as well as by poaching and water pollution.

The following recommendations were given with regard to the flow regulation through the Volgograd dam:

1. the duration of freshet must be increased up to 80-85 days, it will be not less than 60 days;
2. 2water discharge for fisheries needs must be 17000-22000 m3/sec during 30 days;
3. volume of water flow through the dam from April to June must be 120-140 km3, but not less than 90 km3;
4. volume of water flow through the dam from December March must be 50 km3;
5. fluctuations of water level during draught season downstream the dam must be not more than 0,5 m.

It was stated, that the problem of sturgeon conservation is only possible to be solved by concerted efforts of all Caspian states to effectively enforce regulations.

Selected key information:

- **Annual catches of sturgeon by Russian fishermen significantly decreased in the late nineties. (is this only the Caspina sea region??)**
- **Beluga and starlet were the most important commercial species.**
- **Spawning ranges of the different sturgeon species in the Volga river were presented.**
  - **Since 2009 no Beluga larvae was registered below the spawning places below the dam.**
  - **Russian sturgeon decreased 5 times.**
  - **Sterlet sturgeon decreased 9 times.**
- **The amount of different sturgeon species released in the Volga river from 1951-2012 was presented, reaching a maximum between the eighties until the mid-nineties with Beluga sturgeon, Russian sturgeon and stellate sturgeon being stocked in different quantities; since 2006 mainly the Russian sturgeon was stocked in high quantities.**
- **Solving the problem of sturgeon conservation in the Caspian region is only possible by concerted efforts of all Caspian states to effectively enforce regulations.**
  - **E.g. Fyke nets for other species cause bycatch of millions of immature sturgeons from stocking.**
  - **Proportion of female spawners significantly decreased in the past due to selective poaching.**
- **A flow regulation scheme to be applied below the Volgograd dam was developed by the Caspian Research Station, but has not been implemented so far.**

Veselov A.E., Pavlov D.S., Skorobogatov M.A. «Restoration of salmonid populations using artificial spawning redds»

Mr. A.E. Veselov presented work that has been conducted with regard to the **«Restoration of salmonid populations using artificial spawning redds»**.

At the beginning of his presentation, Mr. Veselov stated why there is an interest for artificial incubation of salmonids' eggs in some countries now if this is possible in rivers.

1. artificial fertilization secures 100 percent success.
2. Installation of incubation redds in those rivers and on those rapids that should be colonized with salmon.
3. young salmon are more viable and adapted to the natural conditions and to settle independently on the rapids.
4. The economic issue, i.e. hatcheries need not to be built.

It was found, that salmon populations have been lost from several rivers, and it would not be profitable to build hatcheries at these sites, often very far away from any human infrastructure.

For the development of artificial spawning redds, they started with detailed hydraulic and morphological assessment and description of natural spawning sites of salmon. Also, the dispersal of larvae and the the seasonal distribution of juvenile salmon near the spawning paces were studied. These data were used to determine the most appropriate sites for the implementation of the artificial spawning redds.

From 2003 to 2013 23 types of constructions were developed and tested. Different technologies were described. The final devices got several patents.
Future development efforts on incubation redds are related to the use of the stream underflow and testing on different rivers. One of the areas of development is aimed at creating single constructions that are easy to install on the ground without any special equipment and fixed with their own weight and flat shape. And the second area will be focused on embedding incubators with the help of mechanical devices.
The collaboration between different institutes with regard to the optimization of the hydraulic habitats at restructured sites was pointed out, including hydraulic laboratories with miniaturized test streams.

Selected key information:

- **Artificial incubation redds were seen**
  - **as an important and cheap alternative to support salmon populations in areas far away from human infractructure (where hatchery fish farms are no option)**
  - **favoring the natural development and adaptation of larvae to the specific river system**
- **The proposed design for redds attached above the river sediment is very successful in rivers where the sediment contains a higher proportion of fine sediments.**
- **Habitats after hatching of larvae need to be available for enhancing the success of this specific stocking technology.**

Round table: discussions, concluding talks

The round table discussion allowed clarifying open issues that could not be fully discussed during the meeting so far.
The discussion was about the possibilities to improve the situation for sturgeon in Russian rivers, including an improved management of reservoirs and water flows in rivers. Hereby it was discussed, that water levels in reservoirs could be lowered, and also ecological minimum flows below dams should be defined according the migratory season of fish.
The need for increasing the political interest in issues related to inland fisheries became evident. Currently fisheries are ranked very low in the priority list of economic national activities.
Approaches like the EU-Water Framework Directive that take the whole fish community into account were favored in relation to approaches that only take single species of interest into account. However, it was concluded, that sturgeon conservation and rehabilitation of naturally reproducing sturgeon populations can be taken as a starting point, and that with this approach also the needs for most other species in Russian rivers will be satisfied.
Political will with regard to the improvement of inland fisheries was identified as a major component for future rehabilitation efforts of freshwater fish populations. Control of illegal fishing was seen as a pre-requisite for any rehabilitation strategies for sturgeon populations.
The major discussion points stimulated by Prof. Pavlov were:

1. **Why and what for do we provide fish passage?**
   a. **The answer was, to meet the ecological requirements of fish, that need different types of habitats during their life cycle.**

2. **Are we trying to restore fish stocks or are we trying to simply improve something?**
    a. **A general scheme on 4 principles for protection and rehabilitation of fish stocks was presented:**
        i. **ecological principle which is only applied when the fish populations show signs of impoverishment.**
        ii. **genetical and population principle, when the species is under severe threat – it is important to keep genetic diversity and the meta-population structure.**
        iii. **economic principle, applies to profits can be made by managing specific fish populations**
        iv. **social principle, that applies to the creation and maintenance of jobs and other features of fish stocks, e.g. for recreation etc.**
3. **Should fish passes be built everywhere?**
    a. **First of all an assessment of the ecological carrying capacity above dams has to be made, to judge the potential effects of building a fish pass.**
4. **Downstream migration has to be also considered, although there is still lack of knowledge for structures assisting different age classes of sturgeons migrating downstream.**
    a. **A next meeting should focus on the issue of downstream migration, as this meeting had a focus on upstream migration.**
5. **Poaching needs to be considered in any strategy for rehabilitating sturgeon populations in Russia.**
6. **What could be a future strategy for sturgeons? There has already been a project also involving the world bank in the nineties, with practically no success.**
    a. **Realistic viewpoint is, that sturgeon cannot be restored as they were before**
    b. **Sturgeon inhabited 12 rivers in Russia naturally, only 1 of these rivers maintained a commercial fishery (River Lena), yielding 22-23 tons of Sibirian sturgeon (which is mostly potamodormous).**
    c. **It was mentioned that the international interest with regard to natural populations is falling (only 2 presntations at last conference in Canada, both from Russia); but this might also have to do with the fact, that world-wide only a few natural populations are existing, and the focus has shifted towards aquaculture and artificial stocking.**
    d. **Starting points for rehabilitation could be:**
        i. **protecting the existing population fragments and gene pool existing (especially from poaching).**
        ii. **Increasing the reproduction below weirs by improving habitat conditions and management of dams (water release) there.**
        iii. **Assessment, rehabilitation and management of habitats in sea and rivers (where are still good conditions existing?)**
        iv. **All states concerned e.g. at the Caspian sea need to work together, a commission exists since 1992, and an international program on control and release of juveniles still exists; one task of this commission is e.g. to monitor the reproductive success at the spawning grounds.**

v. **Pollution also represents a problem at some sites (e.g. caused by oil pumping during several times of the year).**
vi. **Only sturgeon and caviar from aquaculture should be consumed, which needs control.**
vii. **The part of the life spent in sea is relatively long for some sturgeon species, being very vulnerable there; therefore the management of sturgeons also needs to include marine fisheries.**
viii. **Taking an optimistic viewpoint, it will be possible to rehabilitate natural sturgeon populations, when ecologists, engineers, managers, politicians etc. work together, also with European experts.**
ix. **It is important to shift fisheries up in the national priority list of the different stakeholders, where the highest priorities are set to energy production, irrigation and agriculture, transport and shipping, recreation and finally fisheries.**
x. **There is a strong need to convince the political sphere that the rehabilitation of sturgeon fisheries represents a valuable goal – as for sturgeons all four priority principles for fish stock protection and rehabilitation (ecological, genetical & population, economical and social).**
xi. **Development of a priority list that is discussed and shared across Europe, which could be different for different countries depending on existing local solutions and problems.**
xii. **Re-establish connectivity at dams**
xiii. **Regulate the development of the construction of new power plants.**
xiv. **The basic problem world wide is: how do people use their resources, which basically represents a social and political problem. This involves information of the public, the local population, managers, politicians and education of the next generation.**

e. **The World Sturgeon Society is a good initiative that needs to be addressed when targeting at sturgeon rehabilitation in Europe.**

7. **How to count migrating fish in turbid rivers? Solutions need to be developed and tested to monitor the efficiency of fish pass solutions.**

Finally, Prof. D.S Pavlov again thanked the workshop participants for their contributions, and thanked especially Herman Wanningen and Dr. Andreas Zitek for initiating the workshop.

Selected key information:

- **Assess and manage existing habitats and population fragments.**
- **Improvement of management of water flows and dams might significantly contribute to habitat enhancement for sturgeon.**
- **Measures taken for sturgeon should also take into consideration the needs of the whole indigenous fish communities inhabiting river systems.**
- **Control of illegal fishing is seen as a pre-requisite for any rehabilitation strategies for sturgeon populations.**

- **Ranking the freshwater fisheries higher in the public and political priority lists of stakeholders is an important step towards new developments in the management of freshwater fish resources in Russia.**
- **Focusing on the sturgeon and caviar as national symbols might support this goal.**
- **Collaboration across borders including marine and freshwater habitats and between different disciplines and stakeholders is needed.**

4th day 19.09.2013

Departure of foreign participants of the workshop and Russians specialists which accompanying them to Krasnodar. Excursion to the Krasnodar hydraulic project (The Kuban River) – visit to the fish lift – invitation by local hosts

The Krasnodarskii Hydraulic project is located on the Kuban River near the city of Krasnodar. The Krasnodarskii Hydraulic project was commissioned in 1975. The structure of Hydraulic project is decompound of soil dam, by-wash, a mechanical fish lift, navigation lock. The calculated throughput by-wash consisting of a four-hole span of 10 m each, with weirs of practical profile with the fish ladder adopted by the project is 1500 m^3/s.

Water discharge of the Krasnodar Reservoir is a four-span concrete construction, which consists of the supply channel, spillways of practical profile, dissipating basin, apron, and discharge canal. The fish lifts of Krasnodarskii Hydraulic project is operated since 1974. It is situated along the axis of the concrete dam between apertures of spillway dam spans and comprises by:

- Fish accumulator tray. It is 71 m length and 10 m wide, with a depth from 2.5 m to 9.8 m. In front of the tray are located support ways walls;
- The spillway of practical profile with stilling basin and dual-gate are setting on the ridge. The gate function is downstream passage of spawner and juveniles from the reservoir to the tailrace of hydrosystem;
- The working chamber are includes cuts out grid and a container behind the stilling basin. A container is made with a slope of output facet 1:3 to the avoid injury of the migratory fish;
- The overpass in the upper reach of Hydraulic project is 58.7 m length. On the overpass there is moving crane and at the end of overpass is release of fish from the container into the reservoir;
- Electric fish screen is installed in the entrance to the dam location of the fish elevator by sluices of Hydraulic project.

15-20 % of the total discharge are released into the attraction channel of the fish pass. At discharges > 700 m^3/s the operation of the fish lift becomes problematic because of the pressure caused by the water masses to the parts of the construction.

The Krasnodar dam creates a water level difference of 28-35 m, and serves the purpose of providing water for irrigation of rice fields. During the visit at the Krasnodar dam at the Kuban river, a full cycle of fish lift operation could be observed. Many fish accumulated in the fish pass, and were forced to move towards the fish lift tank via a moveable screen. When the screen was close to the tank the tank was lifted, and when reaching the working platform, a secondary floor

in the tank was elevated, to study the fish that have been trapped in the fish lift. After observation of the fish, the tank was moved upstream and the fish were set free above the dam in the Krasnodar reservoir. It was explained, that during strong winds and during winter, due to technical reasons, the mechanical fish lift could not be operated. During winter, the fish lift is therefore closed for 2-3 months. Also during hot summers, the transport of fish in the tank towards the upstream section is too long, so fish might get problems with oxygen in the tank, why it was observed that the weakened fish immediately go downstream again after upstream transport.

Selected key information:

- **15-20 % of the discharge is used for attraction flow, there is no hydroenergy production at the Krasndodar dam, which is used for irrigation purposes.**
- **Optimum attraction flow was 1.1 m/s - but the relative difference between the flow velocities caused by the spillway and the attraction flow became important during discharge situations, where the flow velocities at the spillways were above the critical velocity for sturgeons, with lower flow velocities made the entrance easier to fins for sturgeons.**
- **Plans for improving guidance for sturgeons by constructing physical structures below the dam exist, but were not implemented so far.**

5th day 20.09.2013

Excursion to the living gene bank hatchery of M. Chebanov

Different types of sturgeons are reared there (stellate sturgeon, sterlet, Russian sturgeon, Beluga sturgeon, ship sturgeon, Persian, siberian and Kaluga sturgeons). A lot of information on the reproductive cycles of the different species was provided, including a demonstration of the determination of the reproductive state by an ultrasound device. 40 fish farms are participating in the rearing program hodling juveniles until their selection for reproductive purposes based on genetics, and 5 fish farms are forming the living gene bank holding and reproducing adults of the selected species.

Selected key information at sturgeon fish farm:

- **The hatchery visited served as living gene bank for different sturgeon species. In total 5 fish farms are involved as living gene-banks in the Krasnodar region.**
  - **Stellate sturgeon (*A. stellatus*)**
  - **Sterlet (*A. ruthenus*)**
  - **Russian sturgeon (*A. güldenstaedtii*)**
  - **Beluga sturgeon (*Huso huso*)**
  - **Siberian sturgeon (*A. baeri*)**
  - **Ship sturgeon (*A. nudiventris*)**
  - ***Persian sturgeon (A. persicus)***
  - ***Kaluga sturgeon (H. dauricus)***
- **The different species have different developmental cycles, which needs to be considered in fish farms.**

- **The gonadal development can be better controlled in aquaculture**
  - ***Huso huso* - anadromous**
    - **E.g. males of *H. huso* reach maturity in nature at ages between 12-14 years, while they can reach maturity in a hatchery at ages between 6-7 years; males reach maturity from year to year.**
    - ***H. huso* females reach maturity after 20 years in nature, with a gonadal cycle of 3-5 years, where they live in the sea for feeding; they reach maturity after 10 years in hatchery.**
    - **To achieve the best reproductive success, the spawners are moved to semi-natural conditions in hatcheries 1-2 years prior to spawning.**
  - **Sterlet – not anadromous**
    - **90 % of the sterlet reach maturity every year**
  - **Siberian sturgeon (*A. baeri*) – not anadromous**
    - **50 % reach maturity after 1 year and 50 % after 2 years.**
- **Ship sturgeon (*A. nudiventris*) - semianadromous**
  - **Has the highest relative fecundity of all sturgeons species, to compete for increased predation in freshwater**

- **It takes about 50 % of the time to reach maturity in fish farms compared to the natural situation.**
- **Sturgeons must be held in turbid water in fish farms.**
- **Maximum age of *H. huso* is about 100 years in nature (the oldest individual in the hatchery is about 25 years) and 50 years for Russian sturgeon.**
- **Fish spawn in hatcheries 4-5 times.**
- **In Danube sterlet it was documented, that at the age of 15 years partly females become males or hermaphrodite**

After the visit of the living gene bank hatchery, the Fedorovskii hydraulic project (The Kuban River) was visited including a visit to a fish pass and fish protection constructions. The Fedorovskii Hydraulic project was intended for maintenance the levels required water supply to the Kubanskii and the Fedorovskii irrigation systems and was built in 1967. The structure of the dam on the Kuban River include: concrete and earthen dam, navigation lock and fish passage gateway. The retaining facilities are function from the third decade of April to September and it does coincide with the migratory period to the spawning grounds of sturgeon and other species of fish.

In 1982 a fish passage gateway was built out of giant blocks for passing the anadromous species of fish.

The fish pass at the Fedorovskii dam is not operative any more. A first fish pass was constructed at the right side of the dam, but proved to be not functional for several reasons (fish tended to migrate more oriented towards the left bank, vibration of the mechanical devices used for this type of fish lock system; wrong angle in relation to the main flow - >45 °). Then this construction was replaced by a fish lock at the opposite side of the river, and was operated since 1982. Two moveable doors operated in a similar manner as ship locks. The fish pass channel released about 10 % of the total discharge.

Dimensions of the some structural elements of a fish passage gateway as follows:

- The length of the tray - fish accumulator 76.2 m with a width of 9.0 (12??) m and a water depth of 6 m;
- The length of the working chamber 24.5m (it consists of two clinker shutter ichthyology platform);
- The length of the output tray 3.5 m

Selected key information at Fedorovskii dam:

- **The "Soldatov" type of fish way at the right side of the river (a sequence of chambers with moveable division screens, planned by Malevanchik Boris) proved not be efficient for fish passage for different reasons (not at preferred migration route of sturgeons, angle of entrance > 45 °, vibrations of moveable walls)**
- **the fish lock that was added later~~on~~ was more efficient and operated since 1982, but is not operative any more**
- **10 % of the water was discharged through the fish lock.**
- **Again, the ratio between the flow velocities at the distracting discharges beside the fish lock and the fish lock entrance itself roved to be an important criterion for attraction of sturgeons**
- **The idea of a succession of discharges for step by step guidance and attraction to the fish lock was presented – larger discharges act as guidance at larger distances from the dam, with subsequent lowered discharges guiding fish step by step towards the fish pass entrance.**
- **Again it was mentioned, that no solutions for supporting downstream migration of juveniles and adults exist.**
- **The most abundant sturgeon species in Kuban River was *A. stellatus*.**

Also the Tikhovskyi ater divider structure was visited. It represents a structure that has been built to regulate the discharges of the Kuban river and divide it into three different channels for the purpose of irrigation. Nowadays, the dam gates are open and do not represent an obstacle for fish any more. It has 2 fish passes constructed as fish locks ~~lifts~~??.
Finally another sturgeon farm, which was currently partly under construction, was visited.

6th day 21.09.2013

Visit of the University of Krasnodar, and presentation (in more detail) given by Mikhael Chebanov (see the general content in the related section above in this document), final discussions

Selected key information (major issues were already described above):

- **Important points of a general strategy for improving sturgeon populations are:**
  - **Maintaining and re-establishing the genetic diversity in rivers**
    - **Comparison with salmon:**
      - **Salmon exists in many rivers, it is easier to maintain genetic diversity**
      - **Sturgeon only have several spawning rivers, with partition of the spawners in vernal and hiemal spawners.**

        - **Furthemore the water temperature in rivers have changed, why also the developmental gonadal stages of fish might during migration and the migration distances might have changed.**
    - **Improving fish passage in up- and downstream direction**
        - **This also includes guidance of fish already at the river mouths in the sea, where fish are attracted by turbidity in the water, but now due to lower discharges sediment banks block fish from entering the rivers.**
        - **After 10 days below dams without the possibility to spawn, sturgeon start to resorb eggs; this also may happen already in the marine habitats.**
        - **This includes careful consideration of the changed environmental situations in the rivers and the timing of migration (spring, autumn) and potential distances traveled.**
        - **Juvenile sturgeon migrate downstream from end of July to end of September at weights from 5-10 g.**
        - **Attraction and guidance of sturgeons to a fish pass entrance should follow two approaches: guidance by structures and morphology and guidance by flow velocity and discharge situation (**
            - **attraction flow studies taking the existing experiences as starting point should be conducted, taking also account the whole fish community.**
    - **Creation of artificial spawning places**
    - **Gradual rearing of fish in aquacultures towards natural settings before releasing them to rivers.**
        - **Here biochemical genetics has to be applied to discriminate between seasonal races, as molecular genetics only give information at the individual level.**
        - **Variability of juveniles can also be tested by sedatives giving information on their reactions to temperature etc., by melanophore reaction that gives information about the physiological state of the larvae – here standard indices for the behavior of natural fish are existing.**
        - **Sturgeons need about 6-8 hours to adapt to the new environment after stocking, which makes them very vulnerable to predation during this time.**
- **There are still natural populations of sturgeons existing in the Volga river, while the Kuban river would serve as model river for the possibilities for re-introducing sturgeons to habitats from where they have got extinct.**

PICTURES

Fig. 1

Fig. 2 Fedorovskaya Dam

Fig. 3 Fish lift, Krasnodar

Fig. 4 Fisway Soldatova Fedorovskaya

Fig. 6 Krasnodar Dam

Fig. 7 Tikhovsky water divider

Fig. 8, 9 Participants