

Summary Report on the major issues addressed at ISS8 (8th International Symposium on Sturgeons)

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The 8th International Symposium on Sturgeons, Vienna September 10-15th 2017 focused on a wide range of issues with emphasis on status and management of sturgeon populations as well as on aquaculture. About 320 participants from 30 countries attended the meeting. While the subject areas “General Biology” and “Ecology received less attention than in previous Symposia (also with regard to the number of presentations), the main focus was on conservation related topics. This was also stimulated by the focal (regional) themes of the meeting, obtaining substantial inputs from NGOs (e.g. WWF).

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Here, we provide a brief overview on the main subject areas covered by the Conference and highlight some of the pertinent subjects which were addressed in detail. Manuscripts from oral and poster presentations are presently collected and will be submitted to a peer review process. Selected papers will be published in the proceedings of ISS8 as special issue of the Journal of Applied Ichthyology.

Topic	Session Title
Status and Management of Populations	Restoration Ecology
	Habitat Assessment
	Population Assessment
	Ex situ and in situ strategies (juvenile rearing)
	Genetics
General Ecology	Reproductive Physiology
	General Ecology
Aquaculture	Reproduction techniques and rearing
	Fish Diseases
	Nutrition
	Broodstock Management
	General Aquaculture and Caviar processing
Human Impacts	Heritage and Cultural Role of Sturgeons
	Habitat Degradation and adverse Impacts
	Fisheries Assessments & Public dissemination
	Continuum and restoration of migration routes

The Symposium covered four major topics with 16 subtopics addressing a wide variety of issues from basic ecological questions to management related issues. Naturally, a considerable overlap was observed between several main subject areas, especially in the “Broodstock Rearing” and “Nutrition” sessions. This also was indicative for the existence of a variety of unsolved issues in sturgeon biology in general which these subject areas tackled from different perspectives.

While the main topics addressed a variety of issues, it was noticeable that included components on **genetics** were increasingly included in various aspects of the studies presented, indicating clearly that genetic tools gain importance in sturgeon research, being applied in different contexts. Out of six presentations in the first session (contributed by scientists from five different countries) topics covered ranged from the evolution of polyploidy (Vasil'yeva et al., Flajshans), to population genetics (Congiu, Mugue, Fazekas), and ecophenotypic variation (Bani).

The subsequent session on genetics addressed questions on improved methods for the genetic identification of management units (Welsh, Congiu), phylogeny and zoogeography (Mugue), as well as the quantification of genetic diversity both in captive and wild stocks of *H. dauricus* (Zhang).. The overall approach towards conservation of sturgeon biodiversity was challenged in a presentation attempting to outline criteria for prioritization (Cheng).

One major challenge in the field of sturgeon genetics research became clear: Advances could be more rapidly achieved, if greater international collaboration would be more vigorously supported. Scientists working in similar areas could benefit from sharing samples or facilities to improve the overall quality of research results. Students studying genetics could increase their competency by visiting the labs of established researchers. It was decided to address this need for greater collaboration by establishing a cooperative network among sturgeon geneticists worldwide. The World Sturgeon Conservation Society's “*Genetics and Genomics Working Group*” takes over the role to develop this collaborative network.

Under the topic of **General Ecology**, the session “**Reproductive Physiology**” focused on (i) reproductive tools for both field and laboratory applications, (ii) advancements in assignment of sex and stage of maturity, (iii) more precisely identifying the reproductive mechanisms in captive reproduction, and (iv) describing functional aspects of reproductive systems in sturgeons. Webb et al. discussed assignment of sex and stage of maturity of hatchery-origin fish in the Columbia River with the objective of estimating the proportion of the hatchery population that are contributing to natural spawning. Results from their work are important to evaluate the long-term genetic risks associated with programmes on the recovery of wild populations. In captivity studies, Hu et al. evaluated artificial spawning of intersex sterlet sturgeon and evaluated gene expression during sexual differentiation. The authors successfully induced ovulation and spermiation of intersex fish and two self-bred lines were developed for further genetic analysis. Understanding how differential genes are expressed during reproduction can improve our understanding of the mechanisms controlling sexual differentiation. Zhang et al. performed quantitative proteomic analysis of testis and ovary of the Amur sturgeon to identify proteins involved in the reproduction and sex determination. They were successful in identifying some metabolic pathways potentially involved during reproduction that may advance cell development, protect the immune

system and promote protein synthesis. Gilroy and Litvak showed results from work to quantify sperm quality and quantity from hatchery and wild-origin shortnose sturgeon. Their results help improve our understanding of the effects of rearing conditions on spermatozoa kinematics and seminal plasma characteristics. Further, their study provided ideas for additional research that could help optimize conditions for controlled fertilization in aquaculture and describe reproductive behaviour in the wild.

The **General Ecology** session comprised, four contributions that dealt with an applied approach towards ecology. Specifically, the subjects focused on: (i) expert knowledge and beliefs, (ii) overwintering aggregations of shortnose sturgeon, (iii) modeling of downstream migration of juveniles European sturgeon and (iv) development of stress response in the lake sturgeon.

The session “**Status & Management of populations**” received a lot of contributions and continued through most of the conference days and spanned a wide variety of subtopics. The first sub-session on “Restoration Ecology” comprised eight presentations (Sherman Collier, Bronzi *et al.*, Breve *et al.*, Guchmadidze *et al.*, Memis *et al.*, Arndt *et al.*, Friedrich *et al.*, and Gessner *et al.*). providing an initial overview on current and ongoing restoration projects in different watersheds from the US to Eurasia, identifying their different foci. The main topics addressed and highlighted in the subsequent question/discussion periods noted the importance of collaborative and interdisciplinary work needed for (i) conducting successful measures and effective projects; (ii) accepting the necessity to assure upfront the availability of genetically suitable animals for reintroductions; (iii) accepting the significance to prioritize research to gain detailed knowledge on the populations, their life-cycle, and habitat utilization (in order to design appropriate restoration measures and projects); (iv) recognize the absolute necessity to involve the public in planned restoration measures, as well as the need to ensure a quick and well targeted dissemination of the issue through all political and administrative levels,. It should also be understood that sturgeons offer the unique benefit in communicating strategies that are also relevant for conservation of other species, including their specific habitats. Sturgeons exhibit a particular appeal for public attention as “STURGEONS ARE CUTE” (especially the “babies”) which makes them more attractive than most other fish species (an advantage that should be more vigorously utilized for communicating conservation issues), a fact that can be utilized for communication purposes more intensively.

The session entitled “**Habitat Assessment**” included presentations with a focus on (i) dispersal of young-of-the-year (YOY) following release, (ii) the use of telemetry to identify habitat utility and movements within and between habitats, and (iii) combining hydroacoustics and telemetry to estimate abundance and habitat use. Breve *et al.* conducted tracking studies on late juvenile European sturgeon (80cm) to assess their survival and to determine their downstream migration in the Rhine River. Similar to Breve, Acolas *et al.* tracked European sturgeon juveniles that were released in the Gironde-Garonne-Dordogne Basin at different life cycle phases to assess their support of the wild

population. They found that YOY sturgeon leave the freshwater zone of the basin and enter brackish water for feeding at an age between 4 and 10-months. O'Connor *et al.* combined population assessments with telemetry to determine lake sturgeon habitat use in a large study area. Wu *et al.* also used telemetry data and recapture information to study the seaward migration behaviour and distribution of released second generation cultured juvenile Chinese sturgeon. Knowledge on the migration and distribution patterns of the stocked juvenile Chinese sturgeon will help to evaluate the success of conservation aquaculture and help to establish an effective protection strategy for the species in the Yangtze River. Fox *et al.* used a novel approach to infer abundance in habitats by combining acoustic receiver networks and high-resolution side-scan sonar. They used this approach to provide the first direct estimates of the annual spawning run size in the Hudson River which is important for listed species where conventional methods to assess habitat use or abundance gain limited results. The continued use of telemetry to evaluate movements, habitat use, and dispersal would gain benefits from continued collaboration between researchers to align methodologies and, in particular, harmonize data analyses gained through telemetric. Wherever possible, combining multiple methods to provide further confidence in results was also demonstrated during this ISS8 session.

The “**Population Assessment**” session received presentations on (i) estimating abundance of specific life cycle stages, ii) developing population models, and (iii) monitoring demographics of populations, including those that are commercially exploited. Dion and D’Amours estimated in their contribution the abundance of juvenile lake sturgeon before and after a river diversion project where there was a change in prescribed flows. The authors demonstrated that sturgeons were still using available feeding habitats in the Rupert River and juveniles born after the river diversion were represented in the catches. A combination of methods including telemetry, genetics, and population assessment work was conducted to evaluate the status of Sterlet sturgeon in the Danube (Ratschan and Zauner). The authors found a lower population estimate compared to previous estimates but acknowledge that further work is required to adequately characterize the threats and critical habitats for this population. Jaric and Gessner developed a set of age-structured population models to demonstrate the difficulties in managing long-lived species such as Atlantic sturgeon. Results from their work indicated a need for longer time horizons considered for effective management of species like sturgeon, where life history and long lifespans complicate recovery efforts. One example along this line related to attempts for an effective management of the Chinese sturgeon population in the Yangtze River and concluded that as the natural spawning activity of the fish has ceased in recent years that it is on the edge of extinction. Enhanced in-situ conservation measures for the natural population, including fishing ban policy, critical habitat protection and rehabilitation, ecological operation of reservoir, were some of the recommendations needed for recovery. Population assessment of shovelnose sturgeon found that despite commercial harvest, the

demographics of the population remained relatively stable. However, recent data have suggested a decline in physiological condition and further monitoring is necessary to advise management to maintain a sustainable population and to support continued sport and commercial fishing. Finally, Haxton and Friday presented a timely discussion on the importance of the effects that is resulting from ignoring assumptions on population estimates for sturgeons. The inherent nuances associated with sturgeon behaviour can lead to increased error around population estimates and should be accounted for in the design of programs and in the analysis of collected data. These warnings and suggestions aligned with the workshop on stock assessment which focused on the importance of incorporating uncertainty into population assessments.

The joint session between **“Status & Management of populations”** and **“Aquaculture”** focused on Broodstock Management and addressed the importance of live gene banks for ex situ sturgeon conservation. The joint session re-iterated the necessity to use only genetically suitable and adapted animals for reintroductions. While the size and diversity of the captive broodstock population has to be sufficient to achieve the desired restoration effects such broodstocks also must reflect the diversity of natural populations. Furthermore, the need for different systems of holding/ keeping and husbandry within a live gene bank was also highlighted in order to ensure proper care for different species, forms and stages. One obvious shortcoming was strongly emphasized: the short term time horizons of common funding schemes was criticized because they do not at all account for the long-term character of ex situ measures for species of such extended longevity. In conclusion it was urged that building public and political awareness on the necessary long term needs and commitment must be more forcefully addressed globally.

Great attention was paid to the conservation measures required as part of ex-situ strategies, including (i) sturgeon gene conservation in Iran and Hungary (Pourkazemi, Kovacs), (ii) experiments to ensure spontaneous spawning of the sturgeon under controlled conditions (Du), and (iii) assessment of the effectiveness of various markers for conservation and genetic monitoring exemplified in European sturgeon (Roques). The relevance of all the reports considered became obvious and underlines the need for the continuation of the development of these important areas of research

Since the many conference contributions spanned a wide range of topics, several take-home messages can be highlighted. Different approaches should be taken to protect the genetic integrity of sturgeon broodstocks. Genetic integrity includes attention to the ploidy level and genetic diversity (Schreier, vanEennaam, Fiske). To protect a species' ploidy, broodstocks should be screened before spawning to prevent production of 10N individuals. Programmes that release individuals into the wild should avoid producing spontaneous auto-polyploids because they are “evolutionary dead-ends” and progeny may have limited ability to respond to thermal stress. Measures can be taken to only spawn females with high quality eggs, which should reduce the incidence of spontaneous auto-polyploidy in most females. Genetic diversity of broodstocks can be promoted by allowing for natural mate

choice, which may become a viable strategy for captive sturgeon species of smaller body size such as *Acipenser dabryanus*. Natural mate choice allows for sexual selection and may reduce the impact of domestication in a hatchery setting. Developing new genetic markers that are powerful enough to delineate family structure in released progeny of related broodstocks will allow conservation aquaculture programs of critically endangered species to avoid inbreeding. The development of a gene bank for endangered sturgeon species will also protect genetic diversity by providing an additional source of genetic material when wild broodstocks are limited. Future research needs to include studies on the potential benefits and relative performance of spontaneous auto-polyploid sturgeon in culture. Additional experiments should seek to improve natural spawning conditions to increase fertilization rates. International collaborations can increase the size and scope of sturgeon gene banks. Next generation sequencing techniques should be applied to develop SNP markers for broodstock management of other evolutionary tetraploid species.

Furthermore, the joint sessions on broodstock management, the ex-situ and in-situ strategies under Status and Management of populations led also to consideration on “Juvenile rearing & fitness for release”. The presentations and the subsequent questions and discussions with the audience revealed a persisting interest in innovative systems for rearing and release of sturgeon larvae and juveniles (Florian et al.), sex determination of sturgeons in the germline and early development phases (Yarmohammadi et al., Yue et al.) as well as the impact of environmental factors on the development of young sturgeons and the selection for fitness related traits for release into the wild (Shivaramu et al., Kazemi). The latter subject – although highly important - was underrepresented, perhaps due to the fact that a topic-related international workshop had just previously been held in Krasnodar, Russia (May 31st – June 4th 2016) and thus new findings on the subject based on the research initiated in 2016 are not yet available.

The **Aquaculture** related issues were dealt with in the sessions on (i) reproduction techniques and rearing, (ii) fish diseases, (iii) nutrition and (iv) processing and marketing. More specific presentations illustrated the establishment of species in the farming sector in Europe (Williot), the production development in China (Wei *et al.*), and Iran (Abdolhay *et al.*). One main focus was related to biotechnological advances in germ cell handling and processing, as well as production of cell lines and polyploids (Lebeda, Vasilyeva). From a caviar production perspective, the development of clonal female populations received increasing interest. The disease session had surprising few contributions, however, they covered a wide variety of topics.

Despite the importance of disease distribution and its impact both on wild populations and farmed sturgeon, only two papers (from China) presented in ISS8. In both papers some data and analysis were presented on Antivirus related Tim genes in *Acipenser dabryanus* using light and electronic microscopy on the peripheral blood cell. It is highly recommended to

carry out further studies and put a research focus on sturgeon diseases both with a scope on aquaculture development, and the impact of climate change on the ecosystems.

The sessions on “**Nutrition**” centered around the question on how feed can be improved in order to increase wellbeing, growth, as well as ovarian development (Ramezanpour, Kermat-Amirkolaie, Mohseni, Khara, Nagel, Liu, Zelaty, Korentovich, Agh, Houman). The general question on how to adapt formulated sturgeon diets to the diverging requirements of different species and their ontogenetic stages still remains untackled. A field study attempted to determine the nutritional sources using stable isotopes in order to improve our knowledge on the overall feed base optimum in aquaculture (Li).

The “**Processing and Marketing**” session provided insights into the diversity of methods currently used in sturgeon production and market development. The trends were highlighted in more depth in the afternoon during the **Discussion Forum** on this topic, starting with an updated overview presented by Bronzi et al. on the global meat and caviar productions, outlining also the difficulties to obtain reliable data for this industry. The forum was moderated by Peter Hufschmied who led through a series of open questions which resulted in a lively exchange of opinions. The Discussion Forum resulted in an expression of interest by the producers to develop their own association to address the specific and burning issues in a harmonized and united approach while keeping on close cross-link with WSCS. Justin Henry will take the role as contact and coordinator.

The presentations held under the general topic “**Human Impacts**” in the sessions on “**Fisheries Assessment and Management**” as well as “**Public dissemination and capacity building**” started with an outline of the stocking programme for *Acipenser transmontanus* in the Upper Columbia River, British Columbia (Canada) to rehabilitate a non-recruiting population (Crossman et al.). The study spanned a 15 year period and concluded that juvenile survival depended on stocking size. Genetic analysis suggested that survival was driven by maternal groups. In a presentation on commercial harvest of the Saint John River population of *A. oxyrinchus* harvest numbers and population estimates were presented (Ceapa et al.). A project trying to change the attitude of artisans on fish protection and management in the Lower Danube River showed that during the study period, attitudes changed but a heavy reliance on river fish persisted (Jahrl et al.). As a result the government’s sturgeon fishing ban left many fishermen without any means to replace income, which lead to poaching. A regional focus on the protection of sturgeon species in Azerbaijan postulated very few fish remaining in the river and current forecast suggests that five species will be extinct within a five year period. Poaching, as well as dam management and hydro-morphological alterations are considered to pose the major problems. The survey was initially proposed to be a two year project, but revealed the necessity for a long-term commitment (Moore).

Cultural heritage was addressed with case studies from the Austro-Hungarian Danube in comparison with the current public knowledge on sturgeons in the area.

The sessions on **“Habitat Degradation & Adverse Impacts”** as well as **“Continuum and Restoration of migration routes”** documented that sturgeon populations are affected by multiple impacts such as migration barriers, water diversion, navigation, toxic materials in both water and sediments, change of environmental conditions in the sea, poaching, non-native sturgeons escaping from aquaculture facilities, etc.. The studies presented provided detailed insights into behaviour and ecology of sturgeons. Sturgeons are well adapted to natural variation in the environment, e.g. can cope with large natural floods. However, natural reproduction ceased in the Volga River within the last years due to multiple impacts. Examples from the development studies with sturgeon embryos show no acute (lethal) effects but sub-lethal impairments that are simply overlooked or often neglected. Sturgeons certainly can adapt to altered environmental systems as long as key requirements (e.g. available migration routes , sufficient water quality) are guaranteed. This session on **“Continuum and Restoration of Migration Routes”** illustrated the importance of functional mitigation measures at obstacles to allow the completion of the life cycle. The increased susceptibility of sturgeons that attempt passage in blocked river sections was shown to lead to an excessive vulnerability towards poaching (Suciu et al). The necessary linkage of up- and downstream migration for functional and healthy populations, shown in an example from the US (Bruch et al), is only slowly entering the management approaches. Longitudinal and latitudinal connectivity are key issues that -along with habitat functionality -need to be much more addressed more stringently in future conservation programs (Tritthart et al.). An example of the ignorance towards this key issue was given in a case study on the Danube (Badlita et al.). However, some case studies show that in spite of stocking, natural reproducing populations cannot be maintained. In the future it will be essential that aquaculture and conservation objectives should be jointly developed in order to reduce potential conflicts such as non-native escapements into the wild but also implement more vigorously the concept of culture for fitness for survival.