The status of Danube beluga sturgeon (*Huso huso*): Past, present and future

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Status for Donau beluga stør (*Huso huso*): Fortid, nåtid og fremtid

Støren i Donau er i stadig tilbakegang, og langsiktige forandringer i populasjonsstørrelse og struktur av størarter er blitt observert. I dette manuskriptet er beluga stør (*Huso huso*) brukt som en flaggskipsart for en casestudie av stør i Donau. Den rumenske regjeringen brukte i 2006 dokumentasjonen fra disse kritiske forandringene til å tvinge igjennom midlertidige fiskestanse på størarter, samt implementere regionale overvåkingsstrategier. Overvåkingsprogrammet for juvenil stør som ble implementer på grunnlag av dette har samlet ny og vital data på antall fisk samt nedstrøms migrasjonsmønster for juvenil stør i Donau. Suksessfull oppdrett og utsettelse av stør er også trådt i kraft for å bedre fiskebestanden i området. En av de største utfordringene ligger i forebyggingen av illegalt fiske, gitt den gode markedsverdien på stør, og forvaltingsprogrammet utarbeider stadige nye strategier for å håndtere utfordringene. Som et ledd av dette ble Danube Sturgeon Task Force (DSTF) opprettet i 2012 for å ta denne utfordringen i årene som kommer.

Summary

Sturgeons of the Danube River are in decline. Long term changes in both population size and structure of sturgeon species have been observed. Beluga sturgeon (*Huso huso*) as the flagship species of the Danube are used in this manuscript as a case study species. In 2006 the Romanian government used documentation of these critical changes to enforce a fishing moratorium on sturgeon species and

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implement a regional monitoring strategy. The juvenile sturgeon monitoring programme implemented as part of these changes has collected vital new data on the numbers and downstream migration of Danube sturgeon. Juvenile sturgeon have also been successfully produced and released as part of the supportive stocking programme. The greatest challenge lies in the prevention of illegal fishing, given the extreme value of sturgeon. The management programme is constantly evolving to deal with the challenges of conserving Danube sturgeon and in 2012 the Danube Sturgeon Task Force (DSTF) was created to take this challenge forwards.

Introduction

Six species of sturgeon once migrated along the Danube for spawning: The anadromous species beluga; *Huso huso*, Russian sturgeon; *Acipenser gueldenstaedtii*, stellate sturgeon; *A. stellatus*, and the European Atlantic sturgeon; *A sturio* and the river resident ship sturgeon; *A nudiventris* (Bacalbasa- Dobrovici 1997). Only the beluga, Russian, stellate and sterlet; *A. ruthenus* remain and as with sturgeon populations throughout the world, all species are in sharp decline.

The Danube river system has long been subjected to anthropogenic influence from a number of sources altering the entire ecosystem. The fish community, in particular sturgeon species, has been greatly impacted by these changes. Loss of habitat has occurred throughout the system and in particular, historical spawning grounds are no longer accessible due to the construction of the hydropowerdams Iron Gate I & II at river kilometres 942 and 863 in 1970 and 1984 respectively (Hensel & Holcik 1997). These barriers divide the lower and mid Danube halving the historic spawning migrations of sturgeons which were documented extending as far upstream as Vienna (Bacalbasa- Dobrovici 1997).

The lower Danube extends downstream from the Cerna River at river kilometre (rkm) 955 (Hensel and Holcik, 1997), with the Romanian stretch reaching from the Iron Gates II dam at rkm 859 to the Danube delta when the river meets the Black Sea. Many neighbouring countries border along the banks of the Danube (Ukraine, Moldova, Bulgaria and Serbia in the Lower Danube), figure 1. All countries bordering the river downstream of Iron Gate II participate in the sturgeon fishery. The river is, at its widest point, 1 km wide and reaches maximum depths of up to 60 m. At the entrance to the Danube delta the river splits into three main branches forming the delta, figure 1. It also splits and re-joins at several places along its length.

During the 20th Century, world demand for sturgeon meat and caviar has inflated the economic value of sturgeon fishing, with the value of beluga caviar estimated at $1000 per 100 grams (Suciu, 2005). This, when coupled with the development of intense fishing pressure following a lack of fishing controls after the Romanian revolution in 1989 (Kynard et al 2002), has caused the sharp decline in recent documented catches of sturgeon.

In 2006 all sturgeon fishing was banned for ten years by the Romanian

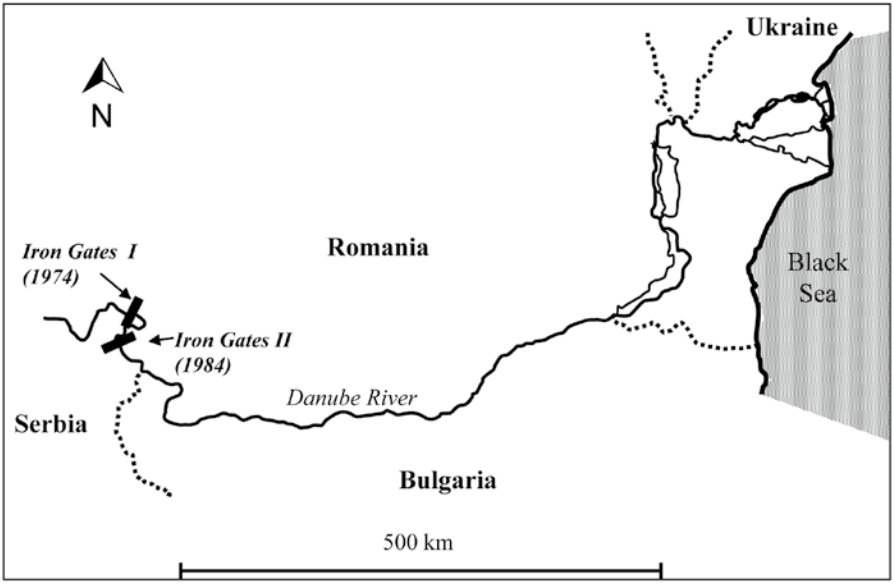

Figure 1. Map of the Danube course through Romania giving the position of the two Iron Gate dams.

government, with the exception of a few individuals to be used for a supportive stocking programme and afterward returned live to the Danube. These strong measures were made possible after documentation of changes in both the size and structure of the sturgeon populations in recent years. This manuscript takes beluga sturgeon, the flagship species of the Danube Commission in Vienna, as a case study and discusses the changes in the population and the management approaches which were developed to aid the recovery of the species.

Past – Historical beluga population

The sturgeon stocks associated with the Danube have, over the centuries, formed the basis of a significant commercial fishery renowned throughout the world. Historical catches of sturgeon are closely related to the development of human settlements and fishing techniques on the Danube. Sturgeon have been harvested on a commercial scale since the 4th and 5th Centuries and from the Middle Ages sophisticated gear was constructed taking advantage of the anadromous movements of these fish. One such method was the construction of fishing weirs; fence traps made of wooden branches, spanning the river and intersected with small gates for river traffic to pass through, figure 2. These would be operated by a team of 100-200 people, catching 1000-2000 sturgeons daily (Bacalbasa-Dobrovici 1997). Such fishing methods resulted in a documented decline of beluga as early as the 16th century and initiated international

Figure 2. Historical method of sturgeon capture on the Danube consisting of fence traps spanning the entire river. These were very efficient capture methods and caught 1000-2000 sturgeon daily at times. Picture taken from Kunike (1979).

disputes between upstream and downstream nations, culminating in the collapse of migratory sturgeon fishing in Austria during the 18th Century (Hensel & Holcik, 1997).

Limited sources of historical data exist for Danube sturgeon populations. However Antipa (1909) made meticulous records of mean weight and sex ratio data. These were compared to data recorded as part of new, more detailed Romanian fishery catch statistics collected since 2003. Only catch statistics from 2003 to 2005 are available because the sturgeon fishing ban was implemented by the Romanian government in 2006.

The beluga sturgeon stock has been relatively variable during the whole period (1920-2006) that records from the Danube have been available, figure 3. A large crash occurred in the early 1940s, coinciding with the Second World War and a reduction in fishing and therefore fisheries records at that time. Stocks have also been in slow decline since the building of Iron Gate dams I and II.

In addition to population size, population structuring of beluga in the Danube has altered during recent history. In the early 20th century (1903-1904) the sex ratio of beluga was strongly skewed towards males during summer and autumn months, gradually increasing towards a 50:50 balance during winter and spring, suggesting earlier arrival of males prior to spawning, figure 4. Fishery statistic

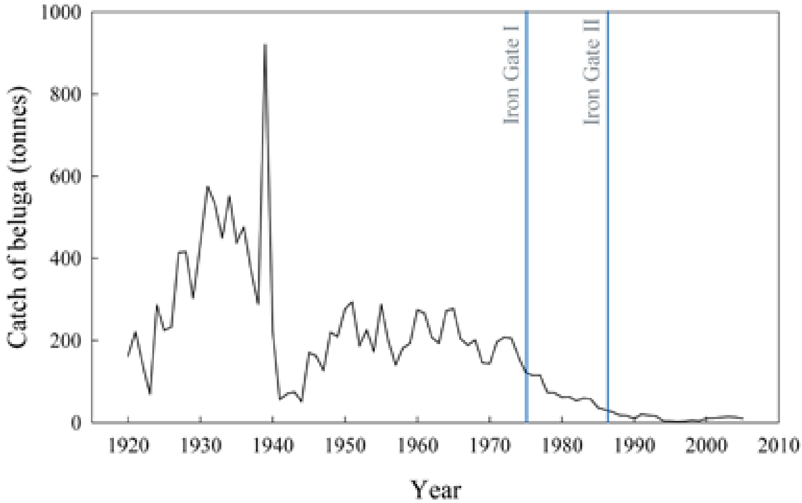

Figure 3. Annual commercial catch of beluga sturgeon (Huso huso) in the lower Danube river / Romania.

data from 2003 to 2005 suggest the same pattern of a bias towards males, evening out as the spawning period approached. However, males were apparently 10 – 20 % more abundant throughout the year than 100 years previously, despite greater variation in the data due to lower sample size. These statistics were used to bring about the 10 year sturgeon moratorium, though later communications with fishermen suggested that these records might be biased, since it was still possible to sell caviar on the internal black market which indicates that the females (particularly large specimens) were under reported in the fishery statistics.

Comparison of current and historical data indicate a significant decrease in mean weight of both male and female beluga between the beginning of the 20th and 21st centuries, figure 5 (t-test; Female $df = 18$, $T = 4.11$, $p < 0.005$; Male $df = 14$, $T = 3.18$, $p < 0.01$). Interrogation of length frequency of returning adult beluga and comparison with length at age taken from Ambroz (1960) demonstrates an apparent lack of first time spawners in the population (first-time spawning traditionally occurred at age 13-15 years in females and younger in males (Otel 2007), particularly affecting females (Figure 6). Lengths of returning beluga during 2003-2005 suggested few first returns of females below age 13, and males below 12 or that the length at age of returning adults had increased.

Present – Current management

A regional monitoring system (RMS) of sturgeon in the Danube was developed by the Black Sea Sturgeon Management Action Group. This was agreed in April 2002 and put into practice in 2003 (Anon.

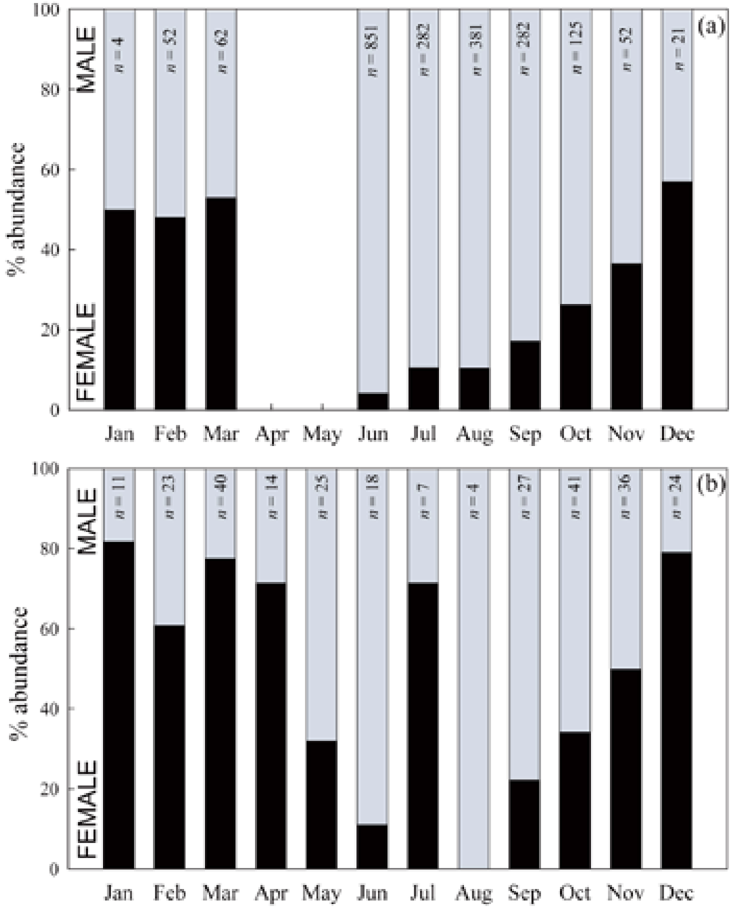

Figure 4. Sex ratio of beluga sturgeon (Huso huso) in the Danube river (a) between 1903 and 1904 and (b) between 2003 and 2005.

2003). The RMS records both adult catch data and also supported a juvenile monitoring programme (first undertaken in 2000).

For the adult monitoring component of the RMS, variables including catch location and date, species, sex, standard length, total weight and gonad weight were reported to the fishery authorities for every legally landed adult sturgeon from 2001 until the sturgeon fishery ban in 2006. Juvenile monitoring is conducted annually during the downstream migration phase of young of the year (YOY). Juveniles are caught with trammel nets to provide catch per unit effort (CPUE) statistics and prior to release all individuals are weighed, measured and tagged with Floyd fingerling tags to enable identification upon subsequent capture.

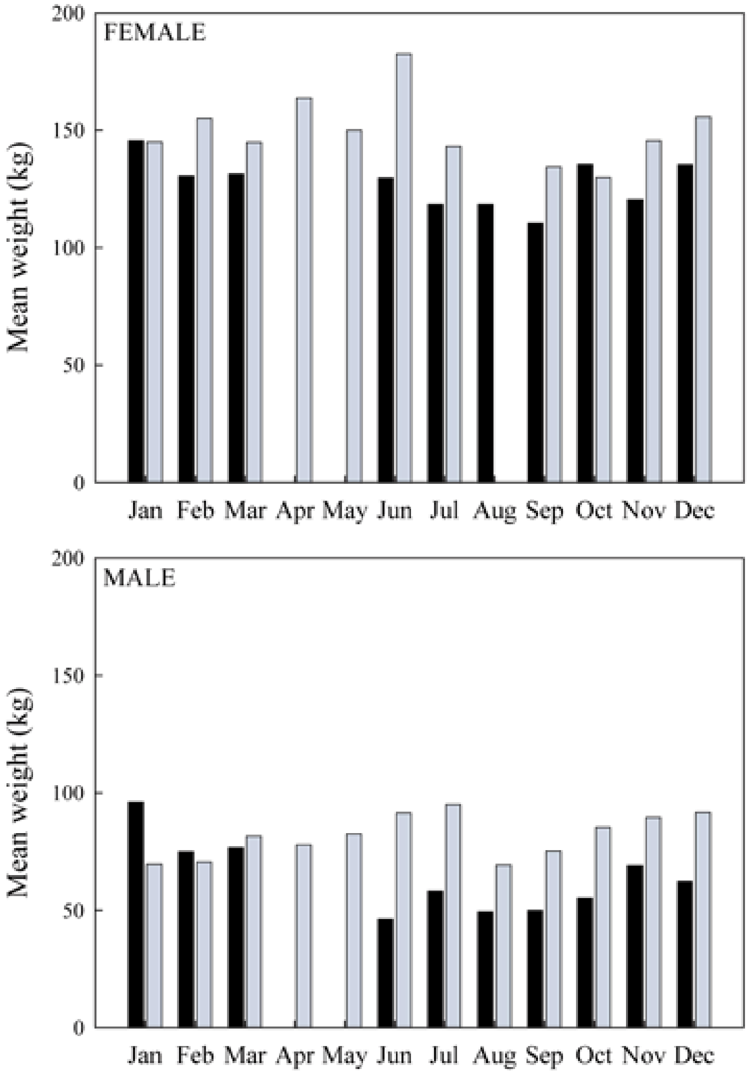

Figure 5. Mean weight of female and male beluga sturgeon in the Danube River in 1903-1904 (grey bar) and 2003-2005 (black bar). Weights differ significantly between time periods (t-test; Female df = 18, T = 4.11, p < 0.005; Male df = 14, T = 3.18, p < 0.01).

The new adult population size and structure data collected as part of the RMS since 2003 led to the development of a more detailed Danube sturgeon management strategy. The goals of this strategy were to prevent total extinction, to preserve the genetic diversity of populations / stocks, to rebuild a natural age

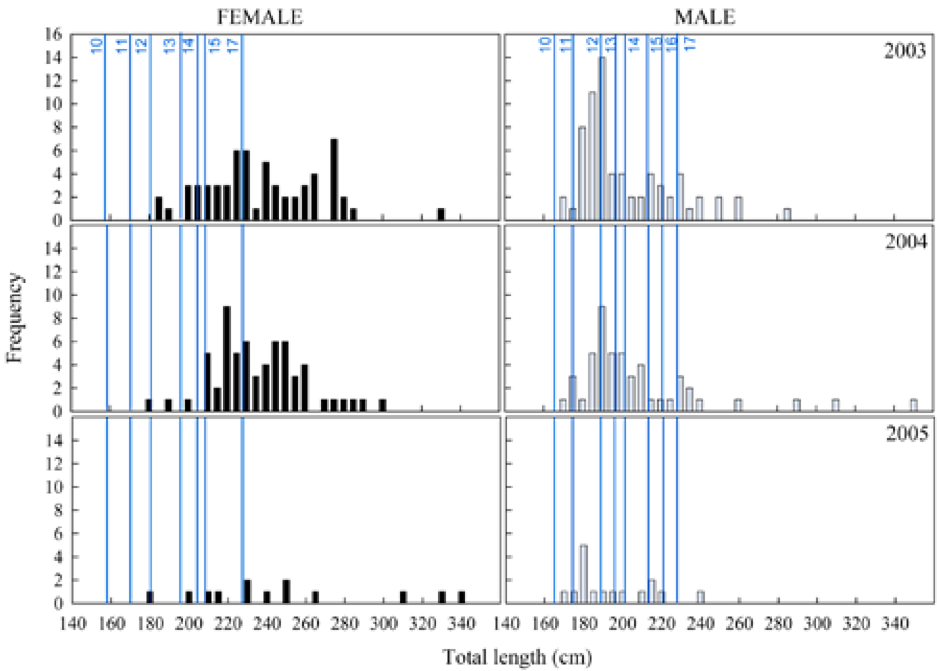

Figure 6. Length frequency distribution (standard length) of migrating beluga sturgeon (Huso huso) in the Danube river during 2003-2005. Dotted bluelines mark length at age taken from Ambroz (1960) and modified to standard length using equations provided in Froese and Pauly (2009).

class structure (in part by implementing a supportive stocking programme), to restore natural recruitment and to develop sturgeon aquaculture to lower market pressure on wild populations. These objectives led to a joint ministerial order in May 2006 designed to support the conservation of wild sturgeon populations and the development of sturgeon aquaculture in Romania. This in turn led to a ten year complete moratorium on the sturgeon fishery, which begun in 2006. While the sturgeon fishery still exists in other Danube bordering countries, all legal fishing of sturgeon in Romanian waters of the Danube halted (the Romanian sturgeon fishery was considered the largest of all Lower Danube border countries (R. Suciu, Pers. Comm.).

The single exception to the moratorium is authorisation to capture a small number of wild brood fish to be used for artificial propagation for both supportive stocking of the Danube and development of sturgeon aquaculture, in accordance with the objectives of the management strategy. A minimum effective number of brood fish are used (based upon having a minimum effective number of 100 brood fish per generation interval

(FAO/UNEP 1981), which in the case of beluga is 7 fish per year). Non-lethal artificial propagation procedures were implemented for the first time in Romania and all brood fish are passive integrated transponder (PIT) tagged and entered onto a database of the National Agency for Fishery and Aquaculture of Romania (NAFA) prior to release back in the Danube. All offspring are grown separately in families to a total length of ≥ 15 cm, tagged with coded wire tags (CWT) and released near to the catch sites of the brood fish. This restocking programme was interrupted in 2010 and 2011 when changing politics in Romania prevented it from happening. However, it is expected to be reactivated by the release of juvenile sturgeons in autumn 2012.

Data on YOY migrations collected as part of the RMS has provided new insights into juvenile beluga downstream migratory behaviour. Juveniles migrate downstream in groups, seemingly actively by the grouping of individuals. Data on downstream migration of beluga juveniles in the Volga River (Khodorevskaya et al 2009) do not refer to such a migratory behaviour. Increased understanding of the juvenile migratory behaviour will assist in designing the most appropriate release strategy for hatchery raised juvenile sturgeon as part of the supportive stocking scheme. It will also help in implementing measures (such as protection of feeding areas in the downstream areas of the Lower Danube) to maximise survival and arrival of juveniles at the Black Sea.

Future

Six years after the implementation of the sturgeon management plan (including the fishing moratorium and the RMS) it is appropriate to begin initial evaluations and modifications. The juvenile aspect, as previously described, consists of three components; monitoring of downstream migrations of wild juveniles, captive rearing of juveniles from wild broodstock for supportive stocking and captive rearing of juveniles from wild broodstock for development of aquaculture. The monitoring has provided vital new data on the behaviour and environmental requirements of YOY sturgeon in the Danube system. It will be continued as it develops into a long term monitoring programme. Juvenile sturgeons have successfully been reared in hatcheries for both release into the wild at two to three months of age and for growing on for aquaculture. 12 500, 15 000, 20 000 and 45 000 juvenile beluga were released in 2006, 2007, 2008 and 2009 respectively as part of the supportive stocking programme. 94% in 2007, 79% in 2008 and 69 % in 2009 (16 of 17, 15 of 19 and respectively 9 of 13 individuals caught) of brood fish were released alive back into the Danube after use for artificial propagation. First returns of hatchery release sturgeon (stellate, as the species with the shortest age at maturity) should occur in 2012, beluga should follow in 2018. This will enable the first evaluation of this part of the management programme. While supportive stocking cannot be seen as a long term solution for conserving Danube sturgeon species (Doukakis et al,

2010) it is considered to provide an important interim measure alongside other conservation actions (DSTF 2012).

The greatest challenge to the Danube sturgeon management plan stems from the closure of the sturgeon fishery. In Romanian waters while all recorded, legal fishing and sale of beluga and other sturgeon species has ceased, there are indications that illegal fishing persists, perhaps even at a high level. The limiting factor in terms of success is in the implementation of the moratorium. To prevent such an economically enticing activity on a river as big and complex as the Danube requires an enormous controlling presence on the river and accordingly immense funds to be able to do so. Romania is currently undergoing rapid change in its status as a new EU member state, but nevertheless such enforcement of the moratorium is not reasonable to expect. Romania is also not alone in this task. The lower Danube passes through four countries before it reaches the Black Sea and a coordinated action is required for conservation measures to succeed.

A further means of improving the success of the fishery management would be to address the importance of the sturgeon fishery from a social perspective. Sturgeon fishing is a historical legacy of the Danube and many villages and towns have developed centred around the best sturgeon fishing locations. Addressing the needs of these communities and assisting with the creation of new economic focuses will enhance the likelihood of success of the management of adult sturgeon catches and thus recovery of the fishery. A recent project, antonym Best Combat, funded by the Norwegian Cooperation Programme for Economic Growth and Sustainable Development in Romania and the Romanian Ministry of the Environment, investigated these social dependences and needs and the potential for the creation of sturgeon ecotourism on the Danube, as well as the current genetic and ecological status of beluga sturgeon in the lower Danube. This multifaceted approach was unique in its approach and increased communication with sturgeon fishermen and improved motivation towards the management measures put in place to restore the fishery.

A combined approach is required not only in a topical sense but also from an international perspective. In January 2012 the Danube Sturgeon Task Force (DSTF) was founded by a group of sturgeon experts, NGO delegates, and representatives of the International Commission for the Protection of Danube River (ICPDR), the Danube Strategy and national governments in the frame of the EU Strategy for the Danube Region, Priority Area 6 (Biodiversity) (http://www.dstf.eu). The DSTF aims to coordinate and foster the conservation of highly endangered native sturgeon species in the Danube River Basin and the Black Sea by promoting the implementation of the Program "STURGEON 2020". The main goal of this program is to secure viable populations of wild sturgeon by reversing the current declining trends for all sturgeon species, increasing the protection status of their habitats and restoring the migratory movements, by year 2020. To achieve this, the DSTF coordinates intensive cooperation between the political, managerial and implementation levels at basin-wide scale. The objectives and actions for the DSTF strategy to implement the Sturgeon 2020 program are based on those of the Danube Sturgeon Action Plan (SAP) which can be grouped into four major categories:

1. basin-wide coordination of sturgeon policy and best-practice management;
2. legislation and enforcement controls for sturgeon fisheries and trade;
3. conservation of sturgeon species and populations, including their genetic integrity;
4. protection, management and restoration of sturgeon habitats, including reopening of migration routes.

Due to the international nature of the Danube River and its sturgeon species it is only by such a cross boarder approach such as the DSTF that a difference can be made to the Danube sturgeon conservation status.

The DSTF will drive different research priorities which, when combined with the policy and enforcement measures, are hoped to turn around the fate of Danube sturgeon. In terms of research it prioritises development of gene banks and a standardisation of breeding and rearing practice for an international supportive stocking programme as a short term conservation goal. This must be implemented alongside long term research objectives including evaluation and development of fish passage at migration blockages along the Danube, identification of key habitats and restoration needs and development of stock assessment systems.

This trend of increased international collaboration with mutual goals for Danube sturgeon is hopefully the turning point for sturgeon conservation on the Danube. After centuries of exploitation the time has now come for the reversal of damages and rebuilding towards a brighter future for Danube sturgeon species.

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References

Ambroz A. I. (1960) Beluga of the Black Sea. *Scientific Annals of the Kishinev University*, tom. LVI, Ichthyology: 77 – 84 (In Russian).

Anonymous (2003) Regional Strategy for the Conservation and Sustainable Management of Sturgeon Populations of the N-W Black Sea and Lower Danube River in accordance with CITES. Agreed document of the Second Regional CITES Meeting on Sturgeon Conservation, Tulcea, 26 November 2003, 7 pp.

Antipa, G. (1909) Ichtyological Fauna of Romania. Inst. De Arte Grafice "Carol Göbl" Bucuresti 264-270 (in Romanian).

Bacalbaşa-Dobrovici, N. (1997) Endangered migratory sturgeons of the lower Danube River and its delta. *Environmental Biology of Fishes* 48:201-207.

Doukakis, P., Babock, E. A., Pikitch, E. K., Sharov, A. R., Biamukhanov, M., Erbulekov, S., Bokova, Y. and Nimatov, A. 2010 Management and recovery options for Ural River beluga sturgeon. *Conservation Biology* 24:769-777.

Danube Sturgeon Task Force (DSTF) 2012 Roof strategy document. www.dstf.eu

FAO / UNEP, 1981. Conservation of the genetic resources of fish: problems and recommendations. Report of the Expert Consultation on the genetic resources of fish. Rome, 9 – 13 June 1980. FAO Fish. Tech. Pap., 217: 43 pp.

Froese, R., and Pauly, D. Editors. (2009). FishBase.World Wide Web electronic publication. www.fishbase.org, version (10/2009).

Hensel, K. and Holcik J. (1997) Past and current status of sturgeons in the upper and middle Danube River. *Enironmental Biology of Fishes* 48: 185-200.

Khodorevskaya R.P, Ruban G.I, Pavlov D.S. 2009. Behaviour, migrations, distribution, and stocks of sturgeons in the Volga – Caspian basin. *Sturgeon Conservation Society: Special Publication No 3*, Neu Wulmsdorf, Germany: 89-112.

Kunike, Adolph (1979) Donau-Ansichten vom Ursprunge bis zum Ausflusse ins Meer. Wien 1824. 2.Teil : von Belgrad bis zur Mündung ins Schwarze Meer nach der Natur aufgenommen von Ludwig Ermini. Abbildung Nr. 247: Der Hausenfang beim Dorfe Tufesti (In German).

Kynard, B., Suciu, R. and Horgan, M. (2002) Migration and habitats of diadromous Danube River sturgeons in Romania 1998-2000 *Journal of Applied Icthyology* 18: 529-535.

Otel, V. 2007. The atlas of the fish species of the Danube Delta Biosphere Reserve. Ed. Centrul de Informare Tehnologica Delta Dunarii, Tulcea (In Romanian).

Suciu, R., Suciu, M. & Paraschiv, M. (2005): Contributions to spawning ecology of beluga sturgeons (*Huso huso*) in the lower Danube River, Romania. *Extended Abstracts of the International Sturgeon Symposium 5*, 309-311.