Management strategies to protect and restore sturgeon biodiversity in Bulgaria

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Abstract Sturgeons are among the most endangered fish species worldwide. Six sturgeon species are native to the Black Sea and the Danube River: beluga (*Huso huso*), Russian sturgeon (*Acipenser guldenstaedti*), stellate sturgeon (*A. stellatus*), sterlet (*A. ruthenus*), ship sturgeon (*A. nudiventris*) and Atlantic sturgeon (*A. sturio*). Nowadays only four reproduce in the Lower Danube River; Atlantic sturgeon is extinct from the region and fishermen occasionally report catching ship sturgeon, but this needs confirmation. This is the result of degradation of the environment over the past 60 years by intense anthropogenic activities coupled with commercial exploitation of the high value sturgeon products, caviar in particular, and considerable poaching and illegal trade in the products. Recent observations in the Lower Danube have indicated that all sturgeon populations are close to extinction. In this paper national and international attempts to protect the sturgeons in Bulgaria are summarized. The system of measures for sustainable management and protection, which have been applied in the last 10 years in Bulgaria and the critical evaluation of their efficiency are outlined.

Introduction

The order Acipenseriformes includes approximately 25 species divided into two families Acipenseridae and Polyodontidae (Birstein 1993). The Danube River and the Black Sea region are inhabited by six sturgeon species: Russian sturgeon (*Acipenser gueldenstaedti* Brandt & Ratzeberg), ship sturgeon (*Acipenser nudiventris* Lovetsky), stellate sturgeon (*Acipenser stellatus* Pallas), sterlet (*Acipenser ruthenus* L.), Atlantic sturgeon (*Acipenser sturio* L.) and beluga (*Huso huso* L.).

Sturgeon species of the Black Sea basin are of high economic importance to the people living along the Danube River and other rivers of the Black Sea Basin. Since the mid-20th century, the annual catches of sturgeons in the Lower Danube River has steadily decreased, signalling the unfavourable status of these populations (Bacalbasa-Dobrovici 1997; Bacalbasa-Dobrovici & Patriche 1999; Reinartz 2002; Paraschiv & Sucio 2006). Nowadays all sturgeon species in Bulgarian waters are present in critically low numbers (Vassilev & Pehlivanov 2003; Bloesch *et al.* 2006), and two, *A. sturio* and *A. nudiventris*, seem to be extinct (Bacalbaşa-Dobrovici & Holčik 2000). The reasons for this situation are: the sturgeon's life history is characterized by a long-live span, late maturity, intermittent spawning frequencies and long migratory movements (Ambroz 1964; Bemis *et al.* 1997). Negative human impacts such as over-fishing, increased fishing pressure (a result of increased number of fishermen and more effective fishery equipment), barriers to migration and water pollution have reduced the number of

sturgeon. For example, the construction of the Iron Gate I dam (1972) and Iron Gate II dam (1984) have prevented spawning migrations of sturgeon into the Upper and Middle Danube, the Lower Danube remains the only river in the Black Sea basin where sturgeon are present. Their main spawning grounds used to be located near Beluga, between river km 1866 and 1766 in the contemporary Slovak-Hungarian stretch (Hensel & Holcik 1997). Currently, the main spawning grounds are located approximately 1000 km downstream of Beluga under the Iron Gate II dam, between river km 863 and 755 (Vassilev 2003).

Several studies have shown depletion in the population structure of the Danube sturgeons, leading to their endangered species status (Ceapa, Williot & Bacalbasa-Dobrovici 2002; Vasilev & Pehlivanov 2003; Lenhartdt *et al*. 2006). They are now the focus of a variety of nature-protection organizations. For example, in 1996 all sturgeon species were included in the Red Book (IUCN, Red List of Threatened Animals). Since 1 April 1998, all species of the order *Acipenseriformes* were in the list of species under the Convention of International Trade in Endangered Species of Wild Flora and Fauna (CITES Appendix II). In the Bulgarian Red Book of endangered species *A. nudiventris* is included, as rare and *A. sturio* is considered extinct.

At the end of the 1990s, the countries of the Lower Danube began to implement different programmes for investigation, conservation and restoration of the sturgeon stocks (Navodaru & Staras 2002; Raikova *et al*. 2004; Lenhardt, Hegedis & Jaric 2005; Reinartz 2006). The Sturgeon Action Plan was accepted in December 2006 and aimed to co-ordinate activities on conservation and restoration of the Danube sturgeons (Bloesch *et al*. 2006).

The aim of this study is to outline the current status of the wild sturgeon populations in the Bulgarian part of the Danube River and the Black Sea, and management practices applied in Bulgaria, to protect and restore the sturgeon populations.

Materials and methods

The National Agency of Fisheries and Aquaculture at the Ministry of Agriculture and Food Supply provided statistical data about sturgeon catches, aquaculture production and restocking activities over the last 20 years. A total of 31 published sources, personal communications, and author observations were used in this study. The taxonomy of fishes was based on the review of Eschmeyer (2006).

Results

State of natural sturgeon stocks in the Bulgarian part of the Danube River and the Black Sea

Sturgeons have been the object of commercial fishing activities in Bulgaria for centuries, mainly in the Danube River (about 90% of the total catch) and less in the Black Sea (remaining 10% mainly along the Northern coast near Romania and to the South of Sozopol). Sturgeon catch data have been kept in Bulgaria since the 1920s

(Drenski 1928). During the period 1920-1926 catches in the Bulgarian sector of the Danube River varied from 30 to 72 t yr^{-1}, with an average of 51 t yr^{-1} (Fig. 1).

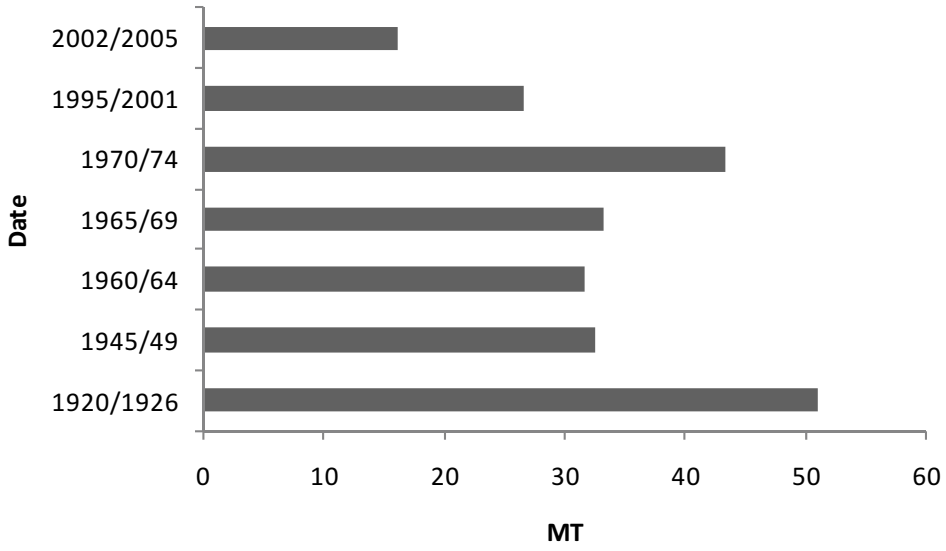

Figure 1. Sturgeon catches in Bulgaria since 1920s.

In 1942, approximately 64 t of sturgeons were caught. During 1945-1949 the average catch of sturgeons was 32.5 t yr^{-1}. The most fishes caught were *A. gueldenstaedti* and *A. stellatus* (Table 1), which comprised respectively 50.8 and 43.4% of the total catches. *Huso huso* was only 5.8%. In the period 1960-1974 catches increased and the average total catch for each 5-year period varied from 150.5 to 196.5 t (31.5 to 43.3 t yr^{-1}), i.e. no significant change was observed in the total quantity of the catch.

Table 1. Catch per year for 3 species of sturgeon, *H. huso, A. gueldenstaedti* and *A. stellatus.*

Year	*Huso huso*	*A. gueldenstaedti*	*A. stellatus*	Total
1996	5.3	0.7	-	6
1997	11.5	1.8	-	13.3
1998	12.3	2.2	-	14.5
1999	10	2	-	12
2000	0.9	-	0.3	1.2
2001	0.3	-	-	0.3
2002	3.5	2	3	8.5
2003	0.6	-	0.3	0.9
2004	2.5	0.5	1	4
2005	0.6	-	-	0.6
Total	47.5	9.2	4.6	61.3
Average	4.75	0.92	0.46	6.13

Changes occurred in the species caught (Fig. 2). The considerable changes in the structure of catches were one of the first signals of disturbance of sturgeons stocks. *A. ruthenus* dominated the catch in the 1960s and comprised 58.3% of the whole catch, followed by *A. gueldenstaedti* (28.7%), *A. stellatus* (8.5%) and *H. huso* (4.6%). The total fish catch from the Danube River was about 600 t yr^{-1} during the 1980s (according to the official statistics data of the state companies), or which sturgeons contributed about 80 t yr^{-1}, 80% were *H. huso*.

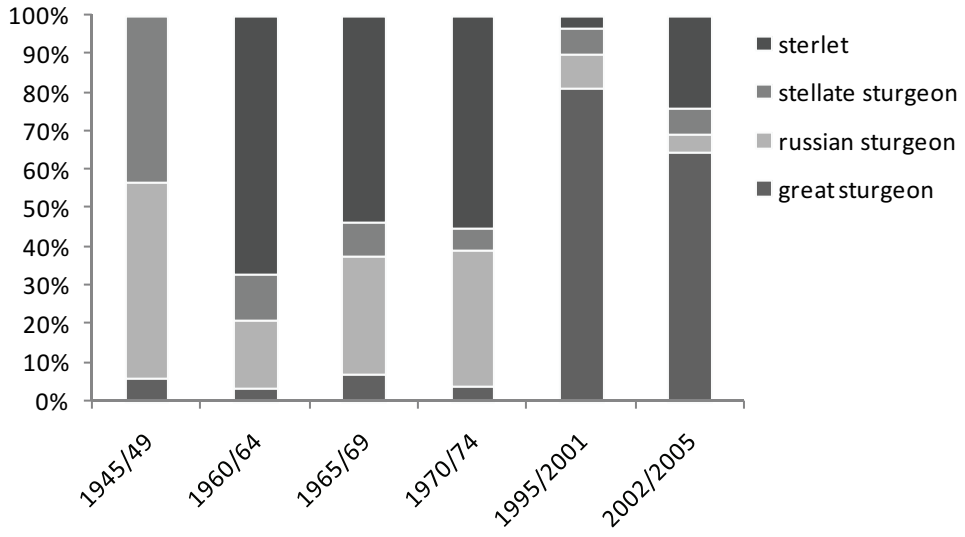

Figure 2. Percentage catches of sturgeon from 1945 to 2005.

Since 1995, sturgeon catches have drastically decreased to 26 t yr^{-1} for the period 1995-2001 and 26 t yr^{-1} for the period 2002-2005 (Table 2, Fig. 1). However, *H. Huso* was still the dominant species in the last 10 years and for the period 1995-2001 it represented 81.12% of the total sturgeon catch, followed by *A. gueldenstaedti* (8.91%), *A. stellatus* (6.39%) and *A. ruthenus* (3.57%) (Fig. 2).

Table 2. Sturgeon catches from 1995-2005.

Year	Beluga (t)	Russian sturgeon (t)	Stellate sturgeon (t)	Sterlet (t)	Total (t)
1995	13.6	0.9	0.1	0.1	14.7
1996	23.5	1.7	0.5	0.8	26.5
1997	30.7	3.6	0.2	0.8	35.3
1998	31.2	5.3	3.7	1.2	41.4
1999	27	4	6	1.5	38.5
2000	18.4	0.9	1.4	1.6	22.3
2001	6.6	0.16	0.03	0.66	9.1
2002	9.9	1.2	1.7	2.8	15.6
2003	8.21	1	1.3	4.5	14.1
2004	9.9	0.5	0.5	3.4	14.3
2005	13.2	0.3	0.7	4.8	18.9
Total	192.21	19.56	16.13	22.16	250.7

Between 2002 and 2005, *H. huso* was the dominant species caught contributing 64.5% of the total catch (average catch 16 t yr^{-1}) (Fig.2), followed by *A. ruthenus* (24.3%), *A. stellatus* (6.6%) and *A. gueldenstaedti* (4.7%), an increase of approximately 6.8 times the previous period. In total, about 80% of all sturgeon species were caught in the Lom and Vidin region (river km 570-850).

Based on published data and sturgeon catches in the Danube River the following trends were identified. During 1945-2005 *A. gueldenstaeti* and *A. stellatus* lost their dominant role (respectively 50% and 43% of the total sturgeons catch, Fig. 2); currently they contribute <7% of catches (Fig.3). *A. ruthenus* showed the strongest change dropping from 58% of the total sturgeon catch between 1960 and 1975) (Fig.2) to less than 5% in the following period, although there has been an increase during the last 2-3 years up to 20% (Fig.3). Beluga catches fluctuated widely. Prior to the 1980s, *H. huso* catches were insignificant (< 5%) of the total catches (Fig. 2) but during the last 20 years have contributed approximately 80% of total catches (Fig. 3). Consequently, Russian sturgeon and the stellate sturgeon are not important for the black caviar yield, produced mainly from Beluga because of its higher quality and market price.

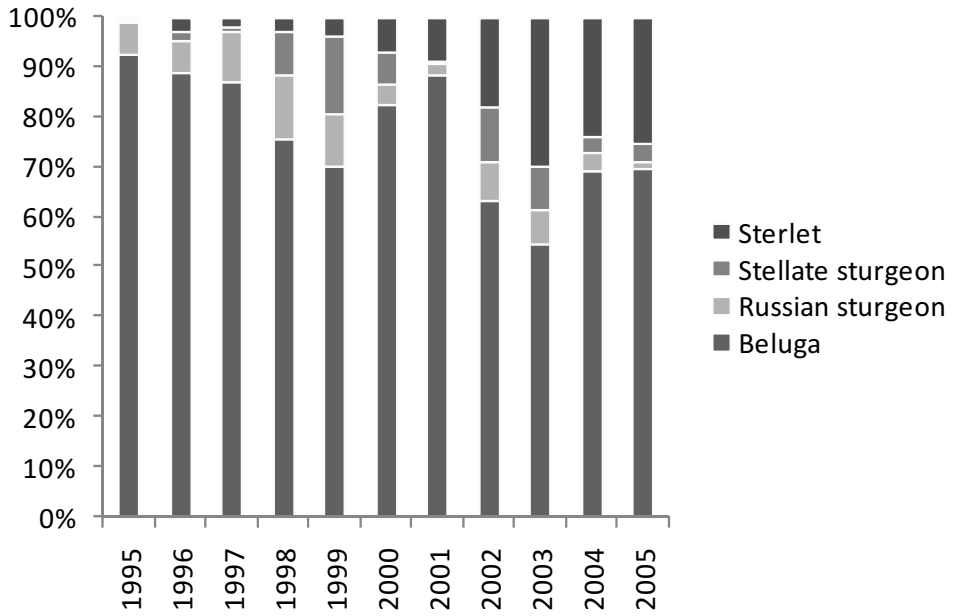

Figure 3. Percentage catches of sturgeon from 1995 to 2005.

In total, Black Sea catches of sturgeon species were 3-4 times lower than the Danube River, but in some years (2003-2001) it was 15-30 times lower (Fig. 4). Currently, sturgeon catches in the Black Sea do not exceed 15 t annually (Table 1). The catches of *H. huso* contribute 77% (Table 2), *A. gueldenstaedti* 15%, and *A. stellatus* only 7.5%. *Huso huso* is usually caught in the south – in the region of Ahtopol -Tzarevo - Rezovo by baited hooks. In the north (near to the Romanian border) the usual catch is Russian sturgeon and rarely *A. stellatus*. There are several cases when sturgeon species were caught in fixed trap nets, but this happens occasionally. The female sturgeons caught in the Black Sea are mostly at an early stage of maturity and consequently of no commercial value.

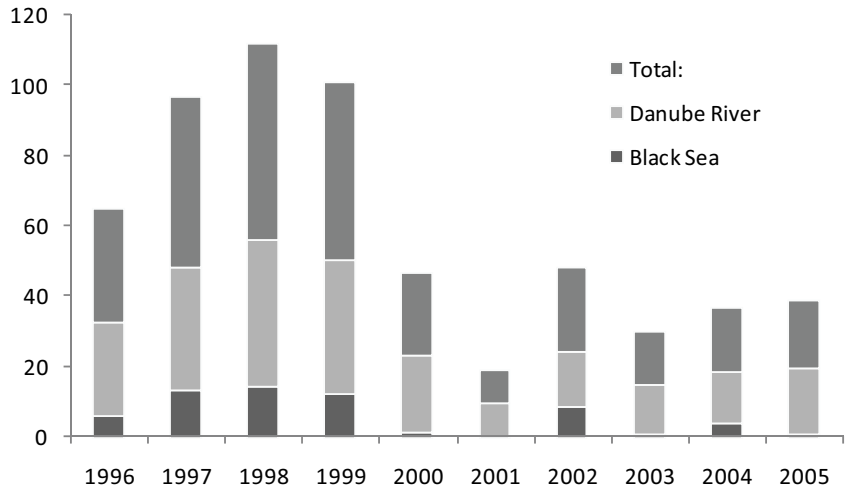

Figure 4. Comparison of sturgeon catches between the Danube River and the Black Sea.

Management strategies concerning the endangered Sturgeons in Bulgarian Waters

Restocking activities

Restocking of the River Danube is an alternative to mitigate the negative impacts on the sturgeon populations in the region. By the end of the 1990s, in conjunction with different conservation projects and to fulfil CITES recommendations concerning the protection of sturgeon stocks, attempts were being made in Bulgaria for artificial propagation and production of restocking material from sturgeons. In 1998, juvenile *A. gueldenstaedti* produced in the Perpen Chobanov fish farm (in the village of Boljartsi) were released into the river near Rousse (river km 493) (Zlatanova 2000; Vassilev 2005).

Since 2003, restocking has been done according to an Order of the Minister of Agriculture and Forestry and the Minister of the Environmental protection and Waters. It obliges the people who receive black caviar export quotas, to restock the Danube River according to their own choice, which is usually *H. huso* and/or Russian sturgeon, based on the rule that a minimum 30 fish and a maximum of 120 fish must be restocked for every 1 kg of caviar exported.

In the period 1998-2005, more than 711 000 sturgeons were released into the Danube River: approximately 670 000 were Russian sturgeon, weighing between 10 And 1 000 g, 37 000 beluga, weighing from 20 to 500 g and 2125 serlets, weighing 15 to 100 g (Table 3). Russian sturgeon contributed 94.5% of all fish released into the river, the Beluga was 5% and the sterlet was 0.3%.

During the period 2006 and 2007, caviar export quotas for Bulgaria were not released by CITES because the export companies were not obliged to restock the Danube River. For that period only 2000 Russian sturgeon with an average weight of 5 g were released.

Since 2007, restocking of the Danube River has been the main task within the framework of the National Program for Support of the Stable Growth of Fish Resources, which was accepted by the Minister of Agriculture and Food Supply in 2008. Accordingly, in 2008 the Danube River was restocked with 30 000 Russian sturgeon and 20 000 Beluga. Financial support was from IARA. An important requirement of this programme is the restocking is of juvenile fish of

Table 3. Number of sturgeon released into the Danube River.

Year		Release site on Danube River	
		Vidin rkm 790	Svishtov rkm 570
1998-2001	Russian sturgeon	0	200,000
2002	Russian sturgeon	42300	20230
	Sterlet	1000	1125
2003	Beluga	5300	0
	Russian sturgeon	115500	45817
2004	Russian sturgeon	67000	144126
2005	Beluga	31950	0
	Russian sturgeon	0	35000
2006	Russian sturgeon	2000	0

Danube origin. This has not always been taken into consideration in recent restocking events where both native and hybrid species were used. For example, Siberian sturgeons (*A. baeri*), Adriatic sturgeons (*A. naccarii*) and hybrids grown in fish farms were previously released into the Danube (Reinarz 2002 & Vasilev 2005). Considerable attention has to be paid to the restocking of two extinct species, Ship and Atlantic sturgeon. The results from the implementation of the Ministry of Environment and Water restocking project in the Danube River have to date been unsatisfactory.

Aquaculture development

The significant decrease of sturgeon catches and the implementation of different restrictions for their catch promoted a serious interest in artificial rearing of sturgeons for the production of both meat and caviar. The beginning of sturgeon aquaculture in Bulgaria was in 1995, when the first sturgeon fish farm was built. The farm is situated in the Southern part of Bulgaria near the city of Plovdiv at a distance of more than 300 km from the Danube River. In 2001 a second sturgeon fish farm was established - Beluga located directly on the banks of the Danube River near the town of Vidin, at river km 790. Sturgeons are also reared in other places in the country, but on a smaller scale. By 2005, there were 5 officially registered sturgeon fish farms, but more are planned, mainly net cage farms. Formerly, Esetra Commerce Ltd., Beluga Ltd. и Aquamash Ltd. was the main producer of restocking material, fish for consumption and caviar.

In the past, producers relied mainly on imported fertilized eggs, mainly from Russia, Krasnodar and Astrakhan, for stocking material. Presently it is from sexually mature specimens, grown on the fish farms.

The main object of rearing has been for the Russian sturgeon (Tables 4 and 5). Beluga, stellate sturgeon and sterlet have been reared in smaller quantities. The production of stocking material is in tanks until the fish weigh 5-20 g. Thereafter, they are moved into nets cages and during the first year the juveniles usually reach 300-500 g.

Table 4. Production (number specimens) of sturgeon stocking material from aquaculture (Source: NAFA)

Species	2002	2003	2004	2005	2006	2007
Beluga	0	21380	7,230	112,960	0	0
Sterlet	0	0	6,100	155,550	0	0
Russian sturgeon	65,000	205,606	108,440	49,550	64320	24897
Stellate sturgeon	0	0	0	385	0	839
Paddlefish	0	0	32,500	445	0	0
(Russian x Siberian)	0	0	0	55,000	0	0
Total:	65,000	226,980	154,270	373,890	64,320	25,736

Table 5. Production (t) of market-size sturgeons from aquaculture (Source: NAFA).

Species	2002	2003	2004	2005	2006	2007
Beluga	0	3.4	3.7	21.5	27.66	46.16
Sterlet	0	0.3	0.1	2.2	2.5	4.58
Russian sturgeon	80	144	6.7	281	113.5	142.8
Stellate sturgeon	0	0	0	0	15.11	2.1
Paddlefish	0	0	2.3	0.05	0.005	0.007
Total:	80	147.7	12.8	304.75	158.7	195.6

Fish for consumption are mainly reared in cage farms. The biggest cage farm in the country is located at the Kardzhali dam, where water temperature throughout the greater part of the year is 20-23 ^{o}C and the oxygen concentrations about 6 mg.L^{-1}. During the second year of rearing, the Russian sturgeon reaches an average weight of 2-3 kg. During the third year, the males and the females are separated using ultrasound, when at an average weight of 4-5 kg. Sex determination without using ultrasound can be done during the fourth year, at a weight of 6-7 kg; when a white coating on the heads of maturing male fish is used as an indicator of sex dimorphism. The males are mostly used for consumption on the home market; the total quantity of fish from all sturgeon fish farms in the country sold was about 80 t. The females are reared to Sexual maturity in females occurs from 6 years old fish, but caviar is only produced from 9 year old fish. About 2-2.5 t of caviar is produced from beluga grown in aquaculture.

In 2003, the paddlefish (*Polyodon spathula*, Walbaum) was introduced into Bulgaria (Hubenov *et al*. 2004) because of its faster growth and high commercial value. It is mainly for rearing in the inland water bodies, mostly in reservoirs. During the first year

it can reach an average weight of 150-200 g, during the second, when reared in ponds or reservoirs it can reach more than 2 kg (Hubenova *et al.* 2007).

Legislative framework

Active procedures on a legislation level concerning sturgeon species in Bulgaria were undertaken at the end of 1995, when the following laws, acts and orders came into force:

- Order by the Minister of Agriculture and Forestry and by the Minister of Environmental Protection and Waters from 2003, which binds the right for caviar export with the obligation to restock the Danube River with 30-120 sturgeon fingerlings against the export of one kg of caviar.
- The "Action Plan for Sturgeons in the Bulgarian Parts of the Danube River and the Black Sea" (Raikova *et al.* 2004), which was elaborated in 2004.
- The Law of Fisheries and Aquaculture (State Gazette, No. 94/11.2005). According to the Article 35, Paragraph 6 of this Law the catches by using bottom hooks from 01.12.2007 was forbidden.
- The Biodiversity Act (State Gazette from 10.2005), Appendix 2 and 3 have included the ship sturgeon and the Atlantic sturgeon as endangered species and their catches have been forbidden.
- Order by the Minister of Agriculture and Forestry and by the Minister of Environmental Protection and Waters from 2006, which disallows sturgeon catches in the Bulgarian Black Sea.
- Order by the Minister of Agriculture and Food Supply and by the Minister of Environmental protection and Waters for moratorium of sturgeon catches for a period of 8 years in the Bulgarian section of the Danube River implemented since May 2008.

From an international aspect the following events and acts have been carried out:

- Meeting of the Black Sea countries on protection and sustainable management of the sturgeons populations in the Black Sea Basin organized by CITES Secretariat and the Ministry of Environmental Protection and Waters in Bulgaria, in 2001;
- Regional Strategy for sturgeon management developed by Bulgaria, Romania, Serbia & Montenegro and the Ukraine in 2003;
- In November 2005 the Government of the USA banned import of beluga caviar from the countries of the Danube, the Black Sea, and the Caspian Sea regions (Bulgaria, Georgia, Rumania, the Russian Federation, Serbia & Montenegro, Turkey and the Ukraine);
- National Action Plan for sturgeon management in fishing waters by Serbia & Montenegro (Lenhardt, Hegedis & Jaric (2005);
- 10-year catch moratorium implemented since May 2006 by the Romanian Government;
- Action Plan for Conservation of Sturgeons in the Danube River Basin 2006.

The unfavourable status of sturgeon populations in the Danube River and the Black Sea was a result of a combined effect, including: over-exploitation, poaching, habitat loss and disruption of spawning migration (Bloesch *et al*. 2006). First data about the declining catches were reported at the beginning of the 20th century. One century later, catches have continued to decline because of increased fishing pressure resulting from improved fishing equipment and the increased number of fishermen. There are several reasons for the long-term delay of adequate measures and implementation for the protection and restoration of sturgeon stocks in that region: 1) the high economic value of sturgeon caviar and meat, and the great demand for them on the world market; 2) the policy of respective authorities in Bulgaria to protect the socio-economic status of sturgeon fishermen, but later analysis showed that despite the high profitability of this activity, only a small percentage of the people make their living from sturgeon.

We should also report that official statistics of catches are inaccurate. The Danube fishery statistics in Bulgaria, as well as the fisheries statistics as a whole, were destroyed for about 10 years during the transition period. There is also lack of data about poaching and these catches can exceed legal ones many times (Bacalbasa-Dobrovici & Patriche 1999; Vassilev & Pehlivanov 2003).

In the 10 years since the first activities to protect and conserve sturgeon populations were implemented there has been little positive effect on the status of sturgeon populations. The different instruments used by the Bulgarian authorities to regulate catches during the breeding season, such as gear restriction, minimum size requirements, restrictions imposed by CITES (such as the quotas for caviar) have not lead achieved the effect desired. One of the main reasons for this has been the considerable delay in the implementation of these measures. The former State Fisheries Inspectorate (now the Agency for Fisheries and Aquaculture) only managed to implement the Fishing Licensing System and to re-establish collection of data for the Danube River and the Black Sea fisheries in 1995. Now this process has been placed under the regulation of the Fisheries and Aquaculture Act (2005), and should be implemented more efficiently.

Serious attempts have been made to ban fishing by all Danube countries. A moratorium has been implemented since May 2006 by the Romanian Government and since May 2008 by the Bulgarian Government, under the Action Plan for the Conservation of Sturgeons in the Danube River Basin (2006). This might be the only means to avoid the complete extinction of sturgeons in the Danube River (Bloesch *et al*. 2006).

The results expected will not be seen quickly and the moratorium will only be effective if the poaching is terminated. However, there are some complications that remain, including insufficient staff and financial resources to control the ban on fishing and the prerequisite for export quotas for caviar from sturgeon aquaculture. This conceals the selling of caviar from wild fish populations on the market under the banner of farm production. Biochemical studies (gene markers) and adequate labelling and control of products will hopefully overcome these problems.

Sturgeon restocking activities in Bulgaria, during the last few years has not been systematic and the quantity of the released fish has not been enough. The estimated quantity of restocked juveniles has varied, but it has decreased during the last two years because of the zero-trade quotas for caviar export from wild populations. Insufficient wild bred stock at existing hatcheries in the country has prevent the production of

enough fingerlings for stocking and the production of stocking material is relatively expensive and requires financial support from the Government that is not forthcoming.

Sturgeon aquaculture has the capacity to solve this problem and an increase of sturgeon farming is the way to restore natural population coupled with reduction in fishing pressure. Also captive rearing of sturgeons is an alternative source of caviar for the market (Pikitch *et al*. 2005). However, considerable capital investment in research programmes directed towards increasing the efficiency of sturgeon production, enhancing the survivability of released individuals, tracing of survivability and migration of tagged specimens is also necessary.

In conclusion, this study shows the need for adequate measures to protect the stocks including: increasing the control on sturgeon protection on behalf of the authorized bodies IARA and the National Forestry Management, to stop poaching; increasing the quantities of restocking material mainly from beluga; tagging and estimating survival to different ages; increase production capacity and efficiency of farms; development of programme to support fish farms in the country to produce stocking material, for example through financial support by the Government, low-interest credits, structural funds financial support by the EC; protection of the regions where sturgeon spawn; investigations about sturgeon population status (age-and size structure); use of genetic tools to support identification of poached fish from aquaculture production. The strengthening and harmonization of the national legislation and the implementation of the Action Plan for Conservation of Sturgeons in the Danube River Basin should be directed towards achieving sustainable management and restoration of the natural habitats and migratory movements of the sturgeons. In conjunction with the existing national and international instruments, the action plan might provide important instruments and mechanisms to avoid the extinction of the sturgeons in the Danube River and the Black Sea.

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