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Conservation and sustainable use of wild sturgeon populations of the NW Black Sea and Lower Danube River in Romania

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Abstract

Sturgeons belong to one of the oldest families of bony fish in existence, having their first appearance in the fossil records approximately 200 million years ago. Their natural habitats are found in the subtropical, temperate and sub-Arctic rivers, lakes and coastlines of Eurasia and North America. In the Romanian waters, five anadromous species of sturgeon, out of the total 25 species known by science, once migrated from the Black Sea into the Danube for spawning: beluga; *Huso huso*, Russian sturgeon; *Acipenser gueldenstaedtii*, stellate sturgeon; *A. stellatus*, ship sturgeon; *A. nudiventris* and the European Atlantic sturgeon; *A. sturio* (Knight, 2009).

The NW Black Sea and Lower Danube River sturgeons, like many Acipenserids, were seriously affected by the rapid changes brought by human development. Being one of the finest caviar producers in the world they were intensively harvested for many centuries. Heavy uncontrolled fishing and destruction of habitat led to the collapse of most of the Acipenserids and the total disappearance of the European Atlantic sturgeon (*A. sturio*) from the NW Black Sea.

Worldwide public attention was focused on sturgeon conservation after their listing in the IUCN Red List of Threatened species in 1996. In 1998, after evaluating their abundance in the wild, CITES also decided to strictly regulate the international trade in all Acipenserids. The paper aims to analyze and review conservation measures that were taken locally, nationally and internationally by humans and the effect they had on one of Europe’s only naturally reproducing sturgeon populations.

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Chapter 1 – N-W Black Sea and Lower Danube Sturgeon species

1.1 Geographical context

1.1.1 Lower Danube River

With a length of 2860 km, Danube is the second longest river in Europe, after Volga. Flowing southeastwards from its source in Germany, it flows through 12 countries and 4 capitals before reaching the Black Sea (Weller, 2009). The habitats created by the river's hydrological basin host more than 2000 types of plants and 5000 animal species, among which there are 40 different mammals, 100 types of birds and 100 fish species (Anonymous, 2009d).

Geographically, the river is divided into 3 major areas: the Upper Danube, the Middle Danube and the Lower Danube (Figure 1). Due to its' substantial natural gradient, the Upper Danube was considered a perfect place to build barrages and hydropower plants. At present this first part of the river holds 59 dams, with a mean distance between them of only 16 km (Anonymous, 2010d). The Middle Danube is separated from the Lower Danube by two dams: Iron Gates I and Iron Gates II. The 1075 km long Lower Danube, situated between the Iron Gates Gorge and the town of Sulina, creates a natural border between Romania, Serbia and Bulgaria (Smalley and Leach, 1978). Shallower and broader than its' upper part, the Lower Danube used to be, as noted by Sommerwerk et al. (2009), *"a typical lowland river, fringed by wide floodplains"*. This changed during the communist regime that governed Romania from 1946-1989, when more than 72% (~5500 km^2) of former floodplains were converted into agricultural land (Sommerwerk et al., 2009). Eighty kilometers upstream of its mouth, the Lower Danube divides into 3 major branches and, due to a slow flow and accumulation of sediments, forms the Danube Delta (Schmedtje, 2005).

1.1.2 NW Black Sea

The Black Sea is a unique semi-closed inland sea, covering 436 400 km^2 and reaching a depth of 2245 m (Kideys, 1994). Danube, Dniester, Dnieper, Don and Kuban are the main tributary rivers (Figure 2). The most unique feature of the Black Sea is the lack of vertical currents, which gives rise to anoxic water deeper than 180 m (Ivanov et al., 1995).

The NW part of the Black Sea differs significantly from the rest of the sea. Rivers bringing a large load of nutrients and freshwater, which lowers the salinity from an average 15-18 ‰ to - 10-12 ‰ (Bartsch, 2004).The continental shelf is very wide in this area, measuring more than 190 km, compared to the rest of the sea where the shelf edge is less than 20 km wide. Low salinity, high concentration of nutrients and shallow, oxygenated waters make the perfect environment for many aquatic species, including benthic fish such as sturgeons (Pannin et al., 2009).

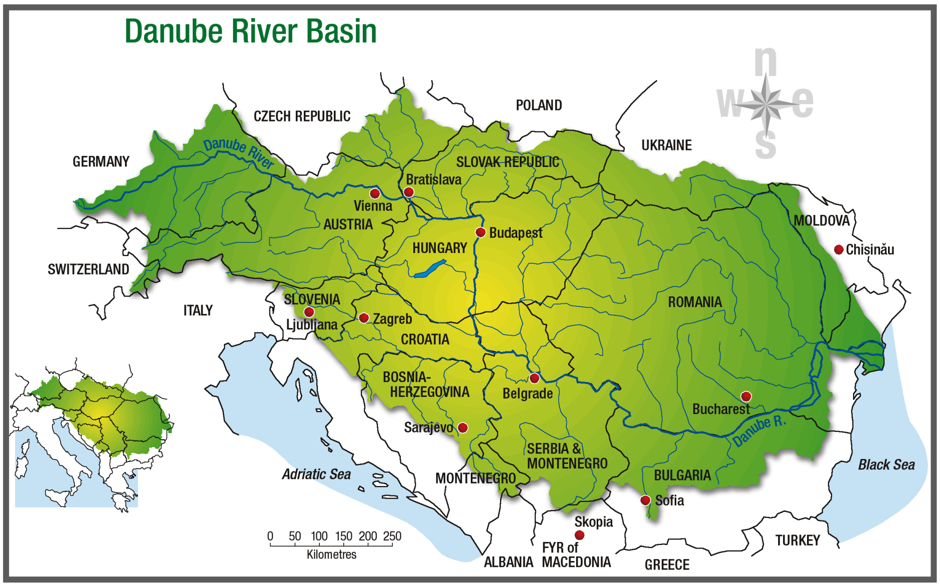

Figure 1 - The Danube River Basin (Anonymous, 2009b)

Figure 2 - The Black Sea Basin (Anonymous, 2010a)

1.2 Sturgeon facts

1.2.1 Systematics

Sturgeons belong among the most intriguing aquatic species. Their unique appearance and well conserved "primitive" traits caught the attention of many early biologists (Vecsei and Peterson, 2005). The first systematic description of the group was made by Linnaeus in 1758 (Vasil'eva, 2009) and since then different scientists have contributed to improve it.

As has happened with many other species, sturgeons have given rise to countless debates about their classification, primarily due to their "*unusual mixture of characters*" (Bemis et al., 1997b), and two aspects in particular: "*reduced ossification of the endoskeleton combined with the presence of an extensive dermal skeleton*" (Bemis et al., 1997b) and the existence of "*a hyostylic jaw suspension and protrusible palatoquadrate recalling the jaws of sharks*" (Bemis et al., 1997b). Keeping this in mind, numerous researchers consider that sturgeons are the missing link between cartilaginous fish (sharks) and more evolved bony fish (teleosts) (Peake, 2005).

Historically, sturgeons are presumed to have evolved most likely from a paleonisciform ancestor (Vecsei and Peterson, 2005) between 200–100 million years ago (Sulak and Randall, 2002). Current systematics places the group in the superorder Condostrean, order Acipenseriformes. The order is composed of 2 families, Polydontidae (paddlefishes) and Acipenseridae (sturgeons) (Garrido-Ramos et al., 2009). Acipenseridae comprise 25 species (Findeis, 1996, Birstein et al., 2002, Ludwig, 2008, Garrido-Ramos et al., 2009, Rejón et al., 2009), among which six were historically found in the NW Black Sea and the Danube River: 5 anadromous species (*Huso huso* or beluga), *Acipenser gueldenstaedtii* or Russian sturgeon, *Acipenser stellatus* or stellate sturgeon, *Acipenser nudiventris* or ship sturgeon, *Acipenser sturio* or European sturgeon), and one potamodromous species, (*Acipenser ruthenus* or sterlet) (Knight et al., 2009). Today only 3 anadromous species are still reproducing in the Danube: *Huso huso, Acipenser gueldenstaedtii* and *Acipenser stellatus. Acipenser sturio* is considered extinct from the river and the presence of *Acipenser nudiventris* is rarely mentioned (Jarić et al., 2009).

1.2.2 Morphology and physiology

First studies on sturgeon morphology were carried out by naturalists in the 1800s (Vecsei and Peterson, 2005). Since then, Antipa (1909), Berg (1968), Scott and Crossman (1973), Holcik (1989), Billard and Lecointre (2001) and Vasil'eva (2009) showed great interest in describing Acipenserids, primarily because of their unique physiology and intriguing life history.

The shape of the snout and the positioning of the mouth (Figure 3) are one of the most important morphological traits that differentiate Acipenserids among themselves and from other fish species (Vecsei and Peterson, 2005). The snout of *Acipenser gueldenstaedtii* is short and rounded, with barbels situated near its tip (Sokolov and Berdicheskii, 1989). *Acipenser nudiventris* has a moderately long, pointed snout with fimbriated barbels located half way between the mouth and the tip of the snout (Bauchot, 1987b). *Acipenser ruthenus* has a narrow, edgy snout with four long and fringed barbels (Birstein, 1993). *Huso huso* has a moderate-size snout, turning slightly upward with oval or flat barbels situated near the mouth (Kottelat and Freyhof, 2008). The longest and narrowest snout of all Danube sturgeons belongs to *Acipenser stellatus* (Bauchot, 1987a). The mouth of all Romanian sturgeon species is subterminal, protractile, thick-lipped, without teeth and equipped with chemosensory barbels, being specially designed for benthic feeding (Vecsei and Peterson, 2005).

Figure 3 - a. *Huso huso*, b. *Acipenser nudiventris*, c. *A. gueldenstaedtii*, d. *A. ruthenus* and e. *A. stellatus* – snout shape and position of mouth and barbels (after Vecsei et al, 2001)

Another essential morphological characteristic of sturgeons is the scaleless spindle-shaped body which is covered by only 5 rows of large bony plates called scutes, and ends with a heterocercal tail (Anonymous., 2007). The scutes are mainly used for defense. Juveniles have most of their bodies covered with them resulting in a thick armor that protects against predators. The distance between the scutes widens with increasing size therefore the role of protection in adults loses its importance (Vecsei and Peterson, 2005). However, counting the number of scutes comprised in each row helps scientists in differentiating between adult species. For instance, *Acipenser stellatus* has between 11-14 dorsal scutes, 30-36 lateral and 10-11 ventral scutes on each side (Bauchot, 1987a). The number of dorsal scutes in all Danube sturgeons ranges from 11 to 19. The highest number of lateral scutes is found in *Acipenser ruthenus* – between 57 and 71 (Birstein, 1993) and the lowest in *Acipenser gueldenstaedtii*, between 24 and 44 (Sokolov and Berdicheskii, 1989).

Body size and longevity (Figure 4) are probably the most noticeable biological features of sturgeons. Several 100-year old belugas, weighing 3000 kg and reachring 5 m length have been caught throughout history (Zaidi and Ireland, 2008). Even without these extreme examples, common belugas live longer than 60 years and easily reach 2.15 m length (Kottelat and Freyhof, 2008). *Acipenser gueldenstaedtii* (Sokolov and Berdicheskii, 1989) and *Acipenser nudiventris* (Bauchot, 1987b) have an average length of 1.35 - 1.45 m and a life expectancy of approximately 30 years. The potamodromous *Acipenser ruthenus* has the shortest length and lifespan - 40 cm and 15 years, respectively (Birstein, 1993).

In terms of physiology, sturgeons have many unique attributes that has helped them survive over time. Like other teleosts, adult Acipenserids are capable of osmoregulation in both fresh and salt water, characteristic which allows them to adapt to different environmental conditions. Larvae lack this ability, so freshwater spawning sites are crucial for all sturgeon species (Vecsei and Peterson, 2005). Unlike teleosts, Acipenserids can still produce ascorbic acid in their kidneys. Also, their sperm contains an enzyme that is similar to mammalian acrosin (Lenhardt et al., 2008), which has the ability to lower the activation energy of catalysis and facilitate quicker penetration of egg envelopes (Ciereszko et al., 2000).

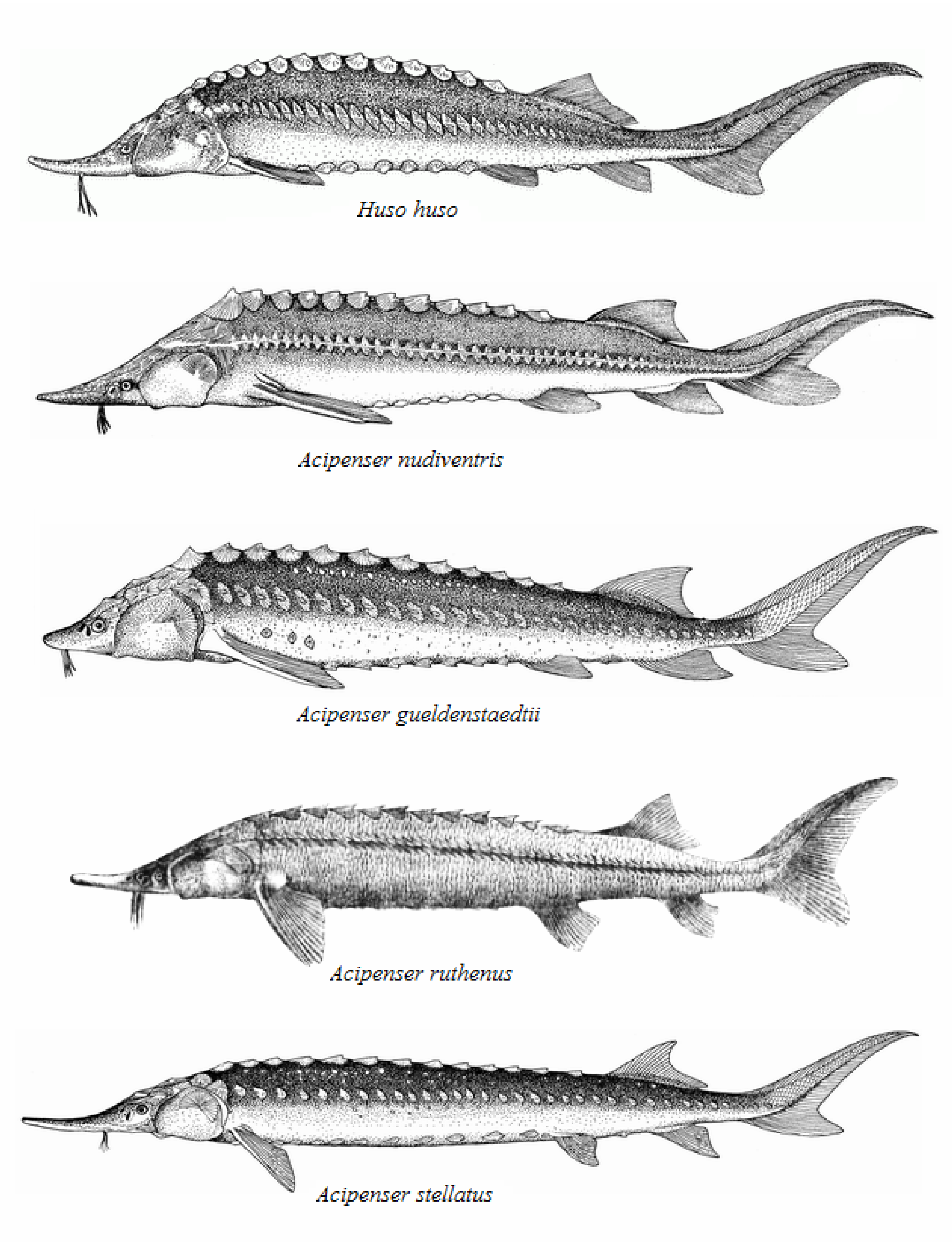

Figure 4 - Body shape and scute display in Romanian sturgeons (FAO, 2011)

1.2.3 Life history and behavior

Although Acipenserids are a highly diversified group in terms of behavior and life history, there are a few common traits that characterize all individuals. First of all, sturgeons have a long lifespan, grow slowly (Pikitch et al., 2005) and utilize a wide range of habitats during their existence (Lagutov and Lagutov, 2008). Second, they are a migratory species with two basic migration patterns: **downstream migration**, which is always related to feeding and **upstream migration**, which is associated with spawning (Bemis and Kynard, 2002).

According to Lagutov and Lagutov (2008), all sturgeons undergo same development stages. Shortly after fertilization the outer layer of the eggs becomes sticky and the newly formed embryos adhere to the rocky substrate of the spawning site. Muscalu-Nagy (2009) found that during their embryonic growth sturgeons go through a series of changes such as gastrulation, neurulation, the appearance of eye protuberances, and the formation of the cardiac muscle and excretory organs. This first life stage lasts between 6 and 10 days, depending on water temperature and species (Muscalu-Nagy and Muscalu-Nagy, 2009). In the prelarval stage, the digestive tract is fully functional and the embryos begin to have a fish-like shape. Swimming is rather difficult for this stage due to their undeveloped fins and the anterior position of the center of gravity (Gisbert et al., 1999). The larval stage begins 12-14 days after fertilization (Lagutov and Lagutov, 2008), as soon as the fish starts feeding on its own, and in the case of *Acipenser ruthenus*, lasts 7 to 8 days (Muscalu-Nagy and Muscalu-Nagy, 2009).

High mortality is noted in all early life periods due to water temperature variations, oxygen deficiency, limited food and predation (Zykova and Kim, 2011). In the fry stage the yolk sac is absorbed completely, hence the motility of the fish is considerably improved. Predation is no longer a threat as a result of their large size in comparison to other fish (25 cm in the case of *Huso huso*) and the existence of sharp protective scutes covering their bodies (Vecsei and Peterson, 2005). During this stage the young fry begin migrating downstream in search of food (Brannon et al., 1985). Morphological transformations are almost complete in the juvenile stage. Apart from body size, shortening of the snout, and bluntness of the lateral scutes, the new generation closely resembles the adults. Excluding *Acipenser ruthenus*, and the freshwater form of *Acipenser nudiventris*, which spend their whole life in the Danube (Pikitch et al., 2005), sturgeon juveniles migrate downstream to higher salinity until they reach the sea.

Romanian sturgeons spend their puberty in the coastal waters of the Black Sea, feeding on benthos biota (worms, mollusks and crustaceous), which is consumed directly (*Acipenser gueldenstaedtii*, *A. stellatus*, *A. nudiventris* and *A. ruthenus*) or indirectly (*Huso huso*) (Kotenev, 2009), by preying on benthos feeders such as small anchovies, gobies and herring (Waldman, 2011). Once they reach sexual maturity, Acipenserids prepare to migrate back to freshwater in order to breed (Lagutov and Lagutov, 2008). Females are ready for their first spawning at an age between 7 and 20 while males mature faster, at an age between 4 and 15, depending on the species (for Danube species see Table 1) (Lagutov and Lagutov, 2008). Due to high mortality during their early life stages, fecundity in sturgeons is quite impressive; females can lay millions of eggs, weighing more than 20% of their body mass (Zaidi and Ireland, 2008).

According to Bemis et al. (1997a), sturgeons reproduce the year round and in variable water conditions. Reproduction occurs repeatedly during their life but most species do not spawn each year (Wilson and McKinley, 2005). Access to favorable spawning grounds is most important for reproductive success. 2–20 m deep waters (Pikitch et al., 2005), flowing at a rate of 0.5–2.0 m s^{-1}) (Lagutov and Lagutov, 2008), with low to medium temperature (9-23 ˚C) and hard substrate (stone, cobble, pebble, gravel and coarse sand) are perfect spawning sites (Bemis and Kynard, 2002). If spawning is not propitious in a certain season, females resorb their roe and the reproductive cycle is postponed until appropriate conditions are encountered (Auer, 1996).

The distance which sturgeons migrate to reach their spawning grounds is another key factor in offspring survival. Lagutov (2008) indicates that larvae and fry during their downstream migration need time to adapt to higher salinity. Historically, pontic sturgeons used to reproduce in many Black Sea river systems; however, at present spawning populations of considerable size can be found only in the Danube River (Pikitch et al., 2005). Here, catch records reveal two peaks in sturgeon landings every year, one in autumn and the other in spring. Further studies of this phenomenon show that species such as *Huso huso, Acipenser gueldenstaedtii,* or *A. stellatus* exhibit two races (Birstein et al., 2000, Birstein and Bemis, 2002, Suciu, 2008). The winter race migrates upstream in the fall, spends the cold season in deep holes along the river and spawns in spring the following year. The vernal race spawns the same year it enters the river.

Table 1 - Status and characteristic traits of sturgeons from the Danube River as compiled from literature (Bauchot,1987a,b, Sokolov and Berdicheskii, 1989, Birstein, 1993, Bloesch et al., 2005, FAO, 2011, Zykova and Kim, 2011)

	Species		*Huso huso*	*Acipenser gueldenstaedtii*	*Acipenser nudiventris*	*Acipenser stellatus*	*Acipenser ruthenus*
Distribution	Lower Danube		EN	EN	CR	EN	VU
	NW Black Sea		EN	EN	?	EN	VU
Biology	Max. length (cm)		800	236	221	218	125
	Avg. length (cm)		120 - 260	110 - 140	130 – 180**	100 - 140	30 - 50
	Max. weight (kg)		3200	115	80	54	16
	Avg. weight (kg)		250 - 350	?	?	6 – 8	6 – 6.5
	Max. age		118	46	36**	35	24
	Avg. age		?	33	?	24*	?
	Feeding regime		marine and freshwater fish (gobies, herring, cyprinids)	benthic organisms (mollusks, crustaceans, corophiids, polychaets)	benthic organisms (mollusks, crustaceans, amphipods, chironomid larvae)	benthic organisms (crustaceans, mollusks, small benthic fish, polychaets)	benthic organisms (insect larvae, small mollusks, annelids, fish eggs)
Migration	Pattern		anadromous	anadromous	anadromous	anadromous	potamodromous
	Seasonal races		vernal - winter	vernal - winter	?	vernal - winter	-
Reproduction	Age at maturity (years)	♂	10 - 13	11 - 13	6 – 9***	5 - 6	3 - 6
		♀	13 - 15	12 - 16	12 – 14***	7 - 10	4 - 7
	Spawning season		April - May	March – November Max: May – June*	April – May***	May - June	April - May
	Opt. spawning temp. (˚C)		10 – 15**	9 - 12	12 – 18.6**	17 - 23	12 - 17
	Current velocity (m/s)		1.5 - 2	1 – 1.5	1 - 2	1.2 – 1.5	?
	Spawning depth		4 - 15	4 - 25	?	4 – 8*	7 - 15
	Spawning periodicity (years)	♂	3 – 4***	4 – 5*	2 -3	2 - 7	every year
		♀	4 – 6***	5 – 6*			every second year
	Absolute fecundity		228 400 – 964 800	29 500 – 406 800	200 000 – 1 300 000	70 300 – 430 000	7000 – 108 000
	Gonad size as % of body weight	♂	3 – 9*	3.9 – 5.5*	?	5.8*	?
		♀	13 – 17*	15*	11 – 23***	25.9*	?

EX = extinct; CR = critically endangered; EN = endangered; VU = vulnerable; - = no occurrence; ? = status is unclear; * = Volga River (Caspian Sea; Russia); ** = Ural River (Caspian Sea: Kazakhstan and Russia); *** = Kura River (Caspian Sea: Azerbaijan); ^ = Rioni River (Black Sea: Georgia); ^^ = Gironde (Atlantic Ocean: France). – data from other river populations are used, as information on the Danube River population is lacking.

1.2.4 Geographical distribution

All sturgeons belong exclusively to the Northern Hemisphere (Billard and Lecointre, 2001). Choudhury and Dick (1998) classified Acipenserids distribution into four broad geographical areas (Figure 5): **North America** is the home of *Acipenser medirostris, A. transmontanous, A. brevirostrum, A. oxyrinchus, A. fluvescens* and of the genus *Scaphirynchus*. In **Asia** live species such as *A. baerii, A. mikadoi, A. schrenckii, A. sinensis, A. dabryanus* and *Huso dauricus*. The genus *Pseudoscaphirynchus* is found in the tributary rivers of the Aral Sea. Sturgeon populations on the Mediterranean coast of **Western Europe** have declined dramatically in the last centuries; however, a few individuals of *A. naccari, A. stellatus, A. sturio* and *Huso huso* continue to inhabit the region.

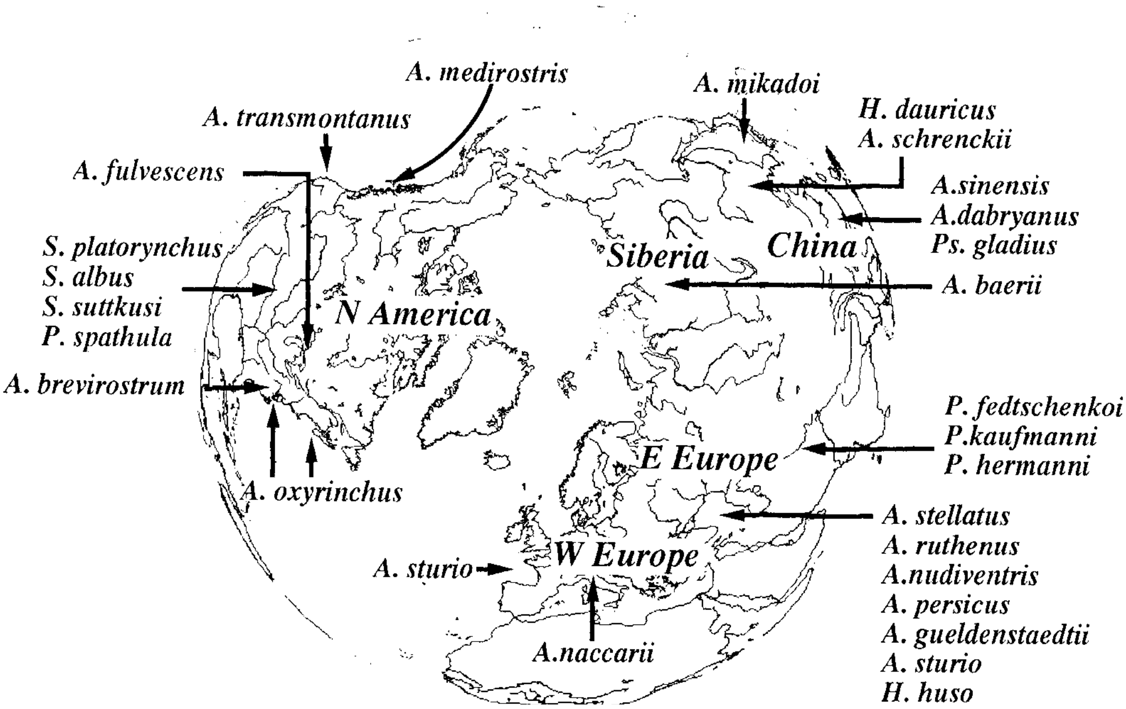

Figure 5 - Geographic distribution of the Acipenseriformes (Billard and Lecointre, 2001)

The **Ponto-Caspian** area presents the greatest species diversity (Figure 6). The Black Sea accommodates important populations of *A. stellatus, A. gueldenstaedtii* and *Huso huso* (Suciu, 2008). *A. nudiventris* is only found in small numbers in the S-W Black Sea, on the Georgian coast and Rioni River (Bauchot, 1987b). It is believed that a small number of individuals of the freshwater form of *A. nudiventris* are established on the Serbian part of the Danube (Jarić et al., 2009). The Caspian Sea holds similar sturgeon species as the ones found in the Black Sea, plus individuals of *A. nudiventris* and *A. persicus*.

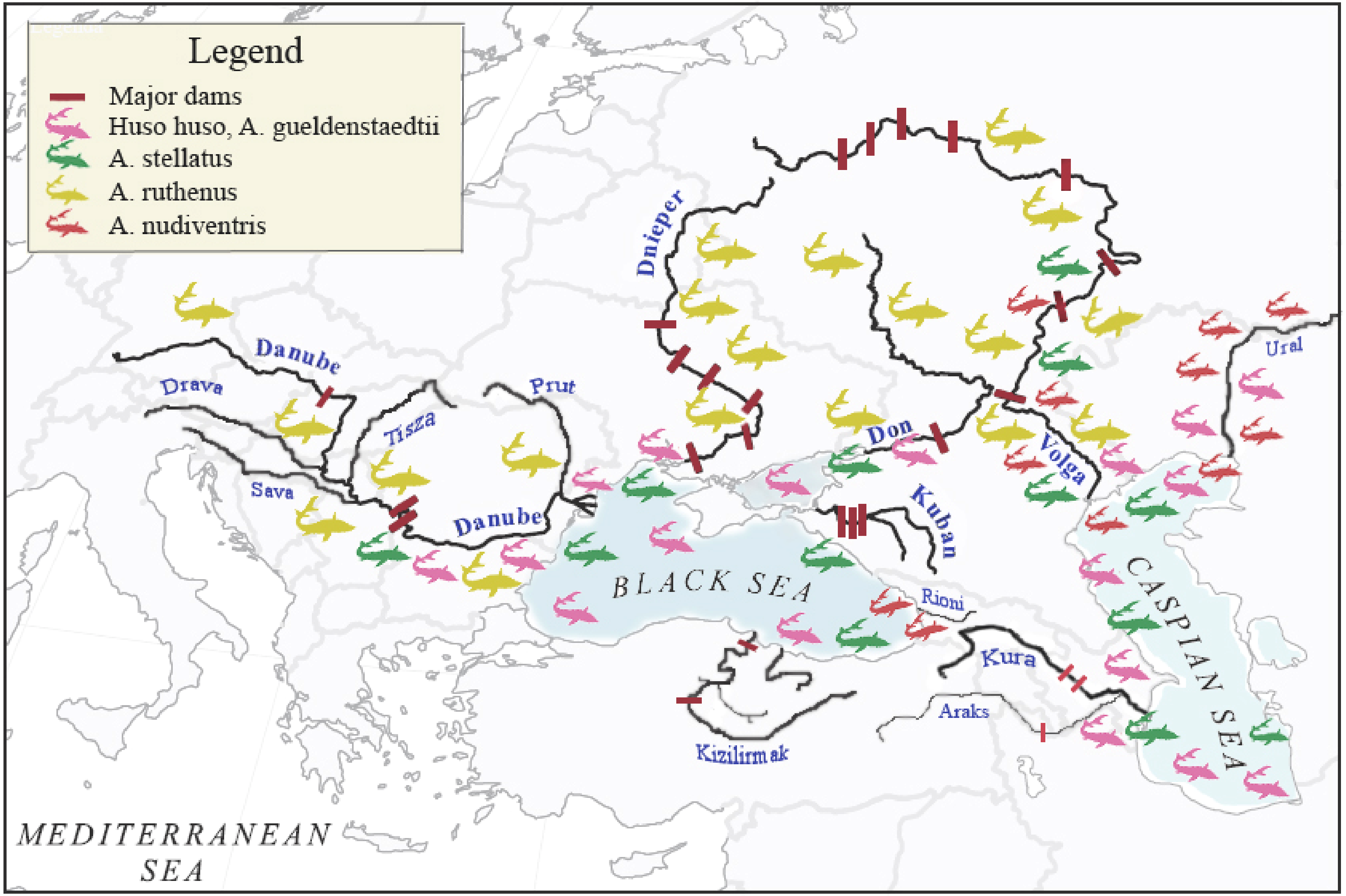

Figure 6 - Distribution of sturgeon species in the Black and Caspian Sea Basins (Pikitch et al., 2005)

1.2.5 Importance

The economical importance of today's Acipenserids has not always been recognized. Before the Middle Ages humans considered sturgeons a nuisance, and when they were caught accidentally by fishermen they were either thrown overboard, used as fertilizer or fed to livestock (Stegemann, 1994). All this changed during medieval times when sturgeon roe started being appreciated by the Russian Royal Court. In England, King Henry I (Anonymous, 2011i) proclaimed the species a "royal fish" and compelled fishermen, by the force of law, to bring their catches to the imperial treasury (Anonymous, 2000c). Soon after, caviar entered the cuisine of nobles from all over the world, and its demand rose significantly. Becoming increasingly rare, the price of caviar (Table 2) soon skyrocketed from less than $ 1 per kg in the early 1900s (Gordon, 2003) to over more than $ 5 000 per kg in 2004 (Pikitch et al., 2005). With more than 95% of the global market, Caspian and Black Sea sturgeons are the world's most important natural caviar producers (Pikitch et al., 2005).

Table 2 - - Retail prices for 1 kg of Caspian caviar (FAO, 2003)

Update	Supplier	Beluga 000	Beluga 00	Golden Osetra	Osetra	Sevruga
01/11/2002	Markys Caviar	$ 1 562	$ 1 278	$ 2 377	$1 014	$ 890
01/11/2002	Paramount Caviar	N/A	$ 1 188	N/A	1 584 $	$ 1 320
01/11/2002	Seattle Caviar Company	N/A	$1 496	N/A	1 760 $	$ 1 408
01/11/2002	Dean & DeLuca	N/A	$ 1 584	N/A	2 224 $	$ 2 100
01/11/2002	Tsar Nicoulai Caviar	N/A	$ 1 254	N/A	1 700 $	$1 448
01/11/2002	Caviateria	$ 3 900	$ 1 463	$ 3 700	1 700 $	$ 1 624
01/11/2002	Petrossian Caviar	$ 3 340	$ 1 500	$ 3 000	2 600 $	$1 980

Today, sturgeons have many purposes: caviar, besides being a gourmet delicacy is also used as ingredient in cosmetics and pharmaceutical products (CITES, 2000), meat is processed and sold smoked, marinated or frozen (Carocci et al., 2004), isinglass is extracted from the swim bladder and used as paint stabilizer (Anonymous, 2009f) or clarifying agent (Anonymous, 2010h) and hides are tanned and used to produce leather items (Stoll et al., 2009). Aquarium shop owners have also found a use for juvenile Acipenserids by selling them as ornamental fish (Carocci et al., 2004).

As it happened with many other economically valuable species, sturgeons were overexploited and catches soon collapsed. In order to satisfy the increasingly high-demand sturgeon farms began developing in the 1900's and are nowadays the main producers of caviar and other sturgeon products, cashing in impressive amounts of money. Only in 2008, according to FAO data, 25 683 tones of sturgeon were produced worldwide with a total market value of $ 105 339 000.

As well as having an obvious economical value, Acipenserids are perfect biological models of watershed health (WWF, 2002a,b). Having almost no natural predators after reaching adulthood, sturgeons are affected only by the environmental conditions (Lagutov and Lagutov, 2008). Their presence or absence from a river system reveals the health of that particular environment. Bioaccumulation is one of the aspects that can be easily studied in sturgeons due to their long life cycle and late maturation (Lagutov and Lagutov, 2008). Acipenserids are also indicator of the anthropization level in different aquatic ecosystems. It has been observed that rivers which suffer severe modifications to their natural environment have fewer or even lack sturgeons, in comparison to their previous condition (Lagutov and Lagutov, 2008).

The social-economical development of particular areas where there has been a history of sturgeon exploitation is another aspect that can be evaluated with the help of sturgeons. In well developed areas, where sound resource management is implemented, sturgeon fishing is either prohibited or strictly monitored by the government, whereas in poor communities poaching and illegal fishing presents a serious threat for wild sturgeons (Lagutov and Lagutov, 2008).

1.2.6 Present population status

The first historical references mentioning sturgeon fishing are more than 2400 years old. It has been suggested that the ancient Egyptians learned how to salt and marinate roe and fish meat in order to make them last longer through difficult times (Gordon, 2003). The oldest record on paper found of the word "kaviar" dates back to the 1240s, in the writings of Batu Kan (Anonymous, 2000c). In the Lower Danube River and N-W Black Sea Coastal area the earliest mentioning of sturgeon fishing originates from the 400s and 500s, during the time of the Greek colonization (Nikcevic et al., 2003). Strabo wrote: "*In the Scythian north sturgeon are caught and they are as big as dolphins*" (Bacalbasa-Dobrovici, 2002). Intense exploitation of sturgeon species began in the 16th century and lasted until the end of the 20th century, when catches began decreasing dramatically.

According to FAO FishStatJ (Figure 7), today sturgeon catches worldwide have fallen from 32 000 t in 1970 to less than 3000 t. The trend also applies to the landings collected from Romania and Bulgaria where in less than 40 years catches were reduced by more than 75%. Statistical data provided by FAO between 1970 and 2005 shows that landings in the region were largest (~325 tonnes) in 1973 and started collapsing significantly after the 1990s. Between the 4 major species that still exist in the Black Sea and the Danube River, the most abundant one, according to Prodanov (1997) is the Russian sturgeon, followed by sevruga and beluga. It has, however, to be mentioned that after the collapse of the communist regime in Romania (after 1989), the catch statistics became unreliable due to administrative corruption and severe poaching.

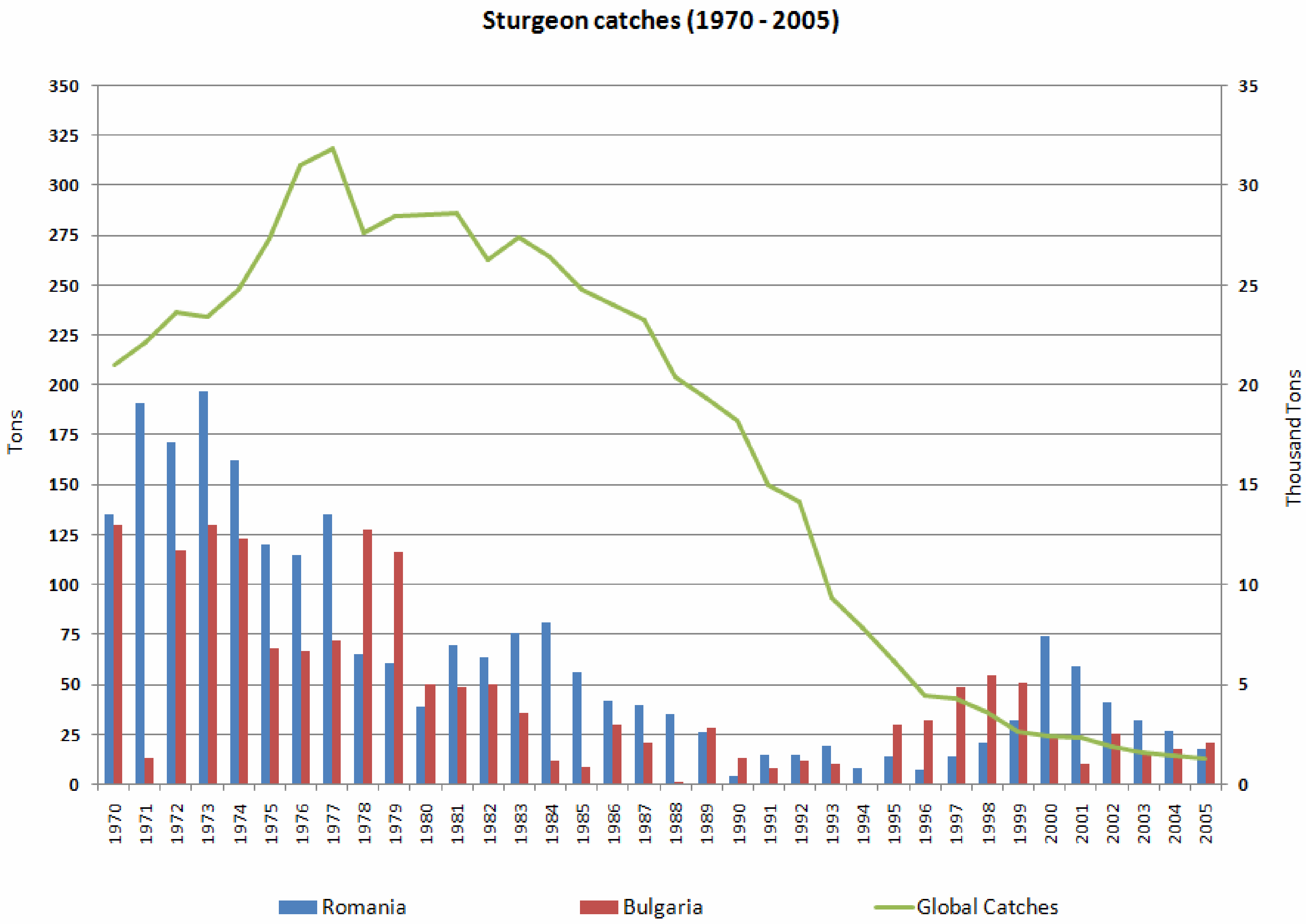

Figure 7 - Romanian and Bulgarian sturgeon catches and the global trend (1970-2005)
(Calderini and Sibeni, 2010 - FAO FishStatJ)

Chapter 2 – Conservation of sturgeons in the NW Black Sea and Lower Danube River

1.1 Causes of decline

Sturgeons are one of the oldest animal species of the planet. Because of their high adaptability, Acipenserids are able to live in very different environments, from the cold rivers of Siberia and Canada to the warm seas of the Mediterranean and the Black Sea (Hernando et al., 2009). In order to survive in these environments they managed to find specific niches that were unoccupied and, after getting adjusted, began their prosperous reproduction.

For the perpetuation of the species to be successful in such environments a number of biotic and abiotic factors need to be taken into consideration (Khodorevskaya et al., 2002):

- water quality (turbidity (Kotenev, 2009), temperature (Ferguson and Duckworth, 1997, Khodorevskaya et al., 2002, Ustaoğlu and Okumuş, 2004), oxygen concentration (Ferguson and Duckworth, 1997), velocity (Graham and Murphy, 2007), salinity (Lagutov and Lagutov, 2008))
- habitat availability (number of reproduction areas, substrate quality)
- distance to the spawning site
- number and fitness of broodstock reaching the spawning site
- food availability to the newly hatched fry

2.1.1 Deterioration of the natural environment

The human invasive development rapidly altered numerous environments that sturgeons got adapted to in millions of years, triggering their decrease in numbers all over the world.

<u>Obstacle to migration and artificialization of rivers</u>

River regulation is among the first on the list of human activities that has a detrimental impact on sturgeon species (Pikitch et al., 2005). Damming of the main rivers inhabited by Acipenserids shortens and in part, hinders their upstream migration to their former historic spawning grounds (Khodorevskaya et al., 2002). Even though homing fidelity has yet to be confirmed for sturgeons, a certain preference for previous reproduction grounds has been observed in several species of sturgeons (Suciu, 2008).

Construction of dams began approximately 5000 years ago, by the Egyptians (Yang et al., 1999), but most of today's existing dams, around half of them were built in the 1960-1980s (Lenhardt et al., 2006). In Europe only 3 major rivers remain undammed: the Guadiana (Portugal), the Amur (Russia and China) and the Ural (Kazakhstan) (Pikitch et al., 2005). Barrages reduced water levels causing the disappearance of more than 85% of the Danube's floodplains (Graham and Murphy, 2007). On the lower part of the river two dams significantly affected the local sturgeon populations: The Iron Gates I and the Iron Gates II. The first was constructed in 1969 at river km 942 and the second in 1984 at river km 868 (Hensel and Holčík, 1997). Shortening the migration distance by half, caused the disappearance of most of the species situated in the middle and upper part of the Danube, with the exception of the potamodromous *Acipenser ruthenus* and the fresh water form of *A. nudiventris*, which were able to survive in small numbers (Jarić et al., 2009).

The considerable shrinking of habitat causes severe concentration of breeders at the remaining spawning sites. For example, in areas preferred by the Russian sturgeon, egg densities higher than 4000 eggs m^{-2} have been observed (Billard and Lecointre, 2001). This agglomeration is not beneficial for reproduction because it leads to embryo suffocation (Smith and Hobden, 2011) and favors fungal contamination (Brannon et al., 1985).

The occurrence of land-locked populations is another problem that emerged with the introduction of hydrotechnical constructions (Puzzi et al., 2009). Unable to spawn with the populations situated on the other side of the barrage, sturgeons from both sides are exposed to the risk of inbreeding and genetic drift which can seriously affect the viability of the species (Ferguson and Duckworth, 1997).

Water quality is another factor that was altered by dams. Temperature, turbidity and water flow are constantly changed by the hydroelectrical power plants located in the vicinity of the dams. The lowered downstream water velocity favors siltation (Billard and Lecointre, 2001) and prevents the formation of floodplains that were once used by sturgeons as spawning grounds (Ustaoğlu and Okumuş, 2004). It has been observed that mud accumulation obstructs eggs from sticking to the hard substrate found on the river bottom (Lagutov and Lagutov, 2008) and leads to a reduced survival of the newly fertilized eggs. Silt also clogs crevices that are found in the rocky substrate, thereby impeding larvae to hide from predators (Anonymous, 2004d).

Other reasons listed in the literature, that led to the degradation of sturgeon habitat are: river bank development (Anonymous, 2009c), gravel extraction (Williot et al., 1997), engineering works for river navigation (i.e. canalization) (Ustaoğlu and Okumuş, 2004), deforestation of alluvial plains (Graham and Murphy, 2007) and water pumping for irrigation purposes (Ustaoğlu and Okumuş, 2004).

Pollution

With the ongoing technological impact on society, more and more agricultural (pesticides, fungicides, herbicides) (Hernando et al., 2009), domestic and industrial sewage (Pikitch et al., 2005) and oil products (Khodorevskaya et al., 2002) end in the rivers. Researchers suspect that these pollutants are responsible for a series of morphological and physiological alterations such as: anomalies in muscles (Khodorevskaya et al., 2002, Graham and Murphy, 2007), degeneration of oocytes (Ruban, 2002), hepatotoxicity (Billard and Lecointre, 2001), accumulation of toxins and heavy metals in tissues (Khodorevskaya et al., 2002), etc. Being benthic feeders and having a long lifespan, bioaccumulation could be a serious problem for sturgeons (Beamesderfer and Farr, 2002).

Due to poor management, pollution in the NW Black Sea and Lower Danube River has reached alarming levels, tens to hundreds of times higher than those found in the Earth's oceans. In the Black Sea over 20 000 kg km^{-3} of polluting agents have been concentrated through time (Bacalbasa-Dobrovici, 2002). In the Danube, nitrogen and phosphorus concentrations increased from 1.4 and 0.10 mg/l in the 1950s to 7.2 and 0.33 mg/l, respectively, in the 1990s (Anonymous, 2011e). The main cause of this high accumulation of nutrients in the river probably originated from the intensive use of agricultural fertilizers during the communist regime. According to Lenhardt et al. (2006), these high concentrations "*led to many hypoxic and anoxic events*" which "*decreased zoobenthos and microalgae stocks*", the main food source of sturgeons, both in the Danube and the Black Sea.

2.1.2 Commercial exploitation

Overexploitation is one of the biggest threats that Acipenserids are exposed to. Because of their high commercial value sturgeons have been fished for more than 5 centuries, but the worst damage to the wild population was made in the 1900s with the advent of new technology (GPS, sonar) (Graham and Murphy, 2007) and high-performance fishing gear (speed motor boats, nylon gillnets, resistant hooks, etc (Nikolaev et al., 2009). Due to overexploitation, the remaining individuals reach sexual maturity faster in order to replenish the already reduced population (Anonymous, 2007c) It has been observed that in less than 50 years global sturgeon catches dropped from 20 thousand tones in the 1960s to less than 5 thousand tones in the 1990s (Pikitch et al., 2005). In the Romanian part of the Danube River catches in the late 1990s were only one tenth of those in the 1960s (Calderini and Sibeni, 2010).

Since catches started collapsing a series of regulations have been issued by global governments but this has not solve the problem. Poaching expanded and is still affecting sturgeon stocks all over the world. Different experts state that the amount of the illegal catches exceeds the size of the legal catches (Ustaoğlu and Okumuş, 2004). It is assessed that on the world market 50% of all trade comes from the black market (Graham and Murphy, 2007). There has been no official evaluation of the unreported sturgeon catches in the NW part of the Black Sea; however, an estimation made in 1995 stated that in the entire Black Sea, approximately 600 tonnes of sturgeons were fished illegally, 12 times the reported catches (Bacalbasa-Dobrovici, 2002). Furthermore, Graham and Murphy (2007) suspect that the level of poaching in the Black and Azov Sea is 19 to 29 times larger than the reported landings.

Commercial fishing and poaching cause serious problems for the sturgeon stock because they aim for certain specimens, usually mature females ready to spawn (Lagutov and Lagutov, 2008). Thus, present populations have a destabilized age structure with many small and young individuals (Bacalbasa-Dobrovici, 2002). Accidental by-catches are also contributing to the extermination of sturgeon species. Juveniles are often caught and die suffocated in nets with small mesh size meant for teleosts (Ustaoğlu and Okumuş, 2004).

2.1.3 Other threats

Along their 200 million years of existence, in order to survive, Acipenserids gained certain advantages that present teleosts lack, such as: a broad feeding spectrum, different patterns of migration like potamodromy and anadromy, wide spawning temperatures, longer fertility of eggs and sperm, the existence of protective scutes in juveniles and so on (Ustaoğlu and Okumuş, 2004). Humans unfortunately profit from many of their biological and life-history adaptations.

Because of their anadromous lifestyles, sturgeons are predictable fishes, so capturing them does not impose a serious problem for experienced fishermen (Ustaoğlu and Okumuş, 2004). With more than 15% of their body weight consisting of caviar (WWF, 2000, Gordon, 2003), females are their main target. Having no sexual dimorphism (Graham and Murphy, 2007), a lot of males are captured as well and then dissected in order to verify if they are carrying roe or not. As a result of their late maturity and infrequent reproduction (Pikitch et al., 2005) sturgeons are unable to compensate for the high loss of individuals and are barely capable to reproduce in order to maintain a genetically viable population (Billard and Lecointre, 2001).

Destruction of benthic fauna

The alterations made by humans in riverine and marine ecosystems did not only affect sturgeons but also the whole living biota (Bacalbasa-Dobrovici, 2002). Changes in salinity, temperature, water flow and pH were strongly felt by numerous organisms, including microalgae and zoobenthos, the main diet of sturgeons (Lenhardt et al., 2006). With less food available sturgeons struggled to survive.

Trophic competition and natural enemies

After the majority of their feeding grounds got destroyed by humans, competition between the remaining benthic feeders intensified. In the NW part of the Black Sea the invasion of the *Mnemiopsis leidyi* ctenophore has the most serious impact on the sturgeon population because it "*reduces the availability of zooplankton and consumes eggs and larvae*" (Billard and Lecointre, 2001). In the Danube, *Silurus glanis* is one of the main fish species that compete with sturgeons for the same food resources (Vecsei, 2001). When this fish reaches adulthood it changes its diet and becomes an opportunist predator (Puzzi et al., 2009), feeding mostly on eggs, larvae (including of sturgeons) and small fish (Vecsei, 2001).

Diseases and infestations

Sturgeons, like many other aquatic species, are exposed to numerous infestations and diseases. Unfortunately, studies on the viral, bacterial and fungal infections of Acipenserids are scarce in general (Bauer et al., 2002) and inexistent for the NW Black Sea and Lower Danube River. Most of the existing researches are undertaken in Russia and the adjacent countries of the Caspian Sea (Bauer et al., 2002). Viral infection of sturgeons is rarely mentioned in the scientific literature, nevertheless this does not mean that it does not occur (Bauer et al., 2002). In North America for example, two types of viruses have been described: iridioviruses and hepatoviruses (Tzankova, 2007). Bacterial infections are listed in literature more often. One of the species that is known to affect, especially, young sturgeons is *Flavobacterium johnsonae.* Fungal diseases are caused by species of the Saprolignicea family which target the eggs of sturgeons, causing extremely high mortality rate (Bauer et al., 2002).

Systematic data on parasite diversity is more or less documented in various scientific studies; however, data about their life-cycle, ecology and prevalence is missing (Bauer et al., 2002). Most of the parasites found on Acipenserids are usually host-specific and include 27 species so far. There are, however, some species that are typical for other groups of fish, such as cypriniformes and salmoniformes (Choudhury, 1997). The most common infectious agents are representatives of the Protozoa (*Trypanosoma anura, Cryptobia acipenseris, Pleistophora sulci*), Cnidaria (*Polypodium hydriforme*), Vermes (*Nitzschia sturionis, Diclybothrium armatum, Amphilia foliacea, Bothrimonus fallax, Eubothrium acipenserinum, Rhipidocotyle kovalae, R. illense, Acrolichanus auriculatus, Deropristis hespida, Skrjabinopsolus semiarmatus, Piscicapillaria tuberculata, Cystoopsis acipenseris, Hysterothylaceum gadi, H. bidentatum, Cucullanus sphaerocephalus, Cyclozone acipenserina, Leptorhyncoides plagicephalus, Piscicola geometra, Hemiclepsis marginata)* and Crustaceans (*Pseudotracheliaster stellatus, Dichelesthium oblangum, Ergasilus sieboldi, Caligus lacustrisi)*. These pathogens and parasites are causing significant harm to Acipenserids, such as: behavioral changes, gill and intestine inflammations, skin deterioration, perforation of the swim bladder, anemia and, if the infestation is large enough, it may even lead to death (Bauer et al., 2002). In the Black, Azov and Caspian seas more than 60 species of parasites have been identified (Mokhayer, 2005) but no specific studies on sturgeon parasites of the NW Black Sea and Lower Danube River have been published.

2.2 Conservation and rehabilitation measures

Along with the growth and development of the human population, more and more natural ecosystems get destroyed in the process. Sturgeons are among the species that are most affected by these rapid environmental changes, not only as a consequence of habitat degradation but also due to overexploitation. It is important to know that Acipenserids, besides their economical value are also important in terms of "*evolution, ecology [….] and recreation* " (Ramsar Declaration, 2005), thus it is crucial that mankind contributes to their survival, not their extermination.

2.2.1 International instruments

With an anadromous life-style and international distribution, local measures for sturgeon conservation are not enough; hence, a series of global and regional institutions have been created with biodiversity conservation as their main purpose.

World Conservation Union (IUCN)

One of the first international organizations to be represented on a global level was the World Conservation Union, formerly known as International Union for the Conservation of Nature and Natural Resources (IUCN) (Anonymous, 2011a). Founded in 1948 after an international conference in Fointainebleu, France, IUCN's main goal is "*to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable*" (Anonymous, 2011a). The organization was also the starting point of many other environmental forums and NGOs. In 1972 for example, at the first United Nations Conference on Human Environment, IUCN suggested the founding of 3 conventions (MacDonald, 2003):

- Convention on the International Trade in Endangered Species (deals with the import and export of vulnerable plant and animal species)
- Ramsar Convention (has as main goal the conservation of internationally important wetlands)
- World Heritage Convention (contributes to the conservation of the World Heritage)

One of its most noteworthy products is the IUCN Red list of Threatened Species (Figure 8), described as „*the world's most comprehensive inventory of the global conservation status on plant and animal species*" (Anonymous, 2011b).

The utility of this product has been in "*determining the most urgent priority areas for conserving biodiversity, from the global level down to the scale of individual sites*"(Hoffmann et al., 2008). The list was first conceived in 1963 and by 1996 5205 species were evaluated, resulting in 11% of all birds and 25% of all mammals being listed as threatened (Anonymous, 2011b). Besides classifying each species in different threat classes, the Red List is also a valuable tool which provides important scientific data about the listed species that can easily be accessed online (Rodrigues et al., 2005).

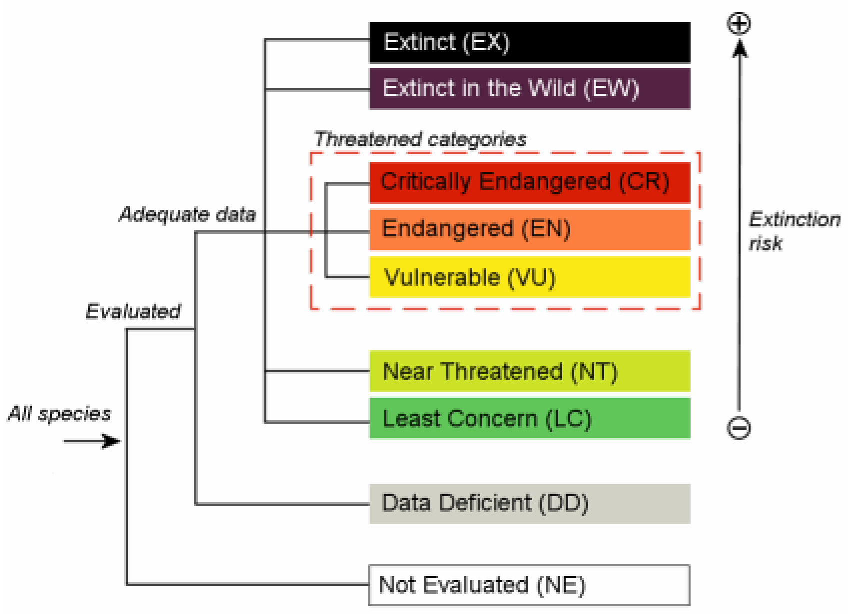

Figure 8 - IUCN Red List structure of categories (Anonymous, 2009e)

The direct implication in sturgeon conservation by IUCN began in 1988 when *Acipenser sturio* was the first of its group to be assessed in the Red List (as endangered). In 1994 the Sturgeon Specialist Group (SSG) was established in order to evaluate the status of the extant Acipenserids (Restivo, 2006). By 1996 all sturgeons were categorized in the Red List (Anonymous, 2009a). From the NW Black Sea and Lower Danube River, *Acipenser sturio* was listed as critically endangered, *A. stellatus*, *A. nudiventris*, *A. gueldenstaedtii* and *Huso huso* as endangered and *A. ruthenus* as vulnerable. Unfortunately, since their first listing in 1996 the situation degraded most likely due to damming and overfishing and the classification needs to be updated (Anonymous, 2010e).

Washington Convention (CITES)

With the amplification of international commerce of wildlife a conservation agreement between trading governments was sorely needed. Hence, in 1969 the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was born. In 1975, with only 21 members, the convention entered into force. Until today, the adherence document has been signed by 175 countries including Bulgaria (1991), Romania (1994), Ukraine (1999) and Serbia (2006) (Anonymous, 2011h).

The convention has multiple roles in wildlife conservation such as informing public opinion, advising stakeholders and supervising trade of endangered species. The agreement of the convention is signed voluntarily by the Parties and has a "non-binding" character (Anonymous, 2010b). However, if the terms are not respected by its members and the range states do not comply CITES has the authority to impose certain penalties such as restricting import and export of species from those states (Anonymous, 2011g).

In order to inform its members to what species are in need of protection, CITES elaborated a listing system composed of 3 Appendices (Anonymous, 2011g):

- Appendix I:
  - includes species threatened with extinction;
  - trade is allowed only under exceptional circumstances such as scientific research or if the species is farmed.
- Appendix II:
  - includes species that are not necessarily threatened with extinction, but may become so unless trade in specimens is not strictly supervised and regulated;
  - trade is permitted only if a permit is granted from CITES.
- Appendix III:
  - includes species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade.

Decisions about the inclusion of certain species in the CITES Appendices are taken during meetings of the Conference of Parties (CoP) held once every 2.5 to 3 years. CoP 10, which took place in 1997, was one of the most important conferences for sturgeon conservation. The outcome of the meeting was the inclusion of all Acipenseriformes in CITES Appendix I and II (Raymakers, 2006). From the 6 species found in the NW Black Sea and Lower Danube River only one is listed in the Appendix I – *Acipenser sturio,* the rest being listed in Appendix II (Anonymous, 2011c).

Listing Acipenserids in its Appendices is not the only contribution that the convention is bringing to help sturgeon conservation. CITES is also involved in consulting and guiding the signatory parties in elaborating adequate legislation and establishing export quotas through several official documents such as:

- 1997, Harare – CoP10 - Resolution Conf. 10.12 regarding the conservation of sturgeons (Anonymous, 1997);
- 2000, Gigiri – CoP11 - Resolution Conf. 10.12 (Rev.) regarding the conservation of sturgeons (Anonymous, 2000a);
- 2000, Gigiri – CoP11 - Resolution Conf. 11.13 regarding the universal labeling system for the identification of caviar (Anonymous, 2000b);
- 2002, Santiago – CoP12 - Resolution Conf. 12.7 regarding the conservation of and trade in sturgeons and paddlefish (Anonymous, 2002a);
- 2002, Santiago – CoP12 - Resolution Conf. 12.8 regarding the review of Significant Trade in specimens of Appendix-II species (Anonymous, 2002b);
- 2002, Santiago - CoP12 Doc. 42. - Implementation of Resolution Conf. 10.12 (Rev.) on conservation of sturgeons (Anonymous, 2002c);
- 2004, Bangkok - CoP13 - Resolution Conf. 12.7 (Rev.) regarding the conservation of and trade in sturgeons and paddlefish (Anonymous, 2004b);
- 2007, Hague - CoP14 Doc. 60.2.1 - Amendment of Resolution Conf. 12.7 (Rev.); Proposal of the standing committee's working group on sturgeons (Anonymous, 2007b)
- 2007, Hague - CoP14 - Conf. 14.7 regarding the management of nationally established export quotas (Anonymous, 2007a);
- 2010, Doha - CoP15 - Conf. 14.7 (Rev.) regarding the management of nationally established export quotas (Anonymous, 2010c).

Bonn Convention

The Convention on the Conservation of Migratory Species of Wild Animals (CMS), also known as Bonn Convention is an intergovernmental treaty established under the patronage of the United Nations Environment Programme (Anonymous, 2004c). The convention was founded in 1979 in Bonn, Germany and entered into force in 1983 (Anonymous, 2008). Throughout its history numerous countries acceded to CMS amongst which Romania (1998), Bulgaria (1999), Ukraine (1999) and Serbia (2008) (CMS, 2011). Today more than 115 states agreed to protect and conserve the world's migratory species.

Like IUCN and CITES, CMS has also adopted a listing system with 2 Appendices (Anonymous, 2004a) which include endangered migratory species in need of conservation:

- Appendix I:
  - contains "*migratory species that have been categorized as being in danger of extinction throughout all or a significant proportion of their range*";
  - capturing individuals is prohibited except for artificial propagation research purposes and extraordinary circumstances;
- Appendix II:
  - contains "*migratory species that have an unfavorable conservation status or would benefit significantly from international co-operation organized by tailored agreements";*
  - capturing individuals and commercial exploitation is permitted only under the convention's guidance and supervision.

In order to protect migratory terrestrial, avian and aquatic animals the treaty (Anonymous, 1982) advises its' Parties:

- to promote, cooperate in or support research relating to migratory species;
- to provide immediate protection for migratory species included in Appendix I;
- to conclude global or regional agreements such as legally binding treaties or Memoranda of Understanding for migratory species listed in Appendix II;
- to conserve or restore the habitats of endangered species;
- to prevent, remove, compensate for or minimize the adverse effects of activities or obstacles that impede the migration of the species;
- to prevent, reduce or control factors that are endangering or are likely to further endanger the species.

In 1999, at the 6^{th} meeting of the Conference of the Parties (CoP 6) the decision to include all Acipenserids in Appendix II was made (Geßner et al., 2010), after realizing that international trade regulation via CITES is not enough to protect the species (Anonymous, 2010g). *Acipenser sturio* was also listed in Appendix I, at the 8^{th} Conference of the Parties that took place in 2005 in Gigiri, Nairobi (Anonymous, 2011d).

2.2.2 National instruments

2.2.2.1 Sturgeon management and legislative history in Romania

Records of fishing regulation in the Lower Danube date back to the Middle Ages, when rich noblemen allowed peasants to fish on the lakes in their domains for a fee. In the 1800s fishermen received leasing rights in certain water districts. After 1896 the State became the major administrator of waters. The income gained from sales of the catch was split into 3 equal parts between the state, the fishing-gear owners, and the fishermen (Navodaru, 1998). From 1947 through 1989, during the communist regime, sturgeon harvesting was strictly controlled by the goverment (Suciu, 2008). The fishermen were employed by state companies, and the caught fish were sold at a fixed price set by the government (Navodaru, 1998). In 1974 a law of fishing was released (Law No. 12 of July, 26, 1974), which remained valid until after the revolution in 1989. The document specified measures to protect and propagate valuable fish species by restoring natural spawning areas, encouraging acclimatization of other commercially valuable non-endemic sturgeon species in the Danube, and supported the establishment of sturgeon hatcheries and fish farms. Catch quotas, size regulation and prohibition periods were also stipulated in the text of the law (Anonymous, 1974). Sturgeon was predominantly fished around the town of St. George for the reason that fishing of sturgeon was only allowed in the Black Sea (Suciu, 2008).

The political instability after the fall of the communist regime in 1989 caused serious damage to the already threatened sturgeon stocks. Following certain political and economical interests, fishing permits were issued easily with no consideration of the state of the exploited resources (Bacalbasa-Dobrovici, 2002). Until 1998, under the Law No. 12 of 1994, the fishery administrators were the stakeholders agreed by the Ministry of Agriculture and Food. Fortunately, Danube Delta Biosphere Reserve Authority managed to obtain partial autonomy from the state and though Law No. 82 of 1993 and Law No. 69 of 1996 was granted the competence to issue individual fishing permits and supervise catches in the Danube Delta region (Navodaru, 1998).

Finally, after 11 years of uncertainty and numerous recommendations from CITES and other national and international forums, a new law of fishery and aquaculture was adopted in 2001 (Law No. 192 of 2001) (Anonymous, 2001). This document introduces more explicit sturgeon conservation measures such as specific prohibition periods during spawning migration and size and mesh regulations. In the same year, CITES hosted the 45th Standing Committee meeting, in Paris. There, Romania and the other Lower Danube River and Black Sea countries were requested to implement an urgent transboundary management system for their sturgeon stocks. Later on that year, after the first Regional Meeting held in Sofia (Bulgaria) concerning the protection of the Lower Danube River and Black Sea sturgeons (Figure 9), where 7 of the Black Sea and Azov Sea basin countries participated (Romania, Serbia, Bulgaria, Ukraine, Russia, Georgia and Turkey) the Black Sea Sturgeon Management Action Group (BSSMAG) was established, having 2-3 representatives of each country. The main communication through the group was made via email, which was monitored by 2 experts of the CITES Secretariat Scientific Support Unit. The purpose of this email group was to share up-to-date information on the status of sturgeon stocks. With the help of BSSMAG, at the Second Regional meeting held in 2003 in Tulcea (Romania), a "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" was defined. The document was fallowed in 2005 by the signing of the official agreement between the Fisheries and CITES Management Authority concerning implementation of the Regional Strategy (Suciu, 2008).

Figure 9 - The participants of the first regional meeting of CITES on the conservation and sustainable use of sturgeons in the Danube (26 of October 2001), from Sofia, visiting the sturgeon farm Boliardze (Suciu, 2010).

The key elements of the agreement were (Suciu, 2010):

a) *Improvement of knowledge of the biology of sturgeon populations spawning in the Danube River*
b) *Progress in description of their genetic diversity, in artificial propagation, and restocking procedures*
c) *Improving monitoring of catches and overall fishery management*
d) *Determining the existence of possible sub-populations and adapting the management plan accordingly*
e) *Improving national regulations and their implementation / enforcement*
f) *Implement adaptive management under CITES*
g) *Revise and implement Management Plan*
h) *Financing of activities described in the Plan*

In the same year (2005), in order to better manage the Romanian fish resources, the National Agency for Fishery and Aquaculture (NAFA) was founded, a public institution of national interest which operates under the Ministry of Agriculture and Rural Development. The agency was established by the Emergency Ordinance no. 69 of December 2004, amending and supplementing Law no. 192 of 2001 on living aquatic resources, fisheries and aquaculture having the following attributes (Anonymous, 2011f):

a) To develop and implement national strategies and regulations relating to: conservation and management of living aquatic resources existing in natural fish habitats, aquaculture, processing and organizing the market in fishery products, aquaculture and fisheries structures
b) To implement the Common Fisheries Policy
c) To manage wild living aquatic resources, except those in the Biosphere Reserve "Danube Delta", which are managed by the Administration of the Biosphere Reserve "Danube Delta"
d) To control and inspect fishing activities
e) To privatize commercial fisheries and their facilities

f) To grant concessions of land where fishing arrangements are located, except those on the Biosphere Reserve "Danube Delta", and other related fields in the public domain, according to law

g) To sell state land that has built fisheries arrangements, including special facilities located on land to represent, on a internal and external level, in the field of activity and within the limits set by the laws in force;

After 4 years (2002-2005) of monitoring 9 essential sturgeon population indicators (number of fishermen, number of fishing hours using standard gillnets of 100 m, number of fish captured, catch/species/fishing zones, Catch per Unit of Effort, sex ratio, distribution of length frequencies/classes, distribution of age frequencies, Rapid Rural Appraisal (RRA) of captures in 5 selected fishing sites) (Suciu, 2008) CITES convinced the newly established NAFA that continuing to harvest sturgeons from the wild would be extremely detrimental for their survival. Hence, through the Joint Ministerial order 262 of April 2006 (Anonymous, 2006) the Romanian Ministry of Environment and Agriculture declared a 10-year moratorium on wild sturgeon fishing. The order was also supported by the Emergency Ordinance no. 23 of 2008 on fishing and aquaculture which prohibited fishing of sturgeons from the wild, except for restocking purposes. In order to approve the 2008 Ordinance, Law no. 317 of September 2009 was promulgated. The normative act however, brought significant changes to the previous text. The phrase “*fishing sturgeon for any purpose other than restocking*” defined in the 2008 Ordinance unlawful, was replaced with the more permissive phrase “*constituted an offence […] unauthorized sturgeon fishing*”. This change caused serious public unrest. National and international NGO’s along with other scientific forums picketed against the modification forcing politicians to revise the newly released normative act. After long debates, in September 2009 a new law was issued (Law no. 219 of November 2010) which again made clear that all wild sturgeon catching was strictly prohibited except for restocking purposes (Anonymous, 2010f). In 2011 Bulgaria joins Romania in its’ attempt to recover the Danubian sturgeon populations by also implementing a complete ban both on the river and in the sea (Suciu et al., 2011). For a better understanding, in Appendix I are showed, synthesized, most important dates concerning sturgeon history and conservation.

2.2.2.2 Sturgeon conservation measures in Romania

Monitoring programmes

During the communist administration all sturgeon harvesting was rigorously controlled by the state (Navodaru, 1998). After the 1989 Revolution the former regime was replaced by a democratic government. This forced Romania to go through a major transitive period which implied serious administrative and legislative changes (Suciu, 2008). Unfortunately, the enforcement of fishing regulations was overlooked and for almost 11 years no adequate monitoring studies of sturgeon stocks were conducted.

Monitoring harvested sturgeons

In 2001, taking into account the CITES recommendations, the Ministry of Agriculture issued a special Order (No. 350 of 2001) which compelled fishermen to install commercial tags (Figure 10) on every specimen of sturgeon caught from the wild and to fill-in special reporting sheets that would later on be sent to the Fisheries Authority. To facilitate access to the collected data, in 2003, a special website was composed called “Sturgeons of Romania and CITES”. The page – (http://www.ddni.ro/rosturgeons/) besides having the role of collecting and disseminating capture data also provided valuable information about BSSMAG and CITES activity, export quotas and current legislation. Since 2003, CITES issued export quotas only for the caviar originated from the sturgeons included in the on-line data base of catches in order to encourage fishermen to respect the new legislation (Suciu, 2008). The measure raised significantly the confidence in the monitoring of harvested sturgeons by bringing most of the caviar to the legal market due to the higher sale prices that stakeholders would obtain from exporting their product. Also, until the 2006 moratorium, the website collected a record amount of individual data on captured sturgeons: 717 specimens in 2003, 863 specimens in 2004, 535 specimens in 2005.

Figure 10 - Commercial tags used to mark legally captured sturgeons (Suciu, 2010)

The data obtained from the captured fish was used in a series of studies including analyzing the age class structure of the Lower Danube sturgeon population. By studying fin rays sections submitted to the Danube Delta National Institute for Research and Development (DDNI) by professional fishermen, collected from the 2003 harvested sturgeons, it was observed that stellate sturgeons (*A. stellatus*) did not seem to be affected by the excessive fishing activities occurring in the river because the percent of the first time spawners involved in the study was high enough (70%). The situation of the Danube sturgeon (*A. gueldenstaedtii*) and beluga sturgeon (*Huso huso*) however, was completely different. The analyzed data revealed very small age classes of first time spawners and could be considered as a consequence of the uncontrolled overfishing during the 1990-2000 (Navodaru, 1998). The 2005 acute age determination results convinced the Romanian authorities to impose the 10 year moratorium in 2006.

<u>Monitoring YOY wild sturgeons</u>

In the 1997-1999 one of the first monitoring programmes regarding the abundance of young of the year (YOY) sturgeons (1.5 – 2 month old / 10 – 30 cm long) started being developed by DDNI on an 8 ha river bottom area. Special trammel nets of 96 m long, 2.5 high, with 20 mm mesh size were drifted downstream at water depths of 6 – 14 m and carried across 850 m along the right river bank (Suciu, 2008). The study continued systematically every year at Danube River Km 118. Until 2009 945 YOY sturgeons were captured, photographed, measured, weighted, sampled fin clips, tagged using Floyd Fingerling Tags (FFT) and released back into the river. Throughout the whole study, only 3 anadromous (*A. gueldenstaedtii*, *A. stellatus* and *Huso huso*) and one potamodromous species (*A. ruthenus*) were found. With the help of an article published by Kynard in 2004 on the reproductive ecology of short nose sturgeons in the Connecticut River, the DDNI Sturgeon Research Group was able to predict when sturgeon breeding occurs in the Danube. The collected data from 1999-2004 revealed that sturgeons reproduce at temperatures between 9 and 17 ºC 1 day before the date which marked the beginning of the continuous decrease of river water in Tulcea. However, in 2009 due to the atypical hydrology of the river, spawning of beluga and sterlet occured at lower temperature than expected, at 7 ºC (Onara et al., 2011). This discovery shortened the time required to monitor sturgeon breeding in future years from approximately 2 months to only 32 days (Suciu, 2010). In 2006, in order to facilitate further sturgeon monitoring studies the Romanian Authorities financed at Isaccea (Danube River Km 100) the construction of the Monitoring Station for Migratory Fish, which became operational from 2009 (Paraschiv et al., 2006).

In 2010 the recruitment rate of the sturgeon data collected between 2000 and 2010 was estimated (Figure 11). Calculating the Catch Per Unit Effort (CPUE) revealed that most successful spawning years were 2000, 2005 and 2010 for *Huso huso*, 2005, 2009 and 2010 for *A. ruthenus*, 2000 and 2005 for *A. stellatus* and the year 2000 for *A. gueldenstaedtii*. If we refer to the reproductive success, the years 2000, 2005 and 2010 were slightly better for beluga, in comparison with other years probably because female beluga who escaped from being captured in 2000 returned to reproduce in 2005 and again in 2010. The highest CPUE from all species studied was found in 2010 in *A. ruthenus*. The most probable reason for this reproductive success was that the 2005 generation was able to reach sexual maturity and spawn for the first time in 2010. For *A. stellatus* and *A. gueldenstaedtii* the 2006-2010 the CPUE values were extremely low, under 0.5 suggesting low reproduction rates and low number of spawners (Suciu, 2010). A detailed table of CPUE results for the 2000-2008 timeline is provided in Annex II at the end of this paper.

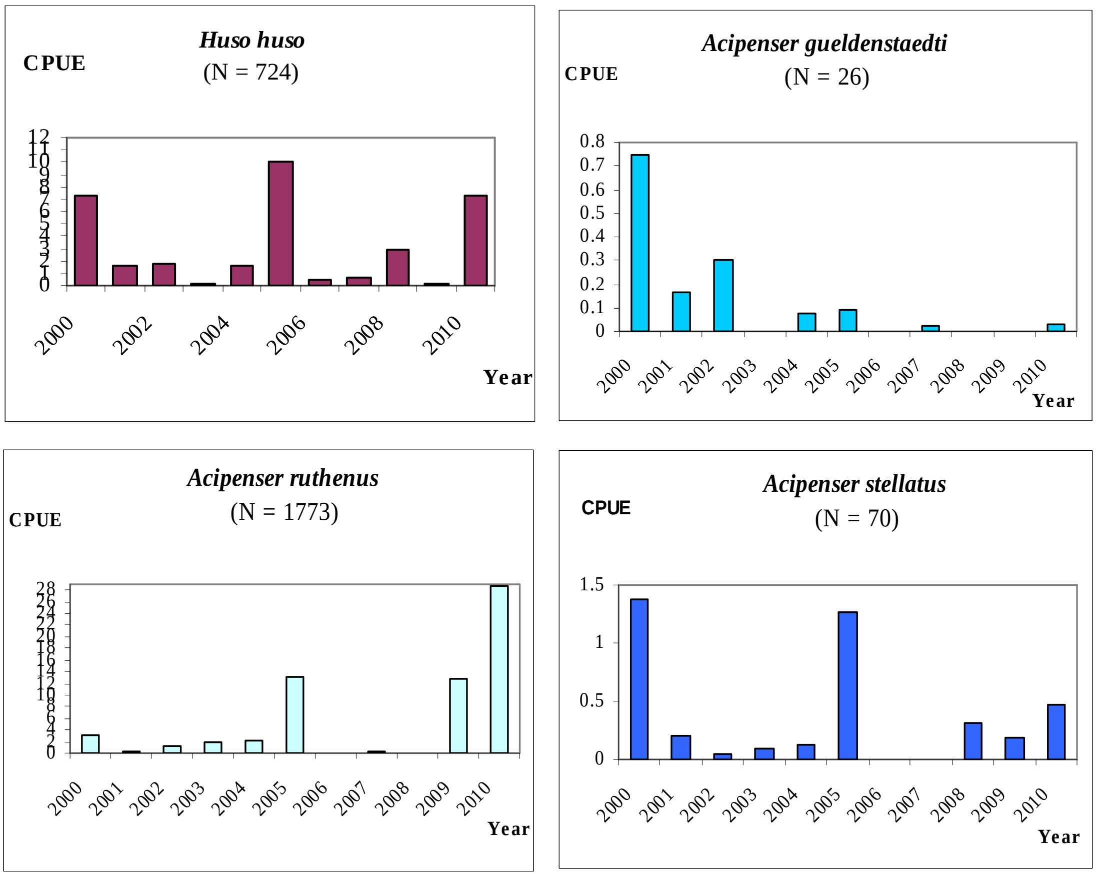

Figure 11 - CPUE evolution of the *Huso* huso, *A. gueldenstaedtii*, *A*, *ruthenus* and *A. Stellatus* between 2000-2011

Monitoring movement and distribution

Between 1996-2003 in order to be able to study the migration of sturgeons from the NW Black Sea and Lower Danube River, DDNI introduced for the first time in Romania, acoustic telemetry (Kynard et al., 2002). In 2009 4 mature beluga males were implanted with acoustic transmitters and released into the Danube in order to study their post-spawning downstream migration. One of the adults was recaptured in April 2010 and used as spawner in the Tamadau sturgeon farm (Onara et al., 2011). In order to locate the fish 7 VR2 automatic receiver arrays were set up in May 2010 on the Danube as showed in Figure 12. Only one male was recorded by the submersible receivers heading towards the Black Sea. The first acoustic telemetry study of stocked YOY beluga sturgeons movement was launched in August 2010, when 26 farmed and 32 wild YOY beluga sturgeons were implanted with acoustic transmitters and released into the Danube. After almost 3 months the VR2 transects were lifted to the surface and the information collected was uploaded onto a PC. 20 out of the 32 wild belugas and all farmed belugas were recorded by the river bank receivers. First data analysis revealed that almost all recorded wild YOY sturgeons migrated on St. George branch while most of the farmed belugas migrated on Chilia branch. Further studies are necessary to understand the phenomena and reach final conclusions (Suciu et al., 2011).

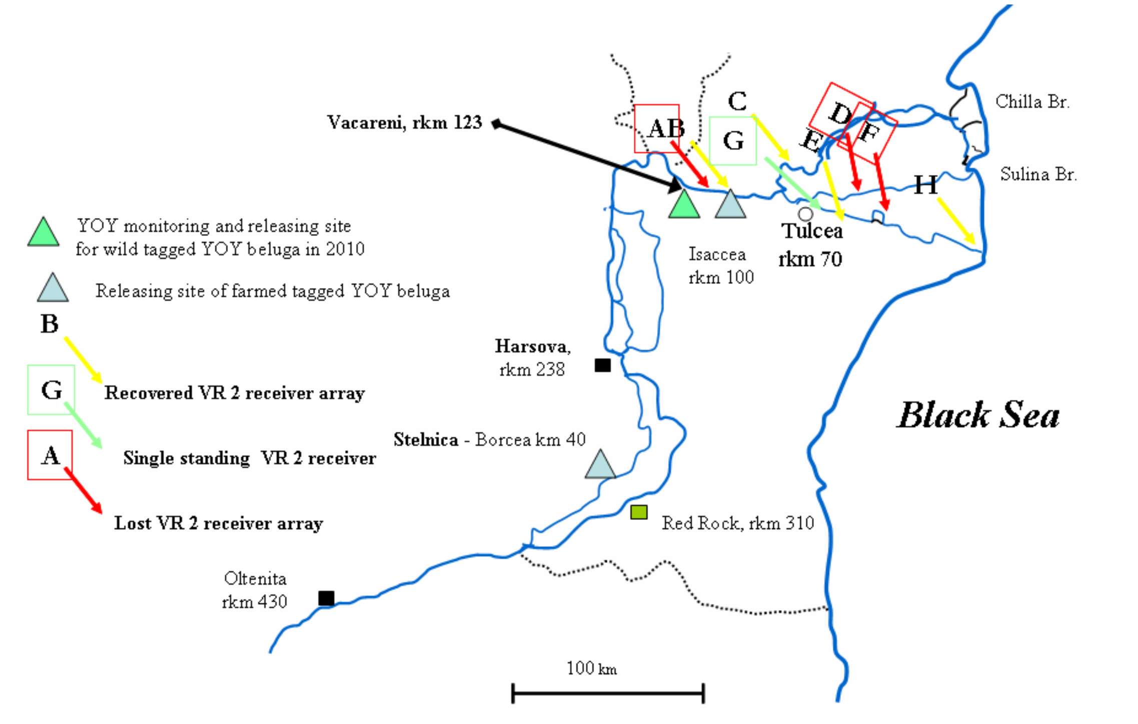

Figure 12 - Map of Venco VR2 arrays set in the Danube (Suciu et al., 2011)

Supportive stocking programmes

First artificial reproductions of sturgeons in Romania were performed during the communist regime at various hatcheries in the Danube Delta (Gura Gârlu□ei near Brăila, Gura Saltavei near Hâr□ova). After the completion of the Iron Gates I, restocking programmes were financed from the Romanian and the Serbian side of the Danube. For 15 years, the Cetate Gorj hatchery sponsored by the Romanian Electrical Organization (RENEL) restocked small quantities of sterlet fry and fingerlings in the Danube. On the other river bank the Serbian (then Yugoslavian) Hydroelectric Organization built and funded each year the Kladovo hatchery, which mainly focused on releasing *Huso huso* fry. Unfortunately, neither of the 2 hatcheries was very successful in their restocking attempt because many of their fry were released too young into the wild (Bacalbasa-Dobrovici, 2002).

In 1991, the Fisheries Research Center of Gala□i, subsidized by the state, started research on the controlled reproduction of *A. ruthenus, A. stellatus* and *A. gueoldenstaedtii* and, after two years managed to restock the Danube for the first time. In order to obtain the biological material for fertilization, wild mature individuals were captured and hormonally stimulated to spawn. After collecting the necessary sperm and roe, breeders were released back into their natural habitat. The eggs were artificially fertilized and kept in special tanks until they reached the optimum size to be released. After only 4 years of funding the government decided to stop payment but the institute continued its' activity. Until 1999 46,000 fry of *A. ruthenus, A stellatus* and *A. gueldenstaedtii* were restocked by the institute (Bacalbasa-Dobrovici, 2002).

In 2005 the results of the monitoring studies submitted by the DDNI institute convinced the Ministry of Environment and Agriculture that the situation of the Danube sturgeon population was critical and vital actions were urgently needed in order to save the remaining stocks. Therefore, in the same year, taking on the risk of insufficient knowledge in terms of the genetic structure of Danube sturgeon populations, a number of low-to-medium level supportive stocking programmes for *A. stellatus* and *A. gueldenstaedtii* captured from the wild were initiated (Paraschiv et al., 2006) and continued throughout the fallowing 5 years. After 2006, other Danube sturgeons were included in the same stocking programme, depending on the captured brood stock. According to the Annex I of the Ministry Order No. 262 of 2006 "*a minimum effective number of 100 brood fish per generation interval*" is required for artificial propagation. This means that the annual effective number (Ne), depending on the species generation interval is 7 in *Huso huso,* 12 in *A. gueldenstaedtii* and 14 in *A. stellatus* (Suciu, 2011).

The supportive stocking programme commenced every year by capturing the required number of wild adult sturgeons by the institutions implicated in the activity. All brood fish were marked and numbered using Passive Integrated Transponder (PIT) tags and moved to hatcheries, but not before clip fins were sampled for future DNA analysis. Females were injected with Nerestin (a synthetic hormone) to induce ovulation. The roe was obtained without killing the fish, by making a small incision in the ovarian duct. Sperm was extracted with a silicon tube attached to a syringe. After artificial fertilization the eggs were moved to the nurseries where they stayed between 5 and 7 months. Adults were safely transported and set free into the wild. After reaching the optimal size (~35 cm for *Huso huso,* 26 cm for *A. gueldenstaedtii* and ~20 cm for *A. stellatus*), the larvae were tagged using Coded Wire Tags (CWT) and released at the same spot their parents were captured (Suciu, 2011).

During 2005-2009 the Danube was repopulated with 432 898 juvenile sturgeons worth over 4 million euro. In 2010 no artificial propagation was possible due to lack of funding. The success of the supportive restocking is currently unknown because no specific studies have been carried out yet. However, during the 2007 experimental fishing conducted between June and September by DDNI to monitor natural recruitment, 7 CWT tagged stellate sturgeons from December 2006 were captured at river Km 100 and 119 (Suciu, 2010). In 2010 no restocking has been carried out due to lack of governmental financing.

Recommendations and conclusions

Sturgeons area one of the oldest living fish in the world. Being highly adaptable, they managed to survive for over 200 million years in a variety of environments. The main morphological and biological features that differentiate them from other fish are: cartilaginous endoskeleton, large elongated bodies, trunk covered by scutes instead of scales, anadromic and potamodromic behavior and long lifespan.

Humans from early beginning discovered numerous uses in sturgeons. Caviar became one of the most appreciated gourmet delicacies in the world. Besides their roe other parts of the fish are highly valued such as: meat for consumption, skin for making tanned leather, isinglass for clarifying different alcohol beverages and live fingerlings for aquariums.

In our days most of the 27 species are vulnerable, endangered or close to extinction and NW Black Sea and Lower Danube species make no exception. Their current threatened status is caused by a combination of factors, almost all of them related to human activities. Romania is one of the last states in Europe that still has wild sturgeons reproducing in its' waters. Unfortunately today these populations are facing extinction due to destruction of spawning habitat, uncontrolled harvesting and lack of an effective management system.

In order to protect the survival of the remaining species a series of measures have been taken locally, nationally and internationally. IUCN, CITES and CMS listed Acipenserids in their lists and appendices concerned on conserving threatened species. Conferences and meetings are organized annually during which different scientific parties share information, debate and sign conservational agreements and treaties. During one of these meetings CITES was assigned to monitor international trade and allocate catch quotas to its members. While some actions proved to be successful (the case of the American Winnebago lake sturgeon) Pikitch (2005) asserts that "*with only a few exceptions, current management practices, restoration capacity and habitat characteristics fall far short of that needed to provide a reasonably good prognosis for local populations*". However, it is of crucial importance to be perseverant and learn from past mistakes in order to achieve better future results.

The NW Black Sea and Lower Danube River sturgeon stocks are shared by more than one country therefore conservational efforts tend to be in vain if not all parties participate in exchanging information and enrolling in conjoined actions. In 2001, in order to better facilitate communication amongst countries that have open access to the NW Black Sea, BSSMAG was founded. With its' help in 2003 a "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" was signed by Serbia, Bulgaria, Romania and Ukraine. In 2006, after DDNI reported the critical situation in which the remaining sturgeons were to the Ministry of Environment and Agriculture, a 10 year moratorium was issued and supportive stocking programmes were initiated. In order to verify if these measures have a positive impact on the species a number of monitoring programmes are being conducted by Romanian research institutes.

Unfortunately, management effectiveness appears to be tightly related to each country's political stability. The World Crisis severely affected Romania in the last years causing numerous changes in ministries and public institutions. As a result funding between 2009-2011 for research and supportive stocking was either cut down completely or delayed. In order to maintain monitoring study and implement a well structured management system the Romanian research institutes were forced to seek international funding.

Continuous future conservation measures are of great importance if sturgeon restoration is to be achieved. In scientific literature a series of solutions are recommended, such as:

- prohibition of all wild sturgeon harvesting
- use of sturgeon farming as an alternative for supplying the world's market demand
- providing former sturgeon fishermen with remuneration activities
- periodical repopulation of rivers using wild broodstock
- implementation of stricter laws and regulations
- elimination of high and low level corruption
- eradication of illegal fishing
- continuous monitoring of the wild population
- improvement of methodology and technological equipment to facilitate *in situ* observation
- enhancement of genetic screening techniques using microsatellites
- raising of public awareness about the importance of protecting sturgeons

For a higher success rate, all the suggestions listed above should not be treated as isolated actions but as complementary measures that work better as a whole. The fact that sturgeons are now threatened is a result of our irresponsible behavior towards the environment we all live in. It is therefore also are responsibility and best interest to help preserve one of the world's oldest gene pool.

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Appendix I

Important events of Danube River sturgeon species (after Bloesch, 2005)

Date	**Event**
200 million years ago	The first Acipenseriformes (order sturgeons and paddlefishes) appear in Europe. Early diversification takes place in Asia, from where the order spreads across the Northern Hemisphere.
65 million years ago	Dinosaurs go extinct; sturgeons survive.
5th to 6th century B.C.	Sturgeons in the Lower Danube River are fished by inhabitants of the Greek colonies in the area.
1053	*Huso huso* is mentioned as providing important rations for troops marching along the Upper Danube River in Austria.
Beginning of the 16th century	Catches in the *Huso huso* fishery of the Middle Danube River decrease rapidly.
18th century	Fishing of migratory sturgeons in the Austrian stretch of the Danube River is abandoned, due to their scarcity.
Beginning of the 19th century	A lack of legislation leads to over-fishing and subsequently the fishery in the Lower Danube collapses. Sturgeon fishery, however, is not seriously affected and catches remain at about 1,000 metric tons.
19th century	Occasional catches of *A. ruthenus* in the Danube between Regensburg and Passau in this part of the Upper Danube River document the remnants of a dying population.
1869	The first artificial propagation of a sturgeon species is performed in Russia.
1926	The last-known specimen of *A. stellatus* from the Slovakian section of the Danube River is caught on February 20, at Komarno.
1950	A Sturgeon Ranching Programme (SRP) is initiated in the former USSR for the Sea of Azov, where sturgeon stocks are decreasing due to the degradation of water quality and damming of rivers.
1962	The implementation by the USSR of a moratorium on commercial sturgeon fishery in the Caspian Sea provides some relief for sturgeon stocks.

1965	The last known specimen of *A. stellatus* from the Hungarian section of the Danube River is caught at Mohacs.
1965	The last recorded sighting of *Acipenser sturio* in the Danube River.
1972	Iron Gates I dam of the Danube River is completed, confining migratory sturgeons to the 942 kilometers downstream of the Iron Gates gorge, cutting off important spawning sites in the Middle Danube River.
1972–1976	Serbian and Romanian sturgeon catches increase significantly below the Iron Gates I dam during the five years following its completion.
1985	Iron Gates II is completed, further reducing the length of the Danube River that is available to migratory sturgeons to just 863 kilometers.
1985	*Acipenser sturio* and *Acipenser nudiventris* are included in the Bulgarian Red Data Book as endangered. No mentioning of the other Danube sturgeon species.
1987	A single *Huso huso* is caught at Paks, Hungary (300 cm in total length and 181 kg in weight; between river kms 1526–1528) on 16 May. This animal might either be considered a relic or potentially documents the occasional passage of migratory sturgeons through the Iron Gates shipping locks. The catch of two specimens of the freshwater form of *A. gueldenstaedti* in the Slovakian stretch of the Danube river suggests that a relict population of this form might still persist.
1989	A second major collapse in Lower Danube River fisheries occurs, this time affecting the sturgeon fishery in particular. A sharp decline in sturgeon catches is observed. A male *A. nudiventris* is captured in Drava river at Heresznye measuring 147 cm and weighting 20.5 kg.
1992	One specimen of *A. nudiventris* is captured in a sidearm of the Danube at Asvanyraro, Hungary.
1996	First listing of all Acipenseriformes in IUCN’s Red List of Threatened Species. All Lower Danube stocks are vulnerable, endangered or critically endangered.
1998	From 1 April, all Acipenseriform species are listed in the appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), triggering the implementation of regulations concerning the international trade in sturgeons and sturgeon products, including a system of catch and export quotas.

1997–1999	5 subadult *A. gueldenstaedti* are caught by fishermen in the Hungarian stretch of the Danube. One of the captured female is 123 cm long and weighs 11 kg
March 1999	Commencement of sturgeon restocking at CITES recommendations. Order RD-94/14.03.1999 issued by the Ministry of Environment and Waters asks that for every 1 kg of caviar to be exported, at least 30 juvenile sturgeons should be released into the Danube River. 26 700 juvenile sturgeon restocked in 1999
October 2003	The catch of a male *A. nudiventris* in the Serbian stretch of the Danube River proves the continuing presence of this species in the Danube Basin.
May 2005	A further specimen of *A. nudiventris* is captured and photographed 4 km upstream from the confluence of the Mura and Drava Rivers on 23 May 2005.
November 2005	Standing Committee of the Bern Convention adopts “The Action Plan for the Conservation of Sturgeons (Acipenseridae) in the Danube River”
April 2006	Romania imposes a 10 year moratorium on sturgeon fishing in the Danube and Black Sea (Government Order 262 of 2006).
2007	CITES decides to ban sturgeon caviar exports collected from wild fish populations in Lower Danube countries.
2008	Bulgaria banns sturgeon fishing in the Black Sea.
October 2009	The details of the Romanian ban are changed by the 317 Law of October 13, 2009. Sturgeon fishing is allowed but only with special authorization
September 2010	The first resettlement of *Acipenser sturio* takes place in Szigetköz, near Győr, in Budapest Vizafogó and in Ercsi in the coordination of the Nothern Dunántúl Directorate of the Environment and Water
November 2010	The text of the Romanian 317 Law of October 13, 2009 is changed by the 219 Law of November, 11, 2010 which again prohibits all sturgeon fishing except for repopulation purposes.
March 2011	Bulgaria banns sturgeon fishing in the Lower Danube for one year.

Appendix II

Results of monitoring YOY sturgeons born in the lower Danube River (2000 - 2008) (Suciu, 2008)

Data	**Nr. of netting**	**Beluga** % No. **CPUE**		**Russian sturgeon** % No. **CPUE**		**Stellate sturgeon** % No. **CPUE**		**Sterlet** % No **CPUE**		**Total** % No. **CPUE**	
12-14.07. **2000**	**8**	**59**	58.42 % **7.375**	**6**	5.94 % **0.75**	**11**	10.89 % **1.375**	**25**	24.75 % **3.125**	**101**	100 % **12.625**
26 – 29.06 2001	16	27	84.37 % **1.687**	2	6.25 % **0.125**	0	0	3	9.38 % **0.187**	32	100 % **2.00**
10 – 13.07. 2001	8	12	57.14 % **1.5**	2	9.52 % **0.25**	5	23.82 % **0.625**	2	9.52 % **0.25**	21	100 % **2.625**
Total 2001	**24**	**39**	73.6 % **1.625**	**4**	7.6 % **0.167**	**5**	9.4 % **0.208**	**5**	9.4 % **0.208**	**53**	100 % **2.208**
19-20.06. 2002	14	59	71.08 % **4.214**	3	3.62 % **0.214**	0	0	21	25.30 % **1.5**	83	100 % **5.928**
03 – 25.07. 2002	29	16	25.80 % **0.551**	10	16.13 % **0.345**	2	3.23 % **0.069**	34	54.84 % **1.172**	62	100 % **2.138**
Total 2002	**43**	**75**	51.72 % **1.744**	**13**	8.97 % **0.302**	**2**	1.38 % **0.046**	**55**	37.93 % **1.279**	**145**	100 % **3.372**
10-26.06. 2003	17	0	0	0	0	0	0	0	0	0	0
9-25.07. 2003	18	***5*** *Hb.*	7.25 % **0.278**	0	0	3	4.35 % **0.167**	61	88.40 % **3.389**	69	100 % **3.833**
Total 2003	**35**	***5***	7.25 % **0.143**	0	0	**3**	4.35 % **0.086**	**61**	88.40 % **1.743**	**69**	100 % **1.971**
22 – 30.06. 2004	14	**40**	70.18 % **2.857**	1+2 *Hb.*	**0.214**		0 % 0	17	29.82 % **1.214**	60	100 % **4.071**
1 – 23.07. 2004	27	**29**	26.61 % **1.074**	0	0	5	4.59 % **0.185**	75	68.80 % **2.778**	109	100 % **4.037**
Total 2004	**41**	**69**	40.83 % **1.683**	***3***	1.77 % **0.073**	**5**	2.96 % **0.122**	**92**	54.44 % **2.244**	**169**	100 % **4.122**
14 – 17.06. 2005	6	**73**	84.88 % **12.17**	1	1.16 % **0.166**	0	0 %	12	13.96 **2**	86	100 % **14.33**
05 – 07. 07. 2005	5	**37**	20.11 % **7.4**	0	0	14	7.61 % **2.8**	133	72.28 % **26.6**	184	100 % **36.8**
Total 2005	**11**	**110**	40.74 % **10**	**1**	0.37 % **0.091**	**14**	5.19 % **1.273**	**145**	53.70 **13.182**	**270**	100 % **24.55**
27 – 30 .06. 2006	13	**3**	**0.23**	0	0	0	0	0	0	3	**0.23**
3– 7. 07. 2006	15	**13**	**0.87**	0	0	0	0	0	0	13	**0.87**
12 – 14.07. 2006	7	**2**	**0.29**	0	0	0	0	0	0	2	**0.29**
Total 2006	**35**	**18**	100% **0.51**	0	0	0	0	0	0	**18**	100% **0.51**

Data	Nr. of netting	Beluga % No. CPUE		Russian sturgeon % No. CPUE		Stallete sturgeon % No. CPUE		Sterlet % No CPUE		Total % No. CPUE	
29 – 31.05. 2007	13	**18**	**1.384**	0	0	0	0	4	**0.308**	22	**1.692**
5 – 8.06. 2007	14	**5**	**0.357**	0	0	0	0	3	**0.214**	8	**0.571**
12 – 14.06. 2007	14	**4**	**0.286**	1	**0.071**	0	0	8	**0.571**	13	**0.928**
Total 2007	41	**27**	62.7% **0.659**	**1**	2.3% **0.024**	0	0	**15**	35 % **0.366**	**43**	100% **1.049**
11 – 13.06. 2008	5	**26**	**5.20**	0	0	1	**0.20**	0	0	27	**7.40**
17 – 20.06. 2008	9	**14**	**1.55**	0	0	1	**0.111**	1	**0.111**	16	**1.778**
23 – 27.06. 2008	12	**34**	**2.83**	0	0	6	**0.50**	2	**0.166**	42	**3.499**
Total 2008	26	**74**	87.06% **2.846**	0	0	**8**	9.41% **0.308**	**3**	3.53% **0.115**	**85**	100% **3.269**
TOTAL		**471**		**25**		**48**		**401**		**945**	