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Endangered migratory sturgeons of the lower Danube River and its delta

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Synopsis

Historically, five acipenserid species migrated from the Black Sea into the Danube River: beluga *Huso huso*, Russian sturgeon *Acipenser gueldenstaedtii*, stellate sturgeon *A. stellatus*, ship sturgeon *A. nudiventris*, and perhaps European Atlantic sturgeon *A. sturio*. The freshwater sterlet *A. ruthenus* thrived in the Danube and its tributaries. Presently, only three anadromous species occur in the Romanian part of the Danube, *Huso huso*, *A. gueldenstaedtii*, and *A. stellatus*, while *A. ruthenus* lives in the Danube and its tributaries. Extreme depletion in the number of sturgeons was caused by many, primarily anthropogenic, factors which affected the Danube and the Black Sea shelf during recent last decades. Measures necessary for saving anadromous sturgeon species in the lower Danube are recommended.

Introduction

The Danube is the second longest river in Europe (2857 km). It is divided into three main regions: the upper Danube from the source to Vienna (890 km river length), the middle Danube from Vienna to Iron Gates Dam I (993 km river length), and the lower Danube from Iron Gates Dam I to the mouth (942 km river length). Thirty-five dams have been constructed on the upper Danube. The middle Danube was cut off from the lower Danube by construction of Iron Gates Dam I, built in 1970 (Figure 1). In 1984, the lower Danube was divided by the Iron Gates Dam II, located 80 km downstream from Iron Gates Dam I.

Until quite recently, five anadromous species of sturgeons migrated from the Black Sea into the Danube for spawning: the beluga, *Huso huso*, Russian sturgeon, *Acipenser gueldenstaedtii*, stellate sturgeon or sevruga, *A. stellatus*, ship sturgeon, *A. nudiventris*, and perhaps Atlantic sturgeon, *A. sturio* (Antipa 1916, 1933, Bănărescu 1964, Bacalbaşa-Dobrovici, 1989). In the 19th century, sturgeons swam upstream to Bavaria (Terofal 1980). The exclusively freshwater sterlet, *A. ruthenus*, also thrived in the Danube and its tributaries (Bănărescu 1964, Bacalbaşa-Dobrovici 1989). Presently, only *Huso huso*, *A. gueldenstaedtii*, and *A. stellatus* occur in the Romanian part of the Danube and their populations are impacted greatly by the dams and other installations (Bacalbaşa-Dobrovici 1991a, b). *Acipenser ruthenus* now lives primarily in the middle Danube and its tributaries. This paper reviews the depletion of populations of anadromous acipenserids in the lower Danube and discusses factors causing decreases in sturgeon populations in the Danube and Black Sea. The status of sturgeons in the upper and middle Danube is described by Hensel & Holčík (1997 this volume).

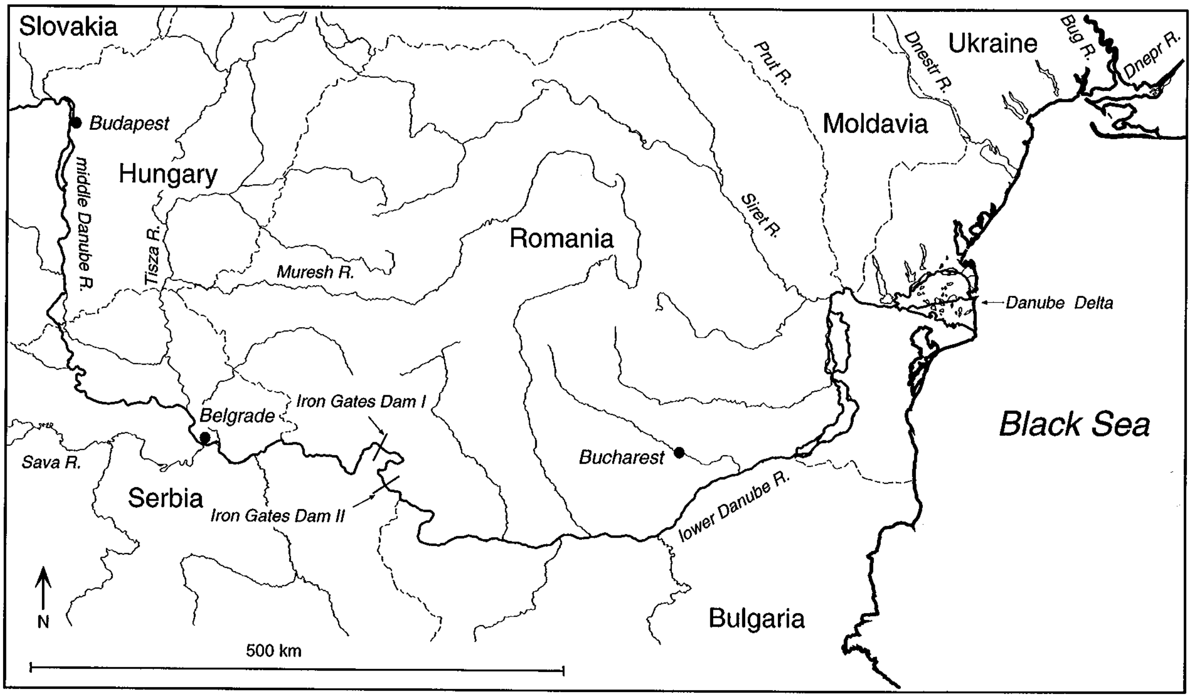

Figure 1. Map of the lower and portions of the middle Danube River and some major tributaries to show features related to sturgeon populations and migrations.

Sturgeon fisheries from ancient times to the 20th century

From ancient times, sturgeons had great economic importance in the Danube River region and were the basis of the population's wealth. Sturgeons of the Danube were mentioned by ancient Greek writers, Herodotus (484? – 425? B.C.) and Strabo (63? B.C. – 21? A.D.). Strabo wrote: 'In the Scythian north, sturgeon are caught and they are as big as dolphins' (translation from Strabo 1853). In Histria (a Greek port which existed 2200 years ago) the inhabitants were allowed to fish in the Danube mouth and to export salted fish to Greece and Rome without charge. Most of the exported fish were beluga and Russian sturgeon.

In the Middle Ages and until the end of the 18th century, sturgeons were an inexhaustible resource of the river (Giurescu 1964). Beluga were caught all along the Romanian part of the Danube (from the mouth to the Iron Gates), in the middle Danube and upstream up to Bavaria. Sturgeons thrived also in tributaries of the lower Danube including the Drava, Sava, Tizsa, Muresh, Siret, and Prut rivers (Figure 1).

In the 12–15th centuries, sturgeons were exported from the Danube area to Poland (Giurescu 1964). In 1409, Mircea the Great (prince of Vallachia) ordered all inhabitants of the villages located along the Danube to catch sturgeons three days a year for the court. The Italian monk Niccolo Barsari, who visited Moldavia in 1633–1639, mentioned that fishermen brought 1000–2000 sturgeons to Chilia every day. From here they were exported to Constantinopole, Poland, and Hungary. In 1690, the Austrian general Marsigli wrote that about 50–100 beluga were caught every day near Adakaleh Island (now submerged). In 1762, the French consul Peysonnel reported that about 25 000 beluga were caught annually in Chilia (Giurescu 1964).

Beginning in the 16th century, the town of Galati on the lower Danube was an important sturgeon fishing and market center. An Italian monk, Barsi, mentioned Galati as having a great abundance of different sturgeons and caviar. In 1646, another Italian, Bishop Bandini, wrote: 'Large beluga are caught here. You would not believe it if you have not seen it with your own eyes' (Giurescu 1964). In 1652, the traveler Robert Bargrave also noted that 'sometimes they catch such a big fish that they need 6–8 oxen to lift them together with a trap'.

Since the Middle Ages, sophisticated gear has been used for catching sturgeons and beluga in the lower Danube. Methods included fences made of wooden branches and provided with small gates for ships to pass through and big cage-like traps for sturgeons. The fence was attached to wooden poles placed into the river bed. Each installation lasted about seven months and was remade each spring because ice destroyed the fence and traps. Each site was operated by a team of 100–200 persons who lived nearby on special platforms.

Fourteen such installations near Chilia caught 1000–2000 sturgeons daily. In the 16th century, additional installations were located near the town of Ismail in the Danube delta (92 km from the mouth, Chilia Branch), in the Borcea Branch (from 248 to 370 km upstream), and in the Hungarian part of the river. In the Iron Gates zone sturgeons were caught by traps and iron baskets (Bacalbaşa-Dobrovici 1971).

Because of intensive fishing, declines in the populations of sturgeons were reported beginning in the early 19th century. In 1835, J. de Hagemeister wrote that beluga were much less abundant in the Danube (Giurescu 1964). In the 20th century, the catch of sturgeons in Romania (the lower reaches of the Danube River) dropped catastrophically and now the harvest is extremely small (Figure 2): only 11.5 metric tons in 1994 compared to about 200 metric tons per year in the 1960s (Bacalbaşa-Dobrovici 1991b). Not only the size, but also the structure of sturgeon populations in the Danube River changed dramatically. Individuals are much smaller and younger than in the past. *Acipenser sturio* disappeared from the sea catch, and there is a noticeable decrease in the numbers of *Huso huso*, *A. gueldenstaedtii* and especially *A. nudiventris*. Also, the population size of *A. stellatus* has decreased. Besides intensive fishing, other aspects of human activities have negatively impacted Danube River sturgeons, including deforestation, construction of hydrotechnical installations and dams, and pollution.

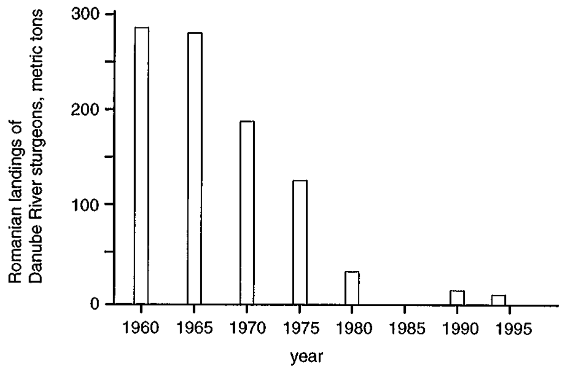

Figure 2. Decrease in the sturgeon catch in Romanian part of the Danube River. Data for 1960s through 1980s are from Bacalbaşa-Dobrovici (1991b).

Anthropogenic factors in the 20th century decline of Danube sturgeons

Deforestation

During the Middle Ages, forests located on the banks of the Danube River regulated the water level, and floods were rare. At the end of the 18th century, logging was officially encouraged, and persons who cut the trees were allowed to cultivate the cleared land. As a result, forested areas in Romania diminished from 55–60% in 1830 to 27% in 1930. Similar processes occurred in neighboring countries: in the Czech and Slovak Republics, only 34%, and in Bulgaria, only 29% of the historically forested areas now exist (Botzan 1984). Deforestation increased alluvial deposits, and water turbidity, which affected the sand, gravel and rock bottom of sturgeon spawning grounds.

Dikes and dams

Flood plains of the Danube changed drastically when dikes were built. Historically, the lower Danube flood plain included areas adjacent to the river (573 000 ha) and the delta (524 000 ha). At present, about 85% of the flood plains have been diked (Botzan 1984). The delta was diked to a lesser extent, and this stopped after the collapse of the communist regime (1989) for ecological reasons.

About 300 reservoirs in the Danube Basin were formed by damming. These lakes retain some alluvial deposits, especially large particles, and affect water levels in the Danube, which is 0.6 m higher than in historical times, and water velocity, which is slower in the riverine lakes region. In 1970, completion of the Iron Gates Dam I located 862 km upstream from the Danube mouth prevented sturgeons from reaching their historic spawning sites. Iron Gates Dam II, 80 km below the first project, shortened the possible migration to 862 km. A joint Bulgarian-Romanian dam at Turnu Magurele-Nicopol is planned, which would reduce the possible sturgeon migration to 265 km.

Pollution

Water pollution by heavy metals and pesticides in the lower Danube is very high (Oksiyuk et al. 1992) and it affects the entire biota (Pringle et al. 1993). No specific data are available on its impact on sturgeons, however.

Irrigation and gravel excavation

Water quality in the lower Danube is degraded by massive irrigation schemes. In Rumania, three million hectares of irrigated land decreases river flow and increases pollution by fertilizers and pesticides. Eutrophication now impacts the northwestern area of the Black Sea. Irrigation pumps kill fish larvae and juveniles. Sand and gravel taken from the Danube bed for construction work in the area near Calarasi (373 km) has destroyed sturgeon spawning grounds.

Water losses due to hydrotechnical constructions

Brackish water areas in the mouth of the Danube River and the northwestern part of the Black Sea depend primarily on flow in the Danube River, but natural flow is decreased by dams and irrigation. Other projects, such as shipping canals and junctions between different river branches in the delta, threaten to further alter the flow of the lower Danube. Fortunately, of all proposed projects (i.e., Levintov 1988), only the Rhine-Main-Danube Canal has been constructed. This canal uses water pumped into it from the Danube.

Diminishing role of the Danube Delta as a biofilter

The Danube Delta is an essential biofilter for the entire region. Also, it is the area of the contact of fresh riverine water with the brackish water of the Black Sea. Changes in water flow and circulation modified the whole ecosystem of the Danube Delta and affected its biofilter abilities. Poorly planned aquaculture and agriculture projects damaged the delta. Formerly, the Danube Delta was the largest area of reeds in Europe (almost 300 000 ha), a major component of its biofilter capacity. Unfortunately, 13.4% of the delta area (61 604 ha) was transformed into agricultural land during the communist regime (1948–1989). Attempts to cultivate reeds in a part of the delta created more problems because the heavy equipment which was used destroyed rhizomes of the natural reeds causing decreases in their area. Ill-conceived attempts at fish aquaculture on 53 000 ha of the delta failed, adding negative impacts on the biofilter capacity of the delta.

As a result of all these changes, eutrophication and turbidity increased in the delta, while biodiversity decreased, which in turn adversely affected the shelf area of the Black Sea. This shelf is crucial for sturgeons in the northwestern part of the Black Sea because this is where sturgeon live during the marine period of their life cycle.

Changes in the Black Sea

Geologic origin

The Black Sea has a long geological history, which has greatly impacted acipenserids. Originally a part of the Tethys Sea during the Upper Miocene (circa 20 MYBP), the Black Sea later, together with the Sea of Azov, Caspian and Aral seas, formed the Sarmatic (or Paratethys) Sea which covered the area from the Vienna basin to the Ural Mountains. In the Pliocene, the Sarmatic Sea was reduced to the smaller Pontic Sea, which included the three contemporary basins, the Aral, Caspian, and Black seas. During the Quaternary, these three basins separated. In the Pliocene (about 5 MYBP) the Strait of Gibraltar opened, and water from the Atlantic refilled the Mediterranean, which had been dry for about 1–2 million years. Eventually, the Mediterranean became reconnected with the Black Sea.

At present, water in the Black Sea is only half as salty as the Mediterranean Sea. The Black Sea water is divided into two strata. Due to the lack of vertical circulation, the lower stratum is abiotic. Within the surface stratum, the northwestern area is greatly impacted by three rivers: the Danube (which provides more than a half of the fresh water flowing into the Black Sea), the Dniester, and the Dnieper (together with the Bug River). This highly productive, low salinity zone is a good environment for the marine life of sturgeons.

The northwestern shelf of the Black Sea

Sturgeons migrating into the Danube River spend most of their life on the northwestern shelf of the Black Sea. The shelf is characterized by shallow water and a relatively flat bottom. Young sturgeon live and grow in this area, and adults return there after spawning in the Danube. Beluga feed mostly on fishes, while Russian and stellate sturgeons eat benthic invertebrates. During the last three decades, major changes in the biological equilibrium of the Black Sea occurred, affecting primarily the biota of the northwestern shelf.

Pollution

Pollution in the Black Sea is from tens to hundreds of times higher than that in the Atlantic or Pacific oceans and it is even higher than in the Mediterranean: 20 000 and 3775 kg km^{-3} of polluting agents in waters of the Black and Mediterranean seas respectively (Zaitsev 1992, 1993). Worse still, pollution is essentially perilittoral due to the perilittoral current in the Black Sea.

Eutrophication

Eutrophication of coastal waters had a serious impact on the Black Sea. Between the 1950s and the 1980s, the quantity of nutrient and organic substances brought by the Danube, Dnestr and Dnepr rivers into the Black Sea increased 400–500% (Table 1; see also Zhuravleva & Grubina 1993), causing intensive growth of phytoplankton from 670 mg m^{-3} (1950s) to 30 000 mg m^{-3} (Zaitsev 1991, 1993). The biomass of the jellyfish *Aurellia aurita* increased enormously from 1 million metric tons in the 1960s to 300–500 million metric tons in 1980. A simultaneous decline in the number of large planktonic crustaceans and planktophagous fishes occurred. Eutrophication also diminished water transparency by 50 to 80 percent and caused a drastic change in the benthic flora (Zaitsev 1992).

Effect of fish trawling

Bottom trawling devastated main areas of sturgeon habitat in the northwestern shelf and the Danube mouth. Over a 50 year period beginning in the

Table 1. Input of nutrient chemicals from the rivers entering into the northwestern part of the Black Sea (all values in parts million^{-1}, data from Zaitsev 1992).

	Danube River		Dnestr River		Dnepr River	
	1950	1986	1950	1986	1950	1986
Organic substances	2000	9800	100	246	250	664
Phosphates	13.00	50.00	0.14	1.00	0.80	4.00
Nitrates	97	238	2	13	55	89

1930s, the macrozoobenthic fauna near the Crimea decreased from 38 to 11 species, and their density diminished from 245 to 99 individuals m^{-2} (Zaitsev 1992).

Temporary hypoxic areas in the northwestern shelf

Eutrophication caused a new phenomenon, the appearance of temporary hypoxic areas, first noticed in August–September 1973. This hypoxic area affected 3500 km^2 between the Danube Delta and the Dnestr estuary (Zaitsev 1991, 1993). Since then, hypoxia has occurred periodically in the 10–40 m depth regions. Biological losses due to hypoxia between 1973 and 1990 were estimated at 60 million metric tons, including 5 million metric tons of fishes (Zaitsev 1993). Because of this destruction and periodic repopulation of the northwestern shelf area, molluscs and other benthic food organisms are represented by mostly young individuals. Besides threatening the survival of young sturgeons, hypoxia caused changes in populations of prey species inhabiting their feeding grounds.

Explosive growth of the ctenophore Mnemiopsis leidyi

The American comb jellyfish *Mnemiopsis leidyi* (or *M. maccradyi* according to Zaika & Sergeeva 1990) seems to have been introduced into the Black Sea in 1982 with the ballast water from ships; before this, it inhabited the North American Atlantic waters (Vinogradov et al. 1989, Travis 1993). In such an isolated marine basin with a depauperate fauna as the Black Sea, *M. leidyi* does not have competitors and its biomass grew very fast so that in August–September 1989 there were 800 million metric tons of this predator, which feeds on zooplankton, pelagic fish eggs, embryos and larvae (Zaitsev 1992). The abundance of *M. leidyi* produced a complete collapse of the anchovy fishery in the Sea of Azov in 1989. Changes in the faunal structure and distribution of invertebrates caused by *M. leidyi* (Kovalev et al. 1994) indirectly impact sturgeons.

Sturgeon survival in the lower Danube and Black Sea: the social context

Since 1878 (the year of the Berlin Peace agreement), the lower Danube and the Danube Delta have been under the control of the Romanian state. For a long time, overfishing of sturgeons in this area was extensive. During the communist regime (1948–1989), the centralized economy did not consider ecological criteria in the sturgeon fishery. The situation, however, has not yet improved in the post-communist period. Moreover, fishing permits have increased, resulting in a lack of information about the extent of the catch, which is now extremely extensive in Romania. The Danube Delta Biosphere Reserve (Gâstescu 1993), in which fish harvest is controlled, is a lucky exception to the generally uncontrolled situation. It is very difficult to organize protective measures for sturgeons in the lower Danube, and all species, especially *Huso huso* and *Acipenser gueldenstaedtii*, should be considered as threatened or endangered in Romania.

Considering all of the negative conditions for sturgeons migrating into the Danube River, the following conservation measures are recommended: (1) an end to fishing in the lower Danube; (2) research on the survival of young sturgeons in the contemporary conditions of the lower Danube and the Black Sea; (3) restocking of the endangered sturgeon species; (4) conservation (cryopreservation) of genetic materials of sturgeons from the Danube populations.[1]

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[1] Since this paper was written, a new five-year project entitled 'Recovery Program of the Danubian Anadromous Migratory Sturgeons' began in 1995 funded by the Romanian Ministry of Research and Technology and a grant of the Global Environment Trust Fund administrated by the World Bank [The Editors].

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