The Sturgeons: Fragile Species Need Conservation

Serap Ustaoğlu[1], İbrahim Okumuş[2,*]
[1] Ondokuz Mayıs University, Faculty of Fisheries, 57000 Sinop, Turkey
[2] Karadeniz Technical University, Faculty of Marine Sciences, Department of Fisheries, 61530 Sürmene, Trabzon, Turkey.

* Corresponding Author: Tel.: +90. 462 7522805; Fax: +90. 462 7522158;
E-mail: iokumus@ktu.edu.tr

Received 04 August 2004
Accepted 27 January 2005

Abstract

Sturgeon is among the oldest fishes in the world. They are living in natural waters of Europe, Asia and the Northern America for 200 million years. Once abundant in lakes and rivers throughout the Northern Hemisphere, sturgeon stocks are now highly endangered, mostly due to over-harvesting and severe habitat alterations. Sturgeons are among the most valuable aquatic species in the world. They are prized for their delicate flesh and world famous caviar. They have also interesting evolutionary status and life history. Several species of sturgeon occurred in the Black Sea basin and in the waters of the neighbouring countries. At present more than 27 sturgeon species are found living throughout the world of which seven species are found distributed in the Black Sea and its drainage basin, namely beluga (*Huso huso*), Russian sturgeon (*Acipenser gueldenstaedtii*), common sturgeon (*A. sturio*), sterlet (*A. ruthenus*), ship (*A. nudiventris*), stellate (*A. stellatus*) and Persian sturgeon (A. *persicus*). The stocks have declined rapidly due to multi-factorial causes such as overfishing, destruction of critical habitats through construction of dams and dikes on the rivers obstructed the migration of the fish, industrial pollutions and fishing during spawning period. In this paper, the present status of sturgeons in the world and Turkey has been discussed in terms of threats, conservation measures and restoration activities

Key Words: Sturgeon species, habitats, management, conservation, restoration, Turkey.

Introduction

The family Acipenseridae includes 25 species in four currently recognized genera in a Holarctic distribution. This is an ancient assemblage with recognizable acipenserid fossils known from the Upper Cretaceous and fossil relatives extending the origin of Acipenseriformes into the Lower Jurassic. Acipenserids are distinctive in morphology and behavior, with numerous features such as armoring trunk scutes, a ventral mouth, rostral chemosensory barbels, and a flattened body contributing to their benthic habitats, and behaviours. Their commercial importance, uniqueness, and almost universal endangered status have promoted a modern ground swell of interest in sturgeon biology, including their systematic and evolution (Findeis, 1997).

Given their singular evolutionary, morphological genetic, and physiological traits, it is no surprise that sturgeon are also ecological unique. However, life history traits which have proven adaptive over the last 100 million years are now a disadvantage in the face of drastic habitat modifications and over fishing during the last century. Sturgeon is presently depleted, threatened, or extinct almost everywhere they occur. Critical habitat requirements and effective protection and restoration measures can be inferred from sturgeon life history. Only a combination of alternatives integrating habitat protection and recovery with harvest restrictions and supplementation can be expected to sustain sturgeon populations that are anything more than museum pieces (Beamesfelder and Farr, 1997).

Amongst the fish species, the acipenserids are particularly highly prized and easy to capture. Indeed, acipenserid species have been fished since long before Christ. According to Geredot, the Scythian tribes fished for sturgeon about 2500 years ago and, in Greece at the time of Pericles (5th century B.C.) no dinner party was completed without one. Pictures of beluga and stellate sturgeon were minted on coins from Olvia and Pantikapea. In the Middle Ages, precious black caviar played a role in politics. Venice and Genoa entered a war over it and ambassadors were sent to Moscow to conclude special agreements about caviar (Luk'yanenko *et al.*, 1999).

Russia has always been the world leader for sturgeon catches, the fishery being predominantly in the Caspian, Azov and Black Seas, and in the rivers of Siberia. The Russian acipenserids are important assets within regional fisheries, providing famous food products with extremely high market value. During the first half of the current century the Volgo-Caspian basin contributed more than 50% of all Russian and world sturgeon catches and, subsequently, the Caspian sturgeon fishery increased to represent 90% of global catches by weight. In the 1980's, the quality of sturgeon habitats deteriorated sharply both in rivers and in the sea, as a result of increasing multifactorial anthropogenic pressures (regulation of flow in the major spawning rivers of the basin, sea and river pollution with industrial sewage, oil products and

pesticides (Luk'yanenko *et al.*, 1999).

This review focuses on general distribution of sturgeon species, threats, conservation efforts, culture practices and current status of sturgeon stocks in Turkish waters. In addition to reviewing latest developments it may also contribute drawing attention of academicians, management authorities and public.

Distribution of Sturgeon

The sturgeons are anadromous and semi-anadromous fishes. Some spend their whole life in fresh waters and others migrate in to brackish or seawater after a certain size, generally staying on the continental shelf, while some of them, e.g. Russian sturgeon, sterlet sturgeon, and beluga, migrate in to brackish waters in the Black and Caspian Sea (Billard and Lecointre, 2001). They are widely distributed in the Northern Hemisphere above the 30th parallel, and within this zone they are found everywhere along the coasts of the Atlantic and Pacific Oceans, the Mediterranean and Black Seas, as well as inland seas (such as Caspian), lakes and rivers. Their abundance in this huge range differs greatly: in many parts of the range they are found only as isolated, sparse populations and occur in significant numbers only in a few regions (Dettlaff *et al.*, 1993). The commercially important sturgeons are migratory fish species that spend most of their life in the sea and enter rivers to spawn. Fish that have reached sexual maturity migrate to the larger rivers, such as the Volga, Ural Rivers, Danube, the Terek, Kura, Kızılırmak and Yeşilırmak Rivers.

Although a few species of *Acipenser* are still under revision, usually 24–25 extant sturgeon and two paddlefish species are included in the Acipenseriformes (Birstein *et al.*, 1997). The Acipenseridae and Polyodontidae within Acipenseriformes diverged prior the Late Cretaceous (Bemis *et al.*, 1997; Birstein *et al.*, 1997). Living species of *Acipenser* belong to different evolutionary lineages which diverged long time ago. It has been proposed that there were at least four main regions in which the speciation and spread of sturgeons took place (Artyukhin, 1995): (i) the Ponto-Caspian area; (ii) China-western America; (iii) the Atlantic area; and (iv) eastern North America. The group of Ponto-Caspian species includes most of the Eurasian species (*Acipenser gueldenstaedtii*, *A. persicus*, *A. stellatus*, *A. ruthenus*, *A. nudiventris*, *Huso huso*, *A. baerii*), as well as Amur River endemics (*A. schrenckii* and *Huso dauricus*), and, possibly, an Adriatic species *A. naccarii*. The origin of Ponto-Caspian species might have been associated with brackish-water derivatives of the Tethys Sea (Birstein *et al.*, 1997). The China-western American group consists of *Acipenser sinensis*, *A. dabryanus*, *A. medirostris*, and *A. transmontanus*; the external morphology of the last two species is very similar (Findeis, 1993, cited by Birstein *et al.*, 1997). The two extant paddlefish species also indicate a trans-Pacific pattern that is strengthened by the inclusion of fossil taxa, such as *Crossopholis* and *Paleopsephurus* (Bemis *et al.*, 1996; Birstein *et al.*, 1997). The third group includes European and American Atlantic sturgeons. According to Nesov and Kaznyshkin (1983) European *A. sturio* in this group has many primitive characters of the genus and it has been considered a subspecies of *A. sturio*. The American Atlantic sturgeons were subsequently split off as a separate species, *A. oxyrinchus*. Later two subspecies, *A. o. oxyrinchus* and *A. o. desotoi*, were described within *A. oxyrinchus*. The freshwater sturgeons of eastern North America, belonging to the fourth group, the lake sturgeon, *A. fulvescens*, and shortnose sturgeon, *A. brevirostrum*, are possibly closely related (Vladykov and Greeley 1963 cited by Birstein *et al.*, 1997) and may have originated on the Eastern coast of North America (Artyukhin and Andronov 1990). Evidence for monophyly of these four groups remains uncertain, and the relationships among them are not known very well (Birstein *et al.*, 1997)

In Euroasia the highest concentration of sturgeon is in the Caspian, Azov and Black Seas. The Black Sea together with Sea of Azov is one of the major distribution basins of the *Acipenser* species (Birstein and Bemis, 1997) and until recently the region made substantial contributions to world sturgeon production. Seven species of sturgeon are found in this basin. These are sterlet (*Acipenser ruthenus*), stellate (*A. stellatus*), Persian sturgeon (A. *persicus*), Russian sturgeon (*A. gueldenstaedtii*), ship (*A. nudiventris*), European sturgeon (*A. sturio*) and beluga (*H. huso*) (Geldiay and Balık, 1988; Pourkazemi *et al*., 1999; Billard and Lecointre, 2001). The largest inland body of water on Earth, the Caspian is fed by more than 100 rivers, the most important of which for sturgeon is the Volga River in Russia, which supplies 75 percent of the Caspian Sea's sturgeon catch. The Caspian Sea is bordered by Russia, Kazakhstan, Turkmenistan, Azerbaijan, and Iran supplying about 90 percent of the world's sturgeon catch and caviar production. The rest of these products come from China, Romania, the United States, Canada and others. Virtually all of the caviar produced by Caspian Sea nations comes from four species, namely beluga sturgeon (*Huso huso*), Russian sturgeon (*A. gueldenstaedti*), stellate sturgeon (*A. stellatus*) and Persian sturgeon (*A. persicus*). These species produce valuable beluga, osetra, sevruga and persian caviars, respectively. In spite of declines in stocks over the last 20 years beluga, stellate and Russian sturgeons are still major contributors to caviar and meat production (DeSalle and Birstein, 1996; Speer *et al.*, 2000).

Threats to Sturgeons

Several species of sturgeon have become endangered due to the destruction of their natural

habitat and to intensive international trade in caviar and products derived from the species. Many authors have blamed the dams as the major cause of the decline of sturgeon world wide, while others have also involved as possible causes the overfishing of mature sturgeon, increasing water pollution in natural waters, and gravel extractions from spawning sites. Most of the dams have not equipped with a fish pass, and therefore imposes the upstream limit on migration of sturgeons. During water collection discharges from both the dams are routinely stopped completely for periods of several hours each day, leaving parts of the river bed dry. Drastically reduced water flow as a consequence of drought, river regulation and channelization could be another important reason precluding or limiting the access of fishes to their spawning sites. The rivers are also suffered from engineering development and channelization, received significant municipal and agricultural pollution. Water abstraction for irrigation of farm land also reduces the quantity of water in the river beds. In addition river mouths have been modified (Çelikkale *et al.*, 2004).

The potential spawning grounds of sturgeons have obviously been drastically reduced by the construction of dams on the rivers, engineering and flood prevention works, water abstraction and pollution. Thus the reduction of upstream spawning areas, the periodic complete stoppage of flow, the changing levels of discharge, changes in water temperature and turbidity have made life difficult for sturgeon spawners in these rivers. The channelization work on the same river will also have reduced the areas of substrate suitable for spawning downstream of the dam. Even the limited areas potentially suitable for spawning which remain will be further reduced by diversion of water into irrigation canals.

The sharp fall in the abundance of sturgeon in many regions, and their complete disappearance in some places has been taken by many researchers as an indication that they are a relic group of fish doomed to extinction as a result of competition with higher fish. Although the Acipenserids indeed are an ancient group of the Osteichthyes, they are well adapted to contemporary environmental conditions and even have great advantages as compared with the Teleost fishes. These advantages include: wide range of spawning temperatures, longer retention of fertilizability by sperm and eggs in water, early euryhalinity of juvenile fish and the broad spectrum of their feeding, protection from predators afforded juvenile fish by their scutes, ecological plasticity as expressed in the existence of anadromous, semi-anadromous and freshwater forms. Thus the decrease in the abundance of sturgeon throughout the world is a result of human activity: fishing over thousands of years, and at present river bed modifications, pollution, and mass destruction of juveniles as a result of their being incidentally caught in small-mesh nets intended for teleost fish. Therefore, the problem of conserving sturgeon and replenishing their stocks in the entire range has become urgent issue for scientists of various countries (Dettlaff *et al.*, 1993). Otherwise, sturgeons reproduce more slowly than other fish. They can take between 6-25 years to reach sexual maturity, and females of many species reproduce once every 3-4 years. Therefore, sturgeons are vulnerable to overfishing and unable to recover quickly. In fact, depleted sturgeon populations may take a century or more to recover. In addition, their predictable migration patterns and bottom-feeding habits make them relatively easy prey for fishermen, who catch the fish for their roe. River pollution and especially pollution of spawning grounds may also seriously impact on sturgeon populations (Speer *et al.*, 2000).

Monitoring of the state of sturgeon stocks in the sea has been conducted by the Caspian Fisheries Research Institute for more than 50 years, most recently with the participation of Azerbaijan and Kazakhstan. According to the data collected, the total number of sturgeons in the sea in 1999 reached 52.3 million individuals, subdivided as follows: 9.3 million beluga, 29.2 million Russian sturgeons and 13.8 million stellate sturgeons. Since 1987 the total number has declined by a factor of two and a half, with the commercial stock reduced to one third, and the spawning population has decreased by a factor of 15. The number of sturgeons entering spawning grounds in the Volga River has decreased by a factor of more than 13 times. The main cause of this drastic decline in adult sturgeon stocks is the illegal sea harvest. This illegal harvest is believed to exceed legal catches several times over, and is conducted most intensively along the western coast of the Caspian Sea (Ivanov *et al.*, 2001).

Production, Trade and International Regulations

Sturgeons have been prized for their delicate flesh and world famous caviar, and fished for hundreds years. According to latest available official catch figures for Acipenseriformes around the world continued to drop, from 5,723 tonnes in 1995 to 3,715 tonnes in 1998, of which 80% originate from the Caspian Sea, 14% from the North American inland and coastal waters and 6% from the Danube River, the Black Sea and the Sea of Azov (Raymakers, 2002).

In order to safeguard sturgeon populations, it is necessary to pass and enforce legislation in all the related countries (e.g. Black Sea and Caspian States) to fight poaching, processing and marketing of sturgeon products. In 1975, under provisions in Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), controls began to be placed on commercial trade in several sturgeon species and their products, including caviar. As of 1 April 1998, all sturgeon and paddlefish as well as their products in international trade fall under the provisions of the CITES. This means controls over

the international trade in all parts and derivates of these species, for instance caviar (roe), meat, live fish and eggs of these fish. Internationally, two sturgeon species (*Acipenser sturio* and *Acipenser brevirostrum*) are listed under Appendix I[(1)] (under which international commercial trade is prohibited) and the rest under Appendix II[(2)] (under which international trade is allowed only with a CITES permit from the management agency of the exporting nation) (Raymakers, 2000; Raymakers, 2002; CITES, 2004).

CITES urges the Parties:

- To encourage scientific research on sturgeon fisheries,
- To curtail illegal fishing and export,
- To monitor the storage, processing and re-packaging of sturgeon specimens in Customs free zones and free ports, as well as for airline and cruise line catering
- To promote regional agreements between range states to bring about proper management and sustainable utilization of sturgeons (Raymakers, 2000)

Until the 1990's, only two nations bordered the Caspian Sea: the Union of Soviet Socialist Republics and Iran. Both held national monopolies on the caviar trade, and the two countries cooperated to prevent overfishing. In 1991, the Soviet Union collapsed, and three new countries joined Russia and Iran on the Caspian Sea: Kazakhstan, Azerbaijan, and Turkmenistan. Initially, none of these new countries instituted quotas on sturgeon harvesting. On the contrary, they were so impoverished that the sale of caviar was pursued zealously. Sturgeon populations quickly collapsed. As harvests of the three primary species dropped, and international demand increased, poachers began overfishing not only the three major species in the Caspian, but the minor species in other rivers throughout Europe and Asia. A hundred years ago, the annual sturgeon catch in the Caspian was 50,000 tons (DeSalle, 2002). According to CITES, the Caspian once accounted for 95% of world caviar, although this percentage is now closer to 90%. Official catch levels fell from a peak of about 30,000 tonnes in the late 1970s to less than one tenth that figure in the late 1990s. Reduced river flow, destroyed spawning sites, corruption, poaching, organized crime and illicit trade all contributed to the decline. One result is that by the late 1990s the illegal catch in the four former Soviet Republics was estimated to be 10 or 12 times higher than the legal catches (Anonymous, 2003a).

CITES trade data for 1998 suggest that the international trade in caviar is substantial, totaling 275 tones, and dominated by a few nations: 95% of the caviar is exported and imported by less than 20 countries. The 1998 world exports, as reported by CITES Parties, also included 44.6 tonnes of sturgeon meat and 0.5 million live specimens (juveniles and fertilized eggs) of sturgeon and paddlefish. The states were recommended to establish annual export quotas for specimens and products of sturgeons, but the scientific bases for setting these quotas are often unclear and would benefit from verification by independent experts. This mechanism was initiated following the decision adopted in April 2000 of incorporating Acipenseriformes in the Significant Trade Review of CITES. Primary results concluded that for six species (*Acipenser gueldenstaedtii*, *A. nudiventris*, *A. schrencki*, *A. stellatus*, *Huso huso* and *H. dauricus*) the provisions of CITES were not implemented properly by range States and international trade may therefore be detrimental to the survival of wild populations (Raymakers, 2002). CITES halted the caviar trade by Azerbaijan, Kazakhstan, Turkmenistan and the Russian Federation in June 2001 under the so-called Paris Agreement. It gave the four states until the end of that year to conduct a scientific survey of stocks and to start developing a common management plan. The fifth Caspian state, Iran, was not subject to the caviar ban, but, commendably, it too joined the regional effort. For the Caspian States, in 2003 total caviar export quotas were 146,210 kg, compared with 140,237 kg in 2002 and 153,620 kg in 2001 (Anonymous, 2003a).

Conservation of Sturgeons

Breeding in hatcheries and restocking assume an even greater importance for sturgeon stock development in view of large-scale illegal fishing. The development of aquaculture and the commercial breeding of sturgeons to meet the demands for meat and caviar are among the other activities that began more than a decade ago in order to conserve and restore sturgeon stocks. For example, 13 sturgeon hatcheries were built in the USSR and a hatchery was constructed in Iran between 1954 and 1965 in order to compensate for damage caused by hydroelectric development. Between 1980 and 1990, more than 100 million sturgeon juveniles weighing 2-3 g in weight were produced annually. Sturgeon hatcheries of the Soviet era produced 2.2 billion young fish between 1955 and 2000. The commercial return from these releases varied depending on year, but did not exceed 1 per cent. From the data gathered by the Caspian Fisheries Research Institute, more than 96 per cent of the beluga population, 56.6 per cent of the Russian sturgeon population and 36 per cent of the stellate sturgeon population consist of captive bred fish. In line with food availability, sturgeon fingerling production could be increased to 150 million fish per year (Ivanov *et al.*, 2001).

Restoration of stocks of *Huso huso* occurs through natural spawning and through releases of hatchery-reared specimens. Some natural spawning replenishment is still occurring for the *Huso huso* population in the lower Volga River and particularly in the Ural River. The *H. huso* fishery in the Caspian Sea is maintained largely through artificial

reproduction programs that have been operating since 1959. For the period from 1959-2002, some 515 million fingerlings were hatcheries-reared and released into the Caspian Sea. More recently, over 11 million *Huso huso* fingerlings have been released by the littoral States into the Caspian Sea in 2002. Currently the share of hatchery-produced *Huso huso* in commercial catches in the Volga is estimated to exceed 97%, indicating that the beluga fishery in the Caspian is maintained largely through a stock enhancement programme. The *Huso huso* fingerling release programmes are now more effective and have been growing steadily under CITES regulation until 1997. Measures approved by the CITES Conference of the Parties, and actively implemented by the Caspian littoral States, are aimed at ensuring that basin-wide management measures in the Caspian Sea are in place, non-detrimental trade in *Huso huso* and other sturgeons can occur, and illegal trade is minimized. The CITES Secretariat believes the current regulatory measures established by the Parties, with the support and endorsement of the Caspian littoral States, are sufficient to ensure long-term recovery of the species and the fishery (Anonymous, 2003b).

It has been suggested that breeding sturgeons in captivity is a good method for their management and conservation (Tagliavini *et al.*, 1999; Dabrowski *et al.*, 1999). In spite of this fact it has also been emphasized that commercial production of sturgeon and paddlefish in captive breeding facilities is not an alternative to overfishing or a solution to conservation of these species in the wild (Pavlov, 1998). However, in many parts of the world, conservationists look upon captive breeding and stock enhancement as "the sturgeon's only chance of survival" (Dabrowski *et al.*, 1999).

In addition, fisheries management regimes were introduced so that the mature fish could predominantly reach spawning sites. For this purpose, size limitations for catch, closed seasons and sites/areas for sturgeon fishing have been introduced. These measures did improve the state of sturgeon stocks, but mostly temporarily. In order to control the fishery, the joint commissions have been established (e.g. Commission on Caspian Aquatic Bioresources). These commissions approve the method for allocating quotas on straddling stocks, which is based on several factors, including the volume of freshwater flow, the number of young fish migrating downstream, the quantities of young fish produced and released by hatcheries and the biomass of food resources available off the coast (Ivanov *et al.*, 2001).

The five range States of the Caspian Sea have made strong commitments to support cooperative research on a number of important issues such as stock assessment, monitoring, the genetic structure of stocks, and other issues highlighted in the recommendations of the Animals Committee of CITES. Priority actions include: 1) the development of an internationally acceptable stock assessment and monitoring system; and 2) the development of a transparent, robust and internationally acceptable method for deriving catch and export quotas from stock monitoring data. For example, the status of the *H. huso* population in the northern part of the Caspian Sea is monitored through trawl surveys in the Caspian Sea and data collected on the spawning segment of the population that migrates into the main rivers of the Caspian Basin (mainly the Volga and Ural Rivers). The Islamic Republic of Iran, which focuses on the southern part of the Caspian Sea, uses a catch-per-unit-effort (CPUE) stock assessment within an adaptive management approach to monitor *H. huso* and determine total allowable catch limits. Both countries have a considerable time series of data on sturgeon stocks and catches, and have used their methods to adjust total allowable catches (TACs) upwards or downwards as circumstances require (Anonymous, 2003b).

Finally, along with measures to protect sturgeon stocks, it is necessary to increase the efficiency of natural reproduction of sturgeons. The first priority is to establish favorable hydrological conditions during the spawning season and thereby increase the number of spawners reaching the spawning grounds, to improve natural spawning sites and to create artificial ones. Given the economic significance of sturgeon species, research institutes are carrying out in collaboration with other fishery research centers extensive studies such as stock assessment studies using tagging methods, genetic and molecular markers; cryopreservation of sperm; establishment of a gene bank; biology or pathology.

Sturgeon Culture

The first experiment of artificial propagation of sturgeon was carried out in 1869 when Owsjannikow artificially fertilized *A. ruthenus* eggs, incubated them, and obtained prelarvae. In subsequent years, fertilization and incubation were also performed for other sturgeon species: *A. fulvescens* by Seth Green in 1875, *A. sturio* by Frauen in 1881, *A. stellatus* in 1884 and *A. gueldenstaedti* in 1899 by Borodin. These and similar experiments were aimed mainly at obtaining materials for various studies. The first experiment especially for fish culture purpose was carried out in 1886 by Mohr who released 500,000 *A. sturio* larvae in the Elbe. However, despite the relatively successful results of the first experiments, most of the work on artificial propagation remained small-scale for a long time. This was mainly due to difficulties in obtaining mature spawners which were caught on spawning grounds (Burtzev, 1999; Williot *et al.*, 2001).

Sturgeon aquaculture has been developing rapidly over the last 10 years. With recent advancements, the requirements of the enhancement activities and industry have been changing and the techniques utilized have been changed and adapted

rapidly too. Based on the former Soviet experiences, a new technology has been developed and the background of sturgeon biology has been enlightened in many respects. Thus efforts on artificial propagation and culture of sturgeons have recently been accelerated in many countries: USA, France, Italy, Hungary, Poland, China and Japan. In the USA successful attempts to reproduce *A. transmontanus*, *A. oxyrhynchus*, and *A. brevirostrum* have been made. A major advance has been made with *A. transmontanus*.

The aquaculture production of sturgeon and paddlefish which was 160 tones in 1987, reached 1,142 tones in 1995 and had doubled in 1997 when it totaled 2,032 tones but the reported value of aquaculture products dropped from USD 16 per kg in 1990 to USD 8.2 kg in 1997. 38% of the global sturgeon aquaculture production in 1997 was produced in the Russian Federation, 35% in the EU and 27% in the USA (Raymakers, 2002).

The level of caviar produced in aquaculture does not currently meet the demand and production costs of meat from farms remain high compared to wild sources. The lack of wild adults of certain species may represent a limiting factor to the wide development of farming of sturgeon and paddlefish species that are not yet bred in captivity because new aquaculture facilities need to constitute a healthy and genetically diverse broodstock (Williot, 1998). In extreme situations, captive broodstock may prevent the total extinction of a population (Chebanov, 1998).

Although breeding and restocking with domestic strains may overcome some practical problems, it could be deleterious for preservation of natural genetic diversity. It is, therefore, important to evaluate the size of natural populations and genetically to characterize wild individuals, captive breeders, and their derived stock (Tagliavini *et al.*, 1999; Dabrowski *et al.*, 1999). The use of captive broodstocks may be advisable for commercial culture and stock enhancement programmes to avoid any additional impact on the wild population and to provide, in some cases, more healthy reproductive conditions. Due to the age of the first sexual maturity, long gonadal cycles and, non-yearly spawning of sturgeon, the management of sturgeon broodstock is more complex and costly than for most other fish species (Williot and Brun, 1998).

However, to preserve intra- and inter-specific biodiversity of Acipenseriformes long term actions should focus on the restoration of river habitats, including access to spawning grounds in combination with other initiatives particularly genetic research (Pavlov, 1998), and on a carefully monitored enhancement of wild stocks (St. Pierre, 1999). Also, potential risks of intensive commercial farming should be taken into consideration, including the possible loss of genetic diversity of a species (Andreasen, 1999). Although literature is apparently lacking on the subject, hybridisation between specimens that would have escaped from farms and specimens of remaining, sometimes endemic, wild populations should not be excluded. This risk should be better studied because it may represent a threat to species that are close to small populations of rare species of sturgeon and paddlefish, particularly in regions where aquaculture is developing fast. The Chinese paddlefish *Psephurus gladius* in China and the common or Baltic sturgeon *A. sturio* in Western Europe are examples of species that might be under such threat.

Current Status of Sturgeon in Turkey

Historical and current status of sturgeon stocks in Turkish waters have been reviewed recently by Çelikkale *et al.* (2004). Five species of Acipenseriformes (*Huso huso, Acipenser sturio*, *Acipenser stellatus, Acipenser gueldenstaedti*; *Acipenser nudiventris*) are native to the Turkish waters of the Black Sea and to the river systems (Kizilirmak, Yeşilırmak, Sakarya, Çoruh and their estuaries). Currently there is little reliable data which would allow estimation the status of stocks sturgeon species occurring in the Black Sea of Turkey. According to the State Institute of Statistics, annual landings fell from over 300 t during the late 1960s to around 30 t in 1970. Annual landings fell around 10 t or less after 1975. The fishery of sturgeon that is smaller than 15 kg has been prohibited since 1975-76. Nevertheless, sturgeons have been taken deliberately and as an accidental by-catch during fishing operations aimed for other species (Anonymous, 1975; Edwards and Doroshov, 1989).

First sturgeon fishing regulatory measurements were taken in 1971 and the fishery for sturgeon has been banned since 1979 with some exception and modifications. The main aims were to prevent fishing during the spawning migration, stop overfishing and reduce by catch and catch of undersized fish. Beluga has also been included sturgeon fishing ban in 1997 and legally fishery completely closed. However, it is very difficult to claim success of these measures mainly due to lack of efficient monitoring and surveillance mechanisms. Apart from overfishing, destruction of critical habitats such as construction of dams and dikes on the rivers obstructed the migration of the fish. Water catchments period of the new dams limited the water level in the rivers. In spite of the bans and restrictions there are substantial amount of illegal landings reportedly as “by catch”. These catches reached 15 tons during 1990s, but dropped sharply after closure of the fishery in 1997. This was mainly because all the specimens caught used to marketed as beluga (Çelikkale *et al.*, 2004).

The conservation measures taken by the Ministry of Agriculture and Rural Affairs (MARA) were not effective as expected and no sign of recovery was observed during 30 years. The illegal or accidental fishing pressure on sturgeons has exerted by trawlers, which operate at a distance greater than 3

miles from the shore along the western part of the Black Sea coast of Turkey, particularly around province of Samsun. The major species still caught are mostly beluga and Russian sturgeon. Apart from trawling, purse seining and gillnetting activities along the shore in the approaches to rivers, and in the mouths of the major rivers themselves are also catching sturgeons. Although not commonly, fishermen are still caught sturgeon "incidentally" in very small amounts by trawlers and purse seiners. These by-catches have not been reported as the catch statistics. Only those entering main fish market (Kumkapı) in İstanbul have been recorded. Occasionally caught large specimens become news items on regional or national newspapers and/or TV channels and may be one of the major information sources for the public.

It is difficult to provide accurate figures for the current population size of sturgeon in the Turkish waters of Black Sea due to lack of data collection and monitoring. Since the lack of central organization of the Turkish fishery, catch statistics for sturgeons are incomplete. Some general information on the presence of sturgeon near Kızılırmak and Yeşilırmak has been collected in 2001 from local fishermen. According to retired old fishermen in the 1960s sometimes about 60-70 sturgeons were used to catch daily near Kızılırmak and Yeşilırmak Rivers in spring months. In the 1970s and 1980s, sturgeons were much less abundant in this region. Today, the sturgeons were rarely caught in estuaries of Kızılırmak and Yeşilırmak rivers accidentally. Besides intensive fishing, other aspects of human activities have negatively impacted sturgeons, including construction of dams and pollution.

Beluga was among the most abundant in Turkish waters of Black Sea, and it was the most valuable. Due to overfishing of brood fish during spawning migrations, catches of beluga started to decline in 1970-1975. Beluga is now very rare in Turkish waters. The Russian sturgeon and stellate sturgeon are also critically endangered in Turkish waters.

Three major rivers (Kızılırmak, Yeşilırmak, and Sakarya River) within the range of the sturgeon have been dammed, preventing use of upstream areas for spawning. The sturgeon is unable to pass through dam systems. Construction of the Altınkaya Dam and Derbent Dam at the Kızılırmak River and Hasan Uğurlu Dam and Suat Uğurlu Dam at the Yeşilırmak blocked further upstream migration of anadromous sturgeons. The lowermost section of the Kızılırmak River between Derbent Dam and the river mouth encompasses ca. 30 km. There are no fish passage facilities on this dam. The section between Suat Uğurlu Dam and the river mouth in the Yeşilırmak River encompasses ca. 40 km and there is also no fish passage on this dam. Fishes in the lower section of the rivers can move freely, if there is enough water, but the dams block any upstream movement.

Today, the sturgeons are rarely caught in estuaries of Kızılırmak and Yeşilırmak Rivers mainly by-catch. Its range has been greatly reduced by the mid-1980s. The sturgeon stocks can be considered as highly endangered in Turkish waters of the Black Sea. The main reasons for stock decline in Turkish waters, as worldwide, are overfishing, construction of dams and stream regulations on the rivers. At the end of the 20th century, the accumulated and prolonged influence of these factors reached a critical level. Legal regulations for sturgeon protection did not stop its decline. Some of the sturgeon species have been listed as endangered and are under special protection until 1996 in the Turkish fishery law. Caught fishes are usually unhurt, can survive easily, even if they are immediately released to the sea again. The legal authorities (Ministry of Agriculture and Rural Affairs) must be take strict measures in order to prevent illegal fishing. It must be undertaken that the caught sturgeons must be release to the sea again.

Conclusion

Most of the twenty seven species of sturgeon are threatened or endangered in at least some of their habitats. Many are nearing extinction. The pressures on sturgeon will continue to grow as the population and environmental degradations increases.

Turkey is one the major countries with substantial historical sturgeon stocks. Unfortunately today these stocks have declined near extinction due to lack of effective management and overfishing, destruction of natural habitats through dam construction and aquaculture stocking efforts. Considering all of the negative conditions for sturgeons in the Turkish waters of the Black Sea, the following conservation measures are recommended: (1) to characterize the current sturgeon population, (2) to examine historical population and harvest assessment data for trends that may have been the result of various regulatory, anthropogenic, and environmental factors, that may have led to characteristics of the current population, (3) to rehabilitation of Turkish rivers for spawning of sturgeons, (4) to reproduction and restocking of the endangered sturgeon species. Public involvement should also be identified as an integral component to effective sturgeon management. Scientific research on sturgeons in Turkish waters should be also supported with priority from by the Government. Especially, more strict measures against illegal fishing are urgently needed in Turkey. In addition, hatcheries must be built for artificial reproduction, of sturgeon in Turkey due to the necessaries in stocking for restoration and management purposes. Adult sturgeons could be obtained from local fishermen which caught accidentally in order to use of artificial reproduction and stock enhancement. Successful efforts of replenish stocks of sturgeons have been

made in Caspian Sea and in the United States. Turkey must carry out same investigations. However, it must be take into consideration that artificial propagation does not completely compensate for the loss of natural reproduction of sturgeons.

(1) Appendix I: Species that are threaten with extinction for which prohibition of international commercial trade in specimens of wild origin.

(2) Appendix II: Species that may become threaten unless their international trade is strictly controlled and for which international commercial trade is authorised with CITES documents: export or import permit and re-export certificates + certificate for the introduction from the sea.

References

Andreasen, L. 1999. Captive propagation as a recovery tool for North American Sturgeon. D.F. Williamson, G.W. Benz, and C. Hoover (eds.) Proceedings of the Symposium on the Harvest, Trade and Conservation of North American Paddlefish and Sturgeon, May 7–8, 1998, Chattanooga, TN. TRAFFIC North America/WWF, Washington, DC, USA: 121–129.

Anonymous. 1975. Gıda-Tarım ve Hayvancılık Bakanlığı Su Ürünleri Genel Müdürlüğünce Yayınlanan Su Ürünleri Avcılığını Düzenleyen 1975-1976 Av Mevsimine Ait 3 Numaralı Sirküler.

Anonymous. 2003a. CITES Authorizes 2003 Caviar Quotas as Caspian Sea Sturgeon Stocks Start to Recover; (http://www.cites.org/eng/news/press/030905_caviar-quotas.shtml; 14.11.2003;15.30).

Anonymous. 2003b. Current Trends in the *Huso huso* fishery in the Caspian Sea and the Beluga Catch and Export Quotas for 2003, CITES 2003. (http://www.cites.org/eng/resources/quotas/huso_trend.pdf; 01.12.2003; 10.15).

Artyukhin, E.N. and Andronov, A.E. 1990. A morphological study of the green sturgeon, *Acipenser medirostris* (Chondrostei, Acipenseridae), from the Tumnin (Datta) River and some aspects of the ecology and zoogeography of Acipenseridae. Zoologicheskii Zhurnal, 69: 81–91 (in Russian); English translation J. Ichthyol., 30: 11–21.

Artyukhin, E.N. 1995. On biogeography and relationships within the genus *Acipenser*. Sturgeon Quart., 3: 6–8.

Beamesfelder, R.C.P. and Farr, R.A. 1997. Alternatives for the protection and restoration of sturgeons and their habitat. Environmental Biology of Fishes, 48: 407-417.

Bemis, W.E., Findeis, E.K. and Grande, L. 1997. An overview of Acipenseriformes. Env. Biol. Fish., 48: 25-71.

Billard, R. and Lecointre, G. 2001. Biology and Conservation of Sturgeon and Paddlefish. Reviews in Fish Biology and Fisheries, 10: 355-392.

Birstein, V.J. and Bemis, W.E. 1997. How many species are there within the genus *Acipenser?* Environmental Biology of Fishes, 48: 157–163.

Birstein, V.J., Hanner, R. and DeSalle, E. 1997. Phylogeny of the Acipenseriformes: cytogenetic and molecular approaches. Env. Biol. Fish., 48: 127–155.

Burtzev, I.A. 1999. The history of global sturgeon aquaculture. J. Appl. Ichthyol., 15: 325.

Çelikkale, M.S., Okumuş, İ. and Memiş, D. 2004. Contemporary Status of Turkish Sturgeon (Acipenseridae) Stocks, Conservation Measures and Recent Studies. Symposium on Aquaculture Development – Partnership between Science and Producer Associations, 26 – 29 May 2004. European Inland Fisheries Advisory Commission (EIFAC), Wierzba, Poland.

Chebanov, M. 1998. Sturgeon culture in the Sea of Azov basin: problems and prospects of a new biotechnology. Caspian Environment Program; Proceedings from the first bio-network workshop. Bordeaux, November 1997. World Bank, Washington DC: 29–42.

CITES. 2004. The CITES Appendices. (http: www.cites.org/eng/append/appendices.shtml.)

Dabrovski, K., Czesny, S., Christensen, J.E., Van Eenennaam, J.P. and Doroshov, S.I. 1999. Fatty acid composition of sturgeon eggs discrimination of domestic and wild origin. J.Appl. Ichthyol., 15: 326.

Dettlaff, T.A., Ginsburg, A.S. and Schmalhausen, O.I. 1993. Sturgeon Fishes, Developmental Biology and Aquaculture. Springer Verlag, Berlin Heidelberg, 300 pp.

DeSalle, R. and Birstein, V. 1996. PCR identification of black caviar. Nature 381, No: 6579:197-198: In: The Sturgeon Quarterly 4, No 4: 6.

DeSalle, R. 2002. Sturgeon: Once Plentiful, Now Endangered; American Museum of Natural History (http://www.amnh.org/learn/pd/genetics/case_study/endangered.html (28.11.2003; 14.30)

Edwards, D. and Doroshov, S. 1989. Appraisal of the sturgeon and seatrout fisheries and proposals for a rehabilitation programme. Technical Cooperation Programme, FAO: 37 p.

Findeis, E.K. 1997. Osteology and phylogenetic interrelations of sturgeons (Acipenseridae). Environmental Biology of Fishes, 48: 73-126.

Geldiay, R. and Balık, S. 1988. Türkiye tatlısu balıkları. Ege Univ. Fen Fakültesi Yay.No.97, Bornova-İzmir (in Turkish), 519 pp.

Ivanov, V.P., Vlasenko, A.D. and Khodorevskaya, R.P. 2001. Status of Caspian sturgeon stocks and their conservation. CITES World Official Newsletter of the Parties, 8: 2-3.

Luk'yanenko, V.I., Vasil'ev, A.S., Luk'yanenko, V., Luk'yanenko, V. and Khabarov, M.V. 1999. On the increasing threat of extermination of the unique Caspian sturgeon populations and the urgent measures required to save them. J.Appl. Ichthyol., 15: 99-102.

Nesov, L.A. and Kaznyshkin, M.N. 1983. New sturgeons from the Cretacious and Paleogene of the USSR. V.V. Menner (ed.) Contemporary Problems of Paleoichthyology, Nauka Press, Moscow: 68–76.

Pavlov, D. 1998. Access to spawning grounds and natural reproduction in Caspian Acipenseridae. Caspian Environment Program; Proceedings from the first bio-network workshop. Bordeaux, November 1997. World Bank, Washington DC: 1–9.

Pourkazemi, M., Skibinski, D.O.F. and Beardmore, A. 1999. Application of mtDNA d-loop for the study of Russian sturgeon population structure from Iranian coastline of the Caspian Sea. J. Appl. Ichtyol., 15: 23-28.

Raymakers, C. 2000. Assesment of the Implementation of CITES listing of Acipenseriformes, TRAFFIC EUROPE, IUCN: 51 pp.

Raymakers, C. 2002. International Trade in Sturgeon and Paddlefish Species – the Effect of CITES listing. Internat. Rev. Hydrobiol., 87: 525– 537.

Speer, L., Lauck, L. and Pikitch, E. 2000. Roe to Ruin: The Decline of Sturgeon in the Caspian Sea and the Road to Recovery. Natural Resources Defense Council, Wildlife Conservation Society, SeaWeb: 26 pp.

St. Pierre, R. 1999. Restoration of Atlantic sturgeon in the northeastern USA with special emphasis on culture and restocking. J. Appl. Ichthyol., 15: 180–182.

Tagliavini, J., Conterio, F., Gandolfi, G. and Fontana, F. 1999. Mitochondrial DNA sequences of six sturgeon species and phylogenetic relationships within Acipenseridae. J. App. Ichthyol., 15: 17-22.

Williot, P. 1998. Conservation of Caspian Sturgeon: some questions and suggestions. Caspian Environment Program; Proceedings from the first bio-network workshop. Bordeaux, November 1997. World Bank, Washington DC: 50–60.

Williot, P. and Brun, R. 1998. Ovarian development and cycles in cultured Siberian sturgeon, *Acipenser baeri*. Aquat. Living Resourc., 11(2): 111-118.

Williot, P., Sabeau, L., Gessner, J., Arlati, G., Bronzi, P., Gulyas, T. and Berni, P. 2001. Sturgeon farming in Western Europe: recent developments and perspectives. Aquat. Living Resour., 14: 367-374.