

Roe to Ruin: The Decline of Sturgeon in the Caspian Sea and the Road to Recovery

Prepared by:

Lisa Speer, Natural Resources Defense Council
Liz Lauck and Ellen Pikitch, Ph.D., Wildlife Conservation Society
Susan Boa, Lisa Dropkin and Vikki Spruill, SeaWeb

December 2000



The authors wish to thank the following reviewers for their thoughtful comments and helpful insights:

Dr. David Secor, University of Maryland; Dr. Boyd Kynard, U.S. Geological Survey; Dr. John Waldman, Hudson River Foundation; Craig Hoover, TRAFFIC/WWF; Dr. Rebecca Goldberg, Environmental Defense; Bruce McKay and Bill Mott, SeaWeb; Dr. Phaedra Doukakis, Dr. Steve Zack, Dan Erickson, Wildlife Conservation Society; Elliott Negin and Elizabeth Heyd, Natural Resources Defense Council.

The views expressed in this report are those of the authors, and do not necessarily reflect those of the reviewers.

Thanks also to: Jeremy Feigelson, Howard Hogan, Rachel Meyer, Dawn Lang, Prosanta Chakrabarty, Bethany Bacher, Laura Siegel, Laura Robb, Russell Unger, Hasten Design and Tom Johnson.

TABLE OF CONTENTS

EXECUTIVE SUMMARY.....	I
STURGEON OF THE CASPIAN SEA.....	1
OVERFISHING, ILLEGAL FISHING, AND LACK OF EFFECTIVE MANAGEMENT	2
HABITAT DESTRUCTION	3
POLLUTION.....	3
STATUS OF CASPIAN SEA STURGEON.....	4
THE INTERNATIONAL CAVIAR TRADE.....	6
THE CONVENTION ON THE INTERNATIONAL TRADE IN ENDANGERED SPECIES (CITES).....	7
SMUGGLING.....	7
IMPLICATIONS FOR STURGEON POPULATIONS IN THE UNITED STATES	8
U.S. COMMERCIAL FISHERIES.....	9
STURGEON AQUACULTURE.....	12
RECOMMENDATIONS	14
POLICY RECOMMENDATIONS.....	14
CONSUMER RECOMMENDATIONS	18
APPENDIX I: CONSERVATION OF CRITICALLY ENDANGERED STURGEON OUTSIDE THE CASPIAN SEA	21
APPENDIX II: LITERATURE CITED.....	23

Executive Summary

Caviar. The very word evokes glamorous lifestyles, exotic travel and glittering festivities. Yet the world's source of this luxury item, the sturgeon, is in grave danger. Sturgeon have survived since the days the dinosaurs roamed the Earth. The question now is whether these “living fossils” can survive the relentless fishing pressure, pollution and habitat destruction that have brought many species of sturgeon to the brink of extinction. Today, the 27 species of sturgeon and their close relatives, paddlefish, are in sharp decline, and those living in the Caspian Sea, the cradle of world caviar production, are in crisis. This report outlines the status of Caspian Sea sturgeon and recommends actions needed to protect these imperiled fish.

Sturgeon are indeed remarkable fish. Clad in bony plates and equipped with broad snouts, some species of sturgeon live to be more than 100 years old and can grow up to 2,500 pounds and 15 feet-long.¹ Like humans, many sturgeon species reproduce relatively late in life; some do not reach sexual maturity until the ages of 15 to 25. A single sturgeon can produce hundreds of pounds of roe, though the very largest fish are extremely rare today, following decades of overfishing. Sturgeon live in rivers, coastal marine waters and lakes in the Northern Hemisphere, and feed on bottom dwelling organisms such as worms, mollusks, small fish, shrimp and insect larvae.² Sturgeon face six major problems:

Overharvesting: Sturgeon are the principal source of one of the world's most expensive and sought-after luxury goods – caviar. The fish eggs, or roe, are collected from female sturgeon after they have been caught and killed. The global caviar market has placed a premium on sturgeon, prompting overfishing and illegal fishing, or poaching, around the world.

Illegal trade: Illegal trade of sturgeon and caviar exacerbates conservation problems. Sturgeon products, particularly caviar, are compact, easy to conceal, and extremely valuable. A number of sturgeon-producing countries, most notably Russia, have experienced political turmoil over the past decade; as a result, black markets have flourished at the same time fishery management and enforcement programs have collapsed.

Life history characteristics: Sturgeon reproduce more slowly than other fish. They can take between six and 25 years to reach sexual maturity, and females of many sturgeon species reproduce once every three to four years. Therefore, sturgeon are vulnerable to overfishing and unable to recover quickly. In fact, depleted sturgeon populations may take a century or more to recover.³ In addition, their predictable migration patterns and bottom-feeding habits make them relatively easy prey for fishermen, who kill the fish to collect the roe.

Lack of Effective Management: Many sturgeon and paddlefish migrate through the waters of different

¹ TRAFFIC, 2000(a). Review of 10 species of Acipenseriformes, prepared for the Sixteenth Meeting of the CITES Animals Committee, p. 88. TRAFFIC is a non-governmental trade monitoring organization. See also, U.S. Fish and Wildlife Service, 1998. Fact sheet dated 3/25/98. A lake sturgeon caught in 1952 was reputed to have been 152 years old. Birstein, V.J., 1993, Sturgeons and paddlefish threatened fishes in need of conservation. Conservation Biology 7(4):773-787.

² DeMeulenaer, T. and C. Raymakers, 1996. Sturgeon of the Caspian Sea and the International Trade in Caviar. TRAFFIC International, p.p. 1, 8.

³ Secor, D.H. and J.R. Waldman, 1999. Historical abundance of Delaware Bay Atlantic Sturgeon and potential rate of recovery. American Fisheries Society Symposium 23:203-216, p.203.

states and countries, often resulting in a patchwork of catch levels, fishing seasons, size limits and other management measures. Many of the world's most imperiled sturgeon populations live in politically and economically unstable countries, further hampering effective management.

Loss of habitat: Sturgeon migrate up rivers to spawn. Dam construction, diversion of river water for irrigation and other purposes, and siltation of spawning and rearing habitats have nearly eliminated spawning runs on many large river systems used by sturgeon. Dams also alter river flow patterns, disrupting the natural signals that sturgeon rely on in their spawning migrations. Fish “ladders,” intended to help fish surmount dams, generally have been ineffective for sturgeon.⁴

Pollution: Pollutants from urban and agricultural runoff and industrial discharges have been linked to significant reproductive and other abnormalities in sturgeon, and to large fish kills.⁵

Some U.S. and international measures are in place to protect sturgeon. Of the eight species of sturgeon and one species of paddlefish found in the United States, five species or subspecies are listed under the Endangered Species Act. Internationally, all sturgeon species are listed under the Convention on International Trade in Endangered Species (CITES), two under Appendix I (under which international commercial trade is prohibited) and the rest under Appendix II (under which international trade is allowed only with a CITES permit from the management agency of the exporting nation).

These measures are not enough, particularly for Caspian Sea sturgeon, which supply the majority of the world's caviar. Beluga sturgeon, the source of beluga caviar, is so depleted that it may no longer be reproducing naturally in the Caspian Sea region. To prevent extinction of this ancient fish and to prevent other sturgeon species from suffering the same fate, the Caviar Emptor Campaign, launched by the Natural Resources Defense Council, the Wildlife Conservation Society and SeaWeb, has called for:

- An international prohibition on trade in beluga caviar;
- Listing of beluga sturgeon as an endangered species under the U.S. Endangered Species Act;
- Greater international funding for efforts to protect and restore Caspian Sea sturgeon;
- Stronger U.S enforcement of international trade restrictions on caviar imports;
- Support for environmentally sound aquaculture as an alternative to wild sturgeon caviar;
- Stronger state management of U.S. sturgeon species.

The campaign further recommends that consumers reduce their consumption of caviar and avoid beluga caviar altogether. If consumers do buy caviar, better choices include “aquacultured” caviar, North Star

⁴ Secor, D.H., V. Arefjev, A. Nikolaev, and A Sharov, 2000. Restoration of Sturgeon: lessons from the Caspian Sea Sturgeon Ranching Programme. *Fish and Fisheries* 1: 215-230. p. 12.

⁵ Debus, L, 1997. Sturgeon in Europe and causes of their decline. *In* Birstein, V.J., A. Bauer and A. Kaiser-Pohlmann, eds. 1997a, Proceedings of the Sturgeon Populations and Caviar Trade Workshop, IUCN SSC Paper No. 17, p. 63. *See also* Birstein, V. Concluding Remarks, same volume, p. 81; *and* Altuf'ev, Y., Morphofunctional abnormalities in the organs and tissues of the Caspian sea sturgeon caused by ecological changes, same volume.

Caviar and Yellowstone Caviar.

Sturgeon of the Caspian Sea

Historically, the Caspian Sea has been home to the world's largest abundance of sturgeon.⁶ The largest inland body of water on Earth,⁷ 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.⁸



The Caspian Sea and surrounding nations

The Caspian Sea is bordered by Russia, Kazakhstan, Turkmenistan, Azerbaijan, and Iran. Russia, Kazakhstan, Azerbaijan and Iran supply about 90 percent of the world's sturgeon catch and caviar production.⁹ The remainder comes from China, Romania, the United States, Canada and others.¹⁰ Virtually all of the caviar produced by Caspian Sea nations comes from four species: beluga sturgeon (also known as giant or great sturgeon), which produces beluga caviar;¹¹ Russian sturgeon, which

⁶ Secor *et al.*, 2000, p. 217.

⁷ U.S. Department of Energy, Energy Information Administration, 2000. "Caspian Sea Region." June, 2000, p. 16. (<http://www.eia.doe.gov/emeu/cabs/casfull.html>).

⁸ Khodoreyskaya, R.P., G.F. Dovgopol, O.L. Zhuravleva, and A.D. Vlasenko. 1997. Present status of commercial stocks of sturgeon in the Caspian Sea basin, *in* Birstein, V.J., J.R. Waldman & W.E. Bemis eds. 1997b. Sturgeon Biodiversity and Conservation. Kluwer Academic Publishers. pp 209-219.

⁹ DeMeulenaer and Raymakers, 1996, p. 60; and Khodorevskaya *et al*, 1997, p. 209.

¹⁰ DeMeulenaer and Raymakers, 1996, p. 6.

¹¹ The beluga sturgeon, an anadromous fish which produces beluga caviar, should not be confused with the beluga whale (*Delphinapterus leucas*), a marine mammal that does not produce caviar.

produces osetra caviar; stellate sturgeon, which produces sevruga; and Persian sturgeon, which produces Persian and osetra caviar.¹² The fifth Caspian Sea sturgeon species, the ship sturgeon, is highly endangered and trade of its caviar is prohibited.¹³

Beluga, stellate and Russian sturgeon populations have declined precipitously over the last 20 years. (The status of Persian sturgeon populations is less certain.)¹⁴ While overfishing is the principal reason for the decline, the loss of spawning habitat and pollution also are responsible.

Overfishing, illegal fishing, and lack of effective management

Overfishing and poaching for the lucrative caviar market is perhaps the single biggest threat to sturgeon in the Caspian Sea region. Each egg-bearing female can produce 8 percent or more of her body weight in caviar.¹⁵ With caviar retailing for as much as \$105 per ounce,¹⁶ the financial rewards of sturgeon fishing and poaching are enormous.

With the collapse of the Soviet Union, regulation of northern Caspian Sea fisheries -- at one time strong and effective -- largely has fallen apart.¹⁷ With the exception of Iran, Caspian Sea fishing nations lack the resources to implement and enforce effective sturgeon management programs. Though several nations have regulations limiting fishing and prohibiting poaching, enforcement has been crippled by lack of funding and reported violence against enforcement officers.¹⁸ Illegal fishing is thought by many to be increasing.¹⁹

As a result, the illegal catch in the Caspian Sea and Volga River is estimated to be 6-10 times greater than the legal catch, and less than 15-20 percent of the actual sturgeon catch is thought to be registered in official reports.²⁰ In 1995, virtually all the Russian and stellate sturgeon migrating to spawn in the Volga river were thought to have been caught by poachers.²¹ By 1998, the U.S. Fish and Wildlife

¹² The scientific names for these sturgeon are: Beluga: *Huso huso*; Russian *Acipenser gueldenstaedtii*; stellate: *Acipenser stellatus*; and Persian: *Acipenser persicus*. There is some dispute as to whether Persian sturgeon and Russian sturgeon are separate species. Birstein, V.J., P. Doukakis, and R. DeSalle, 1999. Molecular phylogeny of Acipenserinae and black caviar species identification. *Journal of Applied Ichthyology* 15:12-16. Osetra is also produced by Amur and ship sturgeon, both of which are endangered.

¹³ Sellars, J. CITES Secretariat, fax to Liz Lauck, December 9, 1998. The scientific name for ship sturgeon is *Acipenser nudiventris*.

¹⁴ Khodorevskaya, *et al.*, 1997, p. 209.

¹⁵ Demeulenaer and Raymakers, 1996, p. 17.

¹⁶ Paramount Caviar website (www.paramountcaviar.com), 12/1/00. Price is for "Beluga Mallasol" caviar. See also, Williams-Sonoma Catalog, Christmas 2000, p. 169.

¹⁷ Secor, *et al.*, 2000, p. 222.

¹⁸ Secor, *et al.*, 2000, p. 224. See also, Abdullaev, N. 2000. "Dagestanis fish for sturgeon, caviar, bribes," *The Moscow Times*, October 11, 2000.

¹⁹ TRAFFIC, 2000(a), p. 23.

²⁰ TRAFFIC, 2000(a), p. 99. See also, TRAFFIC/Europe, 1999. Estimation of the population and population conditions of sturgeon in Russia and monitoring of domestic trade in sturgeon products. TRAFFIC/Europe-Russia, December 1999, p. 3. See also, *Ottawa Citizen*, 11/25/00.

²¹ Khodorevskaya, *et al.*, 1997, p. 209.

Service estimated that more than 50 percent of the worldwide trade in caviar was illegal.²² While international trade requirements adopted in 1998 have helped reduce illegal trade, one sturgeon still can provide the equivalent of a month's salary in the economically depressed region,²³ and there is little reason to believe that poaching for this "black gold"²⁴ will cease any time soon.

Habitat destruction

Sturgeon in the region spawn in the rivers – principally the Volga -- feeding the Caspian Sea. Immediately after hatching, sturgeon larvae of most species migrate to the sea where they live for 6-20 years (depending on the species) until they mature. At that point, females migrate back to their river of origin to spawn.²⁵

Dam construction has taken its toll, particularly on beluga sturgeon. By preventing sturgeon from reaching their main spawning grounds, dams have significantly reduced spawning habitat for sturgeon in the Caspian Basin. Historically, Caspian sturgeon populations spawned in the Volga, Ural, Kura, Terek, and Sulak rivers.²⁶ Now, the Ural River is the last free-flowing river feeding the Caspian Sea, the only such river where sturgeon continue to reproduce naturally, without the benefit of hatcheries.²⁷ However, some believe that the spawning population of sturgeon in the Ural has been essentially destroyed by poachers, and the river suffers from significant industrial and pesticide pollution.²⁸

On the Volga River, the most productive in the world for sturgeon, as much as 85 percent of the spawning grounds for Russian sturgeon and virtually all of the beluga spawning grounds are blocked by the Volgograd dam.²⁹

Pollution

Population growth and industrial development in the Caspian region have generated an immense pollution problem. The World Bank estimates that one million cubic meters of untreated industrial wastewater is discharged into the Caspian annually.³⁰ Ten million people live adjacent to the Caspian

²² USFWS, 1998. New Caviar Import Measures Protect Imperiled Sturgeon, News Release, March 25, 1998.

²³ Horvath, J. 1999. Cousteau Society warns that the Caspian Sea is dying. January. 7, 1999. (<http://www.heise.de/tp/english/inhalt/co/5029/1.html>). See also Ottawa Citizen, 11/25/00.

²⁴ -----, 2000. "Black gold," in Life Magazine, February 2000, p. 28-32.

²⁵ Khodorevskaya, R.P. and Y.V. Krasikov, 1999. Sturgeon abundance and distribution in the Caspian Sea. Journal of Applied Ichthyology. 15:106-113. The twenty-seven extant species of sturgeon and two species of paddlefish generally follow three different types of life history strategies, spending relatively different amounts of time in salt, brackish, and freshwater. Beluga, Russian, and stellate sturgeon follow the anadromous pattern described in the text, see, Bemis, W.E. and B. Kynard, 1997, Sturgeon rivers: an introduction to acipenseriform biogeography and life history, in Birstein et al, 1997a, 167-83, p. 176.

²⁶ Khodorevskaya, et al., 1997, p. 210.

²⁷ DeMeulenaer and Raymakers, 1996, p. 15; Khodorevskaya et al, 1997, p. 209.

²⁸ Demeulenaer and Raymakers, 1996, p. 23.

²⁹ Khodorevskaya, et al., 1997, p. 214. See also Secor et al 2000, p. 218, and Birstein, V.J., W.E. Bemis, and J.R. Waldman. 1997c. The threatened status of acipenseriform species; a summary, same volume, pp. 427-435.

³⁰ U.S. Department of Energy, 2000, p. 19.

Sea and 60 million more live in the Volga River watershed.³¹ Soviet oil extraction left behind polluted soil and water, rusty equipment, and well fires that burned for years.³² The long history of oil contamination combined with untreated sewage from towns along the Volga River, industrial discharges and agricultural runoff have significantly degraded the Caspian Sea.³³ Meanwhile, the five countries surrounding the sea are rushing to exploit still untapped oil deposits. Pollutants from urban and agricultural runoff and industrial discharges have been associated with reproductive and other abnormalities, as well as large fish kills.³⁴

Status of Caspian Sea Sturgeon

Overfishing, habitat destruction and pollution have left a grim legacy. In the late 19th and early 20th centuries, annual sturgeon catches often exceeded 20,000 tons.³⁵ By the late 1990's, the annual catch had declined to roughly 1,000 tons.³⁶ The Russian State Committee for Fisheries projects that catch for the 2000 fishing year will be 441 tons of sturgeon,³⁷ half the Russian quota. Fishermen have been unable to find enough fish to meet their quotas. Russia expects to produce 40 tons of caviar for export, a drop from 110 tons in 1999³⁸ and from 1,200 tons in 1985.³⁹ Similarly, while Iran was authorized to export 90 tons of caviar in 2000, it reduced that amount to 70 tons to conserve sturgeon.⁴⁰ The Russian State Fisheries Committee reportedly is concerned that diminishing catches may compel Russia to ban commercial sturgeon fishing in the northern Caspian Sea by 2002.⁴¹

Table 1: Numbers of spawners in sturgeon populations in the Volga River (thousands)

Years	Beluga Sturgeon	Russian Sturgeon	Stellate sturgeon
1961-1965	26.0	860.3	535.4
1966-1970	26.0	1569.9	538.7
1971-1975	20.7	1983.3	490.0
1976-1980	16.6	2743.0	572.2
1981-1985	14.6	1072.0	626.3
1986-1990	12.7	717.7	683.1
1991-1995	7.0	354.8	289.2
1996-1997	1.8	102.0	132.0

³¹ Horvath, J.. 1999. (<http://www.heis.e.de/tp/english/inhalt/co/5029/1.html>).

³² U.S. Department of Energy, 2000, page 18.

³³ U.S. Department of Energy, 2000, page 18.

³⁴ Debus, L, 1997, p. 63. *See also* Birstein, V. Concluding Remarks, same volume, p. 81, and Altuf'ev, Y., Morphofunctional abnormalities in the organs and tissues of the Caspian sea sturgeon caused by ecological changes, same volume.

³⁵ Secor, *et al*, 2000, p. 217.

³⁶ TRAFFIC/Europe, 1999, p. 1.

³⁷ BBC/Interfax, "Sturgeon season in Caspian to be extended," September 22, 2000.

³⁸ Associated Press, "Black caviar exports cut in half," October 11, 1999.

³⁹ Tyler, P.E. 2000. "Poaching May Kill Fish that Lay the Golden Eggs." *New York Times*, Section A. September 24, 2000. In November, 2000, a Russian official estimated that the number of sturgeon in the Caspian Sea had shrunk from 15 million in 1995 to 4 million in 2000. *Ottawa Citizen*, 11/25/00.

⁴⁰ Fabricant, F. 2000. "The Dearest Eggs Since Fabrege, Iranian Caviar Returns." *New York Times*, Section F, Page 3. October 4, 2000.

⁴¹ Associated Press, "Black caviar exports cut in half," October 11, 1999.

Source: Khodorevskaya, R., *et al.*, 1997.

In the 1950s, the Soviet Union initiated artificial reproduction and population enhancement programs for beluga, Russian and stellate sturgeon in hatcheries along the Volga River.⁴² Although hatcheries have their problems, they have made important contributions to maintaining the three Caspian Sea species, particularly beluga sturgeon, in recent years.⁴³

The one relatively bright spot for sturgeon in the Caspian Sea is the Iranian fishery that operates in the southern part of the Caspian Sea. The Iranian Fishery Organization (IFO), or Shilat, is the government institution that controls the sturgeon fishery and caviar trade.⁴⁴ Only about 5 percent of the Iranian catch is beluga sturgeon.⁴⁵ About two-thirds of Iran's caviar production is osetra, produced mostly by Persian sturgeon, a southern Caspian Sea native whose status is uncertain. Iranian sturgeon fisheries are tightly controlled and generally thought to be well managed.⁴⁶ Despite their controlled system, Iran does not have important spawning grounds for sturgeon and therefore has limited ability to restore threatened Caspian Sea sturgeon.

The Critical Status of Beluga Sturgeon

Beluga caviar is the most coveted of all caviar,⁴⁷ and as a result beluga sturgeon have been the most intensively fished of the Caspian Sea species.⁴⁸ These fish can reach remarkable proportions. In 1908, the largest recorded beluga sturgeon ever caught contained 990 pounds of eggs,⁴⁹ which today would have a street value of \$1.6 million.⁵⁰ Beluga sturgeon are native to the Caspian, Black and Azov Seas, and have suffered extreme depletion in all three seas due to overfishing, poaching, and loss of virtually all of its spawning habitat to dams and pollution.⁵¹ Experts believe beluga sturgeon in the Caspian are so depleted that they may not be reproducing in the wild;⁵² if so, their survival is entirely dependent on hatcheries. Many hatcheries have closed down or suffered from lack of funds since the collapse of the Soviet Union.⁵³ And this year, local fishermen and Russian fisheries officials have complained that there are almost no large beluga available to supply fertilized eggs to the remaining hatcheries,⁵⁴ raising serious questions about the viability of the population. Recent scientific research suggests that Russian sturgeon are close on the heels of beluga.⁵⁵

⁴²DeMeulenaer and Raymakers, 1996, p. 17.

⁴³Secor, *et al.*, 2000, p. 222.

⁴⁴DeMeulenaer and Raymakers, 1996, p. 19.

⁴⁵TRAFFIC, 2000(a), p. 91.

⁴⁶TRAFFIC CITES Conference of the Parties Briefing 1997. Iran maintains a labeling system in which each sturgeon female is numbered and this reference number is maintained on each tin. This system was employed in the former Soviet Union, but is no longer functional.

⁴⁷TRAFFIC, 2000(a), p. 23.

⁴⁸TRAFFIC, 2000(a), p. 88.

⁴⁹Boeckmann, S. and N. Rebeiz-Nielsen. 2000. *Caviar: The Definitive Guide*. John Wiley and Sons, New York. 160 pp.

⁵⁰Assuming \$100 per ounce. Beluga caviar currently sells for up to \$105 per ounce. Paramount Caviar website (www.paramountcaviar.com), visited 12/1/00.

⁵¹TRAFFIC, 2000(a), p. 91.

⁵²Khodorevskaya, *et al.*, 1997.

⁵³Secor, *et al.*, 2000, p. 10.

⁵⁴British Broadcasting Corporation (BBC). "Russia set to stop exporting caviar as sturgeon dwindle." May 25, 2000. Article quotes Deputy Chairman of the State Committee for Fisheries, Vladimir Izmailov as saying, "The amount of sturgeon caught in the lower Volga is very small. Since the beginning of May the catches have been insufficient even for supplying sturgeon to fish hatcheries for obtaining spawn to be used for the reproduction of sturgeon." *See*

The International Caviar Trade

Commercial fishermen have hunted sturgeon for their roe and meat since at least 1100 BC.⁵⁶ Ancient Greek and Roman literature refers to caviar, and the Chinese were trading it as early as the 10th century AD.⁵⁷

Today, the majority of caviar produced is sold on the international market.⁵⁸ Under international labeling rules, only sturgeon eggs can carry the caviar label. Imported caviar sells for \$100 an ounce or more in the United States.⁵⁹

The United States imports about one-third of the world's total caviar imports.⁶⁰ From 1989 to 1997, the United States imported an average of 130,000 pounds of caviar per year, worth about \$6.6 million.⁶¹ Caviar from the three principal Caspian Sea sturgeon species – beluga, Russian and stellate – dominates the U.S. caviar market. Until last spring, when U.S. trade sanctions against Iran were lifted for caviar, Russia supplied virtually all of the caviar imported into the United States.⁶²

Based on figures reported to the United Nations Food and Agriculture Organization, the United States has produced up to 5 percent of the world's total sturgeon (both meat and eggs) since 1982.⁶³ Nearly all of it in recent years has come from aquaculture and inland freshwater fisheries for paddlefish, shovelnose sturgeon, and white sturgeon. This figure is at best a rough estimate -- and likely an underestimate -- because some countries, including the United States, do not have rigorous programs to collect sturgeon fishery landings and aquaculture production information.⁶⁴ Aquaculture of sturgeon and paddlefish for caviar is increasing in the United States and abroad, bringing with it both conservation opportunities and problems as discussed later in this report.

also TRAFFIC, 2000(a), p. 99 and DeMeulenaer and Raymakers, 1996, p. 57. To supply these hatcheries, mature fish are captured each year. The same spawners are generally not kept and used again owing to various technical and biological limitations. *Id.*

⁵⁵ Khodorevskaya, et al, 2000, p. 604.

⁵⁶ Wei, Q., Fu'en, K., Jueming, Z., Ping, Z., Junde, L., Rueqiong, Z., and Wenhua, Y. 1997. Biology, fisheries, and conservation status of sturgeon and paddlefish in China. *Environmental Biology of Fishes* 48:241-255. p. 242.

⁵⁷ DeMeulenaer and Raymakers, 1996, p. 5.

⁵⁸ DeMeulenaer and Raymakers, 1996, p. 32.

⁵⁹ Paramount Caviar website (www.paramountcaviar.com), visited 12/1/00. See also Williams -Sonoma Catalog, Christmas 2000, p. 169.

⁶⁰ Raymakers, C., 1998. Trade in sturgeons from the Caspian Sea, *in* Williamson, D.F., G.W. Benz, and C.M. Hoover (eds.). 1998. 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/World Wildlife Fund, Washington, D.C., USA., p. 156.

⁶¹ Hoover, C., 1998. Import and export of sturgeon and paddlefish in the United States, *in* Williamson, D.F., G.W. Benz, and C.M. Hoover (eds.). 1998. 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/World Wildlife Fund, Washington, D.C., USA., p. 162.

⁶² DeMeulenaer and Raymakers, 1996, p. 42.

⁶³ Hoover, C., 1998, p. 166.

⁶⁴ Hoover, C. 1998, p. 167.

The Convention on the International Trade in Endangered Species (CITES)

Increasing concern about the status of Caspian Sea sturgeon inspired international action in 1998 to regulate the caviar trade by listing all previously unlisted sturgeon species under Appendix II of the Convention on the International Trade in Endangered Species (CITES).⁶⁵ Now, caviar exports must be accompanied by a CITES export permit issued by a designated management agency in the country of export.⁶⁶ A separate “Scientific Authority” in the exporting country must determine that commercial trade is not detrimental to the survival of the species in the wild. Currently all but one (Turkmenistan) of the Caspian Sea border nations are parties to the CITES convention and thus bound by the new requirements. And some countries have implemented additional protections: the European Union, for example, requires an import permit for all Appendix II-listed species.

In 2000, countries that are bound by CITES adopted a resolution requiring that exported caviar must carry a non-reusable label that includes identification of the grade (beluga, sevruga, osetra), the country of origin, the year of catch and an identifying number. These labels are required only for the initial export of caviar, not the re-export. CITES member nations may also accept shipments of caviar imported directly from countries of origin only if they are accompanied by appropriate documents and labels. The resolution further requires parties to establish a system of registration or licensing for both exports and imports.

Smuggling

Significant quantities of poached caviar are exported -- indeed, smuggling such caviar out of the five countries bordering the Caspian Sea is a flourishing business. Russia officially exported \$25 million worth of caviar in 1999, while the value of poached caviar exports was estimated at \$250 million.⁶⁷ Discrepancies between trade statistics of countries importing and exporting caviar can indicate illegal trade. For example, Turkish caviar exports in 1996 totaled 121 tons, even though that country’s sturgeon catch has been limited to a few incidental catches since the late 1980s.⁶⁸

Russia reportedly plans to introduce a state monopoly on caviar production in 2001 to help reduce illegal trade.⁶⁹

Caviar smuggling into the United States is routine. According to the U.S. Fish and Wildlife Service,

⁶⁵ Prior to the 1997 listing of all sturgeon and paddlefish species on CITES Appendices I or II, two sturgeon species, shortnose (*Acipenser brevirostrum*) and Baltic (*Acipenser sturio*), were listed under CITES Appendix I and two species, Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and American paddlefish (*Polyodon spathula*), were listed under CITES Appendix II.

⁶⁶ Products that are re-exported (after repackaging) must also be accompanied by a permit issued by the re-exporting country. These re-export permits can only be granted when the issuing Management Authority is satisfied that the shipments were imported into the country in accordance with the provisions of CITES.

⁶⁷The Ottawa Citizen, 11/25/00.

⁶⁸ TRAFFIC, 2000(a), p. 71.

⁶⁹The Ottawa Citizen, 11/25/00.

illegally imported caviar is seized virtually every week at New York's JFK Airport.⁷⁰ Since April, 1998, 167 seizures have yielded 31,000 pounds of caviar smuggled into the United States.⁷¹

In the first case of enforcement of CITES requirements in the United States, a major caviar importer was sentenced in 2000 to 20 months in a federal prison and fined \$25,000 for smuggling, conspiracy, and violating the Lacey Act, a federal law protecting wildlife taken, transported or sold in violation of any U.S. law or treaty. Warsaw's deputy police chief at the time pleaded guilty to conspiracy to smuggle wildlife. The company's records revealed sales of 21,000 pounds of caviar during a seven-month period; only 88 pounds of caviar had been legally imported.⁷²

In July, 2000, Maryland-based U.S. Caviar and Caviar Ltd. was fined \$10.4 million -- the largest fine ever in a wildlife prosecution -- for smuggling black market Russian caviar into the United States using forged Russian caviar labels, and for passing caviar from American paddlefish and shovelnose sturgeon as Russian caviar. Company officials admitted selling the contraband caviar to victim airlines, caviar wholesalers, seafood suppliers, and gourmet stores.⁷³

While new CITES labeling requirements will help, illegal trade via smuggling, falsely produced labels and other means will likely continue as long as demand fuels very high prices. In addition, CITES actions do not affect domestic consumption of caviar within Caspian Sea countries. Despite the controls placed on the sale and trade of sturgeon products, illegally obtained sturgeon meat and caviar are openly available in Russia; the main difference between the legal and illegal caviar is the price, with illegal caviar costing less than half the price of legal caviar.⁷⁴

Implications for sturgeon populations in the United States

As populations of Caspian Sea sturgeon spiral downward, markets will likely turn to other sources of caviar, including North American sturgeon and paddlefish. During the 19th century, North America was an important source of sturgeon caviar,⁷⁵ but overfishing and habitat loss caused many populations to decline. Of eight North American species of sturgeon and one species of paddlefish, five species or subspecies are listed as federally endangered (Gulf, pallid, shortnose, Kootenai River white, and Alabama) and possession of the severely depleted Atlantic sturgeon is prohibited.⁷⁶ North American

⁷⁰ Personal communication, Ed Grace, U.S. Fish and Wildlife Service to Prosanta Chakrabarty, 11/29/00.

⁷¹ Personal communication, Diana Weaver, U.S. Fish and Wildlife Service to Prosanta Chakrabarty, 11/30/00. Data based on U.S. FWS Law Enforcement Information Management System data.

⁷² TRAFFIC-North America/World Wildlife Fund. 2000. "Caviar smuggling on the rise." TRAFFIC North America Newsletter 3(2): 11-12. See also, U.S. Fish and Wildlife Service, 1999. News release: Caviar Smuggling Convictions Show U.S. Resolve to Protect Imperiled Fish. 11/4/99.

⁷³ U.S. Department of Justice, United States Attorney's Office for the District of Maryland, 2000. Caviar dealers plead guilty to smuggling wildlife." News release, 7/21/00.

⁷⁴ TRAFFIC/Europe, 1999, p. 13.

⁷⁵ Waldman, J.R. and D.H. Secor. 1998. Caviar trade in North America: an historical perspective, *in* Williamson et al, eds. 1998. While roe of sturgeon from the Caspian Sea is the only official "caviar," the term "caviar" is widely used in commerce to refer to the roe of other species and that practice will be followed in this report.

⁷⁶ Alabama: 65 FR 26438, May 5, 2000; Gulf: 56 FR 49653, September 30, 1991; Kootenai River white: 59 FR 45989, September 6, 1994; pallid 55 FR 36641, September 6, 1990; shortnose: 32 FR 4001, March 11, 1967; Atlantic

sturgeon caviar therefore has a very limited ability to replace Caspian Sea caviar in the marketplace.

American sturgeon and paddlefish populations are managed by individual states or by interstate commissions. With a few exceptions, commercial fisheries for North American sturgeon and paddlefish species are not managed and monitored according to appropriate scientific standards, so expansion of these fisheries leaves the species vulnerable to undetected overexploitation. Even where effective regulations are in place, state officials are concerned that increasing prices for American caviar may entice poachers to illegally harvest and sell caviar from American species.⁷⁷

U.S. Commercial Fisheries

Currently, there is commercial caviar production from three North American species: American paddlefish, shovelnose sturgeon, and white sturgeon.

*Paddlefish*⁷⁸ are closely related to sturgeon, and just two species in this ancient family survive, one severely depleted population in China and one in North America. Also called “spoonbills,” paddlefish live in freshwater and can grow to more than 5 feet in length and can weigh up to 150 pounds.⁷⁹ They are named for the long paddle-like snout that is thought to help them detect changes in water flow and keep them afloat.⁸⁰ Female paddlefish mature between the ages of 7-10,⁸¹ fairly early compared to other sturgeon, and produce an average of 7,500 eggs per pound of body weight.⁸² Paddlefish, like sturgeon, are more vulnerable to fishing mortality than are many other commercial and recreational fish because they live longer and mature later.⁸³

Dam construction and channelization of North American river systems have destroyed much of the paddlefish' spawning grounds, and pollution, illegal fishing, and overexploitation have exacerbated the decline of the species. The International Union for the Conservation of Nature (IUCN) has listed paddlefish as “Vulnerable,” and paddlefish was proposed for listing as a protected species under the Endangered Species Act in 1989.⁸⁴

Paddlefish live in 19 states along the Mississippi River and its tributaries and are subject to a diverse

moratorium: 64 FR 9449, February 26, 1999.

⁷⁷ Boyd, Danny, 2000. Heists of fish eggs on the increase; high caviar prices may be a factor. Associated Press, 7/18/00. A survey of 209 state sturgeon biologists and fishery managers in 1997 revealed that paddlefish poaching is a concern in 13 of the 18 states that responded. Hesse, L.W. and J.R. Carreiro. 1997. The status of paddlefish, pallid sturgeon, lake sturgeon, and shovelnose sturgeon. River Ecosystems, Inc.

⁷⁸ The scientific name for paddlefish is *Polyodon spathula*.

⁷⁹ U.S. Fish and Wildlife Service Paddlefish Fact Sheet, (<http://southwest.fws.gov/fishery/species/paddlefish.html>)

⁸⁰ U.S. Fish and Wildlife Service Paddlefish Fact Sheet, (<http://southwest.fws.gov/fishery/species/paddlefish.html>)

⁸¹ The Mississippi Interstate Cooperative Resource Agency (MICRA) Paddlefish/Sturgeon Steering Committee. 1993. Strategic Plan. Columbia, Missouri. June, 1993. p. 7.

⁸² U.S. Fish and Wildlife Service Paddlefish Fact Sheet, (<http://southwest.fws.gov/fishery/species/paddlefish.html>)

⁸³ Boreman, J. 1997. Sensitivity of North American sturgeon and paddlefish to fishing mortality, in Birstein et al, 1997b, p. 402..

⁸⁴ Graham, K. 1997. Contemporary status of the North American paddlefish, *Polyodon spathula*, in Birstein et al, eds, 1997b, p. 279.

patchwork of management regimes.⁸⁵ While several states have prohibited paddlefish fishing due to declining populations, others have management programs limited to seasonal or area restrictions, and still others have virtually no management.⁸⁶ Inconsistencies in state management may be problematic for paddlefish and shovelnose sturgeon. A paddlefish, for instance, may travel hundreds of miles in its lifetime, crossing into the waters of neighboring states where it may or may not be protected.⁸⁷ The Mississippi Interstate Cooperative Resource Agency (MICRA) is conducting a tagging study to assess paddlefish, the first step toward establishing comprehensive, biologically-based quotas and other management measures.

Paddlefish caviar is marketed as “American caviar,” “American premium black caviar,” “Chattanooga Beluga,” and, simply “American paddlefish caviar.” In 1997, Indiana reported 73 pounds of paddlefish eggs from commercial fishing and Tennessee reported 141 pounds of paddlefish eggs.⁸⁸ The joint venture programs run in Montana and North Dakota, discussed later in this report, produce about 3 tons of paddlefish roe per year.⁸⁹

Shovelnose sturgeon produce caviar that is marketed as “Hackleback caviar” and “American sturgeon black caviar.” Shovelnose sturgeon⁹⁰ is one of the smallest North American sturgeon and lives in 18 states in the Mississippi River drainage. Though the population is generally considered healthy, the species is protected or considered vulnerable in eight states where it occurs and has been extirpated from five others.⁹¹ Generally, state fishery managers report that shovelnose sturgeon populations are stable,⁹² but no status review has been compiled for this species in 10 years, and there is no comprehensive collection of harvest data over the range of the species.⁹³ While no state that responded to a 1997 survey expressed a concern about shovelnose sturgeon poaching,⁹⁴ expanding demand for

⁸⁵ Seven states (Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee) currently allow commercial fishing for paddlefish, though annual harvest is not systematically monitored. In recent years, Tennessee, Illinois, and Indiana have tracked large commercial landings of paddlefish, with smaller commercial landings reported by Missouri (Todd, R. “Sturgeon and paddlefish commercial fishery in North America,” *in* Williamson, et al, eds, 1998, p. 47). Alabama has had a moratorium in place since 1989 given concern about the status of the paddlefish population (Hesse and Carreiro 1997). However, the three other states that allow commercial fishing for paddlefish (Arkansas, Mississippi, and Kentucky) may have higher landings than those reported by the four states that do track landings. For example, paddlefish caviar from Kentucky is available through retailers, suggesting that sufficient quantities are landed to make commercial production feasible and the state Department of Fish and Wildlife Resources estimates that approximately 300,000 pounds of paddlefish were captured in commercial fisheries from the Ohio River in 1999 (personal communication, Kentucky DNR, November 8, 2000). The Illinois Department of Natural Resources reports that recent annual production of paddlefish products from commercial fisheries was 423 pounds of roe and nearly 65,000 pounds of meat (personal communication, November 9, 2000).

⁸⁶ Todd, R. 1998, p. 48.

⁸⁷ Grady, J.M. and G.A. Conover. 1998. Mississippi River Basin paddlefish research coded-wire tagging project 1997 annual report. MICRA, P.O. Box 774, Bettendorf, IA. 33 pp + App., p. 6.

⁸⁸ Todd, 1998, p. 46.

⁸⁹ personal communication, Barci Grindheim, November 3, 2000.

⁹⁰ *Scaphirhynchus platyrhynchus*.

⁹¹ Keenlyne, K., 1997. Life history and status of the shovelnose sturgeon, *Scaphirhynchus platyrhynchus*, *in* Birstein et al, 1997b:291-298, p. 294.

⁹² Hesse and Carreiro, 1997, p. 27-31.

⁹³ Keenlyne, 1997, p. 291.

⁹⁴ Hesse and Carreiro, 1997, p. 27-31.

hackleback caviar may lead to illegal fishing in states that prohibit commercial shovelnose fishing and overfishing in states that allow commercial fishing but do not track landings completely.

Commercial fishing for shovelnose sturgeon caviar is allowed in nine of the 18 states where shovelnose sturgeon live in the wild: Arkansas, Illinois, Indiana, Iowa, Kentucky, Missouri, Tennessee, and Wisconsin.⁹⁵ Landings and egg harvest are not completely tracked and reported. Illinois reported a total of 234 pounds of shovelnose sturgeon eggs in 1997.⁹⁶

Given the lack of robust scientific information about the status of shovelnose sturgeon across their range⁹⁷ and market demand for hackleback caviar, more rigorous management and monitoring of commercial shovelnose fisheries is desperately needed. Initial efforts to get a clearer picture of population status and commercial landings should focus on the nine states that allow commercial fishing for shovelnose caviar.

Consumers should be aware that including Missouri, Illinois, Kansas, Kentucky, Indiana, and North Dakota have issued consumption advisories for paddlefish and/or sturgeon caught in certain water bodies. The chemicals of concern are PCBs, chlordane (a pesticide), and mercury.⁹⁸

*White sturgeon*⁹⁹ are found in rivers and estuaries along the western coast of North America and Canada. The largest freshwater fish in North America, they regularly reach more than 10 feet in length.¹⁰⁰ White sturgeon are farmed in California for caviar and meat; they are also fished recreationally in California, and commercially and recreationally in Oregon and Washington. White sturgeon spawn in three major river systems in North America (the Columbia-Snake, the Fraser (British Columbia), and the Sacramento-San Joaquin (California)); the greatest abundance of white sturgeon is in the Columbia River Basin.¹⁰¹ The Columbia and Snake Rivers have both been dammed, costing the white sturgeon population there much of their spawning habitat,¹⁰² and populations are generally less healthy in impounded areas compared with those in the free flowing portions of these rivers.¹⁰³ One population of white sturgeon, the Kootenai River population, is listed as endangered under the U.S. Endangered Species Act.

⁹⁵ Todd, 1998, p. 47.

⁹⁶ Todd 1998, p. 46. Of the four states that reported commercial landings of shovelnose sturgeon, Illinois led at 21 tons of fish, followed by Iowa at 8.8 tons of fish, Missouri at 4.1 tons and Wisconsin at nearly one ton (Todd, 1998, p. 47). Iowa prohibits commercial sale of shovelnose caviar (Hesse and Carreiro, 1997, p. 28).

⁹⁷ Hesse and Carreiro 1997, p. 27-31.

⁹⁸ U.S. Environmental Protection Agency, Listing of Fish and Wildlife Advisories. This report does not address the human health aspects of caviar consumption. For more information about specific waterbodies under consumption advisories, the chemicals of concern and consumption recommendations, go to EPA's fish advisory website: <http://fish.rti.org/form1b.htm>.

⁹⁹ The scientific name for white sturgeon is *Acipenser transmontanus*.

¹⁰⁰ Boreman, J. 1997, p. 402.

¹⁰¹ Miller, A.I., T.D. Counihan, M.J. Parsley, and L.G. Beckman, Columbia river basin white sturgeon. U.S. Geological Survey report, p. 1.

¹⁰² Parsley, M.J., L.G. Beckman, and G.T. McCabe. 1993. Spawning and rearing habitat use by white sturgeon in the Columbia River downstream from McNary Dam. Transactions of the American Fisheries Society 122(2):217-227.

¹⁰³ Beamesderfer, R. 1998. "Management of and trade in Pacific sturgeon," in Williamson et al., 1998.

Only small amounts of wild white sturgeon roe is available to consumers. Commercial sale of white sturgeon roe is permitted for a segment of the Columbia River commercial fishery, but the 60-inch maximum size limit in the fishery precludes any significant catch of mature fish.¹⁰⁴

White sturgeon are also poached for their increasingly valuable roe. In 1990, a caviar dealer and two others were convicted of violations of the Lacey Act for poaching approximately 2,000 adult white sturgeon from the Columbia River. They produced 3,307 pounds of caviar from the illegally captured fish which they testified to having sold as beluga and osetra caviar.¹⁰⁵

Sturgeon Aquaculture

Sturgeon breeding initially began more than 100 years ago for hatcheries to support the wild population. Culturing was attempted from 1880 to 1920 in Europe and North America, but with little success. Only in the Soviet Union was breeding successful, when hatcheries began operating about 1930.¹⁰⁶ White sturgeon were artificially spawned outside the Soviet Union in 1979 at University of California, Davis.¹⁰⁷

Sturgeon farms are expensive to operate, in part because sturgeon females require 8 years or more to reach reproductive size. Aquaculturists have developed techniques to perform repeat “ceasareans” on females, which helps reduce costs. One producer has performed up to five successful operations on a single fish.¹⁰⁸

Aquaculture raises a number of serious environmental concerns related to pollution, escapes of farmed fish (which can carry diseases to wild populations and breed with wild fish), the use of antibiotics to control diseases, and the use of wild fish as food in aquaculture.¹⁰⁹ Sturgeon aquaculture operations in the United States avoid some of these problems by virtue of the fact that they are located on land, in enclosed tanks that recycle waste water. In addition, the number of sturgeon farms is very small by comparison to other types of aquaculture (catfish, salmon, trout).¹¹⁰ However, some concerns remain, particularly regarding escapes.¹¹¹ As sturgeon are naturally omnivorous, questions also remain over the

¹⁰⁴ Beamesdefer, 1998, p. 96.

¹⁰⁵ Cohen, A. 1998. “Sturgeon poaching and black market caviar: a case study,” in Birstein et al, eds. 1997b, p. 245.

¹⁰⁶ Doroshov, S.I. and F.P.. Binkowski, 1985, “Epilogue: a perspective on sturgeon culture” in North American Sturgeon, F.P. Binkowski and S.I. Doroshov, (eds.) dr. W. Junk Publishers, Dordrecht.

¹⁰⁷ Hung, S.S.O., 1991. Nutrition and feeding of hatchery-produced juvenile white sturgeon (*Acipenser transmontanus*): an overview, in *Acipenser*. P. Williot, ed. Cemagref.

¹⁰⁸ Personal communication, Dafne Engstrom, Tsar Nicoulai Caviar, November 8, 2000.

¹⁰⁹ Naylor, R.L., R.J. Goldberg, J. H. Primavera, N. Kautsky, M.C.M. Beveridge, J. Clay, C. Folke, J. Lubchenco, H. Mooney, and M. Troell. 2000. Effect of aquaculture on world fish supplies. *Nature* 405(29):1017-1024.

¹¹⁰ The 1998 Census of Aquaculture showed slightly over 4,000 farms (those that responded to the survey) in the domestic aquaculture industry, only four of which are known to be producing sturgeon for either caviar or meat.

¹¹¹ Although escape of farmed sturgeon from US aquaculture operations is unlikely because they are located on-shore and use tanks enclosed in buildings, any escape of aquacultured sturgeon could pose threats related to the spread of disease and hybridization of wild populations. Aquacultured white sturgeon can harbor disease not common in wild species (Secor et al, 2000, p. 226), and escape of infected cultured sturgeon could spread disease to stressed wild populations, hastening their decline. Escape also poses hybridization threats to wild populations.

amount and source of protein in the feed used in sturgeon aquaculture. Feeds can be composed of a substantial amount of wild fishmeal and fish oil.¹¹² Research is on-going to develop alternative sturgeon feeds to decrease the dependence on wild fish and fish oil.¹¹³

While interest in sturgeon aquaculture appears to be high, few U.S. facilities produce sturgeon, and fewer still produce caviar.

Stolt Sea Farms is the largest U.S. supplier of farmed caviar. Stolt is a multi-national fish farming company that has purchased many smaller farms, and now produces white sturgeon caviar under the corporate name of “Sterling Caviar.” Also in California, longtime sturgeon farmers Mats and Dafne Engstrom run Tsar Nicoulai Caviar. Together, these two farms are expected within two years to produce more than 30,000 pounds of caviar per year.¹¹⁴ The caviar of white sturgeon is said to most closely resemble osetra. Operations in other states are generally much smaller and/or focused on producing sturgeon meat, as opposed to caviar.¹¹⁵

Sturgeon farming is in various stages of development and production in Germany, Hungary, Romania, Italy, France, Spain, Portugal, Israel, Chile, Argentina, Iran, the Czech Republic, and Uruguay.¹¹⁶ France, Italy and the Czech Republic already produce 10 tons of caviar every year. This is only five percent of the total market, but is expected to rise.¹¹⁷ It is estimated that by 2002, the French industry alone could produce as much as 20 tons of caviar a year.¹¹⁸ Practices in other countries may differ from

¹¹² Hung, S.S.O. 1991; and Medale, F. *et al.* 1995. Nutrition of farmed Siberian sturgeon: a review of our current knowledge” in Proceedings of the International Sturgeon Symposium, VNIRO Publishers: 289-299. See also Wittenberg, M. 2000. Aquaculture Working Group Report to the USDA National Organic Standards Board, November 17, 2000.

¹¹³ Personal communication with Silas Hung, University of California-Davis, August 18, 2000.

¹¹⁴ Personal communication, Dafne Engstrom, November 8, 2000.

¹¹⁵ In Florida, sturgeon are currently being evaluated by the University of Florida’s Mitchell aquaculture Farm (an experimental academic facility) for their potential for aquaculture, using Gulf of Mexico sturgeon. However, because Gulf sturgeon is listed on the State’s threatened list and is listed under the federal Endangered Species Act, special exemptions would have to be granted for the fish to be sold commercially. The goal with this type of aquaculture would be to grow the sturgeon for their meat, as there is a market in Florida for sturgeon. (“UF Researchers Harvest Sturgeon,” The Gainesville Sun, November 6, 1999). There is a relatively new commercial farm in the Dade County/Miami area – their sturgeon are 2 years old and the farm is entering the smoked fillet market. Males will be separated from the females and prepared for market. A small specialty farm and market exists in New York for smoked sturgeon fillets. The facility imports Siberian sturgeon (*A. baerii*) and bester (a fast-growing hybrid of beluga and sterlet (*Acipenser ruthenus*)) as eggs and fry from Russia and Italy. The facility is completely enclosed and water is recycled. The same food used in salmon aquaculture is currently used, though the farm is in contact with researchers around the globe who are working to develop a custom feed (one using less fish meal and more soy protein) (Personal communication, Rokaviar, October 19, 2000).

Currently, only one farm in Idaho aquacultures sturgeon, for the meat market only. (Personal communication, Fish Breeders of Idaho, November 6, 2000).

¹¹⁶ In the early 1980s, France undertook a breeding program for Siberian sturgeon (which produces caviar most similar to osetra) and the common European sturgeon (*A. sturio*). Boeckmann, and Rebeiz-Nielsen, 2000, p. 52-53. French sturgeon farms both export fingerlings for repopulating programs and for grow out to produce caviar. In France, osetra caviar is produced from farm-raised sturgeon in Arcachon. <http://www.caviarassouline.com> website, October 2000.

¹¹⁷ Associated Press, November 17, 1999.

¹¹⁸ Boeckmann and Rebeiz-Nielsen, 2000, p. 56.

the US industry, but were not evaluated for this report.

Recommendations

Consumer and government action is urgently needed to address the problems facing sturgeon of the Caspian Sea. The United States consumes about one-third of the world's caviar, so the U.S. government and its consumers have the responsibility to do what they can to ensure the continued viability of sturgeon.

Policy Recommendations

1. Stop the international trade of beluga sturgeon caviar.

Beluga sturgeon in the Caspian Sea region is on the brink of extinction, and decisive action is necessary. While CITES trade restrictions may have reduced export of illegally produced caviar from Russia,¹¹⁹ these restrictions are only a first step in halting the decline.¹²⁰ International trade in beluga caviar needs to be stopped immediately to reduce the pressure on beluga sturgeon.

Two CITES fora provide mechanisms to stop international trade of beluga caviar. The first is the CITES "significant trade review" process, whereby species of concern are evaluated by a CITES committee of experts to determine the status of the species and the effects of international trade on that species. Ten species of sturgeon and paddlefish, including the principal Caspian Sea species, are being evaluated, and findings, recommendations, and requests for more information are expected to be issued to the "range states," (the countries in which the species of concern occur) in December, 2000. Based on the response of the range states, final recommendations will be made during 2001. The United States, and all CITES parties, should pursue a recommendation to halt international trade in beluga caviar in the context of the significant trade review process currently underway.

Over the longer term, the United States and other CITES parties should seek to move beluga sturgeon from Appendix II of CITES, under which international trade is permitted subject to compliance with certain permit and other requirements, to Appendix I, under which all international trade is banned. Beluga sturgeon clearly meet the trade and biological criteria for inclusion in Appendix I.¹²¹ Listing beluga on Appendix I will mean that beluga caviar can no longer be traded legally on the international market. The most promising opportunity to secure such a listing is at the next meeting of the CITES Conference of the Parties in 2002.

¹¹⁹TRAFFIC/Europe, 1999, p. 14.

¹²⁰ Secor, *et al.*, 2000, p. 10.

¹²¹ Beluga sturgeon meet the trade criteria for CITES Appendix I listing in that the species is clearly affected by trade. This species also meets the biological criteria. The wild population is small, has a restricted area of distribution, and is characterized by: an observed, inferred or projected decline in the number of individuals or the area and quality of habitat, and a high vulnerability due to the species' biology and behavior. A decline in the number of individuals in the wild has been inferred or projected on the basis of: a decrease in area or quality of habitat, levels or patterns of exploitation, and threats from extrinsic factors such as the effects of toxins and pollutants.

2. List beluga sturgeon as endangered under the U.S. Endangered Species Act.

Foreign and domestic species can be listed under the U.S. Endangered Species Act of 1973¹²² when such a species is “in danger of extinction throughout all or a significant portion of its range.”¹²³ Many foreign species have been listed under the ESA, including the panda, tiger, certain leopard populations and chimpanzees.¹²⁴

Under the Endangered Species Act and its implementing regulations, once a species is listed as “endangered,” any “taking” is flatly prohibited.¹²⁵ “Take” is defined as “to harass, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.”¹²⁶ It is illegal to import or export, ship in the course of commercial activity, sell or offer for sale any endangered fish or wildlife species.¹²⁷

As the world’s second largest importer of beluga caviar,¹²⁸ and the destination of roughly 28,000 pounds of beluga caviar in 1999,¹²⁹ a reduction in the U.S. importation of beluga caviar would reduce demand for this caviar and improve the prospects for the species.

3. Pursue funding for key programs and initiatives needed to protect and restore all of the Caspian Sea species.

Reduced demand would give the Caspian Sea and other nations the time to implement the following steps necessary to conserve beluga, stellate and Russian sturgeon. These recommendations include those identified by TRAFFIC, an organization with extensive expertise in international trade in endangered species, including sturgeon:

- a) Increase domestic and international funding for enforcement against poaching and for restoration of spawning habitat in the countries bordering the Caspian Sea;
- b) Caspian countries need to enforce a ban on open sea fishing and bottom trawling for sturgeon, reduce annual quotas, and establish or enforce fishing seasons, size limits, provisions for observers on fishing vessels and processing plants, and requirements to release undersized, male and immature sturgeon;
- c) Improve water quality in the Caspian Sea by addressing waste disposal, reducing fertilizer and pesticide runoff, and minimizing oil pollution and industrial discharges;
- d) Maintain and upgrade hatcheries, which are virtually the only sites where beluga reproduction is

¹²² 16 U.S.C. Section 1531, et seq.

¹²³ 16 U.S.C. Sec.1532(6).

¹²⁴ 37 FR 6176 (1972) and 35 FR 84491 (1970) (tiger); 49 FR 2779 (1984) (panda); 47 FR 4204(1982) (leopard); 55 FR 9129(1990) (chimpanzee and pygmy chimpanzee).

¹²⁵ 16 U.S.C. Sec. 1538(a).

¹²⁶ 16 U.S.C. Sec. 1532(19).

¹²⁷ 16 U.S.C. Sec. 1538(a)(1).

¹²⁸ Only Switzerland imports more beluga caviar. TRAFFIC, 2000(a), p. 94.

¹²⁹ USFWS, LEMMIN data, analyzed by Craig Hoover, TRAFFIC, November 6, 2000.

taking place; and

- e) Create an international program to secure and maintain live specimens of each of the Caspian species of sturgeon in captivity as a safeguard against total extinction.

Increased funding for sturgeon conservation from international sources, including the Caspian Environment Program,¹³⁰ is needed to ensure that effective action is taken. The United States should aggressively pursue funding opportunities for sturgeon conservation in international aid programs to the region.

1. Beef up U.S. enforcement of international trade restrictions.

According to the U.S. Fish and Wildlife Service (FWS), there are 12 FWS enforcement agents in the New York area, and 91 others nationwide.¹³¹ These agents are responsible for handling all illegal trade in wildlife. More resources for detecting and prosecuting smugglers are needed to help deter poaching and illegal trade to the United States.

2. Promote environmentally sound aquacultured caviar as an alternative to Caspian Sea caviar.

A number of aquaculture operations in the United States and elsewhere produce caviar or are preparing to produce caviar. These operations have the potential to supply some of the demand for caviar. While aquaculture represents a major opportunity to reduce pressure on wild populations, it also raises environmental concerns, including pollution, possible escape of aquacultured fish, use of fishmeal and fish oil from wild-caught fish, and enforcement issues. The following steps are needed to minimize these concerns.

Closely regulate discharges of pollutants including food waste, excretory products, antibiotics used to control disease, and pesticides used in aquaculture operations. Most sturgeon aquaculture operations in the U.S. employ closed systems, reducing this concern substantially. Regulations requiring all sturgeon aquaculture operations to employ closed systems is an important and needed step.

Minimize feed derived from fish caught specifically for fish meal production. Producers should reduce the amount of wild fishmeal and fish oil used in sturgeon diets. Using wild fish to grow farmed fish raises concerns about fishing some populations to feed others, especially because wild fish are a

¹³⁰ The CEP was started in 1995 by international financing agencies including UNEP (United Nations Environmental Program) and UNDP (UN Development Program), the World Bank and the European Union/Tacis along Azerbaijan, Iran, Kazakhstan, Russia and Turkmenistan. Also involved is the GEF (Global Environment Facility). The goal of the CEP is to promote sustainable development of Caspian countries and environmental management of the Caspian Sea for 20 years. Subsidiary goals are: (1) understanding and learning to live with the Caspian water level fluctuations; (2) abatement of existing and prevention of new types of pollution and deterioration of the Caspian environment and its resources; (3) recovery and rehabilitation of those elements of the Caspian environment (including biological diversity) that are degraded and that still have the potential for recovery; and (4) long-term sustainability of environmental quality and resources.

¹³¹ U.S. Fish and Wildlife Service, pers. com. to Prosanta Chakrabarty 11/30/00.

principal source of protein for many people and play a key role in ocean ecosystems.¹³²

Ensure escape of aquacultured sturgeon does not occur. Given that sturgeon aquaculture in the United States is generally conducted in land-based, enclosed facilities, escapes are much less likely than from ocean pens such as those used in salmon aquaculture. However, should escapes occur, any viruses or other diseases associated with cultured white sturgeon could carry infection to wild populations. Hybridization of wild populations with escapees is also a concern.

Establish certification of aquacultured sturgeon, or otherwise ensure the origin of farmed sturgeon products, so that they don't become a way to "launder" illegally caught or imported sturgeon meat and caviar.

It is critically important that domestic and international standards be developed to address these and other concerns related to aquaculture. Here in the United States, the U.S. Environmental Protection Agency is currently developing regulatory standards for the aquaculture industry. The agency needs to address the environmental issues related to aquaculture in a comprehensive and rapid manner.

3. Strengthen state management of U.S. species of sturgeon

Sturgeon management in the United States is generally patchy. Many states lack scientifically-based controls on the amount of fish that can be landed, particularly for paddlefish and shovelnose sturgeon. Even for those states that do have some controls, basic biological information is not used to determine allowable fishing levels and the fisheries are not closely monitored. It is therefore often difficult to determine whether a given caviar fishery is biologically sustainable.

Inconsistent management programs for U.S. sturgeon species leaves them vulnerable to overfishing if beluga or other Caspian Sea caviar is not available at current levels. States should make development of comprehensive scientific and management programs a top priority for paddlefish and shovelnose sturgeon. The Mississippi Interstate Cooperative Resource Agency (MICRA), composed of 28 states in the Mississippi River basin, is a non-regulatory agency that plays an important role in range-wide cooperative activities for fish of the Mississippi River basin. Congress should consider granting MICRA, or a similar interstate management authority, legal authority to develop and implement comprehensive interstate management plans for paddlefish, shovelnose and other sturgeon of the Mississippi River system.

Remedial action to restore sturgeon spawning and rearing habitat is another priority for North American sturgeon and paddlefish. While fisheries for the largest U.S. populations of white sturgeon are carefully managed using biological reference points, other segments of the population are sparse or below historical abundance.¹³³ Flow regulation and habitat alteration have hurt these populations' reproductive success, and meaningful habitat and flow restoration are needed to help ensure their long-term viability.

¹³² Naylor, R.L., R.J. Goldberg, J.H. Primavera, N. Kautsky, M.C.M. Beveridge, J. Clay, C. Folke, J. Lubchenco, H. Mooney, and M. Troell. 2000. Effect of aquaculture on world fish supplies. *Nature* 405(29):1017-1024. p 1017.

¹³³ Miller, et al, p. 3.

Consumer recommendations

The most important step consumers can take is to reduce their consumption of caviar, the market for which is adversely affecting many sturgeon populations around the world. Caviar needs to become an item limited to only the most special occasions. Avoid beluga caviar in particular. Better choices include:

1. Aquacultured Sturgeon Caviar

While environmental issues remain regarding sturgeon aquaculture, aquacultured caviar is a much better choice for consumers concerned about the future of Caspian Sea sturgeon. These are questions that consumers should ask of producers and suppliers:

- a) What kind of system is the fish raised in?

Tip: A recirculating system is generally preferable to a flow-through system, because it minimizes water use and reduces effluent discharge.

- b) How is wastewater treated before it is released from the sturgeon tanks?

Tip: A polyculture system (where water is reused for the culture of other species) is best. Wastewater should not be released in a manner that pollutes the surrounding environment.

- c) What are the sturgeon being fed? How much wild fish meal and oil are they eating?

Tip: Producers should be lowering the ratio of wild fish used in the production of farmed sturgeon.

1. North Star Caviar/Yellowstone Caviar

North Star Caviar was launched in 1993 as a joint venture of two non-profit organizations, the Williston (North Dakota) Area Chamber of Commerce and the Friends of Fort Union Trading Post. Just across the Yellowstone River in Glendive, Montana is a similar program called Yellowstone Caviar. During the six-week recreational paddlefish season on the Yellowstone River, anglers from the two states get free fish cleaning in return for donating eggs (caviar) to the Chambers of Commerce. The anglers keep the paddlefish meat and the Chambers of Commerce process the caviar. North Star Caviar and Yellowstone Caviar market the caviar and the proceeds are used to fund civic, cultural, and educational community projects (60 percent) as well as to support paddlefish research and conservation (40 percent). State fishery biologists are on hand to collect biological information on the fish, help monitor the fishery and set annual catch levels.

The North Dakota and Montana fisheries together catch up to 3,000 fish each year.¹³⁴ North Star Caviar produced approximately 1,500 pounds of paddlefish roe from the 2000 fishery.¹³⁵ By 1996, Montana's portion of the program alone had grossed over one million dollars and had supported 117

¹³⁴ personal communication, North Star Caviar, November 2, 2000. Because both North Dakota and Montana prohibit commercial fishing for paddlefish, paddlefish caviar from those states is either legally caught and processed under this program or is a product of poaching.

¹³⁵ personal communication, North Star Caviar, November 2, 2000.

community projects.¹³⁶

This program benefits not only the communities of eastern Montana and western North Dakota, but it also helps protect paddlefish and provides an excellent example of a limited fishery for caviar. However, management of this fishery, as well as other paddlefish fisheries, needs to be improved by the application of biological status information to determining sustainable catch levels.

While the North Star program represents a sound approach from the standpoint of sturgeon, consumers should be aware that the state of North Dakota has issued a consumption advisory for paddlefish due to mercury contamination.¹³⁷

North Star caviar, Yellowstone caviar, and aquacultured caviar are better choices for consumers concerned about Caspian Sea sturgeon. But they cannot supply the demand that will be left by the decline of Caspian Sea sturgeon and caviar. In order to prevent demand from serially depleting other sturgeon species, reducing consumption of caviar is essential.

Consumers have a key role to play in promoting the conservation of endangered species of sturgeon by reducing their demand for caviar and choosing their caviar sources with conservation in mind. Consumers can also encourage the U.S. government to aggressively advocate effective conservation measures, restrictions on trade, and funding for conservation, management and enforcement in the Caspian Sea region. But we all need to act, and act quickly, if these remarkable fish are to be saved.

¹³⁶ PERC. 1999. "Environmental capitalists." September 19, 1996.

¹³⁷ U.S. Environmental Protection Agency, Listing of Fish and Wildlife Advisories. This report does not address the human health aspects of caviar consumption. For more information about specific waterbodies under consumption advisories, the chemicals of concern and consumption recommendations, go to EPA's fish advisory website: <http://fish.rti.org/form1b.htm>.

Appendix I: Conservation of critically endangered sturgeon outside the Caspian Sea

While, as a whole, the three main commercial sturgeon species of the Caspian Sea bear the brunt of international commercial demand for caviar and are the focus of this report, there are several other species around the world that are in serious decline due to the same problems that plague fish of the Caspian Sea. Several of these populations are described briefly below.

The Amur River: The Amur River flows for more than 1,700 miles along the border between Russia and China and is home to two sturgeon species, the kaluga (*Huso dauricus*) and the Amur sturgeon (*Acipenser schrenckii*). Like its close relative in the Caspian, the beluga sturgeon, the kaluga is one of the world's largest freshwater fish. It can live more than 80 years, reaching lengths greater than 18 feet and weighing more than one ton.¹³⁸ Historically, both kaluga and the smaller Amur sturgeon have supported Chinese and Russian commercial fisheries in the Amur River. In 1891, 1,322 tons of sturgeon were landed from Amur River fisheries. Through the first two decades of the twentieth century, however, the river's population of kaluga was reduced by two-thirds and the Amur sturgeon population was reduced by four-fifths.¹³⁹ A second period of significant decline has occurred from the early 1960s to the present, characterized by increasingly intensive illegal fishing.¹⁴⁰ Today, total permissible catch by Russia is limited to 110 tons per year,¹⁴¹ though Russian officials recorded 17,000 instances of poaching during the spring 2000 fishing season on the Amur.¹⁴²

The Danube River and Black Sea: The three major sturgeon species that support commercial trade in the northern Caspian Sea -- the beluga, Russian, and stellate sturgeon -- are also found in the Danube River and Black Sea and the species face similar problems in each place. Sturgeon products have been exported from the lower Danube region of Romania for centuries and as recently as the late 1930s, Romania produced 23.1 tons of caviar per year.¹⁴³ Since then, however, the relative sizes of all sturgeon in the Danube has decreased, as have their population sizes. Factors driving the decline include decades of overfishing; deforestation resulting in increased siltation and adverse changes to the substrate; construction of the Iron Gates I (1970) and Iron Gates II (1984) dams on the Lower Danube; water pollution by pesticides and fertilizers; gravel excavation; and water diversion for irrigation. Generally, sturgeon populations are most threatened in the middle and upper reaches of the river and beluga and Russian sturgeon populations of the Danube River are in danger of extinction.¹⁴⁴ The 1989 Romanian revolution dismantled the Communist fishery management program and in the

¹³⁸ Krykhtin, M.L. and V.G. Svirskii. 1997a. Sturgeon catch and the current status of sturgeon stocks in the Amur River, in Birstein, et al, eds., 1997a, p. 30.

¹³⁹ Krykhtin, M.L. and V.G. Svirskii. 1997b. Endemic sturgeon of the Amur River: kaluga (*Huso dauricus*), and Amur sturgeon (*Acipenser schrenckii*), in Birstein, et. al, eds. 1997b.

¹⁴⁰ Krykhtin and Svirskii. 1997a.

¹⁴¹ Krykhtin and Svirskii. 1997a.

¹⁴² Wall Street Journal, "Poachers threaten sturgeon population in Russia." November 13, 2000.

¹⁴³ Bacalbasa-Dobrovici, N. 1997a. Danube caviar in danger. The Sturgeon Quarterly 5 1/2 (January-April 1997).

¹⁴⁴ Bacalbasa-Dobrovici, N. 1997b. Endangered migratory sturgeon of the lower Danube River and its delta. Environmental Biology of Fishes 48:201-207, p. 203; and Hensel, K. and J. Holcik. 1997. Past and current status of sturgeon in the upper and middle Danube River. Environmental Biology of Fishes 48:185-200, p. 189.

meantime poaching operations have become well-organized and powerful and monitoring and enforcement are virtually non-existent.¹⁴⁵

¹⁴⁵ Bacalbasa-Dobrovici, 1997a, p. 4.

Appendix II: Literature Cited

- . 2000. "Black gold," *in* Life Magazine, February 2000, p. 28-32.
- . 1999. "UF Researchers Harvest Sturgeon," The Gainesville Sun. November 6, 1999.
- Abdullaev, N. 2000. "Dagestanis fish for sturgeon, caviar, bribes," The Moscow Times, October 11, 2000.
- Altuf'ev, Y., 1997. Morphofunctional abnormalities in the organs and tissues of the Caspian sea sturgeons caused by ecological changes, same volume. 1997. *In*: Birstein, V.J., A. Bauer and A. Kaiser-Pohlmann, (eds.) Proceedings of the Sturgeon Populations and Caviar Trade Workshop, IUCN SSC p. 81.
- Associated Press. 1999. Black caviar exports cut in half. October 11, 1999.
- Bacalbasa-Dobrovici, N. 1997a. Danube caviar in danger. The Sturgeon Quarterly 5 1/2 . January-April 1997.
- Bacalbasa-Dobrovici, N. 1997b. Endangered migratory sturgeons of the lower Danube River and its delta. Environmental Biology of Fishes 48:201-201.
- British Broadcasting Corporation (BBC). "Russia set to stop exporting caviar as sturgeon dwindle." May 25, 2000.
- BBC/Interfax. 2000. Sturgeon season in Caspian to be extended. September 22, 2000.
- Beamesderfer, R. 1999. Management of and trade in Pacific sturgeon. *In*: Williamson, D.F., G.W. Benz & C.M. Hoover (eds.) Proceedings of the Symposium on the Harvest, Trade and Conservation of North American Paddlefish and Sturgeon. TRAFFIC North America World Wildlife Fund. Washington, D.C., pp. 95-105.
- Bemis, W.E. and B. Kynard, 1997, Sturgeon rivers: an introduction to acipenseriform biogeography and life history. *In*: Birstein, V.J., J.R. Waldman & W. E. Bemis (eds.) Sturgeon Biodiversity and Conservation. Kluwer Academic Publishers, Dordrecht. 1997: 167-83.
- Birstein, V.J., A. Bauer & A. Kaiser-Pohlmann (eds.) 1997a. Sturgeon Stocks and Caviar Trade Workshop, Proceedings of a Workshop Held 9-10 October in Bonn, Germany. IUCN Occasional Paper No. 17. 89 pp.
- Birstein, V.J., J.R. Waldman & W. E. Bemis eds. 1997b. Sturgeon Biodiversity and Conservation. Kluwer Academic Publishers, Dordrecht. 1997.
- Birstein, V.J., J.R. Waldman & W. E. Bemis 1997c. The threatened status of Acipenseriform species; a summary. *In*: Birstein, V.J., J.R. Waldman & W. E. Bemis eds. Sturgeon Biodiversity and Conservation. Kluwer Academic Publishers, Dordrecht. 1997. pp. 427-435.
- Birstein, V.J., P. Doukakis & R. DeSalle. 1999. Molecular phylogeny of Acipenserinae and black caviar species identification. Journal of Applied Ichthyology 15:12-16.
- Boeckmann, S. & N. Rebeiz-Nielsen. 2000. Caviar: The Definitive Guide. John Wiley & Sons, New York. 160pp.
- Boreman, J. 1997. Sensitivity of North American sturgeons and paddlefish to fishing mortality. *In*: Birstein, V.J., J.R. Waldman & W. E. Bemis (eds.) Sturgeon Biodiversity and Conservation. Kluwer Academic Publishers, Dordrecht. 1997. pp. 399-405.
- <http://www.caviarassouline.com> website, October 2000.

- Cohen, A. 1997. Sturgeon poaching and black market caviar: a case study. *In*: Birstein, V.J., J.R. Waldman & W. E. Bemis eds. Sturgeon Biodiversity and Conservation. Kluwer Academic Publishers, Dordrecht. 1997. pp. 423-426.
- Debus, L. 1997. Sturgeons in Europe and causes in their decline. *In*: Birstein, V.J., A. Bauer and A. Kaiser-Pohlmann, (eds.) Proceedings of the Sturgeon Populations and Caviar Trade Workshop, IUCN SSC Paper No. 17: 55-68.
- DeMeulenaer, T. & C. Raymakers. 1996. Sturgeons of the Caspian Sea and the international trade in caviar. TRAFFIC International. pp.71.
- Doroshov, S.I. & F.P. Binkowski. 1985. Epilogue: a perspective on sturgeon culture *In*: F.P. Binkowski & S.I. Doroshov (eds.) North American Sturgeons. Dr. W. Junk Publishers, Dordrecht.
- U.S. Department of Energy, Energy Information Administration, 2000. "Caspian Sea Region." June, 2000. (<http://www.eia.doe.gov/emeu/cabs/casfull.html>).
- Fabricant, F. 2000. The dearest eggs since Fabrege, Iranian caviar returns. New York Times. Section F, p. 3, October 4, 2000.
- Grady, J.M. & G.A. Conover. 1998. Mississippi River Basin paddlefish research coded-wire tagging project 1997 annual report. MICRA, P.O. Box 744, Bettendorf, IA. 33 pp + Appendix.
- Graham, K. 1997. Contemporary status of the North American paddlefish, *Polyodon spathula*. *In*: Birstein, V.J., J.R. Waldman & W. E. Bemis (eds.) Sturgeon Biodiversity and Conservation. Kluwer Academic Publishers, Dordrecht. 1997: 279:289.
- Hensel, K. & J. Holcik. 1997. Past and current status of sturgeon in the upper and middle Danube River. Environmental Biology of Fishes 48: 185-200.
- Hesse, L.W. & J.R. Carreiro. 1997. The status of paddlefish, pallid sturgeon, lake sturgeon, and shovelnose sturgeon. River Ecosystems, Inc. 52 pp.
- Horvath, J. 1999. Cousteau Society warns that the Caspian Sea is dying. January 7, 1999. (<http://www.heise.de/tp/english/inhalt/co/5029/1.html>).
- Hoover, C. 1998. Import and export of sturgeon and paddlefish in the United States. *In*: Williamson, D.F., G.W. Benz & C.M. Hoover (eds.) Proceedings of the Symposium on the Harvest, Trade and Conservation of North American Paddlefish and Sturgeon. TRAFFIC North America World Wildlife Fund. Washington, D.C.
- Hung, S.S.O. 1991. Nutrition and feeding of hatchery-produced juvenile white sturgeon (*Acipenser transmontanus*): an overview. *In*: P. Williot (ed.) *Acipenser*. Cemagref.
- Joint Columbia River Management Staff. 2000. Joint Staff Report Concerning the 2000 in-river commercial harvest of Columbia River fall chinook salmon, summer steelhead, coho salmon, and sturgeon. July 13, 2000. 31 pp.
- Keenlyne, K., 1997. Life history and status of the shovelnose sturgeon, *Scaphirhynchus platyrhynchus*. *In*: Birstein, V.J., J.R. Waldman & W. E. Bemis (eds.) Sturgeon Biodiversity and Conservation. Kluwer Academic Publishers, Dordrecht. 1997:291-298,
- Khodorevskaya, R.P., G.F. Dovgopol, O.L. Zhuravleva & A.D. Vlasenko. 1997. Present status of commercial stocks of sturgeons in the Caspian Sea basin. *In*: Birstein, V.J., J.R. Waldman & W. E. Bemis eds. Sturgeon Biodiversity and Conservation. Kluwer Academic Publishers, Dordrecht. 1997. pp. 209-219.
- Khodorevskaya, R.P., & Y.V. Krasikov. 1999. Sturgeon abundance and distribution in the Caspian Sea. Journal of Applied Ichthyology 15: 106-113.

- Khodorevskaya, R.P., E.V. Krasikov, G.F. Dovgopol, and O.L. Zhuravlev. 2000. Formation of the stock of Caspian Acipenserids under present-day conditions. *Journal of Ichthyology* 40(8):632-639.
- Krykhtin, M.L. & V.G. Svirskii. 1997a. Sturgeon catch and the current status of sturgeon stocks in the Amur River. *In: Birstein, V.J., A. Bauer & A. Kaiser-Pohlmann (eds.) 1997 Sturgeon Stocks and Caviar Trade Workshop, Proceedings of a Workshop Held 9-10 October in Bonn, Germany. IUCN Occasional Paper No. 17: 29-34.*
- Krykhtin, M.L. & V.G. Svirskii. 1997b. Endemic sturgeons of the Amur River: kaluga (*Huso dauricus*), and Amur Sturgeon (*Acipenser schrenckii*). *In Birstein, V.J., J.R. Waldman & W. E. Bemis eds. Sturgeon Biodiversity and Conservation. Kluwer Academic Publishers, Dordrecht. 1997. pp. 231-39.*
- Medale, F., G. Corraze, S.J. Kaushik. 1995. Nutrition of farmed Siberian sturgeon: a review of our current knowledge. *In: Proceedings of the International Sturgeon Symposium. VNIRO Publishers: 289-299.*
- MICRA Paddlefish/Sturgeon Steering Committee. 1993. Strategic Plan. Columbia, Missouri. June, 1993.
- Miller, A.I., T.D. Counihan, M.J. Parsley, and L.G. Beckman, Columbia river basin white sturgeon. U.S. Geological Survey report, 9 pp.
- Naylor, R.L., R.J. Goldberg, J.H. Primavera, N. Kautsky, M.C.M. Beveridge, J. Clay, C. Folke, J. Lubchenco, H. Mooney, and M. Troell. 2000. Effect of aquaculture on world fish supplies. *Nature* 405(29):1017-1024.
- Parsley, M.J., L.G. Beckman & G.T. McCabe. 1993. Spawning and rearing habitat use by white sturgeons in the Columbia River downstream from McNary Dam. *Transactions of the American Fisheries Society* 122 (2): 217-227.
- PERC. 1999. Environmental Capitalists. September 19, 1996.
- Raymakers, C. 1998. Trade in sturgeons from the Caspian Sea, *in Williamson et al., eds, 1998: 150-58.*
- Secor, D.H. & J.R. Waldman 1999. Historical Abundance of Delaware Bay Atlantic Sturgeon and Potential Rate of Recovery. *American Fisheries Society Symposium* 23: 203-216.
- Secor, D.H., V. Arefjev, A. Nikolaev & A. Sharov 2000. Restoration of sturgeons; lessons from the Caspian Sea sturgeon Ranching Programme. *Fish and Fisheries* 1: 215-230.
- Taylor, S. 1997. The historical development of the caviar trade and the caviar industry. *In: Birstein, V.J., A. Bauer & A. Kaiser-Pohlmann (eds.) 1997 Sturgeon Stocks and Caviar Trade Workshop, Proceedings of a Workshop Held 9-10 October in Bonn, Germany. IUCN Occasional Paper No. 17: 45-54.*
- Todd, R. 1998. Sturgeon and paddlefish commercial fishery in North America. *In: Williamson, D.F., G.W. Benz & C.M. Hoover (eds.) Proceedings of the Symposium on the Harvest, Trade and Conservation of North American Paddlefish and Sturgeon. TRAFFIC North America World Wildlife Fund. Washington, D.C., 293 pp.*
- TRAFFIC, 2000(a). Review of 10 species of Acipenseriformes, prepared for the Sixteenth Meeting of the CITES Animals Committee.
- TRAFFIC/Europe. 1999. Estimation of the population and population conditions of sturgeons in Russia and monitoring of domestic trade in sturgeon products. TRAFFIC/Europe-Russia, December 1999. 18 pp.
- TRAFFIC/ North America/World Wildlife Fund. 2000. Caviar smuggling on the rise. TRAFFIC North America newsletter 3(2):11-12.
- TRAFFIC, 1997. CITES Conference of the Parties Briefing.

- Tyler, P.E. 2000. Poaching may kill fish that lay the golden eggs. *New York Times*, Section A. September 24, 2000.
- Urch, M. 1999. "Azerbaijan project tackles pollution," *Seafood International*, September 9, 1999
- U.S. Environmental Protection Agency, Listing of Fish and Wildlife Advisories. <http://fish.rti.org/form 1b.htm>.
- United States Fish and Wildlife Service 1998. New Caviar Import Measures Protect Imperiled Sturgeon, News Release, March 25, 1998.
- United States Fish and Wildlife Service Paddlefish Fact Sheet
(<http://southwest.fws.gov/fishery/species/paddlefish.html>)
- Waldman, J.R. 1995. Sturgeons and paddlefishes: A convergence of biology, politics, and greed. *Fisheries* 20(9):20-22.
- Waldman, J.R. and D.H. Secor. 1998. Caviar trade in North America: an historical perspective, *in* Williamson, et al, eds. 1998.
- Wall Street Journal, "Poachers threaten sturgeon population in Russia." November 13, 2000.
- Wei, Q., Fu'en, K., Jueming, Z., Ping, Z., Junde, L., Rueqiong, Z, and Wenhua, Y. 1997. Biology, fisheries, and conservation status of sturgeons and paddlefish in China. *Environmental Biology of Fishes* 48:241-255.
- Williamson, D.F., G.W. Benz, and C.M. Hoover (eds.). 1998. 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/World Wildlife Fund, Washington, D.C., USA. 293 pp.
- Wittenberg, M. 2000. Aquaculture Working Group Report to the USDA National Organic Standards Board, November 17, 2000.