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Species Profile
Production of Sturgeon

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General Description

Sturgeon are one of the oldest living vertebrates, with fossil records dating back more than 150 million years. Their skeletons are mostly cartilaginous. Distinguishing characteristics are a cylindrical shape; five rows of large, bony plates called scutes; and heterocercal or top-elongated tail fins. Sturgeon are in the family Acipenseridae, which includes about 26 species in four genera—*Acipenser, Huso, Scaphirhynchus* and P*seudoscaphirhynchus*. Eight species of sturgeon are found in North America. There are five species of *Acipenser*: the white (*A. transmontanus*) and green (*A. medirostris*) sturgeon on the Pacific coast; the Atlantic sturgeon (*A. oxyrinchus*) and shortnose sturgeon (*A. brevirostrum*) on the Atlantic coast; and the lake sturgeon (*A. fulvescens*) distributed in large rivers and lakes of the Atlantic Ocean drainage and upper Mississippi River basin. There are also three species of *Scaphirhynchus*—the shovelnose (*S. platorynchus*), pallid (*S. albus*) and Alabama (*S. suttkusi*) sturgeons inhabit freshwater, primarily in the Mississippi River basin.

Natural History

Most sturgeon are anadromous or semi-anadromous; that is, they live in oceanic or brackish waters, respectively, and then migrate to freshwater rivers for spawning. Some, such as the lake and shovelnose sturgeons, are potamodromous and live in freshwater their entire lives.

Sturgeon are long-lived. Atlantic, white and lake sturgeon can live as long as 80 years and pallid sturgeon can live for more than 40 years. Because of their longevity, female sturgeon are slow to mature sexually. They may not begin spawning until 20 years of age and usually spawn once every 2 to 5 years. Males will mature sexually a few years sooner than females. Females usually have a brief reproductive period; they spawn when water is deep and current is strong enough to prevent settling of suspended matter, and where the bottom is covered with stones or gravel. Sturgeon broadcast their sperm and eggs (which are 2 to 4 mm in diameter depending on the species) during spawning and the fertilized eggs become very sticky so that they adhere to rocks. The ovaries of females account for 15 to 25 percent of their body weight, and a female releases from tens of thousands to several million eggs per spawn.

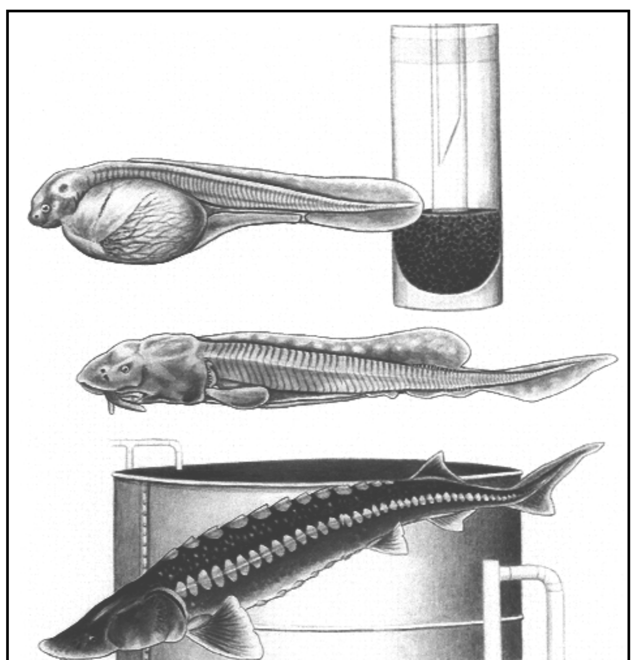

Figure 1. Life stages of the white sturgeon, Acipenser transmontanus.

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Fry hatch in 5 days at a water temperature of 20 ºC, 10 days at a temperature of 10 ºC. Newly hatched fry derive nourishment from their yolk sacs for 5 to15 days depending on water temperature. They begin external feeding when a "yolk plug" is excreted from the spiral valve (specialized intestine). Fry first eat zooplankton, and later worms, larger crustaceans and mollusks. They have extendible mouths (sucker-like) surrounded by taste-sensitive barbels and feed on or near the bottom. Their mobile jaws allow them to hold onto prey and spit out sand and mud before ingesting food.

Current protection and aquaculture as an alternative

For centuries, most sturgeon species have been highly valued for their roe or eggs, which are processed into caviar. Sturgeon are also sought for their firm, boneless meat. Most sturgeon and their products originate from the Caspian Sea, primarily from Russia, Kazakhstan, Azerbaijan and Iran. The most popular species are the beluga (*Huso huso*), the osetra or Russian/Persian sturgeon (*A. gueldenstaedti / A. persicus*), and the sevruga sturgeon (*A. stellatus*).

There is a high demand for caviar. This, along with concern that sturgeon habitat is being altered, caused sturgeon to be added in 1998 to the Appendix II list of the United Nation's Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES). This CITES listing restricts the import or export of sturgeon products into or out of the United States unless a CITES permit is obtained through the U.S. Fish and Wildlife Service.

Aquaculture of sturgeon can help in the conservation of wild populations through restocking and by providing a consistent supply without exploiting wild populations. The main species used in aquaculture production worldwide are white sturgeon (*A. transmontanus*), Siberian (*A. baeri*), osetra (*A. gueldenstaedti*), sterlet (*A. ruthenus*), and a hybrid called bester (beluga female x sterlet male).

Challenges for sturgeon culture

There are several challenges to the production of sturgeon in the United States. Supplies of broodstock and fry are limited. There is a long maturation period of at least 8 years before females produce roe for caviar. Sturgeon require moderate temperatures of 68 to 79 ºF (20 to 26 ºC) for ideal growth, and an ample supply of well water is necessary. Facilities for sturgeon production are mostly intensive, with expansive tank systems, and require large amounts of operating capital. More markets for farm-raised sturgeon and their products need to be developed in the U. S.

Although other sturgeon species have potential for culture, white sturgeon is currently the main species being raised in the U. S. This publication provides basic information about the propagation, production, processing and marketing of sturgeons, much of it based on the white sturgeon. More detailed information can be found in the references.

Propagation

Broodstock

Brood fish were once obtained from the wild. Now, however, brood fish of white sturgeon and a few Eurasian species (e.g., Siberian) are being raised in hatcheries and capturing wild fish is no longer necessary. This certainly improves the potential for sturgeon culture because wild sources are variable from year to year and because regulation by fisheries agencies can be problematic. However, the 8 to 10 years required for many species of sturgeon to reach sexual maturity is both a significant operational challenge and an economic liability.

Brood fish can be transported in conventional hauling tanks of 300 to 500 gallons (1100 to 1900 liters). Water is agitated to supply oxygen and sodium chloride salt is added at 0.25 to 0.50 percent (0.2 to 0.4 pounds per gallon; 25 to 50 g/L) to counter physiological stress. Approximately 2 pounds (1 kg) of brood fish per gallon (4 liters) of water is a safe loading rate for transport. When brood fish are removed from the hauling tank they should be placed on a stretcher (made of canvas or synthetic tarp materials) that supports the entire body so as to prevent injury. Brood fish are first placed in maturation tanks until ready to spawn; then they are placed in spawning tanks. In cooler climates, ponds can be used for long-term holding and maturation of brood fish. Ponds must be at least 6 feet deep and aerated in the summer to keep water temperature cool enough and oxygen level high enough.

Brood fish are selected for spawning by determining the stage of gonadal maturity. Tissue samples from the gonads are obtained through a small incision in the abdomen; tissue forceps (e.g., Brown Adson and Allis forceps) or a stiff catheter may be used to remove the eggs (i.e., oocytes) or a piece of testicular tissue. The general appearance will differentiate males from females. Milt from ripe males often can be collected through the urogenital opening behind the anus. Sturgeon have very dilute semen, unlike the creamy white liquid in most other fishes. The color, size and stage of maturity of the oocytes determines whether a female is ready for spawning. Mature oocytes of most sturgeon species are dark brown-black and 2.5 to 3.5 mm in diameter. Females that can be induced to release eggs will have oocytes that are undergoing final maturation. Oocytes in advanced stages of maturity can be identified by the position of the egg nucleus, called the germinal vesicle (GV; see Fig. 2). Oocytes with the GV close to the edge, or near the surface of the outer membranes of the eggs, are the most likely to ovulate (stages IV, V and VI). To view the nucleus or GV, oocytes are first boiled for 3 to 5 minutes and then cut in half lengthwise through the polar axis with a single-edged razor blade. The polar area is located by the presence of 10 to 12 funnel-shaped holes (micropyles) in the egg membrane. The position of the GV can be estimated either visually (e.g., position I, II, III, etc. from the center to the side of the egg; Fig. 2) or by calculating the oocyte polarization index or PI, which is the distance of the GV to the outer membrane divided by the oocyte diameter (Fig. 3). Females selected for spawning should have a PI of less than 0.07.

An *in vitro* assay also can be used to estimate the readiness of females to spawn. Freshly collected oocytes should be placed in a "maturation" solution (Ringer's solution with 5µg/ml progesterone) and incubated at 74 °F (23 °C) for 16 hours. Movement of the GV (Germinal Vesicle Migration—GVM) during incubation suggests readiness for induced maturation and pending ovulation (Germinal Vesicle Breakdown—GVBD). If more than 90 percent of the eggs are undergoing GVBD, the female is ready to spawn. If the percentage of oocytes at GVBD is less than 90 percent, the female is not a good candidate at that time. Resample oocytes at 1- to 2-week intervals, depending on the water temperature, to determine when the female is ready.

Spawning conditions and hormone injection

Sturgeon can be propagated when water temperature ranges from 50 to 68 °F (10 to 20 °C). Spawning tanks for brood fish are usually rectangular. Tanks should be large enough that fish can

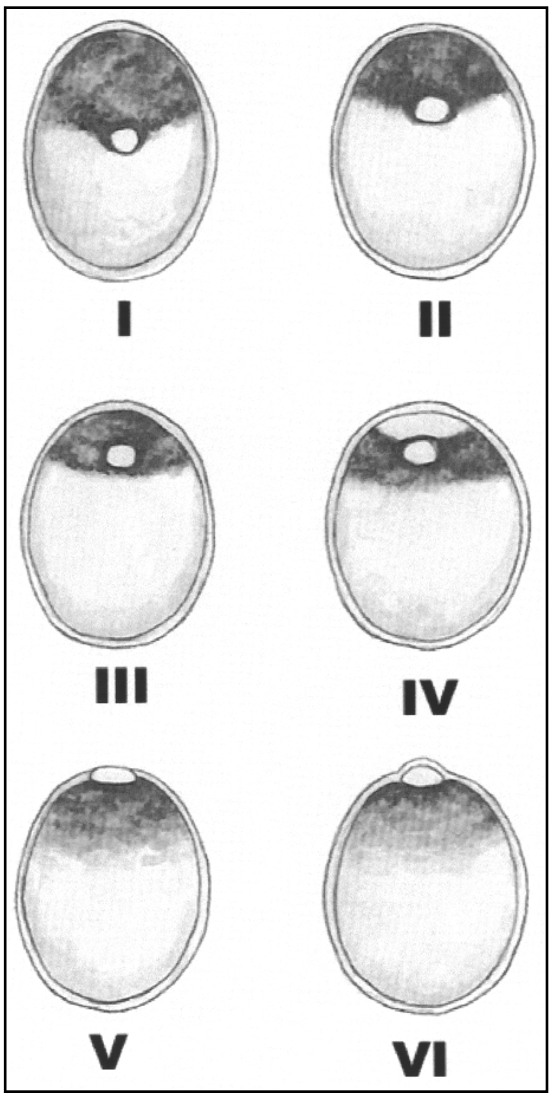

Figure 2. Sturgeon oocyte stages (I-VI). Illustrations are of bisected oocytes showing the germinal vesicle (GV) positions. The stages show the migration of the GV from the center of the oocyte to the animal pole. Stage VI shows an ovulated egg (modified from Shelton and Mims, 1995).

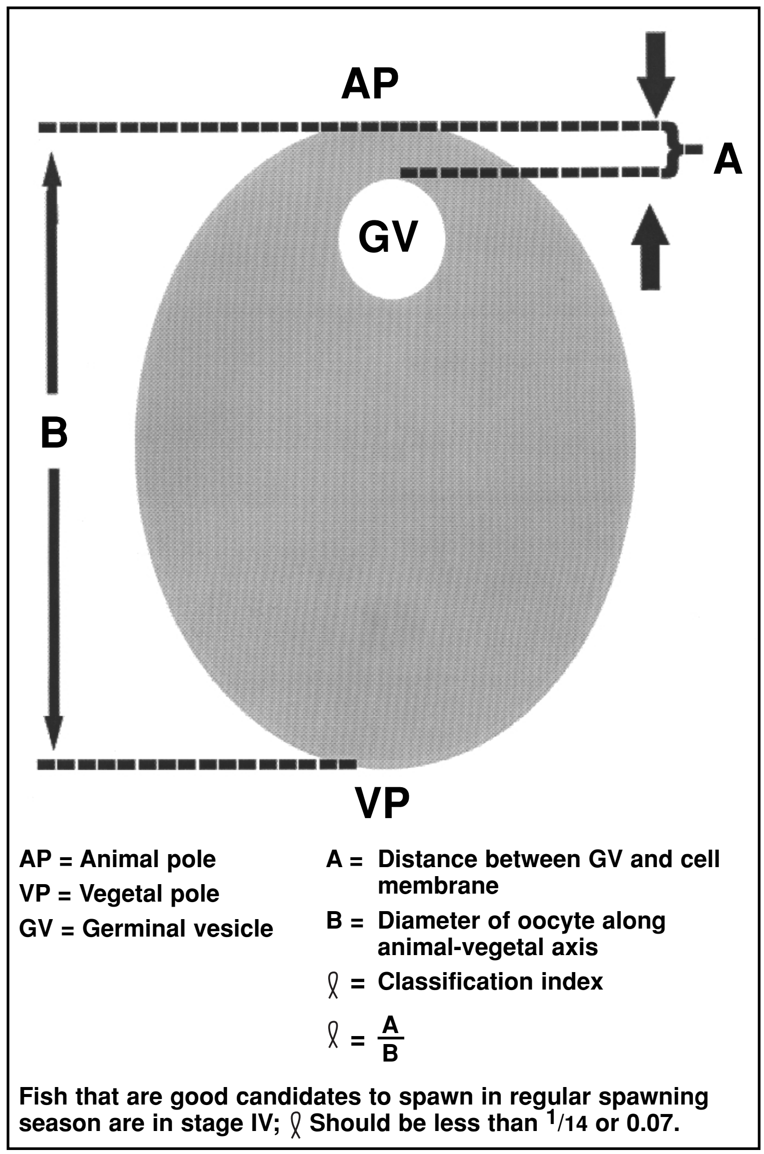

Figure 3. Diagram of a sturgeon oocyte showing the position of the germinal vesicle (GV) at the animal pole and the formula for determining the oocyte polarization index (PI) (modified from Detlaf et al., 1981, and Conte et al., 1988).

move a little but can't turn. For example, a tank 7 feet long, 2 feet wide and 2 feet deep (2m x 0.6m x 0.6m) would be suitable for sturgeon that are 50 to 100 pounds (23 to 45 kg). The height of the tank should be convenient for handling the fish and for moving the fish in and out of the tank with a stretcher. Tanks should be covered with shade cloth secured with rope to reduce lighting and prevent fish from jumping out of the tank. Optimal conditions for spawning are a water temperature of 55 to 63 ^oF (13 to 17 ^oC), a water exchange rate of five or more times the volume of the tank per hour, and water saturated with oxygen (100 percent; about 10 ppm at 62 ^oF or 10 mg/L at 17 ^oC).

Ovulation and spermiation are stimulated by injecting either fresh or dried common carp (CCP) or sturgeon (SP) pituitaries, or a synthetic Luteinizing Hormone Releasing Hormone analogue, LHRHa (e.g., des-Gly 10, D-Ala 6- ethylamide). These hormones are currently not approved for sturgeon; FDA Investigational New Animal Drug (INAD) permits are required for their use. The injections are administered in the muscle between the lateral and dorsal scutes within the area extending from the base of the pectoral fin to the midsection of the fish. Use a 1- to 3-cc disposable syringe with 23-gauge needles. Females should receive a total dose of either 1.8 mg per pound (4 mg/kg) of body weight (BW) using CCP or SP, or a total dose of 0.045 mg per pound (0.1mg/kg) of BW using LHRHa. Administer a priming injection (10 percent of total dose) followed 12 hours later by a resolving injection (90 percent of total dose). If responsive, females will ovulate within 18 to 30 hours after the second injection when water temperatures range from 55 to 63 ^oF (13 to 17 ^oC). Males receive half the total dose that females receive in one injection, usually when the females receive the priming dose. Males should spermiate within 18 to 24 hours at similar water temperatures.

Milt and egg collection

To collect milt (sperm), handle the sturgeon with a restraining net but with the urogenital opening exposed. Blot the urogential area dry and insert tygon tubing, commonly used for aquarium aeration (3/16-inch or 0.5-cm diameter; 2 inches or 5 cm long), attached to a 20-cc plastic syringe into the opening. Collect milt with gentle suction. With this method large quantities (five to ten syringes) of milt can be removed from one male each day for 3 to 4 days without contamination by either feces or water. Use milt from two or three males to fertilize eggs in order to increase genetic diversity. Place a sample of milt in water and view microscopically. If 75 to 100 percent of the sperm are motile the milt can be used. If less than 75 percent of the sperm are motile, use other males. Milt can be collected several hours before needed and stored without aeration in sealed containers. Refrigerate it (39 ^oF or 4 ^oC) or cool it on wet ice (ice sprinkled with water). White sturgeon milt has been stored up to 2 weeks and used successfully when pure oxygen is added to the milt in the syringe and held at 39 ^oF or 4 ^oC.

Traditionally, females are sacrificed to collect the eggs. Blows to the head or severing the spinal cord are common methods. To remove the eggs, the fish is hung vertically on a hook by the mouth or gill opening so the urogenitial opening is at the waist level of the person collecting the eggs. The caudal fin is cut and the fish is bled to prevent contamination of the eggs. The abdomen is cut with a knife from the urogenitial opening up to the anterior of the abdomen. A bowl is held directly under the initial cut to collect the eggs. Additional bowls are filled until all of the eggs are removed.

There are two other methods—caesarean section and the minimally invasive surgical technique (MIST)—that do not require sacrificing the female and are ideal for maintaining brood fish for use in subsequent years. Caesarean section is a relatively quick surgical method (30 minutes); a 4-inch (10-cm) incision is made in the abdomen, the eggs removed, and the incision sutured. The MIST method is more rapid (about 10 minutes). A small incision (0.5 inches or 1.5 cm) is made in the posterior-ventral area of the oviduct just inside the urogenital opening (Fig. 4) using a scalpel with a no.11 straight blade. This permits ovulated eggs to pass from the body cavity through the gonopore without going through the oviducts. With the Caesarean or MIST method only 50 to 90 percent of the eggs can be removed. Regardless of the method used, the eggs must be collected free of water and blood. Female sturgeon

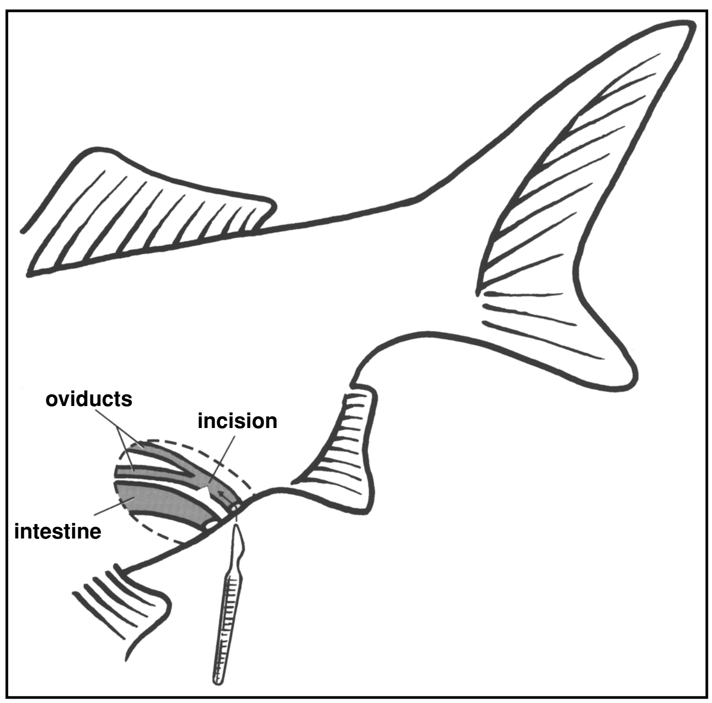

Figure 4. The minimally invasive MIST procedure for removing ovulated eggs from sturgeon (modified from Mims and Shelton, In Press).

weighing 50 to 100 pounds (23 to 45 kg) can release 250,000 to 500,000 eggs.

Fertilization and hatching

The eggs should be fertilized using the "wet method." Milt is added to water (1 part milt to 100 parts water) and then immediately poured onto the eggs [(0.3 ounce (10 ml) of undiluted milt per quart (liter) of water added to a quart (liter) of eggs)]. There are approximately 40,000 eggs per quart or liter. The fertilized eggs become adhesive after a couple of minutes. The adhesiveness must be removed if incubation is to be in flow-through containers. The most common way to do this is to coat eggs with clay or Fuller's earth. One minute after fertilization, the clay suspension is poured onto the fertilized eggs in a proportion of 2 to 4 volumes of clay to 1 volume of eggs. The mixture can be stirred gently by hand so clumped eggs are separated. The clay suspension should be changed every 10 minutes to maintain water temperature and oxygen levels. The time and labor required for de-adhesion depends on water temperature. At cooler temperatures (e.g., 55 ^{o}F or 13 ^{o}C) the process may take up to an hour; in warmer water (63 ^{o}F or 17 ^{o}C) it may take about 30 minutes. When the eggs are not "sticky," flush the bowl with fresh water until the water runs clear. The eggs are volumetrically measured (approximately 50 eggs/ml) and loaded into McDonald jars (2.6-gallon or 10-liter capacity) at about 50,000 eggs per jar. Water flow is adjusted to gently tumble the eggs, which ensures oxygenation and reduces fungus development. Dead eggs and clumps of eggs should be removed by siphoning. The optimal water temperature for incubating eggs of white sturgeon is 58 to 63 ^{o}F (14 to 17 ^{o}C). Fry will hatch in 7 to 9 days and begin to eat after another 7 to 9 days. During this time the mouth and foregut develop, the residual yolk is absorbed, and the body becomes darkly pigmented.

Nursery phase

Producing juvenile sturgeon is probably the most difficult part of the hatchery process. Fry survival depends on having a proper culture system and a complete nutritional program with attention to diet formulation, feeding schedule, food presentation and preference. Fry are initially stocked at 60 to 80 per gallon of water (15 to 20/L). Thereafter, the developing fry should be stocked by weight at not more than 0.4 to 0.6 ounce per gallon (3 to 5 g/L).

Culturists of white sturgeon have found it best to begin offering a prepared diet a few days before the yolk is completely absorbed. This seems to familiarize the fry with the odor of the feed and has improved survival and growth. Modified salmon diets (#0-3 crumbles) are used to feed fry during the first 3 to 4 weeks. Feed is offered at a rate of 25 percent of the total fish biomass every 24 hours, with feeding intervals of 2 to 3 hours. Automatic feeders provide consistent presentation and uniform delivery over a 24-hour period. Young sturgeon have also been fed brine shrimp nauplii for up to 30 days or until they grow to about 1 to 1.3 inches (2.5 to 3.5 cm) long, before weaning them onto commercial starter diets.

Grow-out production

There is little information on the grow-out production of sturgeon in the scientific literature and most information is proprietary. The following information is based on some general practices for the market production of meat, caviar and broodstock.

Grow-out of sturgeon is usually done in circular tanks (6.5 to 9.5 yards or 6 to 8.5 m diameter x 1.1 to 1.7 yards or 1 to 1.5 m deep). Tanks use either aerated, flow-through well water or recirculating system technology. Raceways are also used to a lesser extent. Juveniles don't survive well in pond culture, partly because of high water temperatures and ammonia levels at the soil/water interface of pond bottoms, especially where soils have high organic content. Deeper ponds in temperate climates may contain cooler water during summer. Ideal water temperatures for grow-out for many sturgeon species are 68 to 79 ^{o}F (20 to 26 ^{o}C). Fish are raised for 3 to 4 years for meat, 8 to 10 years for meat and caviar. Sex of fish cannot be determined by tissue biopsy until at least 3.5 years of age.

Because sturgeon forage on the bottom, stocking rates for juveniles are based on surface area of the tank bottom rather than total water volume. Stocking rates are 7 to 40 fish per square foot (75 to 430/m^2) or 1 to 8 ounces per square foot (300 to 2475 g/m^2). Rates vary depending on water exchange rates and the degree of aeration. As fish grow some should be removed so there is ample foraging space. One fish per square foot (11 fish/m^2), with minimal water exchange and diffused aeration, to 2.5 fish per square foot (27 fish/m^2), with greater water exchanges and oxygenation, are common stocking rates for larger juveniles in meat production systems where fish biomass is about 1 pound per gallon (120 g/L). Stocking densities for brood fish are lower and based on biomass. They can be as high as 1 pound per gallon (120 g/L).

Juveniles 1 to 5 inches long are fed 5 to 7 percent BW per day (2.5 to 12.5 cm); this decreases to 3 to 5 percent for 6- to 12-inch fish (15 to 30 cm), and to 1 to 2 percent for fish larger than 1.5 pounds (680 g) or 18 inches (48 cm). Continuous feeding with belt feeders or similar devices is recommended. Research on sturgeon nutrition has been somewhat limited, but studies suggest that juveniles and brood fish should have a diet with at least 40 percent protein and 8 to 10 percent fat. Good growth has been observed with salmonid diets in which fishmeal is the main protein source. Sturgeon are efficient converters of feed. Feed conversion ratios (FCR) of 1.0:1.4 are common for juveniles and 1.6:2.0 for adults.

Sturgeon have one of the fastest growth rates of all freshwater fish—up to 11 grams per day for juvenile sturgeon under ideal water temperatures. Averages of 2.4 to 4.8 pounds per year (1.0 to 2.2 kg/year) are common with some species. In some studies fish grew to 6 pounds within 18 months posthatch. To produce a marketable size fish (1 to 3 kg for the meat market) under optimal environmental conditions, stocking density can exceed 60 to 70 kg/m^3 with oxygen concentration maintained at 5 mg/L. Survival rate is expected to be 50 to 80 percent from fry stage to marketable size. Raising mature fish for caviar production can be accomplished in approximately 8 to 10 years.

Water quality

Sturgeon have been cultured in well and surface waters of varied water quality. Some specific water quality requirements have been identified for a few sturgeon species, largely based on the experience of hatchery and grow-out facility managers. Generalizations can be made about the quality parameters in Table 1. Other parameters, including hydrogen sulfide, iron, heavy metals and chemical residues, are not clearly understood. Managers should have water tested and follow the guidelines that are known for other sturgeon species. As with most species, young sturgeon are more susceptible to minor deviations from ideal water quality than adults.

As an anadromous species, sturgeon are adapted to varied water quality in their natural habitat; most sturgeon live in temperate areas with relatively mild water temperatures in summer (less than 80 °F or 27 °C). Spawning generally occurs in spring when water temperature is 50 to 68 °F (10 to 20 °C) and optimal growth occurs at 68 to 79 °F (20 to 26 °C). Water temperatures above 82 °F (28 °C) slow or stop feeding and growth. The Gulf of Mexico sturgeon can survive summer water temperatures of 86 to 90 °F (30 to 32 °C), but may lose weight and have more stress-related diseases.

Sturgeon can also adapt to variations in salinity. Ideal salinities for early life stages are less than 1ppt; adults can be cultured and transported in salinities of more than 3 ppt. Acclimating juveniles and adults to salinities greater than 20 ppt should be gradually done over 3 to 5 days. Salt baths have been used to treat fungus and certain gill parasites, but fish may initially appear agitated and should be watched closely during treatment.

Like other culture species, sturgeon can survive short periods when the concentration of dissolved oxygen is low (less than 3 mg/L), but prolonged exposure causes feeding to slow and increases the risk of parasitic and bacterial infections. Oxygen concentrations of 5 mg/L or more are recommended for intensive production. Many sturgeon culture systems use supplemental oxygen sources and supply devices. Compressors or regenerative blowers can supply adequate oxygen if the biological oxygen demand (BOD) of the culture system is taken into account and ample airflow is delivered. Sturgeon fry can be susceptible to gas bubble disease when water is supersaturated with dissolved gases (more than 105 percent). Therefore, hatcheries should use adequate degassing technology to drive off excess dissolved gases (see SRAC Fact Sheet 191 on methods for degassing water).

Sturgeon fry and juveniles survive better in tanks than in ponds, possibly because they feed on the bottom where they are exposed to higher concentrations of ammonia and nitrite. Young sturgeon are more sensitive to these parameters than other pond-cultured fishes. Like channel catfish, sturgeon can develop brown blood disease when exposed to high concentrations of nitrite. Adding chloride ions can help, though the required chloride-to-nitrite ratios have not yet been established. Adequate biofiltration or water exchange is required to maintain concentrations of unionized ammonia below 0.01 mg/L and concentrations of nitrite below 0.1 mg/L.

Table 1. Recommended water quality concentrations for sturgeon culture.

Parameter	Recommended concentrations
Alkalinity	50-400 mg/L as $CaCO_3$
Ammonia (unionized)	< 0.01 mg/L as N
Dissolved oxygen	> 5.0 mg/L
Gas saturation	< 105 %
Hardness	50-400 mg/L as $CaCO_3$
pH	6.5-8.5
Nitrite	< 0.1 mg/L as N
Salinity	0-0.5 ppt for fry; 0-3 ppt for juveniles; and 3 ppt for adults
Temperature	varies with species; 50-68 °F (10-20 °C) for spawning, and 68-79 °F (20-26 °C) for grow-out

Diseases

Viral diseases have become a problem in intensive sturgeon culture in the U. S. There is little information on the treatment of these diseases. Four viruses have caused death in cultured white sturgeon: white sturgeon adenovirus (WSAV); white sturgeon iridovirus (WSIV); and two white sturgeon herpesviruses (WSHV-1 and WSHV-2). At least one stressful event (pump failure, handling, transport) occurred 9 to 32 days before the appearance of the diseases. Mortality often occurs over a 4- to 5-month period with up to 95 percent loss of juvenile white sturgeon. These viruses are believed to come from the broodstock, which is known as vertical transmission (i.e., gamete-associated route) rather than from tank-to-tank transmission. No antiviral immunization is currently available. Viral infection might be prevented or controlled on the farm by maintaining selective broodstock for reproduction, stocking fish that survived viral outbreaks, harvesting all fish in a tank ("all-in all-out" production) and decreasing stocking densities. A PCR assay is being developed that might detect infections in virus carriers and make it possible to segregate virus-free broodstock and their offspring.

Bacterial infections rarely have been reported in intensive culture systems, but have been reported in several species of sturgeon obtained from wild populations. The most common bacterial infection was *Aeromonas hydrophila*. Others included *A. sobria*, *Streptococcus* sp., *Edwardsiella tarda* and *Yersinia ruckeri*. Bacteria are sensitive to oxytetracycline at 5 cc per 10 gallons administered for 30 minutes each day for 10 days. Fungus of eggs (saprolegnia) can be controlled by removing diseased eggs or by using a saline (NaCl) bath of 2.6 mg/L for 30 to 60 minutes.

Processing and marketing

Meat

Sturgeon meat is firm, white and boneless, and has long been popular in the U.S. In 2000, approximately 600 tons (544 metric tons) of farmed-raised white sturgeon meat was processed and sold in the U.S. It is presented in two forms—bullet (head, internal organs and fins removed) and fillet. The dress-out percentage for white sturgeon is 70 percent in bullet form and 40 percent in fillet form. Prices range from $3.50 to $5.00 per pound ($7.70 to $11.00 per kg) for bullet and $5.00 to $6.00 per pound ($11.00 to $13.20 per kg) for fillet. Hot- and cold-smoked sturgeon meats are value-added products popular with East and West coast consumers; retail prices for it range from $18 to $24 per pound ($40 to $53 per kg).

Caviar

Caviar, or salted roe, is a nutritious delicacy. More than 90 percent of the caviar in the international market comes from sturgeon caught in the Caspian Sea, but the catch there is declining so sturgeon are being cultured to produce caviar. In 2000, approximately 4 tons of caviar were produced and sold from farm-raised white sturgeon in the U.S. Wholesale prices in the U.S. range from $113 to $531 per pound ($250 to $1170 per kg) depending on the species.

To have high quality caviar, the fish must be sacrificed. After bleeding the fish, the ovaries are removed and pushed through a $^{1}/_{8}$-inch (3-mm) screen to separate the eggs from tissue. There are two forms of processed caviar—malossol and pressed. Malossol (a Russian word meaning "not much salt") caviar is lightly salted and is the most common type. The salt content ranges from 2.4 to 4.4 percent (other caviar may contain as much as 11 percent salt). The lower the salt content the better the caviar, but the shorter its shelf life. Malossol should be refrigerated at 28 to 39 °F (-2 to 4 °C) and has a shelf life of 3 months. Today, most caviar is pasteurized, which increases the shelf life to 12 to 15 months. Pressed caviar is made with a mixture of eggs, with some that may be overripe, underripe, or from different species of sturgeon. The eggs are heated slightly and pressed in a cloth. Pressed caviar is used as a spread on toasts or blinis (small buckwheat pancakes). Caviar is usually packed in tin boxes at the wholesale level and repackaged for retail sales in smaller tins or jars ranging from 1 ounce to 2 pounds (30 g to 1 kg).

Summary

Sturgeon products—caviar and meat—are of high quality and value and have well-established markets in the U.S. and worldwide. With over-fishing and habitat loss, wild sturgeon stocks are limited. Sturgeon aquaculture can help in restocking wild populations and in meeting consumer demand for products. Sturgeon have many positive culture attributes including fast growth, good feed conversion, ability to accept crowding, and relatively good hardiness. Much of the necessary culture technology has been developed. Challenges in sturgeon culture are the long maturation period (5 to 10 years depending on species) and the limited availability of brood fish and seed. A consistent supply of juveniles needs to be developed in order to expand production. Prospective culturists should do a thorough economic analysis of business potential and be prepared to make a significant capital investment.

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