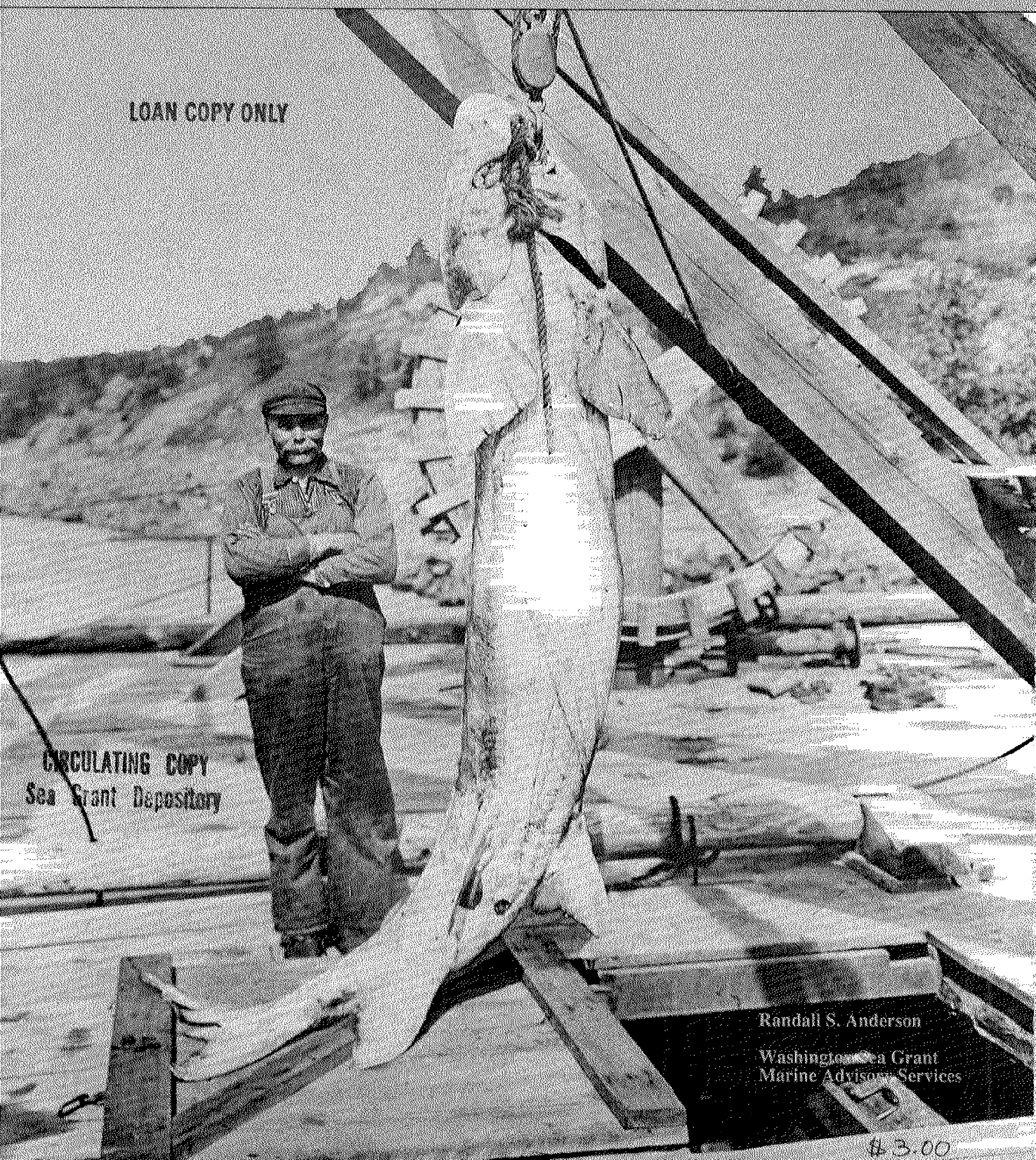
COLUMBIA RIVER STURGEON



Randall S. Anderson

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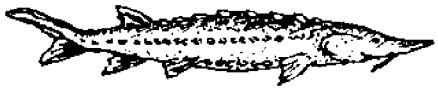


BACKGROUND

The Columbia River is home to North America's largest sturgeon resource—in the world second only to that of Asia's Caspian Sea. Although white sturgeon (*Acipenser transmontanus*) were brought to near extinction by commercial fishing in the late 1800s, populations have slowly recovered and sturgeon are once again an important fishery resource in the Columbia River system.

Sturgeon in the Columbia system are caught by commercial (Indian and non-Indian) and recreational anglers. Prior to 1975, harvest levels were relatively small and stable. In the last 10 years, however, the recreational catch of sturgeon has more than doubled, making white sturgeon an increasingly important sport fish on the river. The total commercial catch by Indian tribes is also increasing—essentially having doubled every year since 1984.

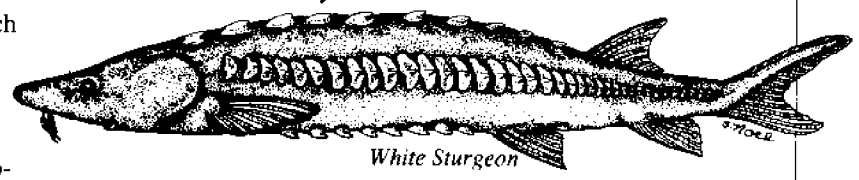
Because of escalating harvests in both sport and Indian fisheries, there is increasing concern about the future of Columbia River sturgeon. Many are advocating that harvest limits be tightened, while others think that sturgeon hatcheries should be constructed to meet future demands. In recent years, Oregon and Washington lawmakers have considered legislation that would curtail or even eliminate the non-Indian commercial fishery.

The white sturgeon has also become a prime candidate for commercial aquaculture ventures. In 1979, researchers from the University of California–Davis developed a prototype sturgeon hatchery. With fishermen's help, the scientists captured ripe, wild sturgeon, which they were able to keep and successfully spawn in captivity. In subsequent years, the Davis researchers further demonstrated that sturgeon fry and fingerlings can be successfully reared in captivity on artificial feed.

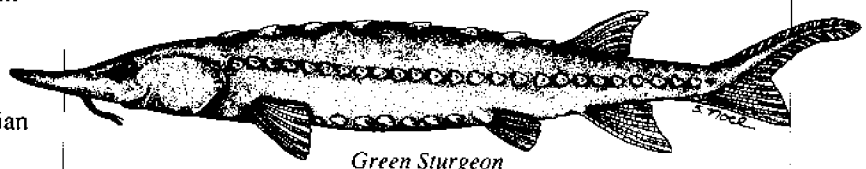
The development of successful hatchery technology for white sturgeon has created a growing commercial sturgeon aquaculture industry in California. Several farms are currently in production and others are planning to enter the field. Although still largely in a research and development phase, the emerging sturgeon aquaculture industry in California has attracted considerable attention from both the general public and private aquaculturists. Sturgeon from the Columbia River are now being viewed as potential broodstock for similar ventures in the Pacific Northwest.

Despite its unique aquaculture potential and its importance to the Columbia River fisheries, little is known about the white sturgeon in nature. Literature on the biology, life history, and habitat requirements has been limited and generally inaccessible to the public. Furthermore, information on recent aquaculture developments often remains too technical to be understood by the general public. This report assembles some of the existing information and makes it both understandable and accessible to the interested public, to policymakers, to managers, and to researchers.

Wherever sturgeon have been commercially exploited, there has been a history of depletion. As both sport and commercial uses continue to increase, the public will be faced with some difficult decisions regarding future use of the Columbia River sturgeon resource. It is hoped that this publication will provide the reader with a deeper appreciation and better understanding of the Columbia River's largest and oldest resident—the white sturgeon, enabling the public to make such decisions wisely.



White Sturgeon



Green Sturgeon

Sturgeon Species of the Columbia River

BIOLOGY AND LIFE HISTORY

Worldwide, there are 23 species or subspecies of sturgeon, all of them found in the Northern Hemisphere. Seven species are found in North America—two on the Pacific Coast.

The Columbia River is home to both Pacific Coast sturgeon species—the green sturgeon (*Acipenser medirostris*) and the white sturgeon (*Acipenser transmontanus*). Green sturgeon spend most of their time in brackish water and are thus found primarily in the lower 40 miles of the Columbia and along the coast. Their distinguishing characteristics include an olive-green color, long shovel-like snout, and sensory barbels that are closer to the mouth than to the tip of the snout. Green sturgeon sometimes reach a length of 7 feet and a weight of 350 pounds; however, their flesh is generally considered to be of inferior quality and therefore of limited commercial importance.

The white sturgeon is more abundant than green sturgeon and is the larger of the two species. In fact, it is the largest freshwater fish species in North America—capable of reaching lengths of almost 20 feet. Because of the high value of its flesh and eggs (used in producing caviar), it is also considered to be the species of most commercial importance.

Oregon Department of Fish and Wildlife

A sturgeon's sensory barbels and protrudable, toothless mouth are a good combination for life at the bottom of the Columbia.

Although somewhat similar to the green sturgeon in appearance, white sturgeon can usually be identified by their gray color, short rounded snout, and barbels that are closer to the tip of the snout than to the mouth.

Resembling some sort of prehistoric creatures, sturgeon are actually the modern relics of an ancient group of fishes. Although they first appeared about 200 million years ago, sturgeon have remained relatively unchanged to the present. They are closely related to paddlefish, another primitive survivor. Both have sharklike tails, a skeleton that is more cartilage than bone, and a unique spiral valve intestine that aids in food absorption.

Instead of scales, sturgeon are protected by a heavy sandpaperlike skin and five rows of bony plates, called *scutes*, which serve as an armorlike covering. Underneath their flattened snout are four sensory barbels and a toothless, "vacuum cleaner" mouth capable of siphoning up food.

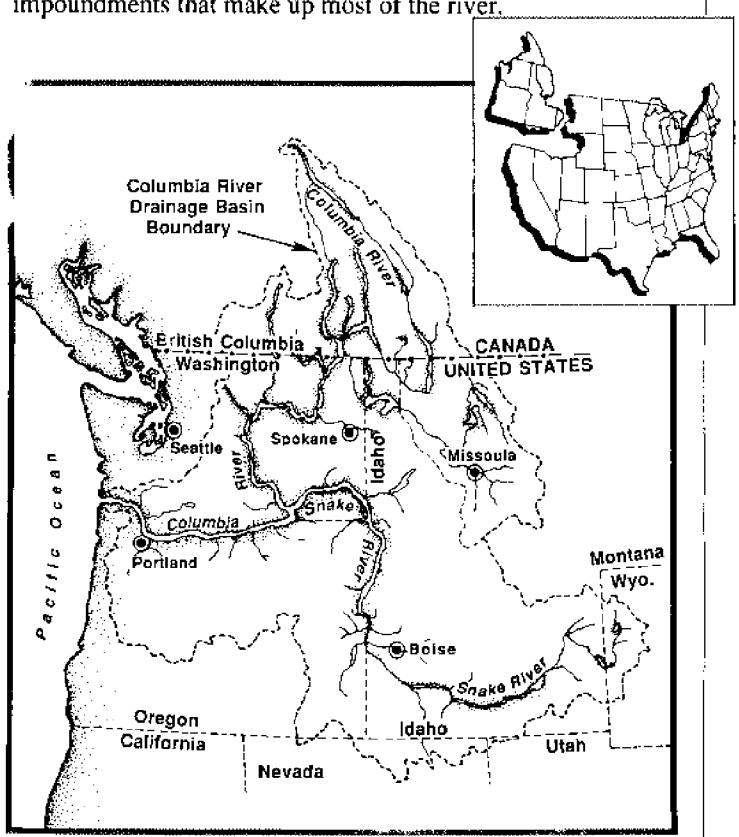
Sturgeon generally feed on the bottom, rooting with their snouts and sucking up organisms that they detect with their long, sensitive barbels. Their diet may include clams, mussels, crayfish, worms, and fish eggs. As the sturgeon grow larger, other fish become more important in their diet. In the Columbia, sturgeon seem particularly fond of smelt, anchovies, lamprey, shad, and salmon. They have also been known to eat drowned cats, tin cans, onions, and spilled wheat from shoreline grain elevators.

Habitat

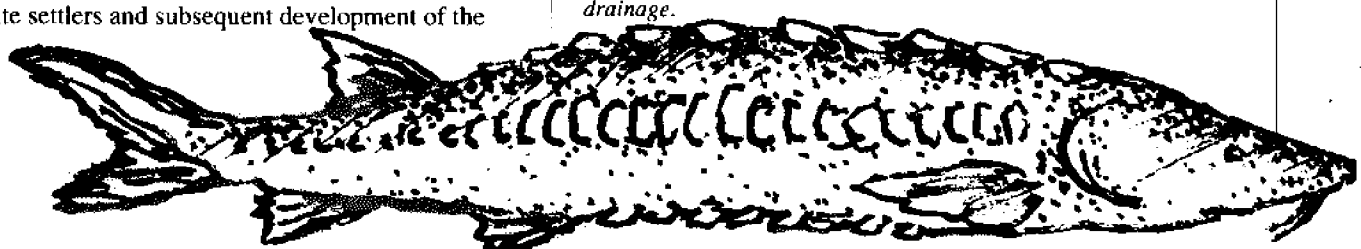
Like Pacific salmon, white sturgeon in their natural habitat are anadromous—living part of their lives in the ocean and ascending large rivers to spawn in fresh water. Before the arrival of white settlers and subsequent development of the Pacific Northwest, white sturgeon were well dispersed throughout the Columbia River Basin from the estuary at the mouth of the river, up the Snake River to southern Idaho, and well into the Kootenai drainage of Canada and Montana.

Historically, white sturgeon made good use of their anadromous condition in spawning and feeding migrations between the estuary and upper river. Thousands of sturgeon were able to feed in the rich marine and estuarine environment of the river mouth and adjacent coastal areas, and return to the river for spawning and early rearing.

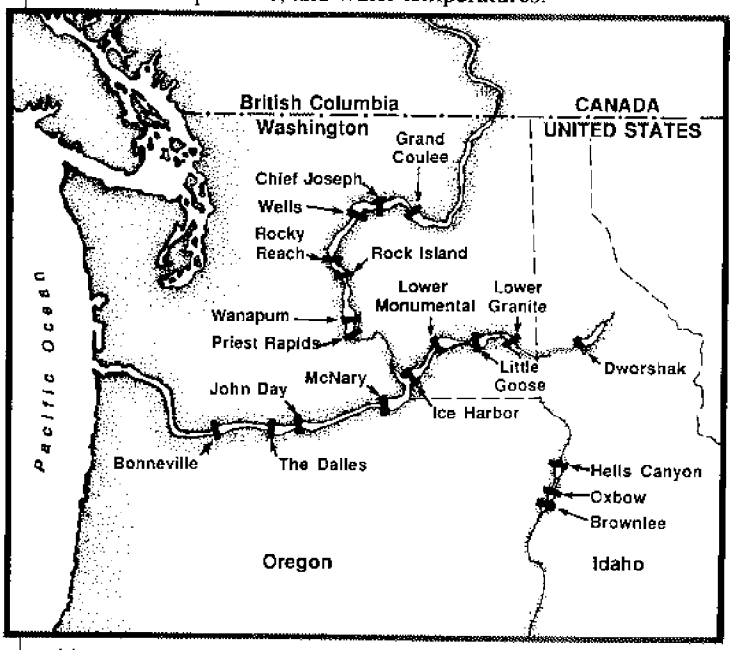
This free river access changed, however, with the advent of hydroelectric development. White sturgeon are still distributed throughout the river system but they are now generally isolated, and their movement is limited within the series of impoundments that make up most of the river.



Sturgeon once ranged extensively throughout the Columbia River drainage.



Although research has been limited, existing studies suggest that construction and operation of the hydropower system have severely impacted white sturgeon populations in the Columbia River basin. Dams have not only blocked upstream spawning and feeding migrations, but they have also altered and/or destroyed much of the spawning habitat. Dams and their associated reservoirs have also altered food availability, natural flow patterns, and water temperatures.



Major hydropower projects on the Columbia/Snake River System have transformed the sturgeon's free-flowing river environment into a series of slack-water reservoirs, blocking migrations and destroying spawning habitat.

Because sturgeon are extremely vulnerable to modifications of their environment, the population status of white sturgeon stocks differs greatly among different reaches of the Columbia River and its tributaries. Sturgeon populations in the lower Columbia, for example, have been considered relatively healthy, whereas stocks in the Snake and Kootenai rivers have become severely reduced. Although it is clear that isolated sturgeon populations are able to reproduce in some impoundments, it is still unknown how well they have adapted to environmental changes and what their long-range status may be.

Only the sturgeon populations below Bonneville Dam are able still to move freely between the river and the sea. The full extent of these sturgeon migrations, however, is still a mystery. Tagging studies on Columbia River sturgeon have shown that these fish commonly migrate along the coast north to Puget Sound and south to Yaquina Bay, Oregon. One fish tagged in 1983 travelled 2,000 miles before being caught by a commercial fisherman near Bristol Bay, Alaska, in 1986. Some California sturgeon, tagged in San Francisco Bay have also migrated along the coastline and entered the Columbia system.

Age and Growth

Sturgeon are perhaps best known for their longevity and large size. The world's largest recorded fish was a beluga sturgeon from the Caspian Sea, which tipped the scales at 4,350 pounds. The largest white sturgeon, caught in Canada's Fraser River in 1912, was 20 feet in length and weighed 1,800 pounds. The biggest recorded sturgeon in the Columbia system was a 1,500-pound fish caught in 1928 in the Snake River.

Since sturgeon do not have scales, biologists estimate a sturgeon's age by removing and examining a small portion of its fin rays. Like rings on a tree, a count is made of the layers of cartilage that are laid down each year. This technique has led scientists to believe that sturgeon have a life expectancy of 100 years or more.

Several recent research efforts have focused on the population characteristics of Columbia River sturgeon. Work conducted by the U.S. Fish and Wildlife Service in 1976 found that sturgeon in the Bonneville Reservoir first entered the sport fishery (i.e., 3 feet) at about age 12 and the commercial fishery (i.e., 4 feet in length) at about age 13. The fish are vulnerable to both fisheries until they exceed 6 feet in length, between the ages of 18 and 20.

Record 1500-pound sturgeon caught in Idaho's Snake River.

Oregon Historical Society, No. 34255

A catch of sturgeon from the Columbia.

Other research indicates that sturgeon in the reservoirs exhibit different growth rates over their lifetime. From age 3 to 12, their growth is relatively constant at about 1.3 inches per year. Between ages 12 to 18, growth is rapid at an average rate of 6.5 inches per year, and from age 19 to 28, growth slows to approximately 3.2 inches per year.

In contrast, researchers have found that lower Columbia River sturgeon populations with free access to estuary and ocean environments grow at a more constant rate. The difference in growth rates is believed to be a reflection of food supply since the populations that are free to migrate into estuaries and the ocean have more food available throughout their life history than landlocked populations.

Reproduction

Sturgeon require many years to reach a reproductive age. Female white sturgeon, for example, do not spawn until they are 15–20 years of age and over 5 feet long. Thereafter, the egg-producing capacity increases with age. Males mature several years earlier at about 12 years of age (approximately 4 feet in length).

Although female sturgeon produce approximately 300,000 to more than 4 million eggs, depending upon their age and physical condition, they may spawn only once every two to eight years. Researchers have also found that if ripe females are subjected to a great deal of stress, they may reabsorb their eggs and lose a spawning cycle.

In the Columbia System, sturgeon spawn primarily during May and June. In their natural environment, spawning sturgeon generally avoid slack water, preferring to deposit their eggs in rocky areas with fast-flowing water. In contrast to salmon and trout, sturgeon appear to require muddy, turbulent water for successful spawning. Mud or silt, it seems, is critical in preventing the clumping and suffocation of eggs, and turbulence allows for proper aeration during development.

Much about the sturgeon's spawning habits remains a mystery. They appear to be mass spawners without an obvious courtship ritual. When a female is ready to deposit her eggs, the males cluster around to fertilize them as soon as they are extruded. The fertilized eggs then sink to the bottom, where they adhere to plants, rocks, and other hard substrates. The adults provide no care to the eggs or young.

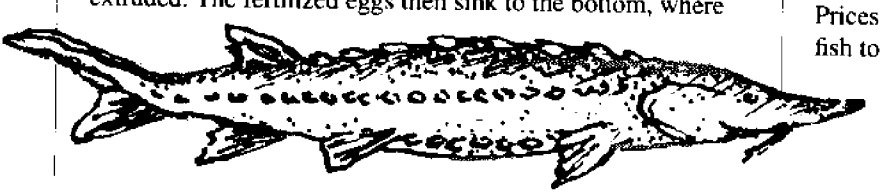
About eight days after fertilizaton, the eggs hatch into squirming, black, tadpolelike fry. At first, these tiny creatures are nurtured by their yolk sacs. Within 12 days, they use up their yolk sacs and begin to feed on aquatic insects and other small animal life. By the time they are 20 days old, they have taken on the physical appearance of their parents and begin to feed on the bottom. Life as a young sturgeon is hazardous. Fewer than 0.1 percent of the fry survive past their first year.

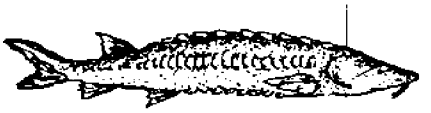
THE HISTORIC STURGEON FISHERIES

"In 1879 the sturgeon were so thick in Baker Bay that we did not consider it safe, early in the season, to put our gill nets out. The fish were so numerous and large that they were able to destroy a great amount of netting." (M.J. Kinney, 1884.)

The history of the Columbia River sturgeon fishery is similar to the fisheries of the East Coast, the Great Lakes, and other areas in the world where sturgeon became commercially important and were then overfished almost to the point of extinction. Although utilized by Indians for thousands of years, sturgeon were still extremely abundant in the Columbia River when the first salmon gillnet fisheries began in the 1860s. At that time and for several years thereafter, tremendous numbers of sturgeon were killed by the fishermen because the fish had no known commercial value and frequently destroyed the fishermen's nets.

By 1880, the commercial value of sturgeon was recognized, and a small sturgeon fishery had started. Sturgeon flesh was sold fresh locally, and some was salted and pickled. Prices ranged from one or two cents per pound for dressed fish to five cents per pound for caviar. It was not until 1888,



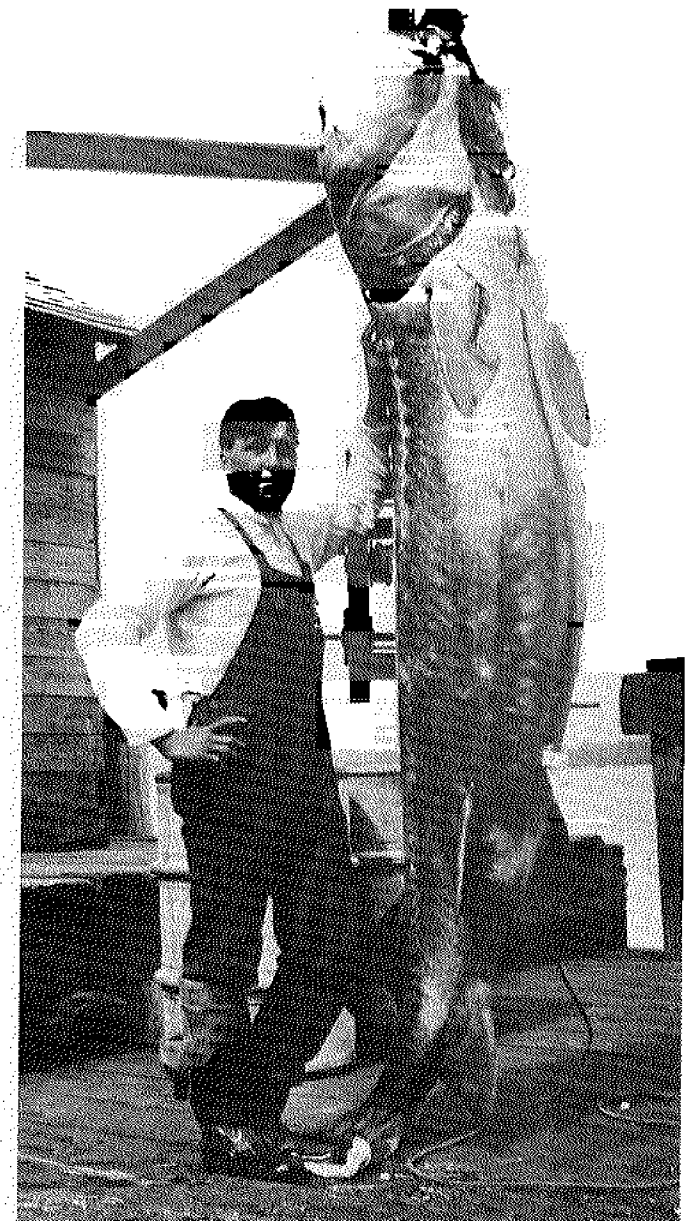


however, that the first regular sturgeon fishery on the Columbia was initiated. In that first year, nearly 1 million pounds of frozen and pickled sturgeon, valued at $15,000 to the fishermen, were shipped by railroad to the East.

The growing acceptance of smoked sturgeon and caviar on the East Coast stimulated a rapid development of the fishery. By 1892, the fourth year of intensive fishing, a peak harvest of 5.5 million pounds valued at $66,000 was reached.

During the peak of the fishery, most sturgeon were taken from the lower river below Kalama, Washington. Fishing was also conducted as far up as the Columbia River Gorge, generally from September to April, during the period when other fishing was suspended. Several types of gear were used including fish wheels, traps, gillnets, and baited setlines. The majority of the catch, however, was taken with Chinese gang lines—a set of lines armed with unbaited, barbed hooks. The average weight of sturgeon taken in the regular sturgeon fishery was about 150 pounds, but fish weighing 500 pounds or more were not uncommon. Fishermen did not even keep fish under 50 pounds.

A 700-pounder caught near St. Helens, OR.



Oregon Historical Society No. 15731

Fishermen began to witness a decline in the sturgeon resource as early as 1893, only five years after the fishery began. To maintain the previous catch levels, they now had to change fishing grounds on a more frequent basis as well as increase the amount of fishing gear used. At each newly discovered fishing ground, the fishermen generally found numerous large fish in a very limited area. But in a relatively short time, all would be caught and the fishermen would again move on in search of new areas. This pattern continued, eventually moving the fishery from the lower Columbia into the Snake River in Idaho.

In February of 1894, sturgeon shipper C.B. Trescott wrote to the United States Fish Commission describing the condition of the Columbia sturgeon fishery:

> Sturgeon fishing has completely failed on the Columbia. There has been no fish caught since last November to amount to anything. At present the entire catch on the river does not amount to over 1 ton of dressed fish a day, and is growing less. We do not expect to be able to fish longer than the 15th of March, and what few we get now does not pay for handling. At present, we do not have much faith in the sturgeon business on the Columbia. Usually we have a good run of fish in January or February, but there are no fish this year and there is every indication of the fish being caught out. We have thought that we would have our usual run of sturgeon on the Columbia in January and February. The sturgeon season will begin again on the 15th of August, and if we do not have our usual run of fish then it will prove that the sturgeon fishing is done for here. There is every indication of the sturgeon business having seen its best days on this coast. The total catch for this season has not been 25 percent of the catch last season, and what fish were caught were caught in August, September, and October.

Similar remarks were made to the Fish Commission in 1894 by M.J. Kinney of Astoria:

> In 1893, there was a good supply of sturgeon. The fish sold for 2 cents a pound. The fishermen as a whole did not do well, however, although the price received was double that of the previous year. In 1879 the sturgeon were so thick in Baker Bay that we did not consider it safe, early in the season, to put our gill nets out. The fish were so numerous and large that they were able to destroy a great amount of netting. For years every sturgeon taken was mutilated or killed with an ax and thrown back into the water. The shores of the river would be lined with dead sturgeon, and numbers could always be seen floating down the river. It is quite different now.

Because of the sturgeon's slow growth rate and the selective removal of so many large brood fish, the annual catch continued to decline rapidly. By 1895, the average weight of sturgeon harvested was only 50–60 pounds. In 1899, ten years after the intensive fishing began, only 73,000 pounds were harvested and the fishery became an incidental one.

STURGEON FISHERIES

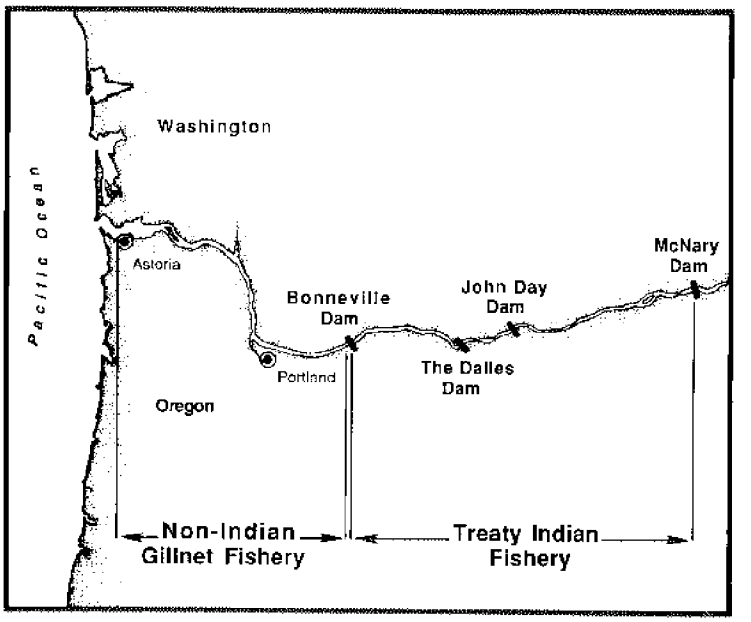
Management

The collapse of the fishery in the late 1890s resulted in the first regulations to protect the remaining sturgeon resource. In 1897, the state of Washington closed the commercial season from March to November and required that all sturgeon under 4 feet long be released. Oregon enacted the same regulations in 1899, and also prohibited the use of destructive Chinese gang lines. Eventually, fish traps, fish wheels, and seines were all outlawed.

For the next half century, commercial sturgeon harvests on the Columbia remained as a small incidental catch to salmon gillnet fishing. Then, in 1950, more protective regulations were enacted. On the basis of research by Oregon Fish Commission biologist Alex Bajkov, a maximum 6-foot size limit was adopted to protect the large broodstock. Additional regulations adopted that year included a minimum 30-inch size limit for sport-caught fish and a limit of five fish per day. During the next several years, the sturgeon sportfishing regulations were tightened further by decreasing the daily limit to three fish per day (1951) and by increasing the minimum size limit to three feet (1958).

Twenty years after the adoption of minimum and maximum size limits, the Columbia sturgeon populations again began to flourish. Sturgeon landings tripled in the 1970s and continued to set record highs in the 1980s.

At present, commercial sturgeon fishing in the Columbia River encompasses an area from the river's mouth to McNary Dam. Within this area, there are two distinct fisheries separated geographically by Bonneville Dam. All fishing by treaty Indian tribes occurs above Bonneville Dam, an area informally set aside for their use. All non-Indian commercial fishing occurs on the lower Columbia (i.e., below Bonneville Dam). Because this section of the river forms the border between Oregon and Washington, the commercial fishery is managed jointly by both states under the authority of the Columbia River Compact.



Sections of the Columbia River open to commercial sturgeon fishing.

Recreational sturgeon fishing occurs in many areas of the Columbia and Snake rivers. Most of the fishing activity, however, is concentrated below Bonneville Dam, primarily in the Columbia estuary. As with other sport fish, each state manages the recreational fishery separately.

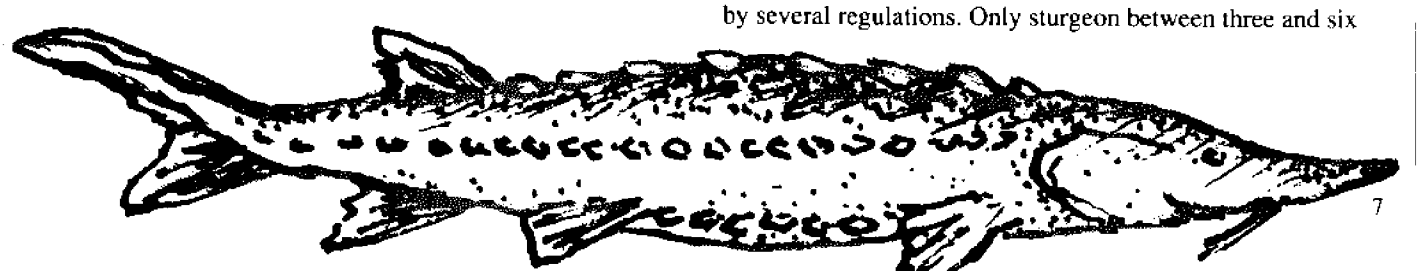
Lower Columbia Fisheries

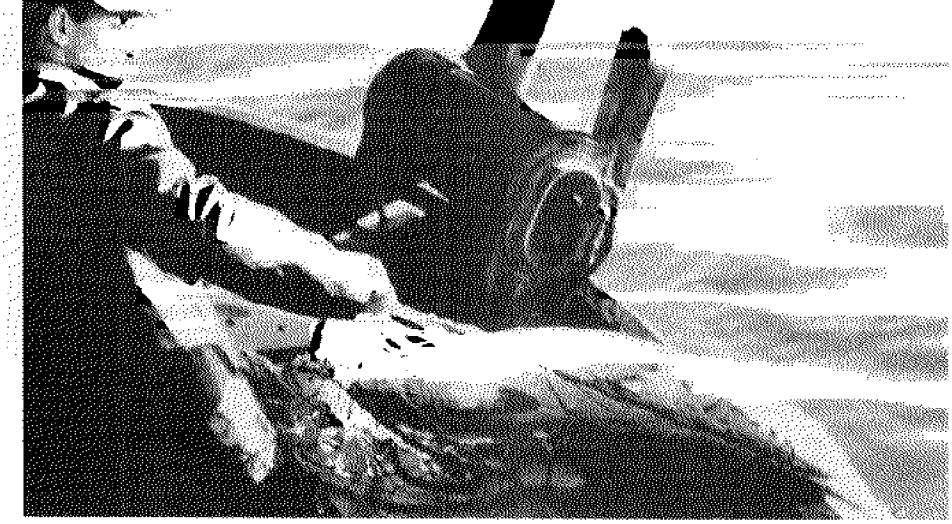
A record harvest of approximately 72,000 sturgeon were caught below Bonneville Dam by commercial and sport fishermen in 1987. In terms of numbers of fish, this modern peak catch is almost double the number of fish caught during the historic peak catch of 1892.

The commercial harvest of white sturgeon in this section of the river occurs at several different times of the year. Many of the fish are harvested incidentally during the salmon gillnet seasons. There are also targeted sturgeon gillnet seasons during the winter and summer.

The commercial harvest on the lower river is largely limited by size restrictions (gillnetters can keep only fish four to six feet in length) and the number of fishing days available. As a result, the commercial harvest has remained fairly stable over the past 15 years. In 1987, approximately 11,600 white sturgeon were landed.

The recreational catch, on the other hand, has experienced some dramatic increases—doubling over the past five years and tripling in less than a decade. Sport fishermen must abide by several regulations. Only sturgeon between three and six





Oregon Department of Fish and Wildlife

Gillnetters on the lower Columbia harvest approximately 10,000–15,000 sturgeon each year. Although there are several target sturgeon fisheries, many are caught as an incidental fish in salmon nets.

feet can be kept. There is also a daily limit of two legal fish per day; however, there are no seasonal restrictions as the sport fishery remains open all year. Oregon currently limits the personal catch to 30 fish annually.

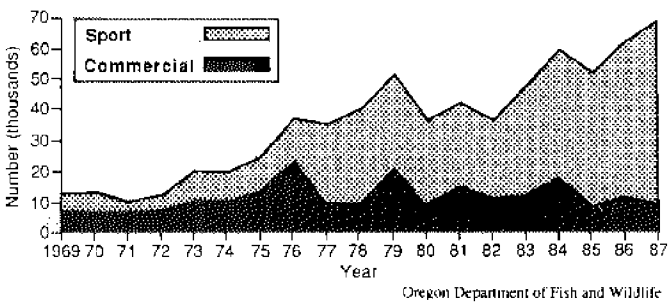
As salmon and steelhead fishing seasons have become more restrictive because of resource conservation concerns, more recreational anglers have started fishing for sturgeon. In response to this increased interest, the charter fishing fleet has also begun actively to market the opportunity to catch sturgeon, and sturgeon are now the principal sport fish on the lower Columbia, with angler trips exceeding 100,000 each year since 1979. In 1987, a record 60,400 sturgeon were caught.

Fisheries above Bonneville Dam

The other sturgeon fishery experiencing rapid growth is the commercial Indian fishery in the Bonneville, The Dalles, and John Day dam pools. Indian fishermen are allowed to sell legal-sized sturgeon (i.e., fish four to six feet in length) that are incidentally taken during their salmon and steelhead setnet seasons. They are also allowed a commercial setline fishery that is open 10 months of the year.

The commercial catch by all Indian tribes, using salmon set nets and sturgeon setlines, has essentially doubled every year since 1984. From 1960 to 1978, the sturgeon harvest was usually fewer than 1,000 fish. By 1984, the Indians' catch had increased to almost 3,000 fish; and by 1987, a record high of 11,100 fish were taken. The sport catch in the three reservoirs has remained fairly stable at an estimated 5,000 fish annually.

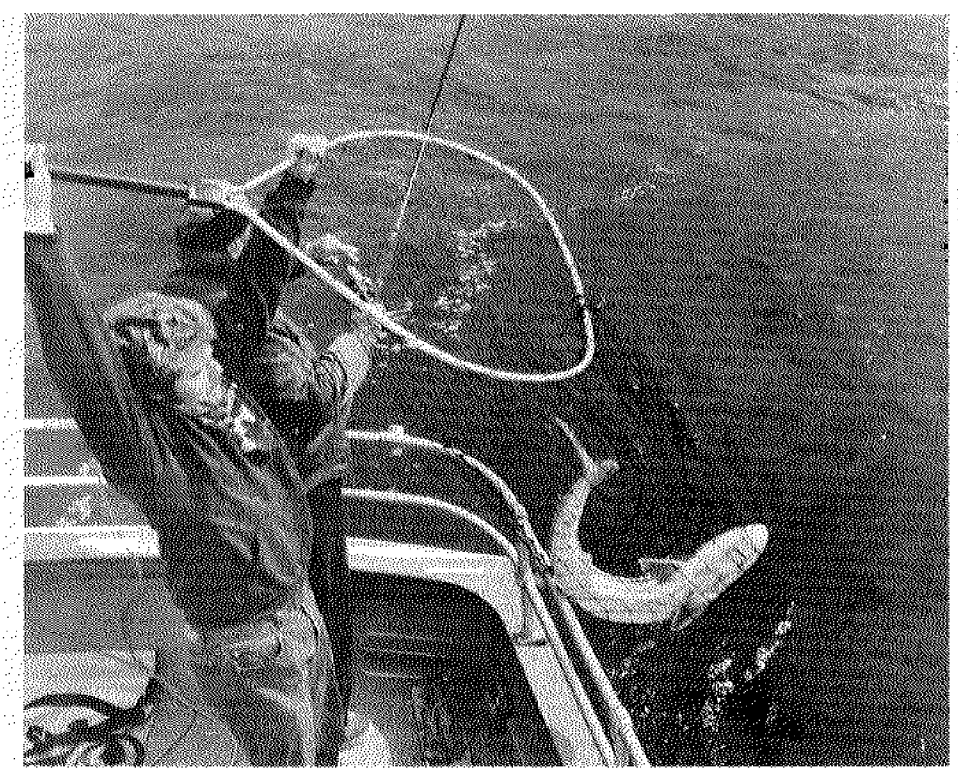
The jump in harvest levels by treaty Indians is largely the result of increased fishing effort and changes in fishing techniques. Beginning in 1984, several Indian fishermen began using large-mesh sunken nets to target on sturgeon during the salmon setnet seasons. This has proven to be a very successful fishing method and has thus been adopted by an increasing number of fishermen.



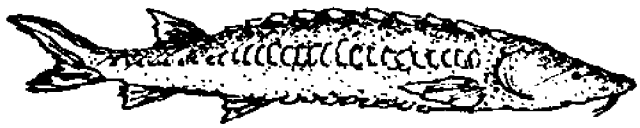
Oregon Department of Fish and Wildlife

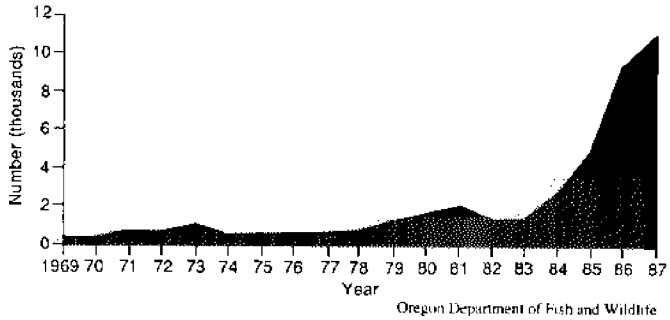
White sturgeon catch on the lower Columbia.

Sturgeon have become a major offering for the lower Columbia charter fleet struggling to cope with the cutbacks in salmon seasons.



Tom McAllister/The Oregonian





Commercial sturgeon catch by treaty Indians above Bonneville Dam.

In addition to their commercial fisheries, treaty Indians are also allowed to harvest sturgeon for subsistence purposes. The subsistence fishery is open year-round with 3–6 foot size limits and no limit on the number of fish that may be taken. Although no record is kept of subsistence catches, it is likely that at least several thousand fish are used for subsistence each year.

It is in this section of the Columbia, between Bonneville and McNary dams, that the greatest management concern currently exists. Recent tagging studies in the reservoir above The Dalles Dam revealed a harvest rate of about 30 percent. This catch rate is three times higher than what most researchers believe is acceptable for the long-term production of the slow-maturing sturgeon. In an effort to reduce harvest rates, the minimum size limit for sport fishing above Bonneville Dam was recently raised from 36 to 40 inches. Although that action provides some immediate protection for the fishery, most acknowledge that it is not a long-term solution to the problem.

Sturgeon management in the reservoirs above Bonneville is complicated by a number of factors. In the past, management in the Columbia system has been based largely on early research conducted on the lower Columbia River stocks. However, as the researchers have uncovered differences between the various stocks, new questions have emerged regarding how the isolated reservoir populations should be managed.

Another problem exists because of the great incentive for poaching oversized fish. An 8-foot female sturgeon, for example, could bring the illegal fisherman as much as $1,500 for the meat and roe. It is these large fish, targeted by poachers, that are the brood fish so important to the future of the fishery.

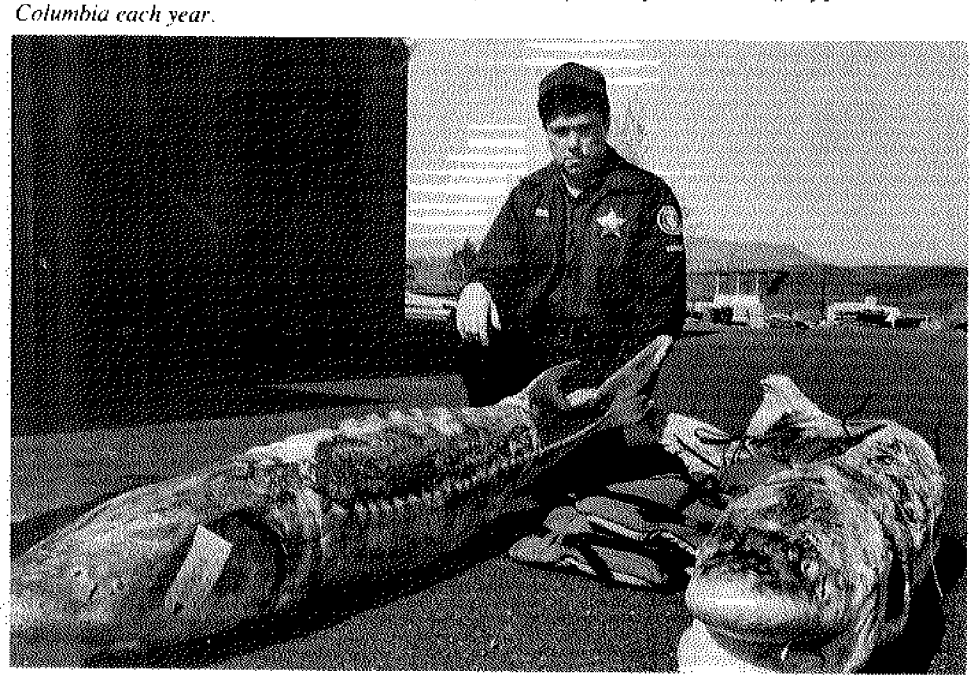
To prevent poaching large fish for roe, non-Indian fishermen must sell their catch whole. Indian fisherman, however, can sell gutted fish to commercial processors as long as the head and tail are still attached.

The problem is further complicated by the fact that even though most Indians abide by the 6-foot maximum size limit, some have claimed the right to take larger fish for subsistence. While these subsistence catches cannot legally be sold, they do not have to be recorded so it is uncertain how many large, mature fish are also being removed.

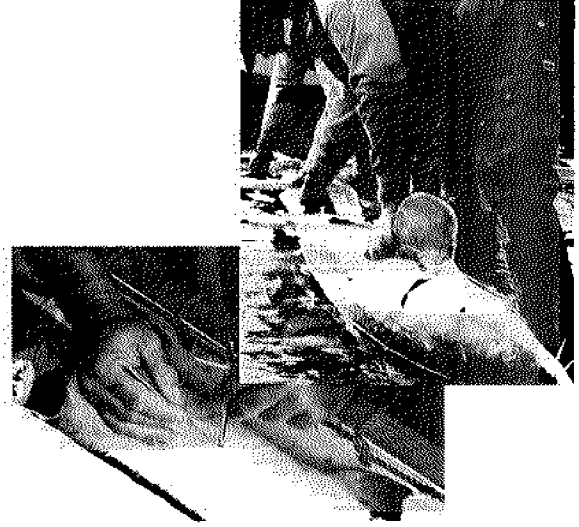
RESEARCH EFFORTS

For years, sturgeon have ranked behind salmon and steelhead in relative importance to anglers and researchers. Now, with interest in sturgeon running at an all-time high, researchers from state and federal agencies have stepped up efforts to collect and update management information. Several studies are currently underway to gather much-needed information. One study, funded by the Bonneville Power Administration, is attempting to estimate what effect hydroelectric dams have had on the sturgeon populations. Sturgeon from The Dalles pool are captured, examined, tagged, and released in an effort to gain information on growth rates, population size, and natural mortality. This information will then be compared to the results of a second, related study of sturgeon in a "pre-dam" environment below Bonneville.

These oversized sturgeon represent only a few of the many brood fish taken illegally from the Columbia each year.



Tom McAllister/The Oregonian



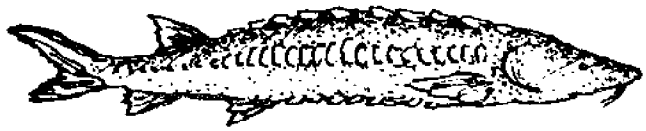
Oregon Department of Fish and Wildlife

Adult sturgeon from The Dalles pool are examined to collect information on the spawning potential of the reservoir populations.

Information on sturgeon reproduction, early life history, and habitat requirements is also being collected. Using a variety of nets and sampling techniques, eggs, larvae, and juvenile fish are being captured above and below Bonneville Dam. When completed, these studies will help define the type and amount of habitat that is available for spawning and rearing sturgeon. The studies will also shed new light on spawning success in the mainstem reservoirs.

A BPA-funded study is also underway on the Kootenai River in Idaho. There, the Idaho Department of Fish and Game and the Kootenai Tribe are looking into factors limiting natural production and will be assessing the feasibility of sturgeon culture. On the Snake River, a sturgeon culture experiment has been undertaken by the Idaho Department of Fish and Game and the College of Southern Idaho.

Sturgeon are not the only ones under investigation. Additional research information is also being collected from recreational sturgeon anglers, who are now being asked to record their catch on a sturgeon punchcard. The punchcards will provide new data on sturgeon harvest rates and will also help cover some research expenses. All of this information is crucial in developing future programs to protect and enhance sturgeon populations in the Columbia Basin.



STURGEON CULTURE

With the decline of sturgeon catches in some areas of the Columbia, the possibility of sturgeon hatcheries is being studied. The concept of using hatcheries to augment wild sturgeon populations is not new. Nearly a century ago, the U.S. Fish Commission started a hatchery program on the Delaware River. The early attempts had only limited success, however, as the sticky sturgeon eggs usually clumped together and suffocated.

By the 1950s, Russia's sturgeon stocks were in trouble because of dam building on the Volga and Don rivers. Soviet scientists, intent on developing a sturgeon hatchery program, discovered that silt could be mixed with the sturgeon eggs to inhibit clumping. The same scientists also pioneered the use of hormone injections to induce spawning. Today, the Soviet Union has one of the world's largest fish hatchery programs, and each year releases more than 100 million sturgeon fingerlings into the Caspian Sea.

Sturgeon Culture in the United States

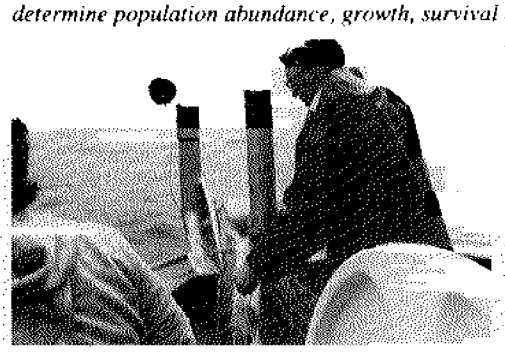
The success of sturgeon hatchery efforts in the Soviet Union has created renewed interest in sturgeon research and hatchery development in the United States. In 1980, Professor Serge Doroshov (who had conducted sturgeon research in the Soviet Union before moving to the United States) demonstrated at the University of California–Davis that he could hatch white sturgeon by catching adults in the wild and hormonally inducing ovulation and sperm production. Doroshov also showed that sturgeon fry and fingerlings could be raised in ponds, tanks, or raceways on artificial feed.

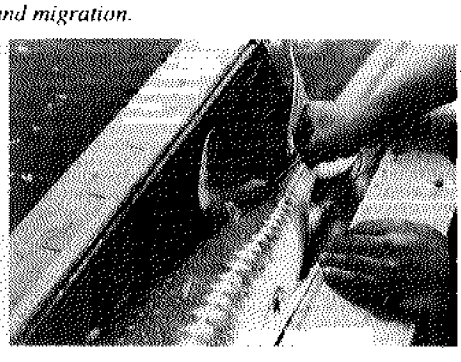
This new hatchery technology for white sturgeon has stimulated the creation of a growing commercial sturgeon aquaculture industry. California presently has 12 private sturgeon hatcheries and 10 growers, with others planning to enter the field.

Several sturgeon characteristics have caught the attention of commercial growers:

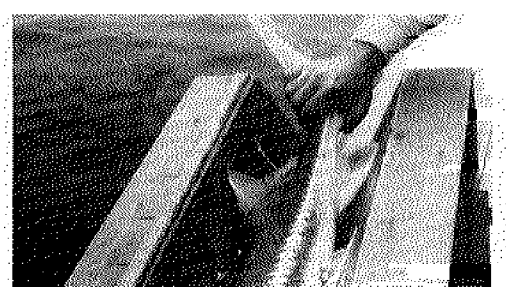
- They have firm flesh that is traditionally in demand in North America and Europe.

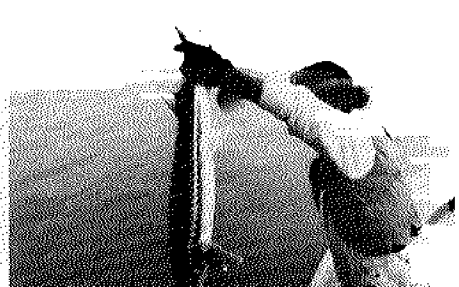
Over the past decade, thousands of sturgeon have been captured, tagged and then released to determine population abundance, growth, survival and migration.

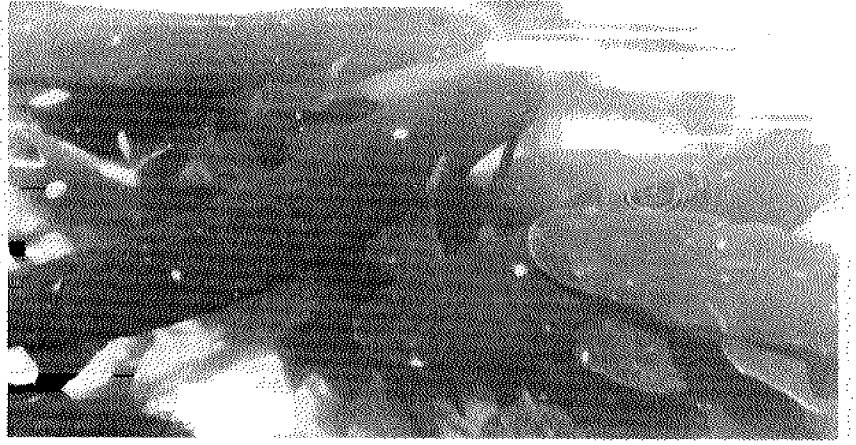




Gayle Kreitman/Washington Department of Fisheries







Although still in its infancy, California's emerging sturgeon aquaculture industry has attracted considerable attention from the general public and private aquaculturists. Sturgeon from the Columbia River are now being viewed as the potential stock for similar ventures in the Pacific Northwest.

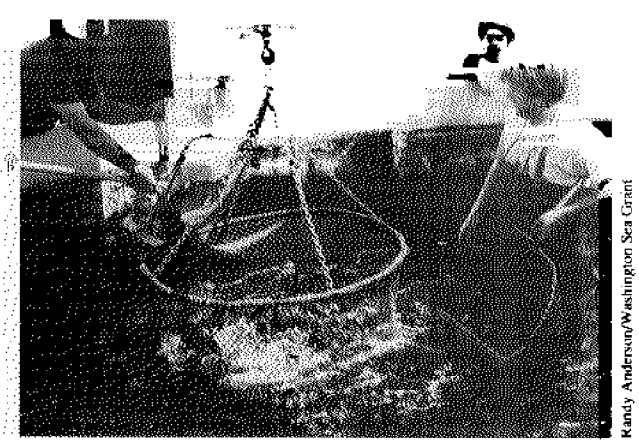
- Although the sturgeon is a delicate creature as a fry and fingerling, it becomes an extremely hardy animal capable of tolerating wide ranges in water quality.

- The optimum rearing temperature of white sturgeon is between the 15°C optimum of rainbow trout and the 30° C optimum of catfish. Therefore, sturgeon offers culture opportunities in locations not suitable for these other two species.

- Through the use of warm water and generous diets, sturgeon can be raised to 1–2 pounds in one year and 6–8 pounds in two years.

- Sturgeon can be raised in tanks or raceways on artificial feed, achieving feed-to-weight conversion ratios of 1.5 to 1 or better.

To date, most sturgeon aquaculture production in California has been for fingerling sales to other growers in the United States and Europe, and to the aquarium trade. With the increase in 8- to 12-pound inventories, growers have now started selling food-sized fish to the "white tablecloth" restaurants. In the meantime, growers are also attempting to rear their own broodstock—first for breeding and possibly later for caviar production.



Randy Anderson/Washington Sea Grant

California farm–raised sturgeon on their way to East Coast restaurants.

The American sturgeon farm industry began in 1980 and is still considered to be in a phase of research and development. Most questions for large-scale production have been answered, however, and one of the major problems now is to match production with the market.

Overview of Culturing Techniques

The following section presents a brief overview of the current techniques used in the culturing of white sturgeon. The techniques are adapted from a detailed hatchery manual recently developed by extension and research personnel at the University of California–Davis (Conte et al. 1988).

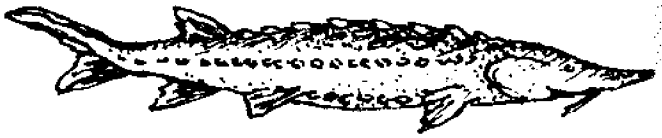
Broodstock

The broodstock used in commercial sturgeon aquaculture can be grouped into three categories: 1) mature fish that are captured in the wild and are ready to spawn; 2) fish captured in the wild that will require holding and further maturation before spawning; and 3) hatchery-produced fish that are being reared as future broodstock. The first efforts to establish captive broodstock of white sturgeon were initiated in the early 1980s at University of California–Davis. These hatchery-produced fish represent the oldest generation of hatchery-reared white sturgeon. Males from the 1981 year class have produced viable sperm at the age of 4 years (in comparison to 12 years in the wild). To date, however, the females from this same year class have not reached sexual maturity.

Until captive female broodstock is available, the sturgeon farmers must continue to rely on wild stocks for eggs. The California sturgeon producers, for example, capture mature females in the Sacramento or San Joaquin River, hormonally induce ovulation, then surgically remove the eggs. The eggs are then fertilized with milt from male stock, and the fry are raised in tanks or raceways on commercial trout feed. After the eggs are removed, the females are sutured, held until recovered, then returned to the river.

Conte et al. 1988

Loading captured sturgeon aboard the collection boat.

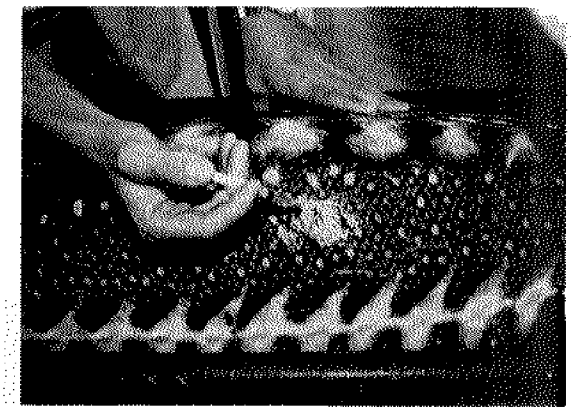


Sturgeon broodstock taken from spawning areas often exhibit signs that will help indicate their sex. Mature spawning females are generally recognized by an enlarged, soft abdomen. Mature males are recognized by the presence of milt, determined by applying gentle pressure to the posterior abdominal region.

Induction of Spawning

Since captured sturgeon may not be ready to spawn, the broodstock are taken to the hatchery and injected with hormones to induce the spawning process. The most frequently used hormone is from the pituitary gland of the common carp (acetone-dried common carp pituitary gland powder–CCP).

The hormone is administered to the females in two separate injections with the total dose based on the weight of the fish. The first injection contains only 10 percent of the total dose. The final injection is given 12 hours later. Males are given only one injection 2–6 hours before the female's final injection.



Conte et al. 1988

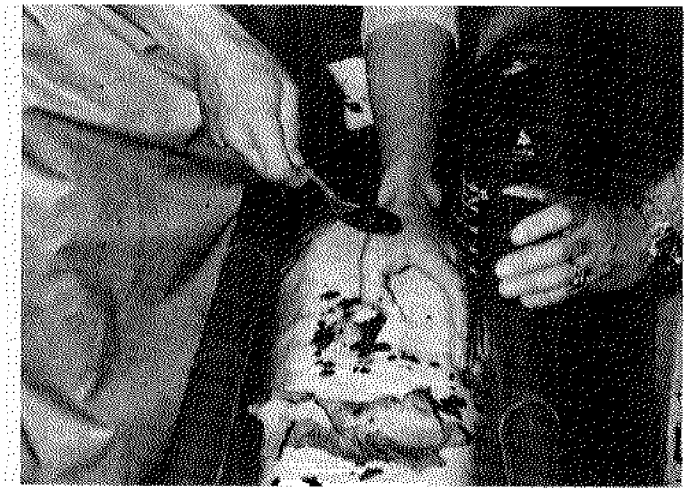
Milt Extraction

Milt can be collected several hours before use in egg fertilization. The first sign that a male sturgeon is ready to spawn may be a cloudiness that develops in the holding tank's water caused by the release of a small amount of sperm. Milt is collected by using a plastic syringe equipped with a short piece of tubing. The fish is placed on its back and the tube is inserted into the genital opening. As the abdominal area is massaged, milt is released into the genital collecting ducts and then removed using the syringe. If the milt will not be used immediately, it can be stored for up to 12 hours by refrigerating the collection syringes.

Conte et al. 1988

Egg Extraction

Ovulation can be expected 20–40 hours after the female's final injection. The first indication that the female may be ready to spawn is the appearance of several eggs stuck to the sides or bottom of the holding tank. The fish is then removed from the tank and positioned on its back on a stretcher. A watertube is placed in the mouth to keep aerated water flowing over the gills. After the abdominal area is disinfected, a small incision is made to expose the eggs. The eggs are removed using a stainless steel or plastic spoon and then placed in stainless steel bowls. After the eggs are removed, the incision is sutured and the fish is returned to the holding tank for recovery.

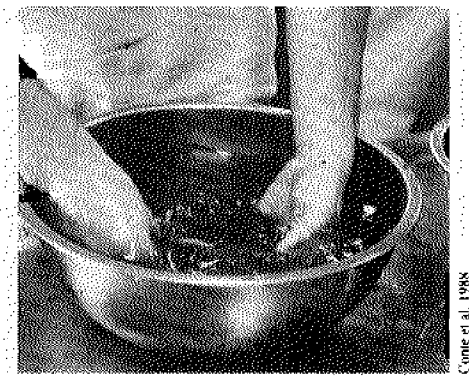


Conte et al. 1988

Egg Fertilization

Fertilization is accomplished by pouring the diluted milt solution into the bowl containing the eggs. The eggs and milt are then mixed by hand for up to three minutes or until the first sticky eggs are noticed. The excess liquid is then poured off and the de-adhesion process is started immediately.

Conte et al. 1988



Conte et al. 1988

Egg De-Adhesion

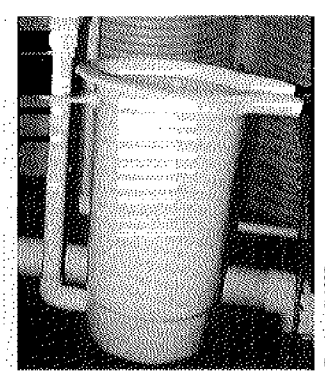
Under natural spawning conditions, silt in the river keeps the eggs from sticking together. This same condition is thus replicated in the hatchery. To start the de-adhesion process, a silt suspension (water and silt) is poured into the bowl containing the fertilized eggs. The mixture is then gently stirred by hand until the eggs have lost their stickiness. The process may take as little as 20 minutes or as much as an hour. The silt suspension is replaced every 10 minutes to ensure that the proper temperature and oxygen levels are maintained.

Egg Incubation

Most of the existing sturgeon hatcheries use a two-stage incubation system incorporating modified trout egg barrels and a MacDonald jar system. Eggs are first placed in the egg barrels and then transferred after several days to the MacDonald jar system.

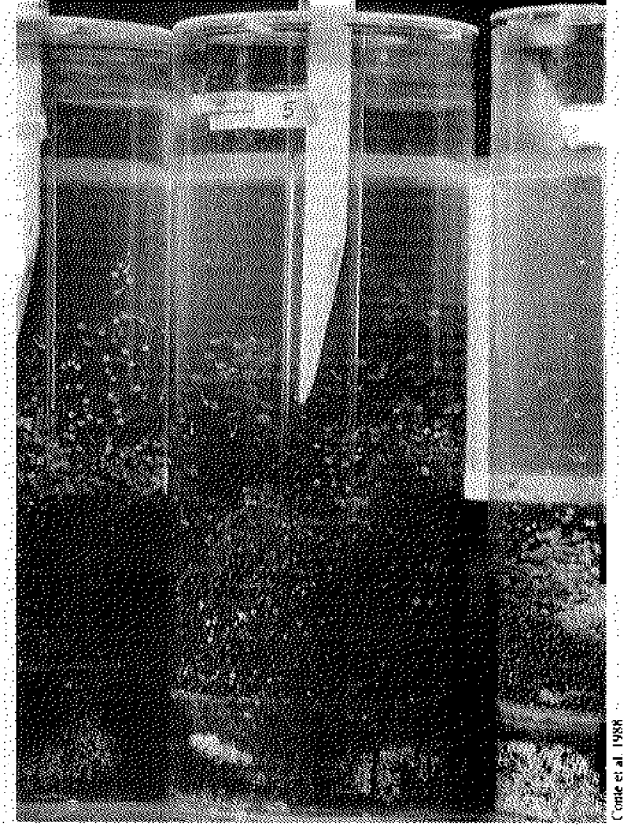
The MacDonald system consists of a head tank, a series of jars that contain the eggs, and a catch basin. Water (14–16°C) is passed through an ultraviolet sterilizer into the head tank and is then distributed to the individual jars. The system is designed to provide a constant flow of water that will gently move the eggs. As the water flows out of the jars, it is collected in a trough and delivered to the catch basin.

Hatching occurs approximately seven days after fertilization. When the eggs are nearly ready to hatch, the system is converted so that the water flowing out of the jars goes to a fry collection tank rather than the catch basin. As the eggs hatch, the water flow carries the young fry to the top of the jar and eventually to the collection tank.



Conte et al. 1988

Modified trout egg barrel used in the early incubation of sturgeon eggs.



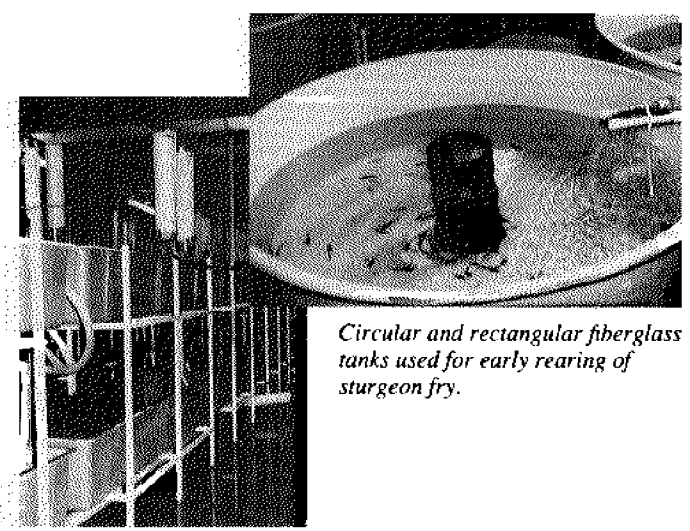
Conte et al. 1988

Sturgeon eggs in MacDonald jars after water flow is initiated.

Early Rearing

Optimum rearing systems for young sturgeon are still evolving. Most of the existing systems are based on equipment used in rearing other fish species. Square, rectangular, and circular tanks have all been used successfully.

Hatchery rearing of fingerling sturgeon is currently one of the most difficult aspects of production. For several days after hatching, the young fry subsist on their yolk reserves. Within 12 days the fry use up their egg sacs and must find food. Since prepared sturgeon rations have not yet been fully developed, aquaculturists have used the same pellet feeds used in rearing salmon and trout. While these feeds will nourish sturgeon, efforts are being made to develop specific sturgeon diets to reduce early stage mortalities.



Randy Anderson/Washington Sea Grant

Circular and rectangular fiberglass tanks used for early rearing of sturgeon fry.

Growout

Sturgeon growout facilities are a rather new development, and a wide variety of systems are being tested. Large tanks, ponds, and raceways are all being tried by different commercial growers.

Like that of many other aquatic species, a sturgeon's growth rate is highly responsive to water temperatures. Researchers at University of California–Davis have found that sturgeon fingerling growth increases dramatically when water temperature is increased from 15 to 23°C. When reared at the 23°C optimum, sturgeon exhibit growth and feed efficiency rates that are similar to catfish culture and much higher than the rates currently obtainable with salmon and trout culture.

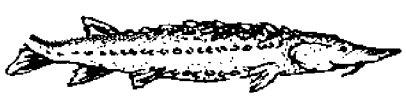
Through the use of warm water and artificial feeds, it takes growers about 30 months to produce a 10-pound food-sized fish. To date, most of these fish have been shipped for sales in Sacramento, San Francisco, and New York restaurants.

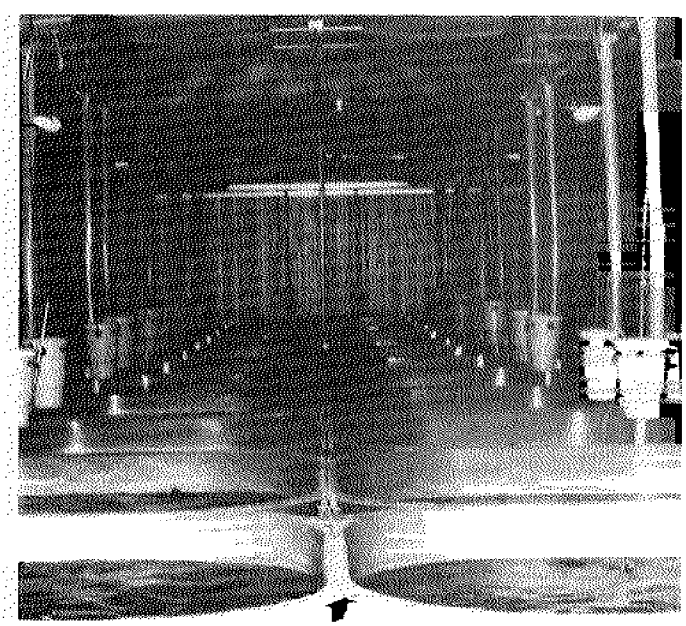
As growout techniques have become more refined, the top industry priority is now to produce mature females from the cultured stock. This will decrease the dependence upon the risky and expensive method of catching large, mature females in the wild. More efforts are also being aimed at developing cost-effective commercial feeds and more efficient feeding strategies.

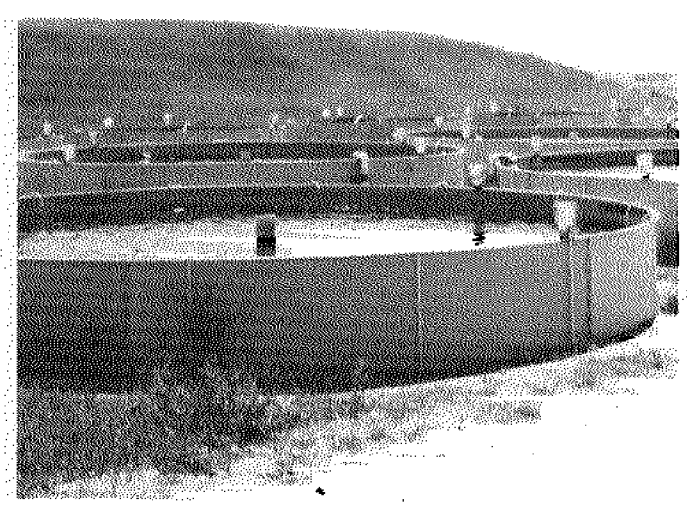
Sturgeon Culture in the Northwest

Although California has been actively pursuing the sturgeon farming industry, developments in the Pacific Northwest have been limited. A private sturgeon hatchery operated by California growers has existed in Oregon since 1981 at Covert's Landing, four miles below Bonneville Dam. Most of the young fish reared at this location have been sold overseas or have been used to support the sturgeon rearing operations in California. Some of the production has also been given to several state universities and agencies in support of sturgeon research projects.

In 1988, Oregon established a special permit system that allows the development of additional sturgeon propagation facilities and provides for the collection of up to 18 oversize female sturgeon each year for the purpose of obtaining eggs. Under this new system, each permittee may collect up to six females (over six feet) and twelve males (under six feet) for spawning purposes. All fish used must eventually be returned to the river in good condition. As mitigation, 5,000 fingerlings from each female spawned must be made available for stocking programs within the state. Permittees must also begin developing their own captive broodstock eventually to support their propagation activities. There are currently no sturgeon growout facilities in Oregon or Washington, nor has the state of Washington permitted any private sturgeon hatcheries.

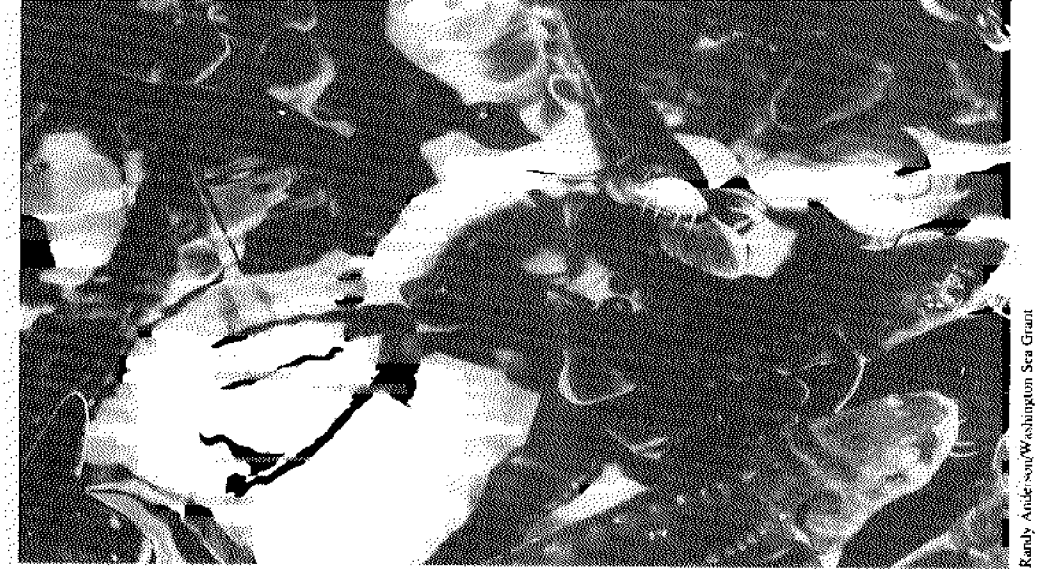






Randy Anderson/Washington Sea Grant

Most production facilities currently use large, fiberglass tanks for rearing sturgeon to marketable size.



Randy Anderson/Washington Sea Grant

THE FUTURE

For 200 million years sturgeon have been able to adapt and survive the many natural changes in their environment. Yet, in less than one sturgeon's lifetime, man has brought this prehistoric fish to the brink of extinction, and back again. If nothing else has been learned about sturgeon during the past century, it should be clear that mismanagement of this important resource or its habitat can have very rapid and disastrous consequences.

Biologists have already detected signs indicating that sturgeon populations in some areas of the Columbia may be in serious trouble. Some emergency regulations have been passed to reduce the risk of overharvest. Whether these measures will be enough to offset the escalating harvests is still only speculation. Ultimately, additional regulations such as reduced fishing times, lower bag limits, and/or sanctuary areas will be needed to protect the spawning broodstock.

Whether or not additional sturgeon hatcheries become a reality in the Pacific Northwest remains to be seen. Judging from the success of the hatchery programs in the Soviet Union and elsewhere, the possibility of enhancing wild sturgeon populations in areas of the Columbia and Snake rivers seems promising. Before enhancement efforts can be planned, however, additional information is needed on the conditions limiting existing sturgeon populations. For example, enhancement through stocking hatchery-raised sturgeon fry will probably not occur below Bonneville Dam because there spawning success does not appear to be the limiting factor. In contrast, some of the isolated reservoir populations might benefit from hatchery plants since the exploitation rate appears to be high and recruitment limited. Food availability, however, may be another limiting factor in these areas.

Development of a hatchery program for supplementing depressed wild stocks will also require additional information on the genetic makeup of fish that reside in different locations of the river. Then if enhancement efforts are justified, the populations can be reinforced from their own resident gene pool.

The element of time becomes increasingly important in any management plans considering hatchery supplementation. Because of information gaps described above, an acceptable sturgeon hatchery program would likely take years to implement. It would then take approximately 12 more years before the first hatchery fish entered the fishery.

The potential for additional private hatchery developments along the Columbia has raised a number of concerns. The one existing hatchery operation has handled only relatively small numbers of spawning fish. Until captive broodstocks are developed, however, any new hatcheries will also have to rely on the capture of wild, mature fish for their operation. If increased numbers of spawning fish are to be taken, there is insufficient information to measure what impact this may have on the river populations.

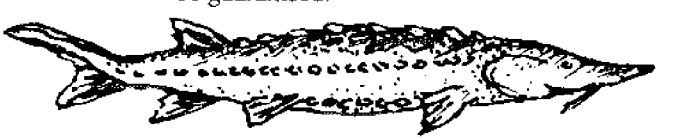
An additional concern is the fact that the state of Washington has not yet permitted any private sturgeon hatcheries. Since Oregon and Washington must co-manage the anadromous resources of the Columbia River, a consistent policy between the states is essential.

Probably the biggest factor that will limit development of sturgeon growout facilities in the Northwest will be the availability of water at the 23°C optimum rearing temperature. Most groundwater temperatures in this region are too low to support a commercial operation; however, the possibilities for geothermal and waste-heat aquaculture do exist.

In attempting to deal with the problems and opportunities associated with Columbia River sturgeon, much can be learned by taking a closer look at California's sturgeon experience. Because of an innovative and aggressive research program, a great deal has been learned about sturgeon reproduction, nutrition, physiology, and disease. These efforts have not only spawned a new private industry, but have also contributed information useful in managing wild sturgeon stocks.

Private sturgeon growers, in turn, are multiplying these research benefits by working closely with researchers on feeding strategies, rearing systems, and broodstock development. Furthermore, these growers are developing the facilities and expertise that may someday help wild sturgeon stocks in California and across the country.

Only through similar forms of innovation, committment, and cooperation can the best use of Columbia River sturgeon be guaranteed.



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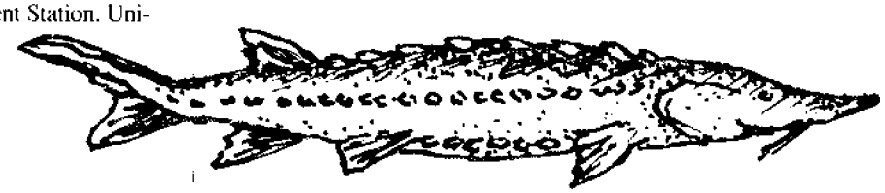

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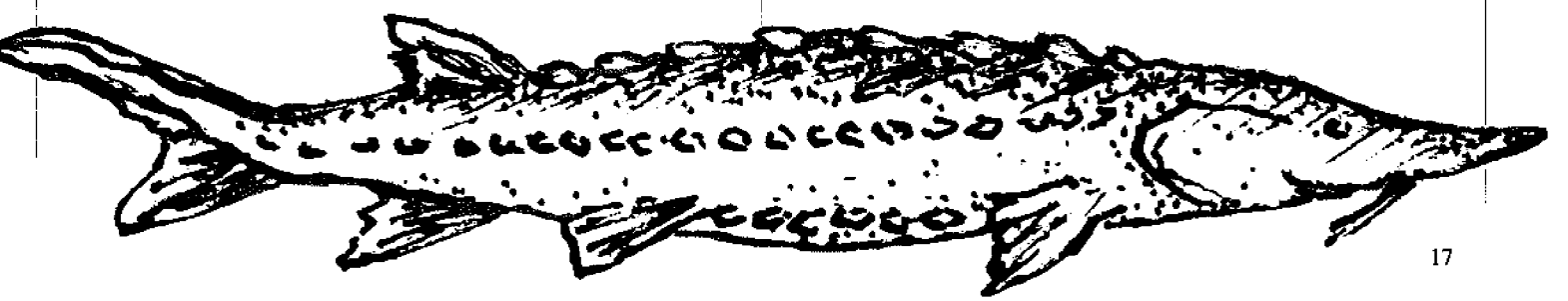

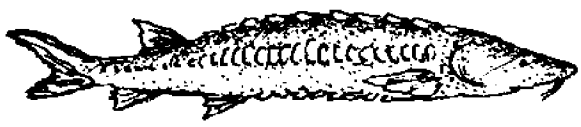

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