Section 1

Background Information

BIOLOGY OF THE PADDLEFISH

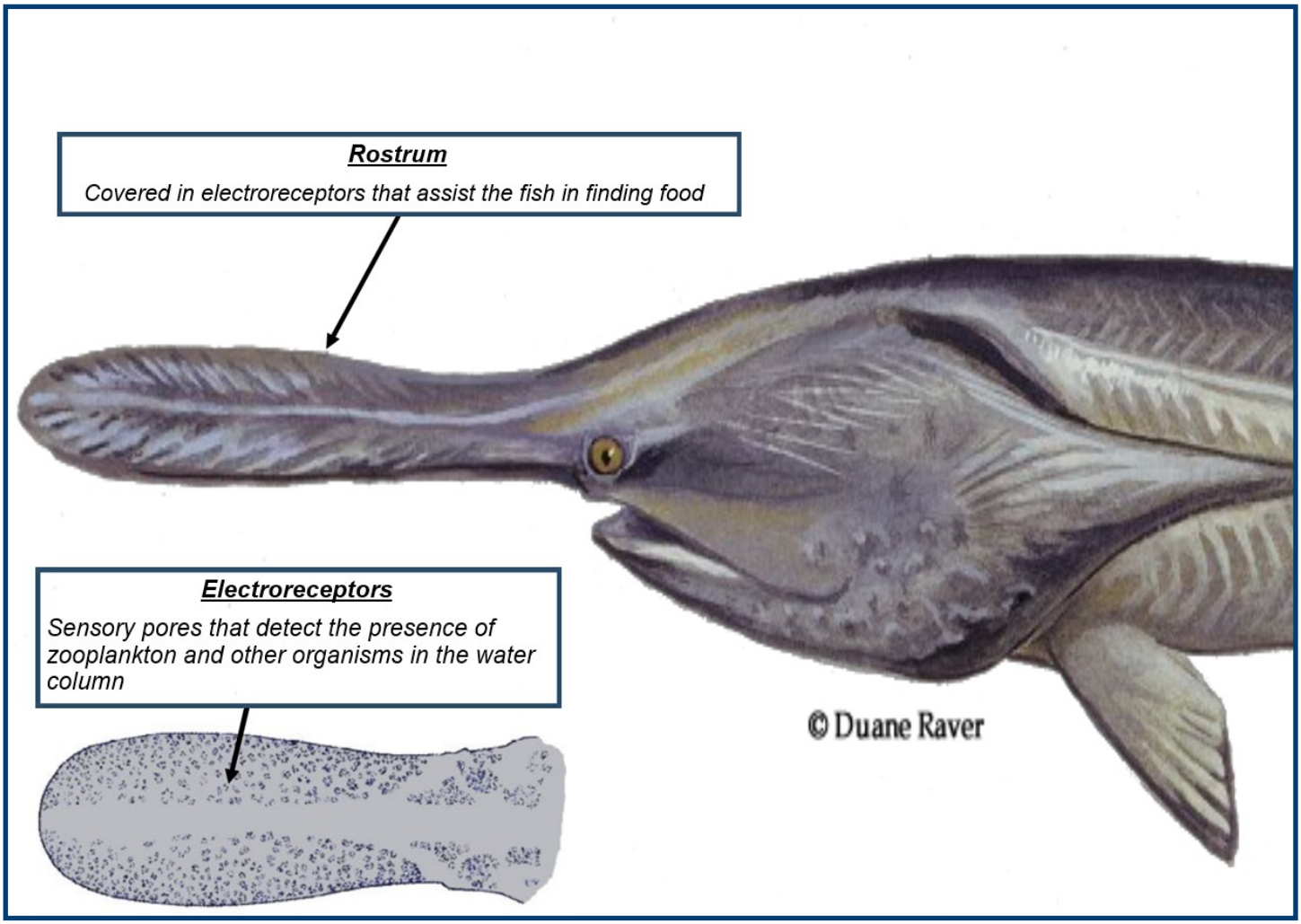
American Paddlefish (*Polyodon spathula*) are large, gray to bluish freshwater fish. Adults usually reach about 5 feet in body length (excluding the rostrum) and weigh up to 60 pounds, but can be much larger in some areas. The largest ever recorded Paddlefish was caught in 1916 in Iowa, and was 7 feet, 1 inch long! Here in Louisiana, adult Paddlefish reach an average of about **2.5 feet** in body length and weigh from **10 to 15 pounds**.

As its common (or species) name ***spathula*** suggests, the Paddlefish has a long paddle-shaped snout or **rostrum** equivalent to one-third of the fish's total body length. On the rostrum you'll find 2 small **barbels** (like a catfish's "whiskers") as well as tiny pores called electroreceptors that help the Paddlefish locate it's food, which we will learn more about in a later section. The adult Paddlefish has a large, **toothless** mouth on the underside of its head and the fish is scaleless, except for a small patch near the caudal (tail) fin.

Paddlefish Taxonomy

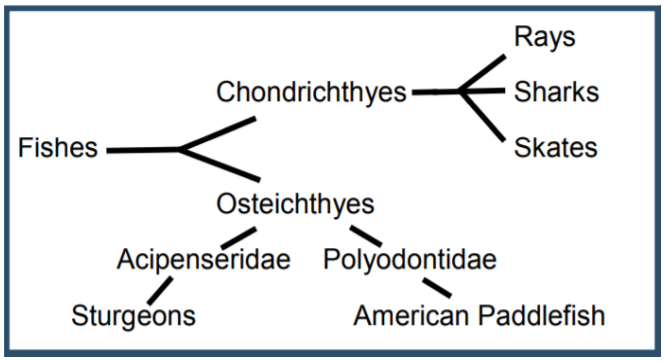
Kingdom - *Animalia*
Phylum - *Chordata*
Superclass - *Osteichthyes*
Class - *Actinopterygii*
Subclass - *Chondrostei*
Order - *Acipenseriformes*
Family - *Polyodontidae*
Genus - *Polyodon*
Species - *spathula*

Taxonomy of the American Paddlefish



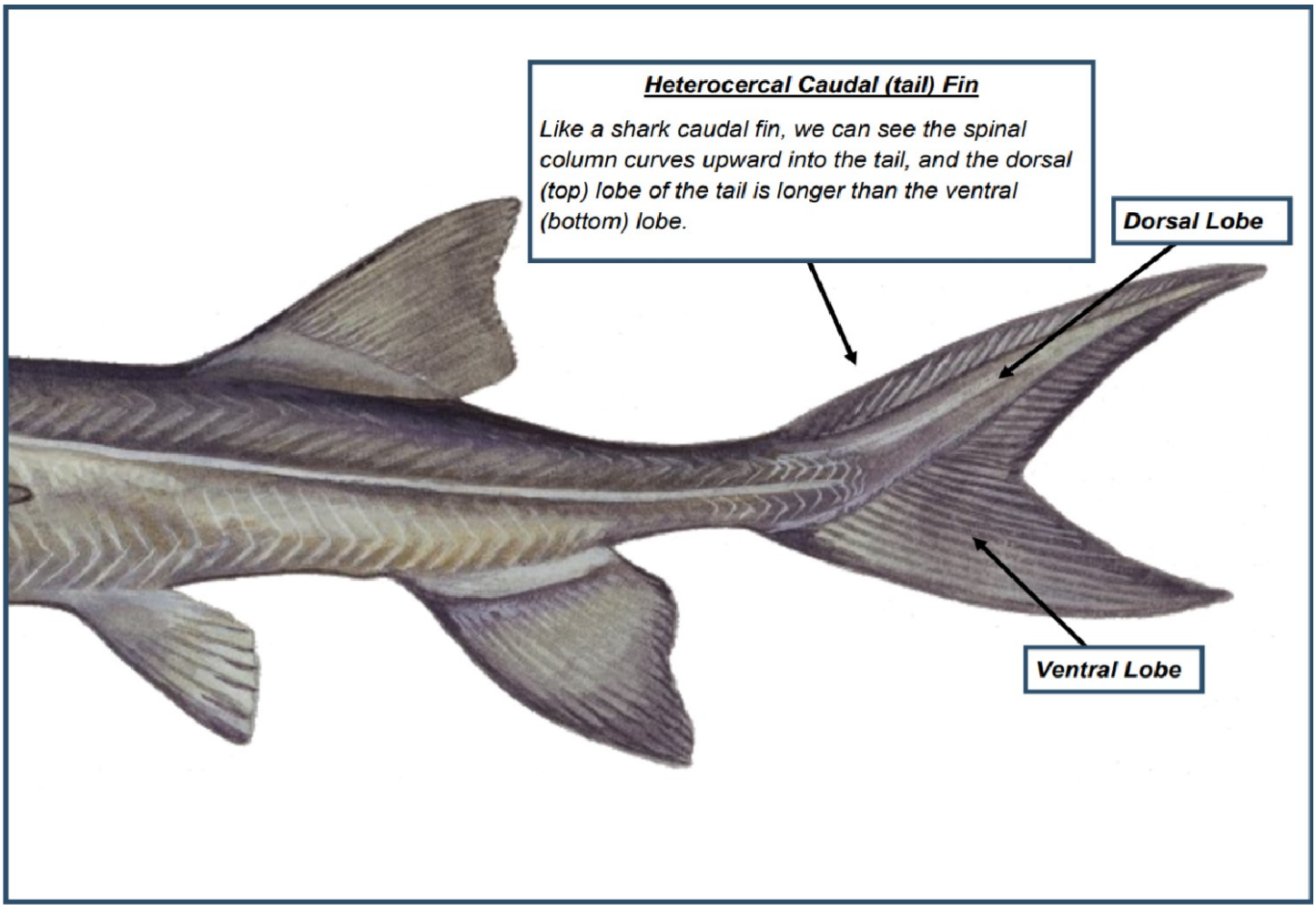
BIOLOGY OF THE PADDLEFISH

Paddlefish caudal fins are **heterocercal**, like that of a shark. This means that the dorsal (top) lobe, with the vertebral (spinal) column extending into it, is longer than the ventral (lower) lobe. The skeleton of the Paddlefish is mostly **cartilaginous**, with the exceptions of bone-like material found in the dentary (jaw) region and **ossified** (turned into bony tissue) skull structures found in mature Paddlefish.



Simple phylogenetic tree showing evolutionary relationship of Paddlefish and other fish species

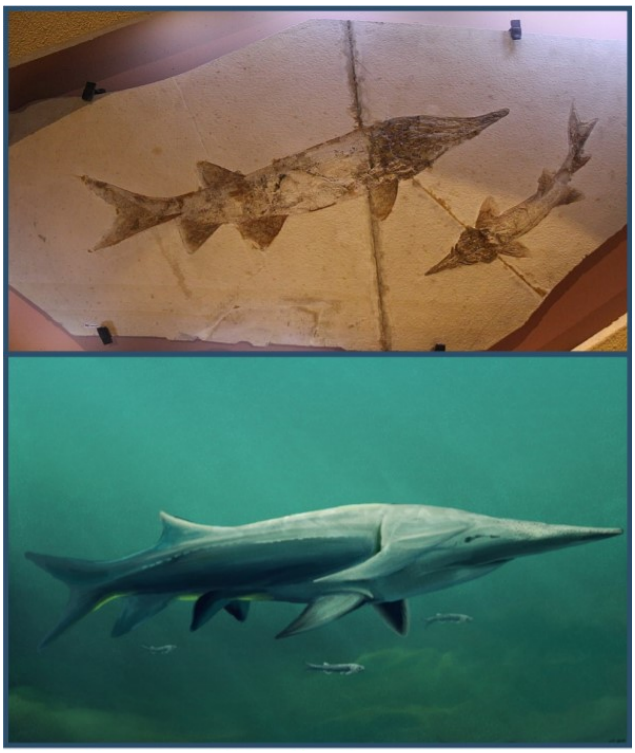
The Paddlefish looks like it is related to sharks, and was often mistaken as one when the species was first discovered and documented. In 1797, French naturalist ***Bernard Germain de Lacepede*** was one of the first scientists to disagree with the notion that Paddlefish were a species of shark. Bernard established the genus ***Polyodon*** for Paddlefish, of which the American Paddlefish is now the only living member. The German naturalist ***Johann Julius Walbaum*** had given the Paddlefish their species name *spathula* in 1792, five years before Lacepede, and thus is given credit for first scientifically naming the Paddlefish. Modern genetic analysis has proven that Paddlefish are more closely related to sturgeon, gar, bowfin, and other ray-finned fishes as opposed to sharks.



BIOLOGY OF THE PADDLEFISH

American Paddlefish are one of the largest freshwater fish in the world and can potentially live for **50 years** or more. It is the last remaining living species of Paddlefish in the world, with the Chinese Paddlefish (*Psephurus gladius)* being officially declared extinct in 2019. Unlike the American Paddlefish, the Chinese Paddlefish fed on other fish, had a sword-like mouth and could reach lengths of 9-10 feet or more!

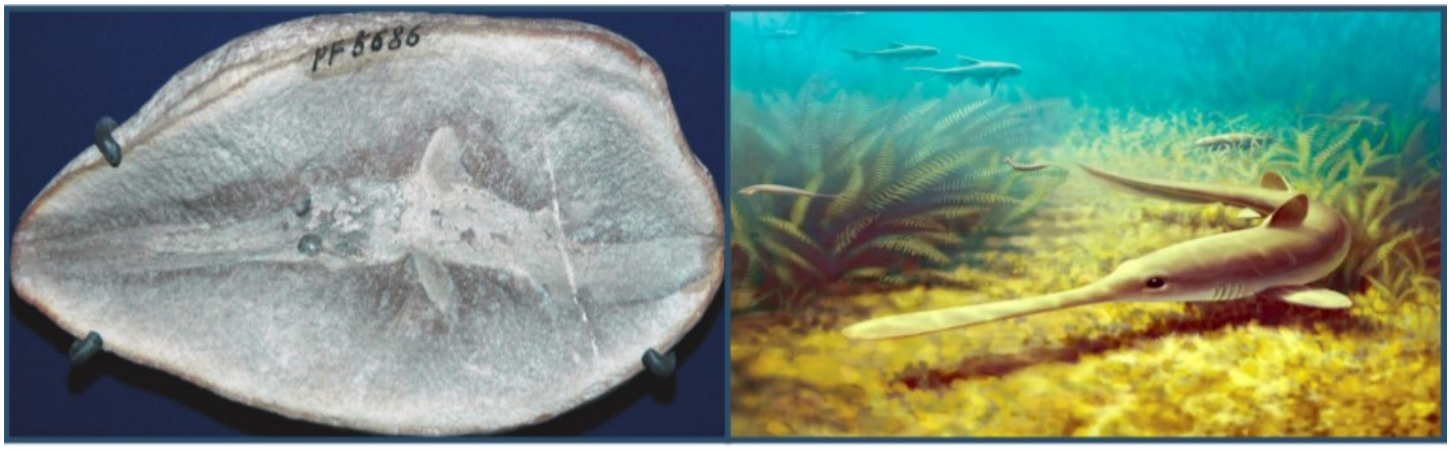
Paddlefish in general are also one of the oldest living groups of fish. The oldest known Paddlefish fossils date back to the early Cretaceous period about **125 million years ago**, 60 million years before the extinction of the dinosaurs! Paddlefish are considered to be a **primitive species**, meaning they are physically similar to their ancestor species and show little evolution (change) over millions of years. Like its extinct relatives, the Paddlefish has a simple body and organ structure, a mostly cartilaginous skeleton, and few scales.



*125 million year old fossilized remains of extinct Paddlefish species "**Protopsephurus liui**" alongside artists recreation of what the fish may have looked like.*

If we look even further back in the fossil record, we can find species that, while not members of the Paddlefish family (***Polyodontidae***), share a striking resemblance to our modern day Paddlefish. One such species is ***Bandringa rayi,*** a primitive species of shark found as far back as 350 million years in the fossil record, which is 100 million years before the first dinosaurs! It's fossil, seen below, looks much like a Paddlefish and very different from what we normally think of when we picture a shark. *Bandringa rayi* not only looks like a Paddlefish, but scientists believe it behaved like one as well, with their rostrums also containing the same electroreceptors that our Paddlefish use to find food today.

This phenomenon, when similar features evolve in independent species, is called **Convergent Evolution** and is one of the many fascinating aspects of the evolution of fish and of life in general. Another example of this is the fish-like body shape evolving not only in fish, but in mammals (Dolphins), reptiles (the now extinct Ichthyosaurs) and even some birds (Puffins) as well.



300+ million year old fossilized remains of extinct primitive shark species "Bandringa rayi" alongside artists recreation of what the fish may have looked like.

PADDLEFISH SPAWNING

Spawning is the release of eggs and sperm into the water for the purpose of reproduction. Paddlefish spawn only under specific environmental conditions and if all these conditions are not present, the fish will not reproduce. These necessary environmental factors include an increase in the time/length of daylight (**photoperiod**), a **temperature rise**, a significant increase of water flows (**flood pulse**), and **firm substrate** (coarse sand, gravel, cobble, mussel beds, or rip-rap) clean of silt. These conditions typically occur in Louisiana from **late February through March**. In more northern latitudes, such as Montana, they may not occur until May or June.

Males may spawn every year, but females do not. Once females reach maturity, it takes **2 or more years** for a female to produce mature eggs. When ready, a female can produce up to 10-12 pounds of eggs which can equate to as many as **500,000 eggs** or more per female! Once a female has enough eggs, she still may not spawn if the environmental conditions listed above are not favorable.

Recently hatched Paddlefish fry
Source: USFWS

During spawning, a large female accompanied by several smaller males will swim over selected suitable substrates, where males release milt (sperm) and females release eggs in the water simultaneously. Scientists call this spawning method **Broadcast Spawning**. In Louisiana, Paddlefish have adapted to spawn over hard substrates such as logjams and mussel beds because there are few gravel bars left in the state. The **naturally sticky** fertilized eggs adhere to the substrate, and are not washed away in river currents. The swift current keeps the eggs well oxygenated, and prevents debris and silt from covering them. Without these adaptations, the eggs would not be able to survive. If all goes well, the eggs will hatch in **about a week** and the larval fish are then swept downstream to quieter waters.

When first hatched, baby fish are called **fry**. The very beginnings of the fry stage in fish is called the **sac fry** stage. The name sac fry refers to the **yolk sac** that is still attached to the baby fish after it hatches (much like the yellow yolk of a chicken egg you would eat.) The fry uses this yolk sac as sustenance (food) until it is fully absorbed and the fry have grown large enough to begin feeding on zooplankton. After the fry stage, Paddlefish move on to the **fingerling** stage where they begin developing features more similar to their adult form.

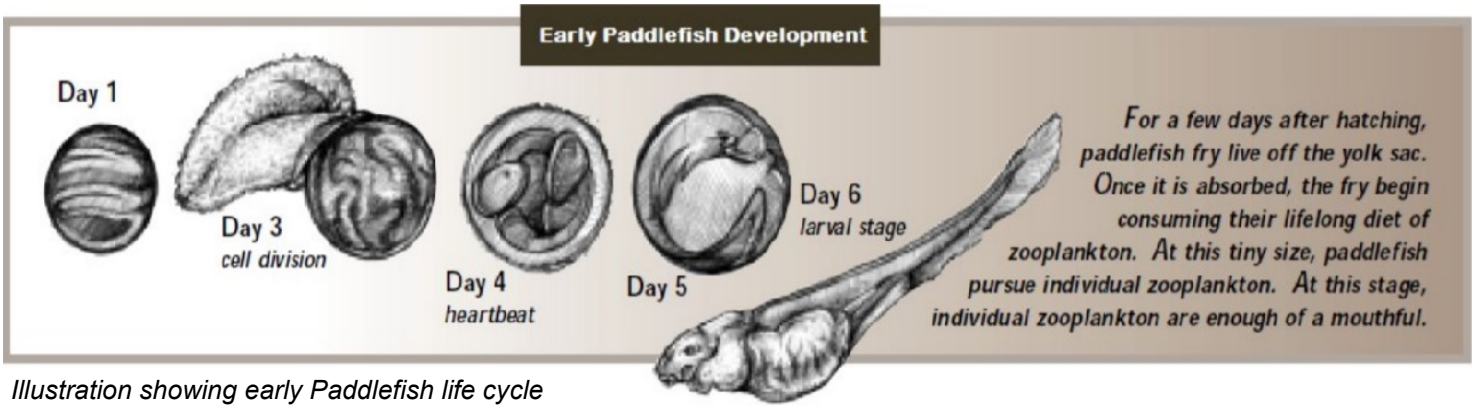


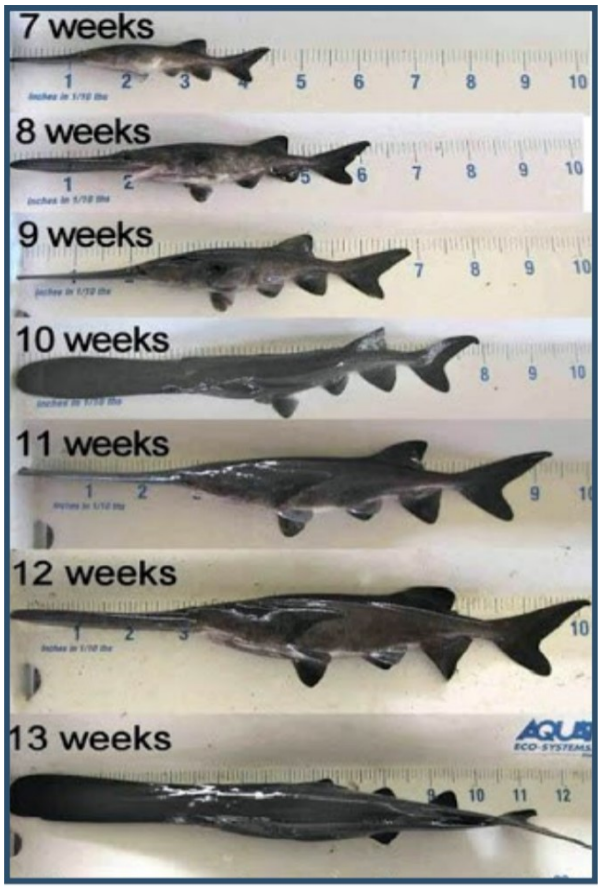
Illustration showing early Paddlefish life cycle
Source: Pennsylvania Angler & Boater

PADDLEFISH SPAWNING

Paddlefish hatch without their distinctive paddle-shaped rostrum, which begins to develop at the end of their fry stage. In fact, Paddlefish fry are actually **born with teeth**! This is why Paddlefish have the genus name ***Polyodon***, which means “many teeth” in Greek. They use these teeth to feed on individual zooplankton in the water column, which they will continue to do until they reach a large enough size to filter out many zooplankton at a time.

Example of variation in growth rates of Paddlefish fingerlings (all fingerlings shown are 30 days old)
Source: Garrison Dam National Fish Hatchery

By now you might be wondering, what is zooplankton? The term **plankton** refers to organisms that live in the water column and cannot swim against the currents, they just float. **Zooplankton** specifically refers to animal plankton (zoo meaning animal in Greek), as opposed to plant plankton which is called **phytoplankton**. Zooplankton usually comes in the form of microscopic crustaceans, however some zooplankton can be seen with the naked eye, such as certain species of Jellyfish.



Example of quick growth of a Paddlefish fingerling
Source: Southeastern Outdoors

Despite their ability to grow rapidly, Paddlefish mature late in life. Males reach sexual maturity between **7 and 9 years** of age, or at one-fourth of their expected life span. Females mature between **10 and 12 years** of age, or at one-third of their expected life span. Because of this, they are a particularly sensitive species when it comes to damage to their population. If the individuals of spawning age are somehow removed from a population, it could be years before new Paddlefish fry are spawned!

The Paddlefish at Booker Fowler Fish Hatchery will be **artificially spawned**, in a process that will be detailed in another section, and the eggs will then be taken back to the classroom by the teachers and their students and placed in an **incubation jar** until hatching

PADDLEFISH FEEDING

With its large size, most people would probably guess that the Paddlefish is a predator who pursues large prey. However, as we've learned so far the Paddlefish is actually a **filter feeder**, feeding on zooplankton and aquatic insects. Daphnia spp**.** (water fleas), copepods, and ostracods comprise the majority of the Paddlefish's diet, while they sometimes also feed on small-prey items such as larval fish. The mouth of the Paddlefish has numerous gill arches containing filaments called **gill rakers**, which are comb-like filaments that allow the Paddlefish to filter zooplankton out of the water.

Photo of Paddlefish gill rakers

Scientists once believed that the Paddlefish used its rostrum to dig into the sediment for food, it wasn't until more recently that we discovered that their rostrums are covered in sensory pores called **electroreceptors** (see illustration on pg1). These electroreceptors can detect weak electrical fields, allowing Paddlefish to use their rostrum like an antenna to find zooplankton and other organisms in the water near them. The receptors are so sensitive, that not only do they detect the presence of zooplankton, but the individual feeding and swimming movements of the zooplankton's appendages as well! These sensory pores extend from the rostrum to the top of the head and to the tips of the **operculum** (gill flaps) and take up nearly half the skin surface of the fish. Paddlefish have to rely on their electroreceptors to find food because they have **poorly developed eyes**. If the rostrum is damaged, a Paddlefish will still be able to locate food items because of electroreceptors located on the head region. Therefore, the rostrum is not the sole means of food detection but an important tool nonetheless.

As we discussed before, feeding habits of young Paddlefish differ from those of adults. Fingerlings less than 7 to 8 inches long do not have well developed gill rakers and are unable to strain zooplankton from the water. At this stage they are **selective feeders**, capturing zooplankton one at a time. Some young Paddlefish will selectively feed for up to one year or until they reach a total length of about 1ft.

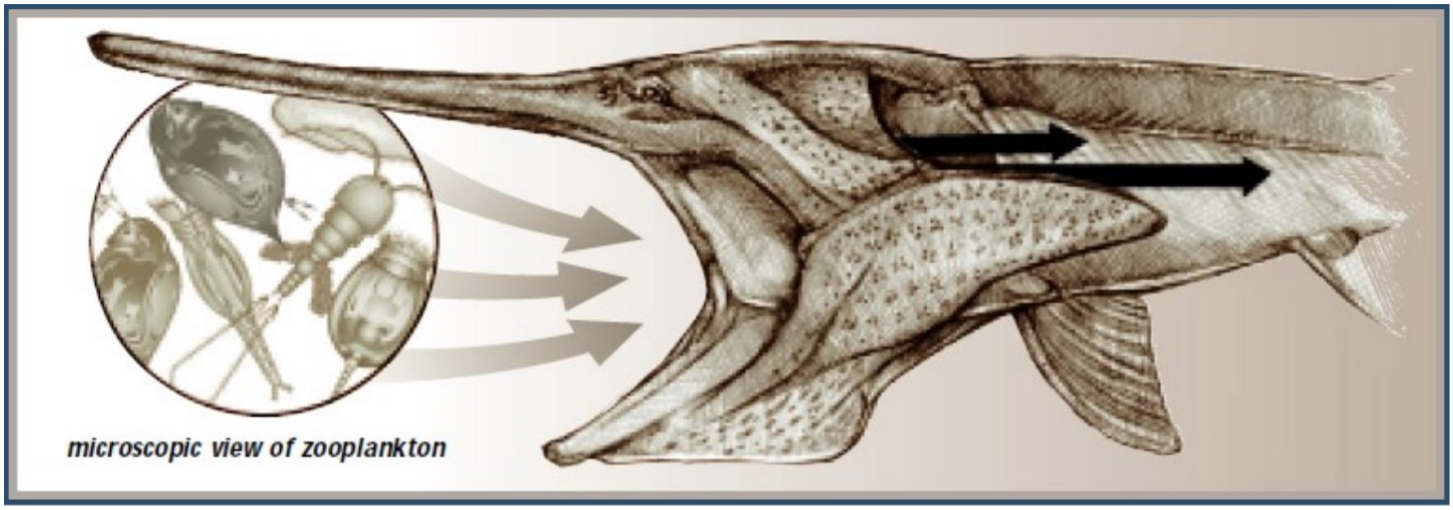
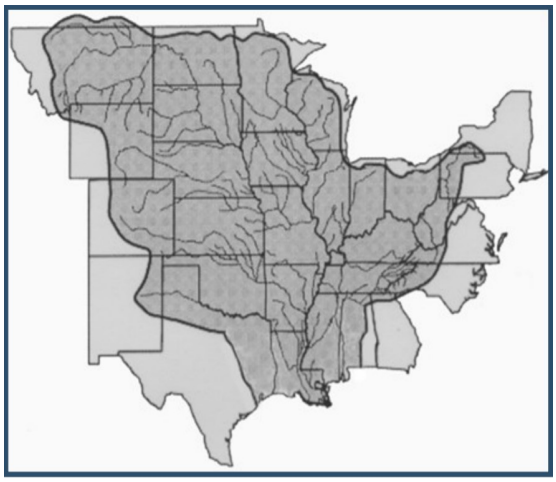


Illustration showing Paddlefish filter feeding
Source: Pennsylvania Angler & Boater

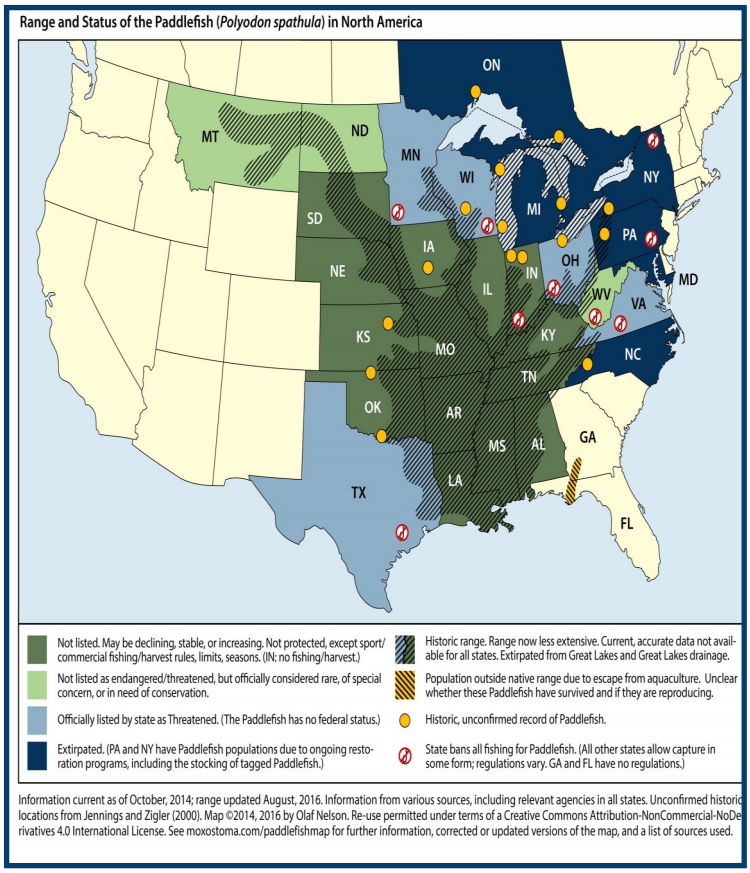
PADDLEFISH RANGE

It's often suggested that Spanish explorer **Hernando de Soto** was the first European to document Paddlefish when he traversed the Mississippi River in 1542. However, the first published European description of Paddlefish actually came from one of De Soto's crew members years later in 1557. Referred to as **A Gentleman from Elvas** (identity unknown), the Portuguese soldier described fishes caught by local Native Americans using nets in the Wabash River. Called **piexe pall** (shovel fish), they described the fish as "having a snout a cubit in length with the tip of it's upper lip being shaped like a shovel."



Historic range of Paddlefish
Modified from Williamson 2003

At that time, Paddlefish were found throughout the **Mississippi River drainage basin**, including the Great Lakes and rivers in Ontario, Canada. As of 2020, Paddlefish populations are now officially **extirpated** (naturally occurring populations no longer exist) in Canada, Pennsylvania, Maryland, New York, Michigan and North Carolina and their population range has been reduced to the Mississippi and Missouri rivers and tributaries, the Mobile Bay drainage basin, and Southwest Louisiana. Small Paddlefish populations do exist in Pennsylvania and New York thanks to ongoing recovery programs, however they are not yet self sustaining enough to officially say Paddlefish have returned in those states.



See Appendix V for larger image of map

In some parts of its current range, Paddlefish form stable populations and are **harvested** commercially and as sportfish by recreational anglers. The meat is eaten and is considered flavorful. More desirable than the meat are the **unfertilized** eggs, called **roe**. Paddlefish roe, like sturgeon caviar, is considered a delicacy. Harvesting of their roe has made the Paddlefish an economically valuable species, but has also had negative impacts on the species overall population.

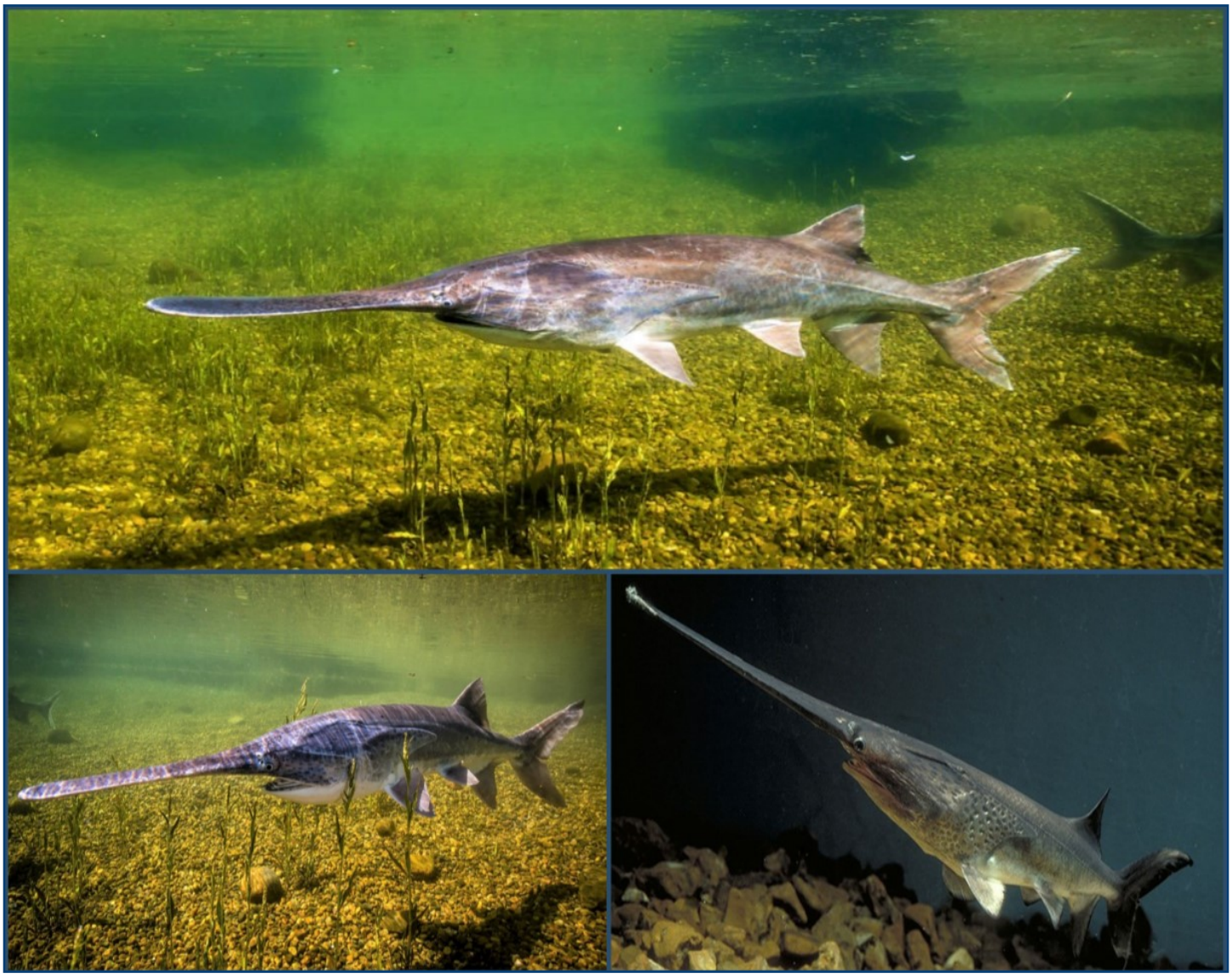
Outside of its naturally occurring range, there were also **non-indigenous** (not naturally occurring) populations of Paddlefish in Georgia which spread to Florida, although it is unknown whether or not these individuals have reproduced. They were accidentally released from an aquaculture facility along the Flint River in Georgia during Tropical Storm Alberto in July of 1994.

PADDLEFISH HABITAT

Paddlefish are found in many types of **riverine habitats** within the Mississippi River drainage basin. Many find homes in deeper, low-current areas of river systems. Some of these areas include side channels, backwaters, oxbow lakes, natural lakes, reservoirs, and tail waters below dams. For spawning habitat, as we discussed before, they prefer to have river systems with firm substrate (coarse sand, gravel, cobble, mussel beds, or rip-rap) clean of silt.

In Louisiana, Paddlefish are found in numerous rivers, lakes, and bayous, and are in **every river basin in the state**. Though primarily a freshwater fish, Paddlefish can also be found in more saline/brackish (salty) waters such as the estuarine systems of Lake Pontchartrain and Grand Lake where salt and freshwater mix.

The fish are highly migratory and can travel up to **2,000 miles** in a river system, typically swimming near the surface, with tagged fish from Oklahoma being recaptured as far away as Tennessee for example.

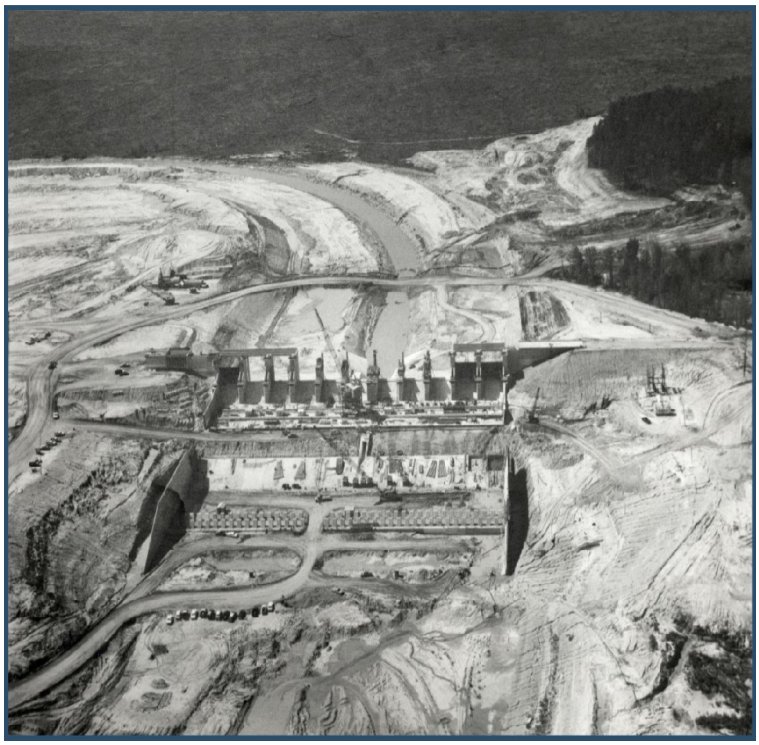


Paddlefish in their natural habitat
Source: USFWS

CAUSES OF POPULATION DECLINE

Paddlefish are found in only **22 states** as of 2020 (excluding small recovery populations in Pennsylvania and New York). In some of the states where Paddlefish are found, the populations are protected under federal or state laws due to **severe population decline** in the past, although populations have successfully rebounded in some areas. As of 2020, **15 states** allow commercial and/or sport fishing for Paddlefish.

One of the primary causes of the decline in Paddlefish populations are the human activities that have led to widespread **habitat alteration, degradation,** and **loss**. There are several well-known limiting factors that affect Paddlefish populations, either by directly harming the fish or damaging habitat critical for the species' survival. These include **dam construction**, **pollution**, and **overharvesting**.



Toledo Bend spillway construction
Source: Toledo Bend Lake Country

Spawning areas are degraded mainly by human efforts to improve flood control and navigation, including **dredging of rivers** and **construction of levees**, **locks**, and **dams**. Dams significantly alter the surrounding environment, affecting all forms of life in the local vicinity in two ways. First, dams form reservoirs with deep, open water and slow currents that may inundate areas that were once ideal Paddlefish spawning areas. Secondly, dams reduce water flow downstream, which will increase the release of sediment into the water covering clean gravel bars Paddlefish prefer for spawning. Dams also affect Paddlefish populations by creating barriers that prevent migration to spawning grounds and migration up and down the waterway for food. **Pollution** from industry, municipalities, and agriculture also further degrades water quality and Paddlefish habitat.

A good example of dam construction that impacted Louisiana's Paddlefish population specifically would be the **Toledo Bend Dam and Generating Complex**, built on the Sabine River. The purpose of this dam is to produce electricity, to maintain water supply, and to support recreation (especially for sport fishing). **The Toledo Bend Reservoir** covers 185,000 acres of land and is 65 miles long and 15 miles wide, making it the largest human-made body of water in the south. Unfortunately, this dam was constructed over critical spawning habitat (clean gravel bars) for the Paddlefish in that area, so currently fingerlings released there that move below the dam are unlikely to ever spawn due to the **lack of suitable habitat**. Lack of spawning habitat will eventually cause **drastic declines** in populations over time, as older fish start to die off without being replaced by new ones. This was the result of an **oversight** by the biological surveys conducted in the summer months pre-dam construction, which showed no signs of Paddlefish spawning since they only spawn during the **spring months** in Louisiana. **Since 1990**, Louisiana Department of Wildlife and Fisheries and Texas Parks and Wildlife have worked jointly to restore the Paddlefish populations **above the dam**, and because of those restoration programs the Paddlefish populations above the dam have been restored to **healthy levels**.

CAVIAR INDUSTRY

Overharvesting for roe (unfertilized eggs) is another cause of additional stress to imperiled Paddlefish populations. This stress becomes more of a concern as sturgeon stocks rapidly decline worldwide and Paddlefish, a close relative with similarly sized roe, is sought as a replacement.

Image of Paddlefish "caviar"

Sturgeon species from the Black and Caspian Sea basins are the most common/sought after species harvested for their roe. Sturgeon species are the only fish to legally have their roe labeled simply as caviar under the Food and Drug Administration's (FDA) food labeling regulations, **21 CFR Part 101**. If the roe of another species is placed in a container labeled caviar, it must also include the name of the fish it was taken from with the font of the words the same size and prominence (**FDA warning letter 2002**). Trade of meat and roe harvest from sturgeon species listed as endangered is regulated under the **Convention on International Trade in Endangered Species of Wild Fauna and Flora** (CITES), which we will learn more about in another section.

Overfishing, poaching, and industrial pollution have greatly diminished populations of sturgeon species. As of 2020, all Caspian sturgeon species are listed as critically endangered by the **International Union for Conservation of Nature** (IUCN). Overall, sturgeon are one of the most critically threatened groups of animal in the world, with 85% of sturgeon species being at risk for extinction (63% listed as critically endangered).

Image of Beluga Sturgeon, the Caspian sturgeon species most commonly harvested for its roe for caviar (caviar shown on the right)

CAVIAR INDUSTRY

In more recent years, sturgeon **aquaculture farms** have been gaining popularity and are resulting in a resurgence of sorts for the global sturgeon caviar industry, especially when it comes to roe from the critically endangered **Beluga Sturgeon**. While still heavily regulated and restricted, this has allowed for the sale of caviar from **captive bred** Beluga Sturgeon without impacting wild populations, and in some cases the aquaculture farms also contribute to efforts to restore those wild populations. In the United States, **Sturgeon AquaFarms** in Bascom, Florida was the first facility to be granted an exemption from caviar trade laws on June 15th, 2016. The exemption was granted with the agreement that Sturgeon AquaFarms would commit to aiding in the **restoration** of wild Beluga Sturgeon **populations** and **habitat**, in addition to other agreed upon conditions. The exemption allows Beluga Sturgeon born and raised at the aquaculture farm to be harvested for meat and roe and to be traded in interstate commerce.

Beluga Sturgeon from Sturgeon AquaFarms aquaculture facility in Florida

Source: Merkle Photography

Roe harvested from Paddlefish

Source: Bobby Reed, LDWF

Because of the declining wild sturgeon populations and increased restrictions on the sale of their roe, other species such as the Paddlefish have been sought as replacements, as we've discussed. With its gray color and nutty flavor, Paddlefish roe is very similar in color, size and taste to caviar from Sevruga Sturgeon (*Acipenser stellatus*) from the Caspian Sea. In the United States, Paddlefish roe can yield fishers roughly **$260 per kilogram** ($120 per pound) and retail at **$810 per kilogram** ($192 per pound). Hopefully, aquaculture facilities like Sturgeon AquaFarms will soon be able to sufficiently supply the sturgeon caviar trade, ideally decreasing the need/desire for alternative sources of roe such as Paddlefish.

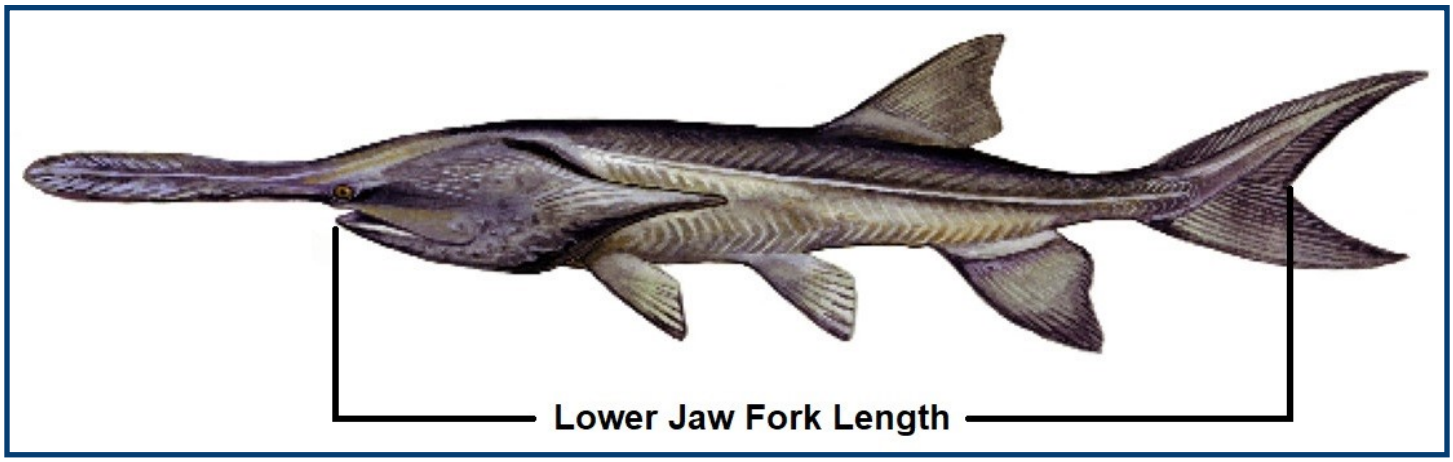
PADDLEFISH CONSERVATION

Depending on the state and the health of the specific population in question, the status of Paddlefish populations varies from federally protected and/or state-protected to unprotected. In 1992, the Paddlefish was listed in **Appendix II** of the **Convention on International Trade in Endangered Species of Wild Fauna and Flora** (CITES). CITES is an agreement among governments to ensure that international trade of a species will not threaten the species' survival. Species that are listed in Appendix II are not necessarily threatened with extinction, but the trade of these species is regulated. For the specimen to be exported, the exporter must show that they have a permit that certifies the specimen was legally obtained, that the specimen will face minimal risk of injury during transport, and that the trade of the specimen will not be detrimental to the survival of the species.

In 1991, 28 state natural resources management agencies formed a Mississippi River basin-wide conservation effort called the **Mississippi Interstate Cooperative Resource Association** (MICRA) to improve inter-jurisdictional management of aquatic resources. MICRA established the **Paddlefish/ Sturgeon Subcommittee** whose mission is to provide information and recommendations to conserve and manage Paddlefish through inter-jurisdictional coordination, communication, and assessment.

In Louisiana, Paddlefish are still considered protected though the population is stable. As of 2020, recreational anglers are allowed to take **two Paddlefish per day** with a **maximum lower jaw-fork length of 30 inches** (example shown below). This is meant to protect large mature females from harvest because, as we discussed earlier, Paddlefish take quite some time to reach the age of sexual reproduction (up to 10-12 years for females). Commercial fishing for Paddlefish however is **illegal in Louisiana**. Other states with sustainable Paddlefish populations that can support commercial and/or sport (recreational) fishing are Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Mississippi, Missouri, Montana, North Dakota, Oklahoma, South Dakota and Tennessee. Commercial fishing in Alabama was brought back in 2013, however due to declining quality of reports from Paddlefish fisherman, which caused the state to start suspecting illegal sales, commercial Paddlefish fishing was again closed indefinitely in 2018.

Throughout the Paddlefish's natural range, there are many programs to help restore populations to healthy, sustainable levels. In addition to crucial habitat conservation, restoration, and improvement efforts, fish hatcheries also play a very important role in this process by artificially spawning Paddlefish and releasing new fingerlings into the wild. **Programs**, **regulations**, and **facilities** like the ones we've discussed are extremely important to the conservation and preservation of Paddlefish, and as we'll see in the next section detailing the story of the Chinese Paddlefish, the absence of such efforts can lead to gross misuse and abuse of natural resources that can cause potentially irreversible damage to wildlife species and the ecosystems they live in.



PADDLEFISH CONSERVATION

Conservation Status

When discussing/researching the conservation of any species, you're likely to come across terms such as threatened, protected, endangered, etc. You might be wondering, what do these terms mean and where do they come from? Terms like these are known as a species **conservation status** or conservation status level and are used by numerous global, national, and statewide agencies/organizations to categorize species based on their conservation needs. In other words, assigning a conservation status for a species lets you assess which species are in the most dire need of **assistance** and **management**. The exact definitions of these terms will change depending on the particular source you're looking at, but they tend to have very similar definitions.

The most popular and common list of conservation statuses was established in 1964 by The International Union for Conservation of Nature and is called the **IUCN Red List of Threatened Species**. The IUCN Red List is currently the worlds most comprehensive information source for the global conservation status of animal, fungi and plant species. It created **9 categories** which species can be grouped into (all detailed in a table on page 14). In most cases, these terms do not come with any legal backing to them as they're often created by non-government conservation organizations. However, conservation statuses outlined by state and federal agencies do have legal backing to them and are used to enforce those laws and guide species management.

Endangered Species Act

The most well known conservation law in the United States is the **Endangered Species Act** (ESA). Passed in 1973, the ESA created 2 potential listings for species: **Endangered**, which means a species is in danger of extinction throughout all/most of its natural range without proper management, and **Threatened,** which means a species is likely to become endangered in the immediate future without proper management. Species listed as either Endangered or Threatened under the ESA will have federal protections with legal ramifications for individuals who disturb these species. In addition to the ESA, each state also has their own conservation legislation and laws governing protections for species that compliment the federal laws.

Louisiana State Conservation Statuses

State statuses for Louisiana can be found in **Title 56 of the Louisiana Revised Statutes** as well as relevant rules and regulations adopted by the Louisiana Wildlife and Fisheries commission and the Secretary of the Louisiana Department of Wildlife and Fisheries. Louisiana generally uses 5 categories for the conservation status of species: **Endangered**, **Threatened/Endangered**, **Threatened**, **Prohibited** and **Restricted Harvest** (all detailed in a table on page 14*).* As of 2020, Paddlefish are still protected in Louisiana and fall under the **Restricted Harvest** status.

In addition to these conservation statuses, Louisiana (as well as all other states) also has a population ranking system further detailing the status of a species' population in the state, containing **12 possible rankings** (all detailed in a table on page 15*).* These rankings differ from the more well known conservation statuses in that they strictly deal with the health of a population within the state as opposed to it's legal or management conservation status. One way to think about it, is that a species population rank can advise us on which conservation status it should receive. As of 2020, Paddlefish are given a rank of S4 in Louisiana, meaning their population is likely secure in the state.

PADDLEFISH CONSERVATION

IUNC Red List - Conservation Statuses	
Status:	*Definition:*
Extinct (EX)	No known living individuals
Extinct in the Wild (EW)	Known only to survive in captivity, or as a naturalized population outside it's historic range
Critically Endangered (CR)	Extremely high risk of extinction in the wild
Endangered (EN)	High risk of extinction in the wild
Vulnerable (VU)	High risk of endangerment in the wild
Near Threatened (NT)	Likely to become endangered in the future
Least Concern (LC)	Lowest risk; does not qualify for a higher risk category
Data Deficient (DD)	Not enough data to make an assessment
Not Evaluated (NE)	Has not yet been evaluated against the criteria

Table detailing the IUNC Red List conservation statuses and definitions of each

Louisiana State Conservation Statuses	
Status:	*Definition:*
Endangered	Species at risk of extirpation or extinction. Take or harassment of these species is a violation of state and federal laws.
Threatened/ Endangered	Imperiled species with populations of conflicting protection status. Take or harassment of these species is a violation of state and federal laws.
Threatened	Species at risk of becoming endangered. Take or harassment of these species is a violation of state and federal laws.
Prohibited	Possession of these species is prohibited; no legal harvest or possession allowed without valid Scientific Research and Collecting Permit issued by LDWF.
Restricted Harvest	Restrictions regarding the take and possession of these species.

Table detailing the Louisiana state conservation statuses and definitions of each

PADDLEFISH CONSERVATION

Louisiana State Population Rankings	
Ranking:	*Definition:*
S1	Critically imperiled in Louisiana because of extreme rarity (5 or fewer known extant populations) or because of some factor(s) making it especially vulnerable to extirpation
S2	Imperiled in Louisiana because of rarity (6 to 20 known extant populations) or because of some factor(s) making it very vulnerable to extirpation
S3	Rare and local throughout the state or found locally (even abundantly at some of its locations) in a restricted region of the state, or because of other factors making it vulnerable to extirpation (21 to 100 known extant populations)
S4	Apparently secure in Louisiana with many occurrences (100 to 1000 known extant populations)
S5	Demonstrably secure in Louisiana (1000+ known extant populations)
B or N	May be used as qualifier of numeric ranks indicating whether the occurrence is breeding (B) or nonbreeding (N)
SA	Accidental in Louisiana, including species (usually birds or butterflies) recorded once or twice or only at great intervals hundreds or even thousands of miles outside their usual range
SH	Historical occurrence in Louisiana, but no recent records verified within the last 20 years; formerly part of the established biota, possibly still persisting
SR	Reported from Louisiana, but without conclusive evidence to accept or reject the report
SU	Possibly in peril in Louisiana, but status uncertain; need more information
SX	Believed to be extirpated from Louisiana
SZ	Transient species in which no specific consistent area of occurrence is identifiable

Table detailing the Louisiana state population ranks and definitions of each

THE CASE OF THE CHINESE PADDLEFISH

When discussing the conservation of our American Paddlefish (*Polyodon spathula*), it's important to compare with the fate of the recently extinct **Chinese Paddlefish** (*Psephurus gladius*). At one time this fish joined the American Paddlefish as one of the only 2 living species of Paddlefish in the world and could be found primarily throughout the **Yangtze River** in China. However, the Chinese Paddlefish was officially declared extinct in a 2019 paper published by scientists from the Yangtze River Fisheries Research Institute in China who estimated the species went extinct sometime around 2005-2010, and was likely **functionally extinct** (no more reproducing individuals of the species) by 1993.

As it's species name gladius suggests (gladius is the Latin term for sword), this Paddlefish differed from the American Paddlefish in that it's rostrum was pointed and sword-like. They were a much bigger species of Paddlefish, averaging around 3 meters (9.8ft), and unlike their filter-feeding relatives, the Chinese Paddlefish ate larger prey, primarily fish and crustaceans. The Chinese Paddlefish also differed from it's American counterpart in that it was an **anadromous** fish, meaning it spent part of it's life cycle in salt water. The fish would spend part of their life in the lower, brackish portions of the Yangtze River but would migrate further upstream to spawn.

The main causes of population decline and ultimately extinction for this species were a combination of **dam building** (primarily the construction of the Gezhouba and Three Gorges dams), which fragmented the population and prevented the fish from migrating to their spawning locations, and **overfishing**. Fishing of Chinese Paddlefish has a history dating back centuries. By the 1970s, harvests were reaching near **25 tons per year**. The Chinese Paddlefish was listed as critically endangered by the IUCN in the 1990's, and was last seen alive around 2003. The fate of this species is an important case study in how policy/regulations, conservation programs, and in many ways public sentiment, play an invaluable role in preserving our wildlife and natural resources and can be the difference between species going extinct, like the Chinese Paddlefish, and species rebounding and in some cases thriving, like the American Paddlefish.

One of the only known photos of the Chinese Paddlefish in existence

Source: Unknown

AQUATIC INVASIVE SPECIES

Plants and animals living outside their natural geographic boundaries can be called by many names: **exotic**, **introduced**, **nonindigenous**, **invasive**, **non-native**, and **nuisance**. Some of these organisms have been intentionally introduced by humans for reasons such as use in agriculture, the pet industry, and fish and wildlife management. Others have entered accidentally in ships' ballast waters, in packing materials, as hitchhikers on other plants and animals, or even in hurricanes. Because of its mild climate and geographical location, Louisiana is **very susceptible** to the introduction of a variety of non-native plants and animals.

When non-native species make their way into natural ecosystems, they can threaten native habitats and the organisms that live there. Once established, non-native species can displace native plants and animals, alter ecosystems, cause disease, and interfere with industry, agriculture, and recreation. Once a non-native species begins negatively impacting the native environment, they're referred to as **invasive species**.

A great example of an invasive species in Louisiana are the **Asian Carp**, which is a group of freshwater invasive fish species from China and other parts of East Asia. Included in this group are many species that people across the US have grown familiar with in recent years, such as the **Bighead Carp** (*Hypophthalmichthys nobilis*), **Grass Carp** (*Ctenopharyngodon idella*), **Silver Carp** (*Hypophthalmichthys molitrix*), and **Black Carp** (*Mylopharyngodon piceus*).

These invasive carp species affect Paddlefish in several ways, especially the Bighead Carp and Silver Carp. Both of these species **feed on zooplankton**, which we've learned is the Paddlefish's primary source of food. By competing with Paddlefish for the same food sources, these carp can have significant negative impacts on Paddlefish populations in Louisiana by limiting the amount of resources available to sustain the Paddlefish population. The Silver and Bighead Carp also encroach on Paddlefish habitat, adding another layer of negative impacts onto the already significant **resource depletion** caused by sharing a food source.

BIGHEAD CARP

Source: US Fish and Wildlife Service

The adult Bighead Carp reaches **51 centimeters** (20 inches) in length and can weigh about **9 kilograms** (19 pounds). It has irregular black blotches on its body as well as small scales. The body shape is distinctive with a short body length and large head. It is a filter feeder that eats plankton throughout the water column.

SILVER CARP

Source: US Fish and Wildlife Service

The adult Silver Carp reaches **120 centimeters** (47 inches) in length and can weigh about **9 kilograms** (19 pounds). It is a silver-colored fish with a toothless, upturned mouth that has fused and sponge-like gill rakers. This fish feeds on plankton in the upper portion of the water column and prefers to inhabit impoundments or backwaters of large rivers.

AQUATIC INVASIVE SPECIES

GRASS CARP

Source: US Fish and Wildlife Survey

The adult Grass Carp reaches a length of **127 centimeters** (50 inches) and can weigh about **27 kilograms** (60 pounds). Its coloring is dark bronze on the back with a silver belly. The scales are darkly colored on the edges, giving the fish a cross-hatched appearance. Grass carp feed on soft aquatic vegetation.

BLACK CARP

Source: USGS

The Black Carp reaches **132 centimeters** (52 inches) in length and weighs up to **68 kilograms** (150 pounds). It is brownish-black in color with black-gray fins. The body shape is long and thin, and it has a mouth full of teeth made to crush prey. Found in large rivers and lakes, this fish prefers to inhabit the bottom portion of the water column, closer to its prey. The black carp eats snails, mussels, aquatic insects and crustaceans. It closely resembles the grass carp, but is darker in color.

ZEBRA MUSSEL

Source: USGS

Another aquatic invasive species that can have a negative effect on the Paddlefish's food source is the **Zebra Mussel** (*Dreissena polymorpha*). Zebra Mussels are small **filter feeders** that live in freshwater and have alternating dark and light bands on their 2-inch-long shell. They are known to take more food out of the water column than they can actually use, which affects all other filter feeders in the area by decreasing the amount of plankton in the water column. While primarily a lake mussel, they can have serious impacts on river ecosystems as well.

Invasive species are a very serious issue all over the world, especially when it comes to their impacts on environmentally sensitive/threatened species such as the Paddlefish. A 2005 paper published on the economic impacts of invasive species calculated that invasive species cost the U.S. alone more than $120 billion in damages every year, in addition to the hundreds of million spent each year to try and mitigate the issues caused by invasive species.

FISHERIES MANAGEMENT AND HATCHERIES

Louisiana Department of Wildlife and Fisheries (LDWF) is the lead agency in the state to conserve and protect living renewable resources for present and future generations of Louisiana citizens. The mission of the **Office of Fisheries** is to conserve and protect aquatic resources by controlling the harvest and replenishing of aquatic species, and enhancing fishery stocks and habitat. The Office of Fisheries manages fish populations and habitats for the conservation and improvement of recreational and commercial fishing. These aquatic resources are managed to provide for the needs of consumptive and non-consumptive users, to maintain environmental health, and protect imperiled species. This is accomplished by setting fishing seasons, size and possession limits, gear restrictions, or other means of protecting key resources including replenishing species and conserving, restoring, and enhancing their habitats. Ongoing research provides insight into the proper functioning of natural systems, and public education programs promote the wise use of these resources.

ROLE OF HATCHERIES

What is a hatchery?

A hatchery is a place where fish species such as bass, catfish, and sunfish are hatched, raised, and then stocked in waterways to enhance natural populations. LDWF operates four fish hatcheries; **Beechwood Fish Hatchery**, **Monroe Fish Hatchery**, **Lacombe Fish Hatchery** and **Booker Fowler Fish Hatchery**. The Beechwood, Monroe and Lacombe Hatcheries are older facilities constructed in the 1920s and 1930s and the newer Booker Fowler Fish Hatchery began fish production in the spring of 1997.

Why are hatcheries important?

Resource managers nationwide acknowledge hatcheries as valuable tools for the preservation of our nation's fish resources. Fish are stocked for several reasons. Some are stocked to **enhance** recreational fishing, others to **restore** native species to waters they formerly occupied.

The LDWF fish hatchery system has a rich history of fish production and research. Much of the technology used in modern catfish and Striped Bass aquaculture practices was developed at the department's hatchery facilities. Historically, the hatchery system functioned primarily as support for technical assistance to pond and small lake owners and for stocking new and renovated lakes with native species, predominately Largemouth Bass and Bluegill. Today, Louisiana's hatcheries produce fish for bodies of water that have been damaged by habitat destruction or overuse, as well as stocking select lakes with popular sport fish, primarily the Florida subspecies of the **Largemouth Bass** (*Micropterus salmoides floridanus*).

Why stock Florida Largemouth Bass?

The primary reason to stock **Florida Largemouth Bass** is that the Florida subspecies of Largemouth Bass grow larger than our native bass, and thus are more enjoyable for anglers to catch. By stocking the Florida subspecies, we can enhance the genetic makeup of our native Largemouth Bass through **cross breeding**, which will naturally occur in the wild. This will lead to an overall increase in the average size of our native Largemouth Bass, a trend we have seen successfully taking place since the first introduction of the Florida subspecies in the 1980's as state weight records for the species have been increasing ever since.

BOOKER FOWLER FISH HATCHERY

The **Booker Fowler Fish Hatchery** was built with federal disaster relief funds that were allocated to Louisiana due to damage to the Atchafalaya Basin in 1992 by Hurricane Andrew. Paddlefish populations were decimated; 100,000 fish were lost to this storm. The total cost to build this state-of-the-art facility was $13 million. It is the **largest fish hatchery** in Louisiana, and has been designated as the department's primary fish production facility. The hatchery produces all fry and provides most of the fingerling production for the state of Louisiana.

Hatcheries can be warm-, cool- or cold-water facilities. Booker Fowler Fish Hatchery is a warm-water station involved in spawning, hatching, and rearing young fish (fingerlings). Fingerlings are raised to a size and age that provides them the best chance of survival in the wild. Louisiana's hatchery system supports the management plans implemented by LDWF's Inland Fisheries biologists, providing them with healthy sportfish fingerlings to stock into Louisiana's public waters.

Booker Fowler Fish Hatchery has spawned Paddlefish since 1997 and has since produced millions of fry and fingerlings. The hatchery cannot provide Paddlefish with all the environmental factors required to spawn naturally (see spawning section), therefore, Paddlefish are **artificially spawned** in the hatchery. Wild Paddlefish stock are collected because they are river inhabitants and do not respond well to living in hatchery ponds. In Louisiana, mature fish are collected from flooded tributaries in February. Once collected, Paddlefish are transported in hauling trucks.

Overhead view of retention ponds at Booker Fowler Fish Hatchery, used to raise fish for stocking

Outdoor "raceways" used to house adult Largemouth Bass for spawning

At the hatchery, the fish are sexed, weighed, and tagged. Next, the fish are injected with the **LHRHa hormone** (luteinizing hormone releasing hormone analog), which stimulates spawning. The female is given **two injections**, one 24 hours and one 12 hours prior to spawning to help the eggs ripen (become ready to be spawned). Males are given **one injection** about 24 hours prior to spawning to increase milt (sperm) production. The following morning, female Paddlefish are examined for softened abdomens, which is a sign that eggs are mature. When eggs begin to flow from the vent of the female, artificial spawning begins.

BOOKER FOWLER FISH HATCHERY

Eggs can be removed from the female Paddlefish in two ways: the female may undergo a **Caesarean section**, or she can be stripped of her eggs. During the Caesarean section procedure, the female is placed on a stretcher on her dorsal side (belly up) and kept irrigated via water running across her gills. A small incision is made on her abdomen, and the eggs are quickly removed. The incision is sutured; an antibiotic is administered, then the female is returned to the holding tank to recover. The advantage of this procedure is that more eggs are collected from the female. During the **stripping procedure**, the female is placed on the stretcher while a small incision is made near the **urogenital opening**. Then the female is held by her rostrum while pressure is applied to the female's abdomen to force eggs out, and eggs are collected. The female is then stitched up and returned to her holding tank. After artificial propagation, females are usually held for about **21 days** to allow for withdrawal from the hormone and to ensure survival before returning them to their collection site.

Booker Fowler Fish Hatchery staff removing eggs from female Paddlefish by stripping

Through both procedures, eggs are handled in the same manner. They are collected in plastic tubs and kept moist, but relatively dry. Each egg has a small pore (**ovipore**) located on its surface, which will begin to close once it is inundated with water. Likewise, a sperm does not become active unless it comes in contact with water. Once all the eggs are collected from one particular female, milt is collected from several males in a separate container by applying pressure to their abdomens. Eggs and sperm are then ready to be mixed. Adding water **activates the sperm**, which is then poured over the eggs, and fertilization begins when eggs start to clump together.

As mentioned previously, Paddlefish eggs are naturally sticky and will spread out and adhere to substrate when the fish spawn in the wild. At the hatchery however, a clay mixture called **fuller's earth** is added to the fertilized eggs to prevent them from sticking together. This is critical, as clumping can cause **fungal growth** or **lack of oxygen** which could prevent eggs from hatching. The eggs are stirred continuously with a turkey feather for **30 minutes** to make sure they are adequately coated with the clay.

After sufficient mixing, eggs are rinsed free of the fuller's earth mixture and placed into incubation jars and **tumbled** against one another for aeration, where they will hatch in **5 to 7 days**. The newly hatched fry swim up and out of the incubation jars into collection tanks, where they are then transported to indoor "raceways", similar to the outdoor raceways we saw on the previous page.

PADDLEFISH QUICK FACTS

- The first written description of a Paddlefish from a European came from a member of Hernando De Soto's crew, who described seeing Native Americans catching fish who's upper lips resembled shovels
- The American Paddlefish (*Polyodon spathula*) is the only extant (living) species of Paddlefish in the world
- Hurricane Andrew caused the death of 100,000 Paddlefish in the rivers and lakes of Louisiana. The majority of the loss occurred in the Atchafalaya River basin.
- Paddlefish are among the largest freshwater fish in the world, reaching lengths of over 5ft.
- Paddlefish sometimes travel 100 to 200 miles to find an ideal habitat for spawning.
- The Paddlefish is considered a living fossil, dating back to at least the Cretaceous period (65-125 million years ago)
- Similar to sharks, Paddlefish have mostly cartilaginous skeletons. However, they are still located within the taxonomic group of "Bony Fishes" (Osteichthyes)
- While the American Paddlefish are filter feeders, some other extinct Paddlefish species were more predatory, such as the Chinese Paddlefish
- Paddlefish have smooth skin and few scales, the skin feels like a wet tire
- The genus name for Paddlefish, Polyodon, is Greek for "many teeth" and refers to the Paddlefish's many diamond-shaped teeth in its fry stage. The species name, spathula, is Latin for "spatula" or "blade" and refers to the paddle-shaped rostrum of the fish.
- Common names of the Paddlefish include: duckbill cat, Mississippi Paddlefish, spadefish, spoonbill cat, and spoonbill catfish.
- The largest American Paddlefish ever caught was taken with a spear in 1916 in Okoboji Lake, Iowa. It was 7ft 1in long and weighed 198lbs
- There are some reports of Chinese Paddlefish getting nearly 23ft long and over 1000lbs, though a more generally accepted max size was around 660lbs and 10-12ft.
- The Paddlefish have a "3rd eye" on the top of their skull, called a Parietal eye. It doesn't work the same as a normal eye, but it is photoreceptive and aids in regulating the organisms circadian rhythms and hormone production. Many other fishes, amphibians, and reptiles also have this "eye"