



AN EDUCATOR'S GUIDE TO

SAVAGE ANCIENT SEAS

SAVAGE ANCIENT SEAS

Millions of years ago when dinosaurs roamed North America, another ecosystem full of monstrous animals were fighting for existence in a vast interior seaway which spanned the latitude of the continent, dividing North America down its center. The Western Interior Seaway covered most of the American Midwest between the Arctic Ocean and the Gulf of Mexico and was home to some of history's most fearsome, real sea monsters.

Paleontologists have been hunting these ancient creatures preserved as fossils in the Late Cretaceous sediments of Kansas for more than a century and a half. The skeletons displayed in the exhibit have been produced by replicating the original fossil specimens stored and exhibited in many of the world's most prestigious museums and fossil collections. Technologies like molding and 3D scanning applied to fossil bones allow us to 3D print and pour cast replicas of real fossils without damaging specimens. The fossil replicas arranged and mounted in articulations they would have had in life allow scientists and casual observers to grasp what these ancient sea monsters might have looked like and how they lived.

Savage Ancient Seas is a highly informative and engaging exhibition featuring fossil sea creatures, primarily from the Late Cretaceous between 87 and 70 million years ago. It is the largest exhibit in the world addressing marine vertebrate paleontology, traveling or otherwise. Awe-inspiring mounted skeletons ranging in size from 1 to 45 feet in length coupled with hands-on and interactive kiosks convey lessons about our ancient world's deep past and the science applied in unraveling these mysteries of nature.

This exhibition is appropriate for curious minds of all ages. Within this complimentary exhibit guide are tools for educators to get the most out of their group visit. These tools include classroom activities, frequently asked questions and examples of addressable national science curriculum standards as you prepare for and recap your visit to the exhibit.

Right: *The creator of this exhibit, Mike Triebold, showing a film crew from Animal Planet's River Monsters around the chalk outcrops of Western Kansas.*



PREPARING FOR YOUR VISIT TO SAVAGE ANCIENT SEAS



Above: The giant sea turtle, *Protostega*.



Above: Adult & Baby *Dolichorhynchops*.

GET READY FOR THE SAVAGE ANCIENT SEAS!

Here are some tips for educators, chaperones and their students to help ensure the richest experience for all visitors to the exhibit:

- *Always be mindful of your surroundings and respectful of other visitors.
- *Everybody wants a turn. Share the interactive and touch exhibits. Making a line can help maintain order if a particular part of the exhibit is in high demand.
- *Photography in the exhibit is not only allowed, but encouraged! Feel free to bring your camera, phone or tablet to the exhibit.
- *Context helps. We recommend a pre-visit discussion or activity addressing how long ago 80 million years is and how the remains of animals from so long ago are preserved and found by paleontologists today.
- *Think long term. If your curriculum does not address fossils directly or at the time of your visit, look through the examples of addressed standards. Recapping earlier lessons or laying foundations for lessons to come can help your visit strengthen learning throughout the year.
- *These are dinosaur-aged creatures, but are technically not dinosaurs. Discuss what it means to be a dinosaur and why the fossil fish, pterosaurs and marine reptiles in the exhibit are not dinosaurs.
- *The exhibited skeletons are homologous to our own skeletons. In most cases, the same bones have the same names in all vertebrate skeletons. Discussing this before your visit can help students compositionally analyze the anatomy of the fossil skeletons they are viewing.
- *The names of these creatures are composed of the same Greek and Latin roots that form many of the words in the English language; especially science-related terms. Studying these root words in advance can make pronouncing the names of these creatures easier and creates a foundation for recognizing and learning all kinds of terminology.

SAVAGE ANCIENT SEAS

FREQUENTLY ASKED QUESTIONS

Q: Are these real fossils?

A: There are some real fossils in the exhibit, but the skeletons are cast copies of real fossil skeletons. Real fossils are unique, unreplaceable, and often quite fragile. Using casts allows us to place metal armatures inside the bones instead of obscuring the bones on the outside with metal and removes the risks that come with traveling fragile, unreplaceable skeletons around the world.

Q: Are these real sea monsters?

A: Every creature in the exhibit represents a species that really lived and went extinct millions of years ago. Each has been reproduced from casts of real fossils and restored using state-of-the-art paleontological knowledge and techniques.

Q: Are any of these sea monsters still living today?

A: We still have sharks, fish, sea turtles and birds in our modern world, however the only modern species in the exhibit is the coelacanth model. The other fossil reptiles in the exhibit, including pterosaurs, mosasaurs and plesiosaurs, are all extinct with with no modern members of those orders surviving beyond the extinction event at the end of the Cretaceous, 65.5 million years ago.

Q: When did these sea monsters live?

A: Most of the creatures in the exhibit lived in the Western Interior Seaway during the Late Cretaceous period, between 87 and 70 million years ago.

Q: Where did these sea monsters live?

A: The Western Interior Seaway covered most of the American Midwest between the Arctic Ocean and the Gulf of Mexico. Most of the fossils in this exhibit come from the fossil sea beds of this ancient seaway that are exposed today in Western Kansas.

Q: Why are there no pterosaurs, plesiosaurs or mosasaurs today?

A: The same mass extinction event that wiped out the dinosaurs 65.5 million years ago also rendered these groups of reptiles extinct. An asteroid that was approximately six miles in diameter crashed into the Gulf of Mexico at that time causing a sudden and drastic change in climate which no pterosaurs, plesiosaurs, mosasaurs or dinosaurs (except for a few species of birds) were able to adapt to.

Q: Are these "ocean dinosaurs"?

A: Except for the birds, there are no dinosaurs in this exhibit. Dinosaurs lived on land and are only very distantly related to marine reptiles like mosasaurs and plesiosaurs. Pterosaurs, the flying reptiles, are a sister-clade to dinosaurs, meaning they are closely related to dinosaurs, but evolved separately as a different group.



Left: While these creatures lived during the Mesozoic, the Age of Dinosaurs, the only dinosaurs in the exhibit are the birds, Hesperornis and Ichthyornis.

SAVAGE ANCIENT SEAS

FREQUENTLY ASKED QUESTIONS

Q: What is a pterosaur?

A: Pterosaurs are a group of flying reptiles that lived along side dinosaurs throughout most of the Mesozoic Era, between 230 and 65.5 million years ago. Their wings were formed of a fleshy membrane stretched between the sides of their bodies and the tips of their modified fourth finger on each hand.

Q: What is a mosasaur?

A: Mosasaurs are a group of lizards that lived in Earth's oceans between 92 and 65.5 million years ago. They were similar to and closely related to today's monitor lizards and the Komodo dragon, except they had paddle-like arms and legs adapted to swimming.

Q: What is a plesiosaur?

A: Plesiosaurs are a group of ocean-living reptiles that had broad, flat, turtle-shaped bodies and powerful flippers, each formed of dozens of small spool-shaped phalanges (finger & toe bones). Plesiosaurs first appeared at the end of the Triassic, 204 million years ago and diverged into one clade of short-necked, large-headed reptiles called pliosauroids and another clade of long-necked, small-headed reptiles called plesiosauroids.



Left: *The plesiosauroid plesiosaur from Western Kansas, Elasmosaurus*, next to an undescribed species of pliosauroid plesiosaur from Manitoba, Canada.

Q: If these are not the real fossils, where are the real ones these casts were made from?

A: The original fossils the sea monsters in this exhibit represent are stored in some of the world's most prestigious natural history museums. The 42' long *Elasmosaurus*, for example, is a cast of the famous type specimen in the Academy of Sciences in Philadelphia. Our dueling *Tylosaurus* were reproduced from one specimen at the University of Kansas Natural History Museum and another almost equally enormous specimen from the Royal Ontario Museum.

Q: How are these casts of original fossils made?

A: Once a fossil has been prepared free of rock and stabilized with glues and consolidants if needed, a mold of that fossil is made using flexible rubber like silicone or latex. The rubber is brushed or poured onto the fossil as a liquid and peeled away from the fossil once it turns solid. Molds are filled with resins that harden into plastic forming plastic copies of bones which can then be assembled into skeletons and skulls like those displayed in the exhibition.

Q: How are fossils found?

A: Fossils must first form through the natural burial and preservation of the remains of ancient life. They must then remain buried for thousands to billions of years before being exposed again and found by someone who recognizes them as fossils. Fossils are found by professional paleontologists and avocational fossil hunters alike. Even you can find a fossil!

NOTEWORTHY SEA MONSTERS OF THE **SAVAGE ANCIENT SEAS**

EACH EXHIBITION VENUE HAS A UNIQUE ARRANGEMENT AND SELECTION OF CONTENT. HOWEVER, THE FOLLOWING SEA MONSTERS ARE REGULARLY SIGHTED ON DISPLAY:



Elasmosaurus platyurus

Discovery locality: Kansas
Length: 12.8 m (42')

This is the famous "Cope Elasmosaur" which started the fossil wars of the 1870's when E.D. Cope published the skeleton with the head on the wrong end and O.C. Marsh publicly embarrassed him. These enormous, long-necked marine predators probably specialized in ambushing prey from below. With eyes facing more upward than forward, Elasmosaurus seems best adapted to scanning for silhouettes of fish passing above and striking into schools using its neck which was more than twice the length of the rest of its body.

Polycotylus bonneri adult & juvenile

Discovery location: Wyoming / South Dakota border
Length: adult- 457 cm (15')
juvenile- 81 cm (2' 8")

Fast and agile, this short-necked plesiosaur was wider than long. *Polycotylus'* conical, interlocking teeth were perfect for capturing fish. The adult is cast from a virtually complete fossil skeleton. The baby was sculpted using the adult as a guide and adjusting for expected allometry.



Clidastes liodontus

Discovery location: Kansas
Length: adult- 335 cm (11')

Probably a shallow diver, *Clidastes* was the smallest of the primary mosasaur genera of the Niobrara Chalk. It possessed a proportionately longer torso and shorter tail than either *Platecarpus* or *Tylosaurus*.



Platecarpus planifrons

Discovery locality: Kansas
Length: 550 cm (18')

This is the most abundant reptilian predator found in the Cretaceous sediments of the Western Interior Seaway. *Platecarpus* was probably not a picky eater and it had a variety of potential prey and scavengable carcasses available in the warm waters of the shallow epicontinental seaway it prowled.

Toxochelys latiremis (Juvenile)

Discovery location: Kansas
Length: 25 cm (10")

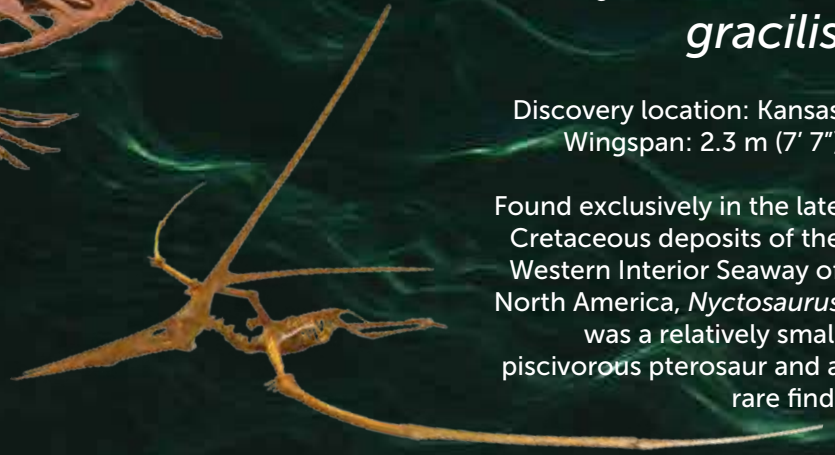
Toxochelys latiremis is the most common species of fossil turtle known from the Niobrara Chalk. This tiny sea turtle was recovered from the lower Niobrara and represents one of the most complete specimens ever found in these sediments.



Nyctosaurus gracilis

Discovery location: Kansas
Wingspan: 2.3 m (7' 7")

Found exclusively in the late Cretaceous deposits of the Western Interior Seaway of North America, *Nyctosaurus* was a relatively small piscivorous pterosaur and a rare find.



Protostega gigas

Discovery locality: Texas
Flipper-span: 472 cm (15' 6")

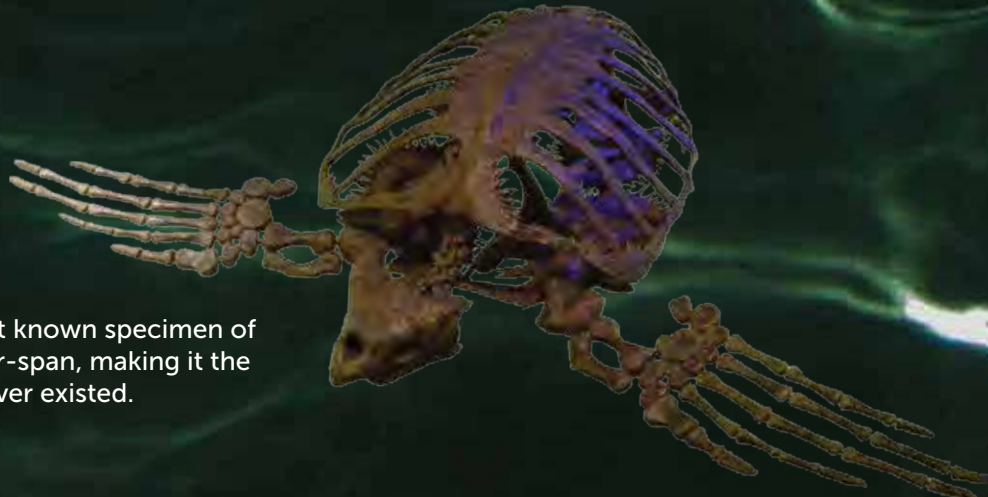
First discovered in Kansas in the Niobrara Chalk and named by E.D. Cope, *Protostega* had a somewhat reduced shell for streamlining and weight reduction. This replica is cast from a specimen which was found near Dallas, Texas and is the largest *Protostega* in the world.



Archelon ischyros

Discovery locality: South Dakota
Flipper-span: 518 cm (17')

This replica is cast from the largest known specimen of *Archelon*, and has a 17-foot flipper-span, making it the largest known sea turtle to have ever existed.



Megacephalosaurus eulerti

Discovery location: Kansas
Skull Length: 170 cm (5' 7")

Megacephalosaurus was a pliosaurid plesiosaur from the Carlile Shale of Russell County, Kansas. The Carlile Shale is slightly older than the Niobrara Chalk from which most of the specimens in this exhibit were found in. Before the advent of mosasaurs, *Megacephalosaurus* would have been the marine reptile with the most gape to its maw in the Western Interior Seaway allowing it to tackle the largest prey it cared to.



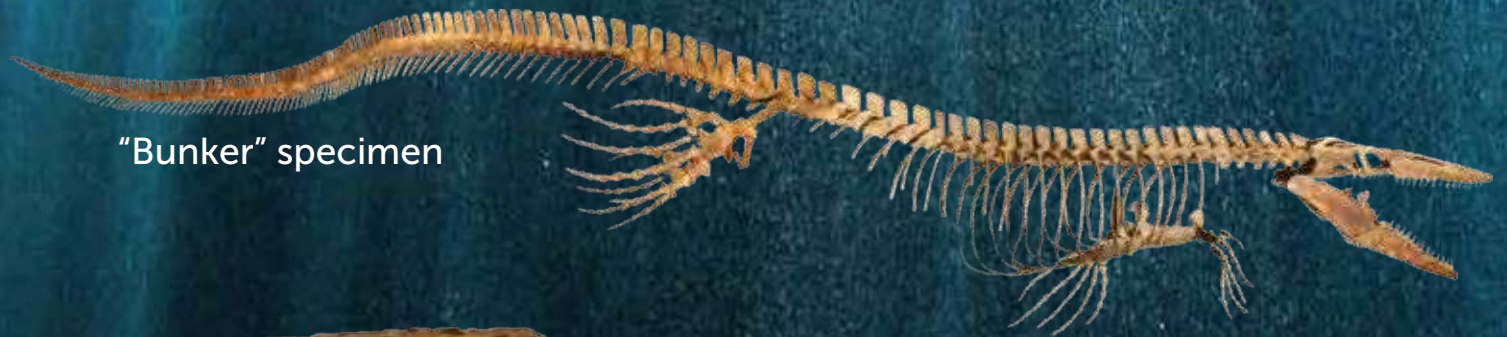
Chelosphargis advena

Discovery locality: Kansas
Carapace Length: 16 cm (6")

The smallest member of the Savage Ancient Seas cast, this specimen of *Chelosphargis* fits on a saucer and represents a rare, well-preserved juvenile sea turtle.



"Bunker" specimen



Tylosaurus proriger

Discovery locality: Kansas & Texas
Length: 1371 cm (45') & 1280 cm (42')

The exhibit presents two incredible specimens of this enormous species. Our largest mosasaur, the "Bunker" specimen from the Niobrara Chalk of western Kansas, is the largest complete tylosaur skeleton known. Our slightly smaller "Sophie" specimen features one of the best preserved *Tylosaurus* skulls known and bears a number of traces left by sharks and other mosasaurs.



"Sophie" skull



Prionochelys nauta

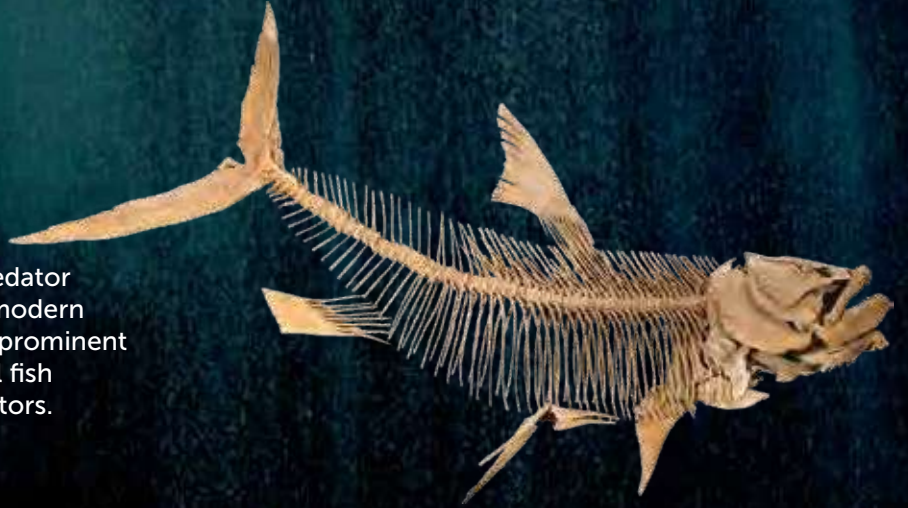
Discovery locality: Alabama
Length: 82 cm (2' 8")

Prionochelys was a spiky sea turtle that lived during the Late Cretaceous in Alabama around eighty million years ago. With beautifully scalloped margins, this is one of the most visually appealing of all Cretaceous sea turtles.

Pachyrhizodus caninus

Discovery location: Kansas
Length: 183 cm (6')

Pachyrhizodus was a powerfully-built mid-level predator capable of rapid acceleration. It is comparable to modern tarpons in size and physique. *Pachyrhizodus* has a prominent lower jaw forming a large mouth for catching small fish capable of eluding slower and less tenacious predators.



Ichthyodectes ctenodon

Discovery location: Kansas
Length: 183 cm (6')

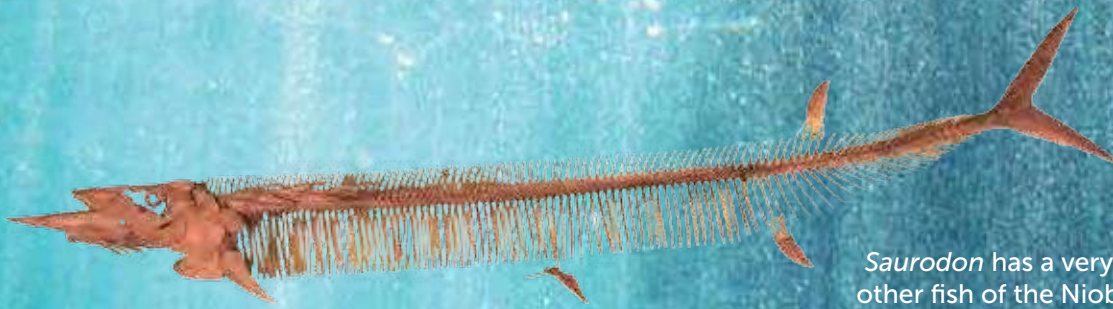
Nearly identical to *Xiphactinus* in body shape but less than half the length, the closely-related *Ichthyodectes* found itself as an occasional meal for the bigger contemporary predator. *Ichthyodectes* was a formidable predator in its own right and is aptly named as *Ichthyodectes* translates to "fish biter".

Xiphactinus audax

Discovery location: Kansas
Length: 520 cm (17' 5")

Xiphactinus is the largest known bony fish from the Western Interior Seaway and was a voracious predator. A number of specimens have been recovered with the intact remains of smaller fish preserved as stomach contents.





Saurodon leanus

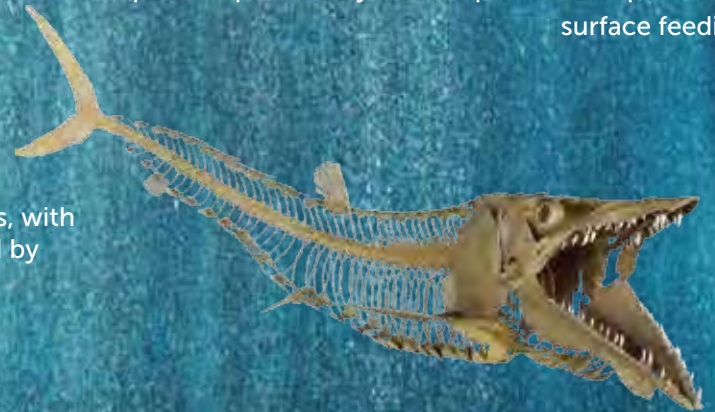
Discovery location: Kansas
Length: 246 cm (8' 1")

Saurodon has a very distinguished profile, unique from other fish of the Niobrara chalk, provided by a long and pointed prementary bone, a possible adaptation for surface feeding.

Cimolichthys nepaholica

Discovery location: Kansas
Length: 154 cm (5' 1")

Cimolichthys would have resembled modern freshwater pikes, with narrow lower jaws, several series of teeth and bodies covered by large, heavy scutes.



Ichthyornis dispar

Discovery locality: Kansas
Length: 20 cm (8")

Ichthyornis was one of the first known toothed birds. *Ichthyornis* probably lived much like a modern sea gull, feeding on small prey in tide pools or just offshore.

Hesperornis regalis

Discovery locality: Kansas
Length: 90 cm (3')

Hesperornis was a flightless bird and probably lived much like a penguin, diving after small fish. Its arms were greatly reduced to vestigial elements of the wings of their ancestors.

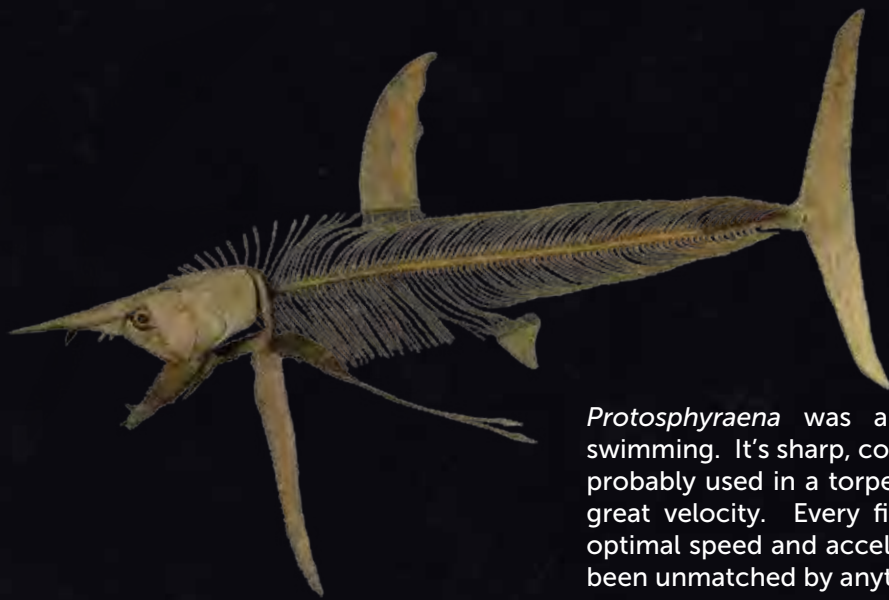


Enchodus petrosus

Discovery location: Kansas
Length: 154 cm (5' 1")

Enchodus was a large predatory fish that appeared in the Late Cretaceous and transcended the End Cretaceous extinction to survive into the Eocene. It had 2 inch long fangs in both upper and lower jaws to hold and slice its prey.





Protosphyraena perniciososa

Discovery locality: Kansas
Length: 244 cm (8')

Protosphyraena was a large predatory fish adapted to high-speed swimming. Its sharp, conical snout and forward-facing anterior teeth were probably used in a torpedo-like attack to spear through prey head-first at great velocity. Every fin of this incredible fish was adapted to provide optimal speed and acceleration. The speed of *Protosphyraena* might have been unmatched by anything, reptile or fish, in the Western Interior Seaway.



Pteranodon longiceps

Discovery locality: Kansas
Wingspan : Female-335 cm (11')
Male- 731 cm (24')

The exhibit often displays both male and female models of *Pteranodon longiceps* based on the most complete *Pteranodon* ever found. CT scans of this incredible specimen were used to prototype the male which has been scaled to match the largest known *Pteranodon* with a 24-foot wingspan.



Carcharocles megalodon

Discovery location: Florida
Width: 284 cm (9' 4") Height: 244 cm (8')

Commonly referred to by its species name, "*Megalodon*" preyed the waters off of the East Coast of the US just a few million years ago and was the largest shark ever.

DIDACTIC HANDS-ON TOUCHSCREENS AND KIOSKS:

The exhibition includes hands-on content that elaborates on the science and technology behind Savage Ancient Seas. On our large-format touchscreens, follow paleontologists through finding, excavating and preparing fossils for research and see the state of the art in the techniques used to replicate fossil skeletons for museum exhibition.



TOUCH AND LEARN

Students deserve the real thing. We are the first to admit that genuine fossil bones do not feel the same as the plastic casts that are usually handled by students. Even when visually indistinguishable from the real thing, a cast is still going to provide a tactile experience more like the material the cast is made from than that of an original fossil bone. This is why we have embedded a number of real fossils into our touch stations. Even the rare and delicate bones from the wings of a *Pteranodon* that soared over the Western Interior Seaway 85 million years ago are within reach of all visitors to Savage Ancient Seas.



MEET THEM WHERE THEY ARE...

Whether you embrace or resist the role mobile devices play in the lives of young people, their attachment to their screens cannot be ignored. This is why Savage Ancient Seas is augmented with virtual content accessible through the wifi broadcast from within the exhibit. QR codes in the graphics within the exhibit allow visitors to view and manipulate 3D life models of the fossil creatures featured in the exhibition. Visitors utilizing this additional digital content have been observed spending more than twice as much time engaged with the exhibit and appear to absorb and retain vastly more information than those who do not partake of the content on their devices.

