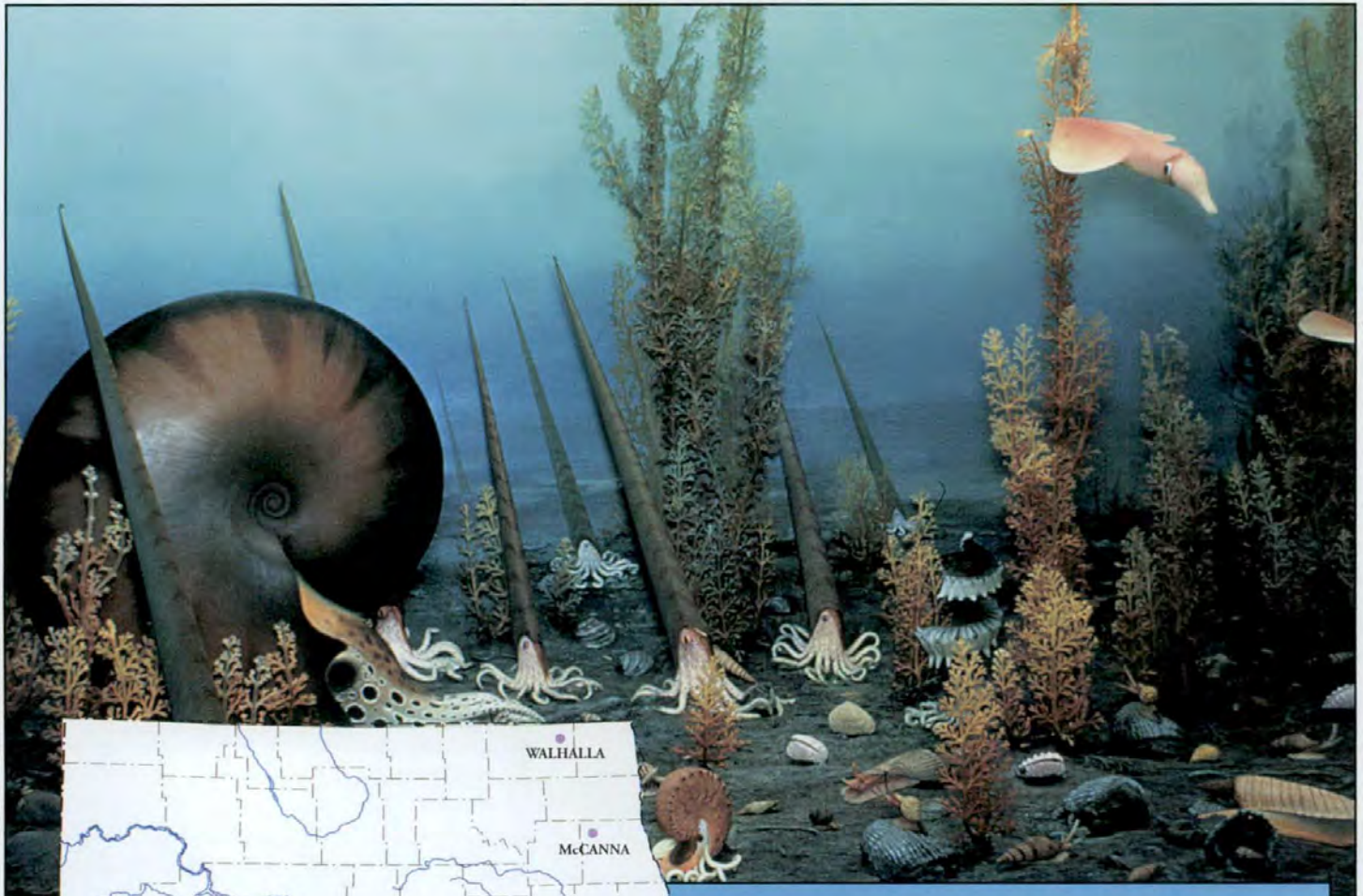
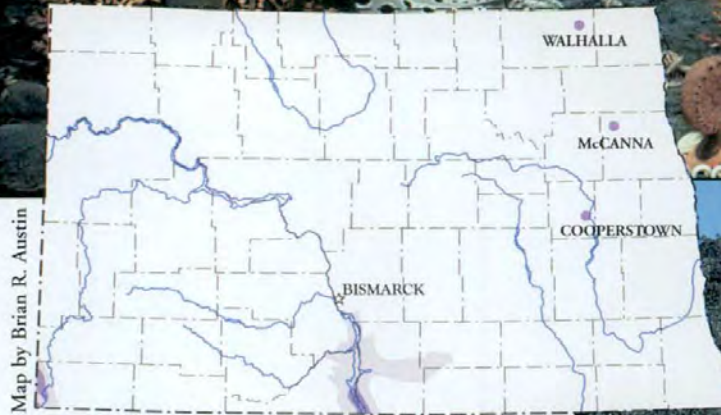


NORTH DAKOTA'S CRETACEOUS UNDERWATER WORLD



Courtesy of Smithsonian Institution



Map by Brian R. Austin

CRETACEOUS

- Fox Hills Formation
- Pierre Formation

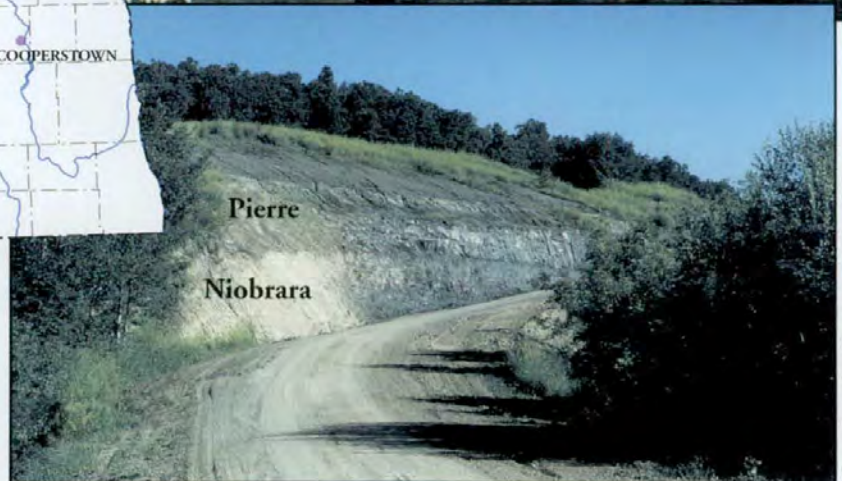


Photo by John Heganson

This diorama illustrates a Cretaceous seafloor community. North Dakota was covered by warm, shallow oceans during the Cretaceous from about eighty-five to sixty-five million years ago. Fossils of animals similar to many of those shown here have been found and are illustrated on the following pages. Right: Photograph of Niobrara and Pierre Formation outcrops near Walhalla in Cavalier County. Left: Map indicating where outcrops of the Pierre and Fox Hills Formations are found.

During the Cretaceous Period, from about eighty-five million to sixty-five million years ago, North Dakota was either completely or partially covered by shallow, subtropical to warm-temperate oceans similar to those that had covered the state during Paleozoic times. These oceans occupied what is called the Western Interior Seaway, so called because at times they were extensive enough to connect

the Arctic Ocean with the Gulf of Mexico, splitting the North American continent in two. In North Dakota these Cretaceous seas were probably never more than about five hundred feet (150 m) deep. Fine-grained sediments, mostly silt and clay, deposited on the floor of those oceans have become rock and now make up the Carlile, Niobrara, and Pierre Formations. Near the end of the Cretaceous, shallow marine and shoreline habitats existed in central North Dakota, as indicated by sandstones and siltstones of the Fox Hills Formation. These Cretaceous marine rocks are the oldest rocks exposed in the state and contain fossils of the animals and plants that inhabited these ancient oceans.

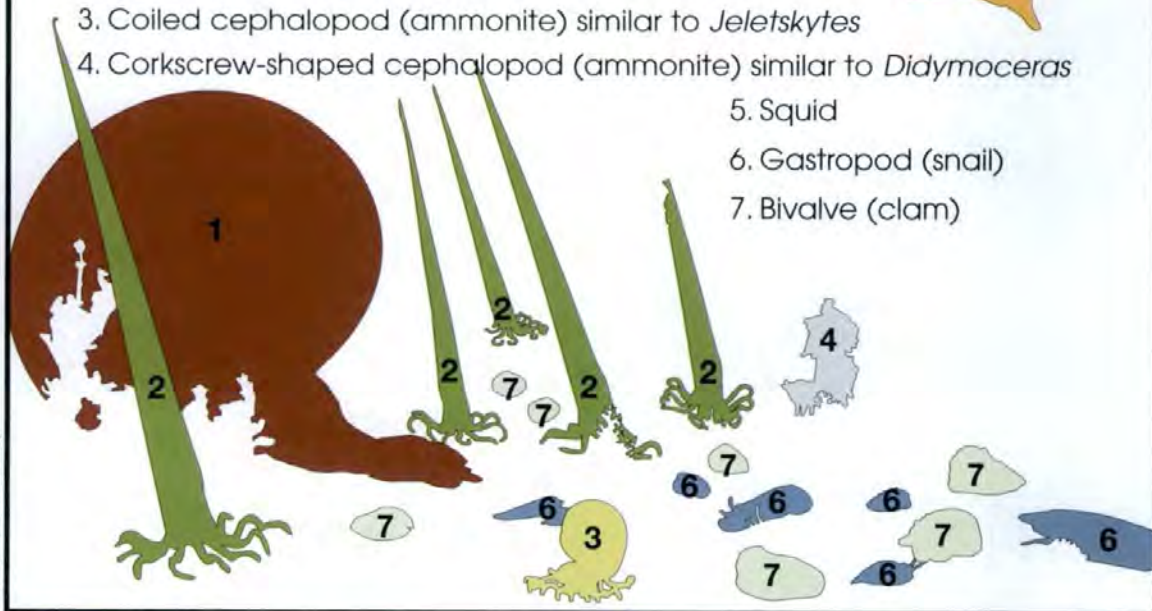
We know these oceans were shallow and warm primarily because of the fossilized remains of the animals that lived in them. One fossil site that illustrates what a Cretaceous underwater animal community was like is the seventy-five-million-year-old Pierre Formation site in Griggs County near Cooperstown. Fossils of corals, gastropods (*Trachytriton*), bivalves (*Nemodon*, *Inoceramus*), cephalopods (*Didymoceras*, *Solenoceras*, and *Baculites*), shrimp (*Callianassa*), crabs, echinoderms (starfish and sea urchins), coral-like bryozoans, and clam-like brachiopods (*Lingula*) are found weathering out of the rocks there. The most spectacular fossils discovered at the Cooperstown site, however, are those of the large vertebrate animals: mosasaurs, sea turtles, sharks, and seabirds.⁸

A nearly complete twenty-three-foot-long (9 m) skeleton of the mosasaur *Plioplatecarpus* was collected from this site by the North Dakota Geological Survey and is now on display at the North Dakota Heritage Center. Mosasaurs

Cretaceous Seafloor Diorama Key

1. Coiled cephalopod (ammonite) similar to *Sphenodiscus*
2. Straight-shelled cephalopod (ammonite), *Baculites*
3. Coiled cephalopod (ammonite) similar to *Jeletskytes*
4. Corkscrew-shaped cephalopod (ammonite) similar to *Didymoceras*
5. Squid
6. Gastropod (snail)
7. Bivalve (clam)

Key by Robin Pursley



were huge marine lizards, some forty feet (12 m) or more in length, that inhabited the world's oceans during the Cretaceous. The name *mosasaur* means "Meuse Reptile" and refers to the initial discovery of fossils of these animals in the 1770s along the Meuse River near the town of Maastricht in the Netherlands. Mosasaurs are related to monitor lizards such as the Komodo dragon that lives in Indonesia today. Unlike those of their terrestrial lizard relatives, mosasaurs' limbs were modified to form paddles or flippers. They swam by moving the back parts of their bodies and flattened tails from side to side. Their paddles were used primarily for steering rather than for propulsion. Mosasaurs were active predators and among the main carnivores in the Cretaceous oceans. They had a good sense of sight and a poor sense of smell. They probably preyed on other mosasaurs, fish, turtles, and invertebrates such as cephalopods. Although mosasaurs were not dinosaurs, they lived at the same time as dinosaurs and also became extinct when they did—about sixty-five million years ago.

Teeth of several species of sharks, including the "tiger shark" *Squalicorax* and the "dogfish shark" *Squalus*, have also been found in the Pierre Formation at the Cooperstown site. Sharks, rays, and ratfish are in the group of fish (Chondrichthyes) whose skeletons consist mostly of cartilage rather than bone. We generally only find teeth of these fish because their cartilaginous skeletons seldom fossilize before decomposing. These ancient tiger sharks were predators high on the food chain that probably competed with mosasaurs for prey. Dogfish sharks, which still exist, are small sharks that grow to lengths of about three feet (1 m).



Brachiopod
Lingula
Length 4 mm
ND 95-12



Bivalve
Nemodon
Width 3 mm
ND 00-11



Cretaceous Sea — 85 Million Years Ago

- Alluvial Plain
- Swamps
- Mountains
- Coastal Plain
- Highlands
- Active Volcano
- Pierre Sea

Map of the Western Interior Seaway, which was occupied by oceans during the Cretaceous from about eighty-five to sixty-five million years ago.

All fossils on this page are from the Pierre Formation and, unless otherwise indicated, were found near Cooperstown, Griggs County.



Cephalopod
Solenoceras mortoni
Length 22 mm
ND 00-11.3



Coral
Height 9 mm
ND 00-11.10

Cephalopod
Baculites gregoryensis
Length 56 mm
ND 00-11.5



Gastropod
Trachytriton
Height 20 mm
ND 00-11.9



Cephalopod
Didymoceras
Height 27 mm
ND 00-11



Shrimp claw
Callianassa
Width 20 mm
ND 00-11.2



Bivalve
Inoceramus
Bowman County
Width 68 mm
UND 1332A



Left: This skeleton is from one of the mosasaurs called *Plioplatecarpus* that inhabited the Pierre Sea about seventy-five million years ago. It was discovered in 1995 by Mike Hanson and Dennis Halvorson on Orville and Beverly Tranby's farm in the Sheyenne River valley near Cooperstown, Griggs County, North Dakota. A study of the nearly complete skull and other parts of the skeleton indicate that this is a new species of *Plioplatecarpus* that has not been found anywhere else in the world. The skeleton is twenty-three feet (7 m) long. ND 97-115.1

Beverly and Orville Tranby and Bev's sisters, Gloria Thompson, Jacqueline Evenson, and Susan Wilhelm, donated this fossil to the North Dakota State Fossil Collection for exhibit and study at the North Dakota Heritage Center.

This painting depicts an animal community that lived in the shallow-water, subtropical Pierre Sea that covered North Dakota about seventy-five million years ago. The scene is based on fossils found in the Pierre Formation at a site near Cooperstown, Griggs County. The large, predatory mosasaur *Plioplatecarpus* is attacking the diving seabird *Hesperornis*. *Hesperornis* has just captured a salmon-like fish, *Enchodus*. In the background the carcass of a decaying *Plioplatecarpus* is being scavenged by a frenzied group of dogfish sharks, *Squalus*. The mosasaur on exhibit at the Heritage Center was found in this position, with gnaw marks on some of its bones from feeding dogfish sharks. In the painting, the large sand-tiger shark *Carcharias* cruises near the sea floor. Shells of an ammonite, *Sphenodiscus*, with a snail crawling on it, and of the large clam *Inoceramus*, encrusted by oysters, litter the bottom.

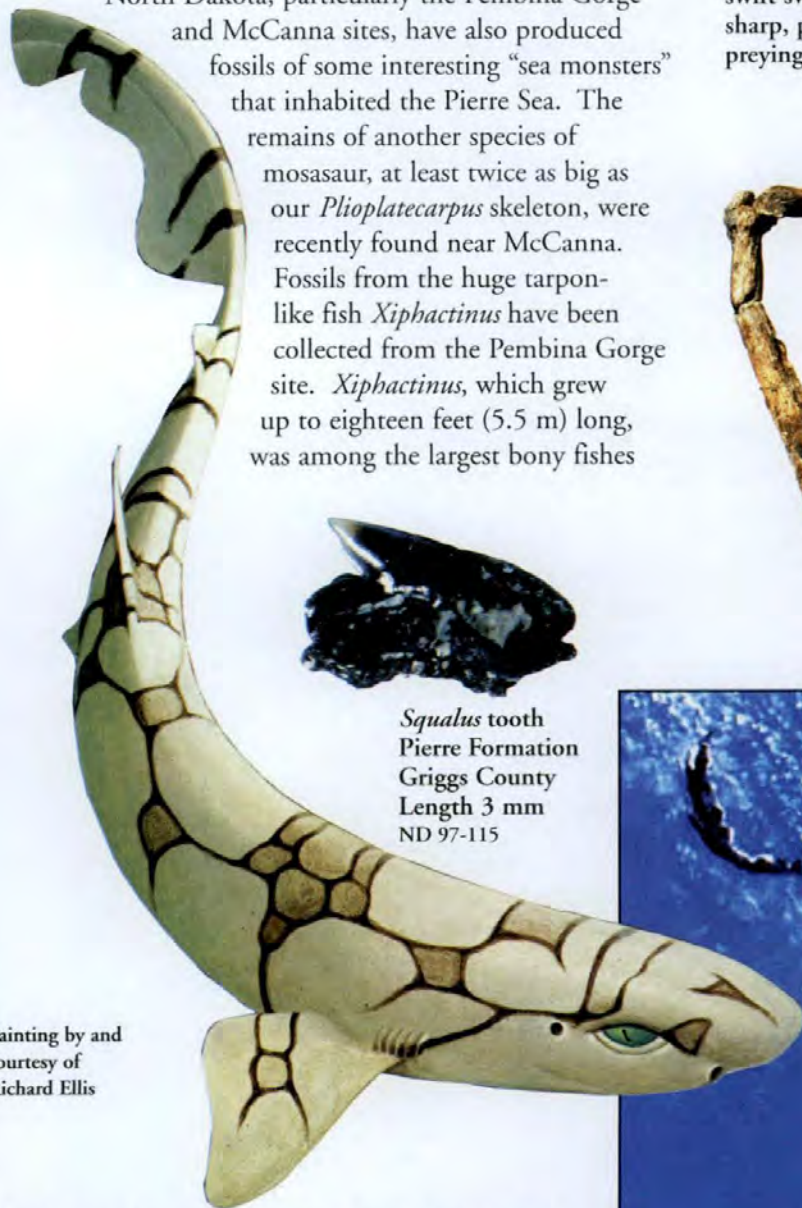
Painting by David Miller, North Dakota Heritage Center



They usually live in schools and eat bony fish, other sharks, various invertebrate animals, and even marine mammals. We know that *Squalus* was also a scavenger of mosasaur carcasses during the Cretaceous because we have found gnaw marks on bones of our *Plioplatecarpus* and other mosasaur skeletons that are identifiable as having been produced by *Squalus* teeth. It is likely that sharks at times would prey on mosasaurs, and at other times mosasaurs would prey on sharks.

Prey of both sharks and mosasaurs was *Hesperornis*, a large diving seabird that grew to about five feet (1.5 m) tall. Although incapable of flight, it was a swift swimmer that could propel itself through the shallow coastal waters of the Pierre Sea with its powerful hind legs and grebe-like webbed feet. Its jaws were equipped with sharp, pointed teeth adapted for preying on fish and squids. Other sites in

North Dakota, particularly the Pembina Gorge and McCanna sites, have also produced fossils of some interesting "sea monsters" that inhabited the Pierre Sea. The remains of another species of mosasaur, at least twice as big as our *Plioplatecarpus* skeleton, were recently found near McCanna. Fossils from the huge tarpon-like fish *Xiphactinus* have been collected from the Pembina Gorge site. *Xiphactinus*, which grew up to eighteen feet (5.5 m) long, was among the largest bony fishes

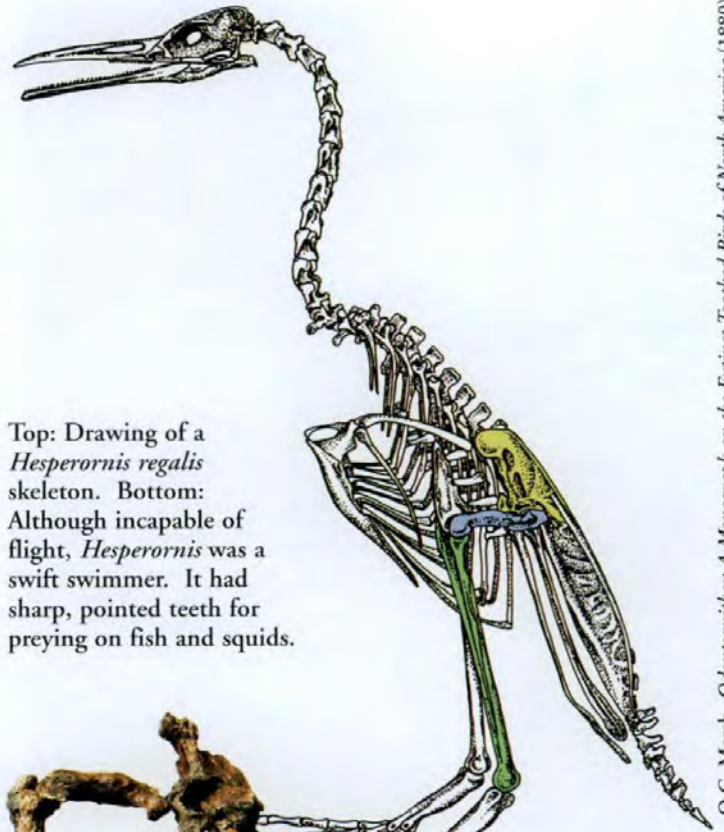


Painting by and courtesy of Richard Ellis



Squalus tooth
Pierre Formation
Griggs County
Length 3 mm
ND 97-115

The *Squalus* tooth shown above is almost identical to that of the modern dogfish shark illustrated here.



Top: Drawing of a *Hesperornis regalis* skeleton. Bottom: Although incapable of flight, *Hesperornis* was a swift swimmer. It had sharp, pointed teeth for preying on fish and squids.



Pelvis, femur, and tibia
Hesperornis regalis
Pierre Formation
Cavalier County
Length 280 mm
ND 06-12.2



Painting by and courtesy of Dan Varner

to inhabit the Pierre Sea. Its large size, long body, powerful tail, and bulldog-like jaws suggest it was an efficient predator. *Xiphactinus* had large, ghoulish fangs at the front of its mouth, which it probably used to strike prey during initial attack.

The remains of another huge animal, a giant squid called *Tusoteuthis longa*, have also been found at Pembina Gorge. Squids, although they are invertebrates, have a rigid support structure in their bodies called a *gladius* or *pen*. The pen is in many ways similar to a backbone but is made of shell-like material, not bone. These pens are rarely found as fossils. One was discovered at the Pembina Gorge site, however, and it is six feet (1.8 m) long—indicating that the squid from which it came was a giant, perhaps fifteen feet (4.5 m) long!

By about sixty-eight million years ago the Pierre Sea had receded from western North Dakota, and the huge Hell Creek Delta—similar to the Mississippi Delta today—had begun to form. The eastern edge of this delta was near Bismarck. The shoreline of the Fox Hill Sea (the name geologists give to the less-extensive ocean that replaced the Pierre Sea) was located in south-central North Dakota. Associated with this shoreline were estuary and lagoon habitats that formed adjacent to the delta. The sands, silts, and muds deposited in these shallow marine areas are called the Fox Hills Formation. We know a great deal about invertebrate life in the shallow marine Fox Hills waters because of the abundant and beautifully preserved fossils found in this formation.⁹ Among them are bivalves



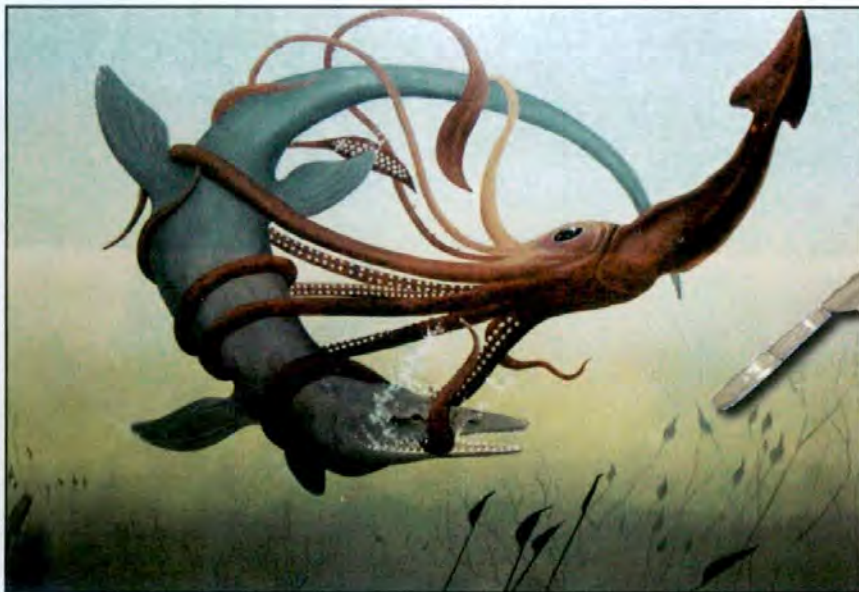
Painting by and courtesy of Dan Varner

The tarpon-like *Xiphactinus*, which grew up to eighteen feet (5.5 m) long, was among the largest fish to inhabit the Pierre Sea and an efficient predator.

(*Corbicula*, *Tancredia*, *Crassatellina*, *Panopea*), gastropods (*Euspira*), cephalopods (the ammonites *Sphenodiscus lenticularis* and *Jeletzkytes nebrascensis*), sea urchins, lobsters, horseshoe crabs (*Casterolimulus kletti*), shrimp (*Callianassa*) and their burrows (*Ophiomorpha*), and many others. At times these fossils provide information about the behavior and interaction between animals. Breakage of many snail shells, for example, indicates predation by crabs and other animals.¹⁰

Remains of vertebrate animals that inhabited the Fox Hills Sea are less abundant but include sharks (*Carcharias* and *Squalicorax*), ratfish (*Ischyodus rayhassi*), rays (*Myledaphus bipartitus*), and several species of bony fish (e.g., *Vorbisia vulpes*).¹¹ Sea turtles and mosasaurs also resided in the shallow marine and estuarine habitats.¹² Mosasaurs and sharks were the main predators in

these waters, with ratfish and rays feeding primarily on the invertebrates. As would be expected, remains of animals that lived on the delta—salamanders (*Opisthotriton kayi*, *Lisserpeton bairdi*), turtles, crocodiles (*Borealosuchus*), crocodile-like champsosaurs, birds, and dinosaurs (*Tyrannosaurus*)—would occasionally be washed into the marine waters and are now part of the Fox Hills Formation fossil record.¹³



Painting courtesy of the Canadian Fossil Discovery Centre

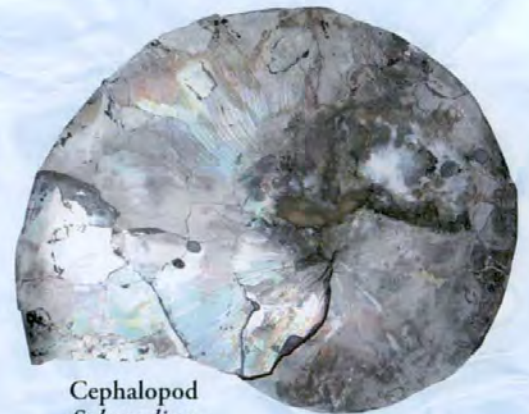
A *Tusoteuthis longa* squid locked in battle with a mosasaur. Right, pen of a *Tusoteuthis*, found near Walhalla at the Pembina Gorge site. This pen would have been part of the spear-like tail of the squid, and indicates an animal perhaps fifteen feet (4.5 m) long.

Pen
Tusoteuthis longa
Pembina County
Length 1.8 m
ND 00-60.1



Map of the Hell Creek Delta as it formed in western North Dakota while the Pierre Sea receded. The less extensive ocean that followed the Pierre Sea is known as the Fox Hill Sea.

These shells, remains of invertebrate animals, are examples of the beautifully preserved fossils found in the Fox Hills Formation. Most of the animals represented by these fossils lived near the Fox Hills Sea shoreline; these species indicate that the sea was warm. The shell of *Sphenodiscus lenticularis* (a type of ammonite) is perforated by several small punctures, probably caused by predation, possibly by a mosasaur.



Cephalopod
Sphenodiscus lenticularis
Emmons County
Width 365 mm
ND 99-118.1

Gastropod
Euspira
Logan County
Length 23 mm
ND 99-6



Cephalopod
Jeletzkytes nebrascensis
Emmons County
Width 118 mm
ND 7.2



Bivalves
Corbicula
Morton County
Width 281 mm
ND 00-11.2



Bivalve
Tancredia
Logan County
Width 42 mm
ND 99-6



Bivalve
Panopea
Sioux County
Width 105 mm
ND 00-6.2



Bivalve
Crassatellina hollandi
Logan County
Width 159 mm
ND 95-13.1



Sea Urchin
Emmons County
Width 42 mm
ND 21.3

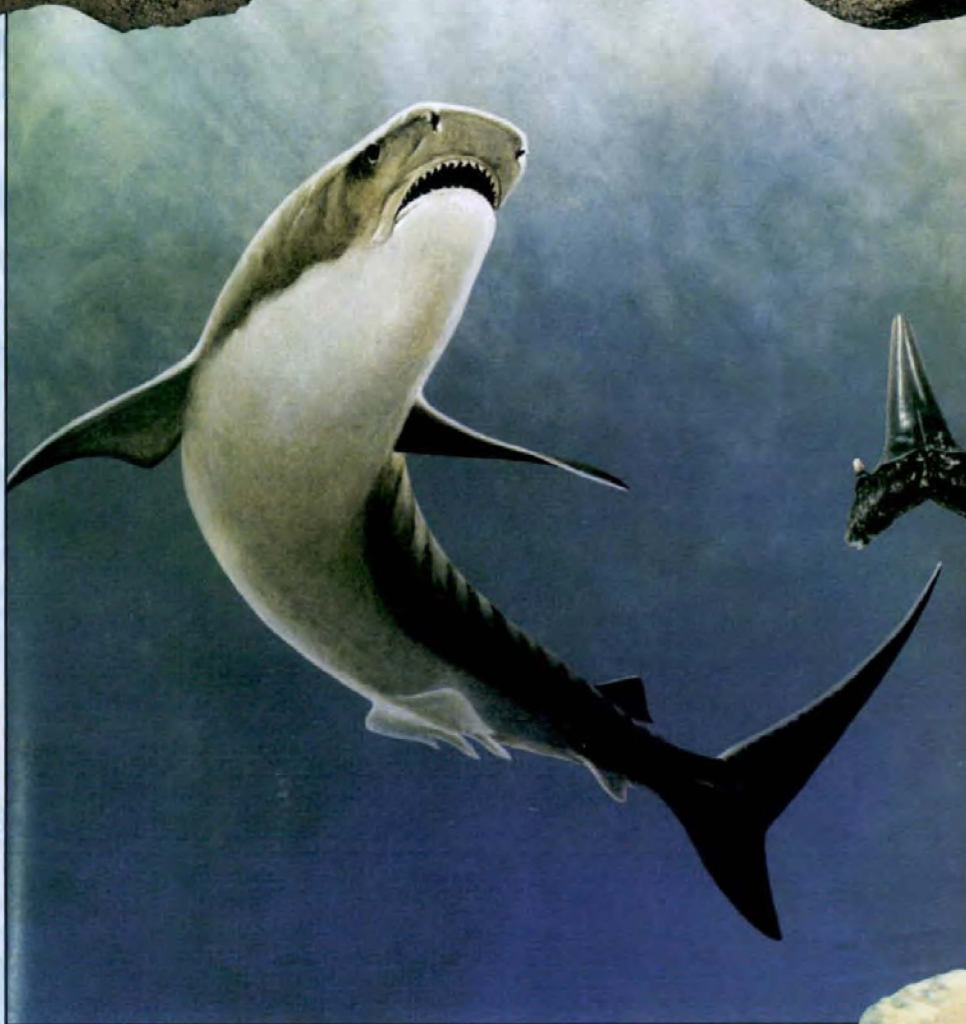
Fossils of vertebrate animals from the Fox Hill Formation consist mostly of isolated fish teeth and dental plates. Fish ear stones—structures in the inner ear of bony fish like *Vorbisia vulpes*, a catfish—are unusual fossils also found in the Fox Hills Formation. These fossils indicate the kinds of predators that lived in the Fox Hills Sea.



Shark tooth
Squalicorax pristodontis
Bowman County
Width 22 mm
SLU 1832



Ratfish dental plate
Ischyodus rayhaasi
Logan County
Width 65 mm
ND 99-6.1



Painting by and courtesy of Richard Ellis

Shark teeth
Carcharias
Griggs County
Height 7 mm
ND 95-40

Modern tiger shark



Catfish ear stone
Vorbisia vulpes
Logan County
Width 4 mm
ND 95-13.35



Ray tooth
Myledaphus bipartitus
Morton County
Height 7 mm
UND RMF134-80-3

