

# The Final Days...

- Today: Mesozoic Marine Reptiles
- The Mesozoic WORLD
- Mammals
- Extinctions
- FINAL
  - Not cumulative
  - Saturday, May 5th, 2018 8am-11am
  - **Exact same format**
  - Green Scantron



# Readings for flying and swimming reptiles:

Earth Archives  
(link on website)

The screenshot shows the homepage of Earth Archives. At the top, there's a navigation bar with links for PLANTS AND ANIMALS, FOSSILS AND EVOLUTION, EARTH, CLIMATE CHANGE, and HUMANS. Below the header is a large, dramatic image of a marine reptile, likely a plesiosaur, swimming in deep blue water. Overlaid on this image is the title "Not every extinct reptile is a dinosaur" in white text. To the right of the title, there's a small bio box for the author, Pepe Anthony. Below the main image, there's a detailed scientific article summary for "The Evolution of Marine Reptiles" by R. Motani. The summary includes a brief introduction, the full article text, and a list of references. At the bottom of the page, there's a footer with the Springer logo.

EARTH ARCHIVES

PLANTS AND ANIMALS FOSSILS AND EVOLUTION EARTH CLIMATE CHANGE HUMANS

Not every extinct reptile is a dinosaur

R. Motani (2009) 2:221–230  
DOI 10.1007/s10641-009-0199-0  
ORIGINAL SCIENTIFIC ARTICLE

The Evolution of Marine Reptiles

Ryuji Motani

Published online: 24 May 2009  
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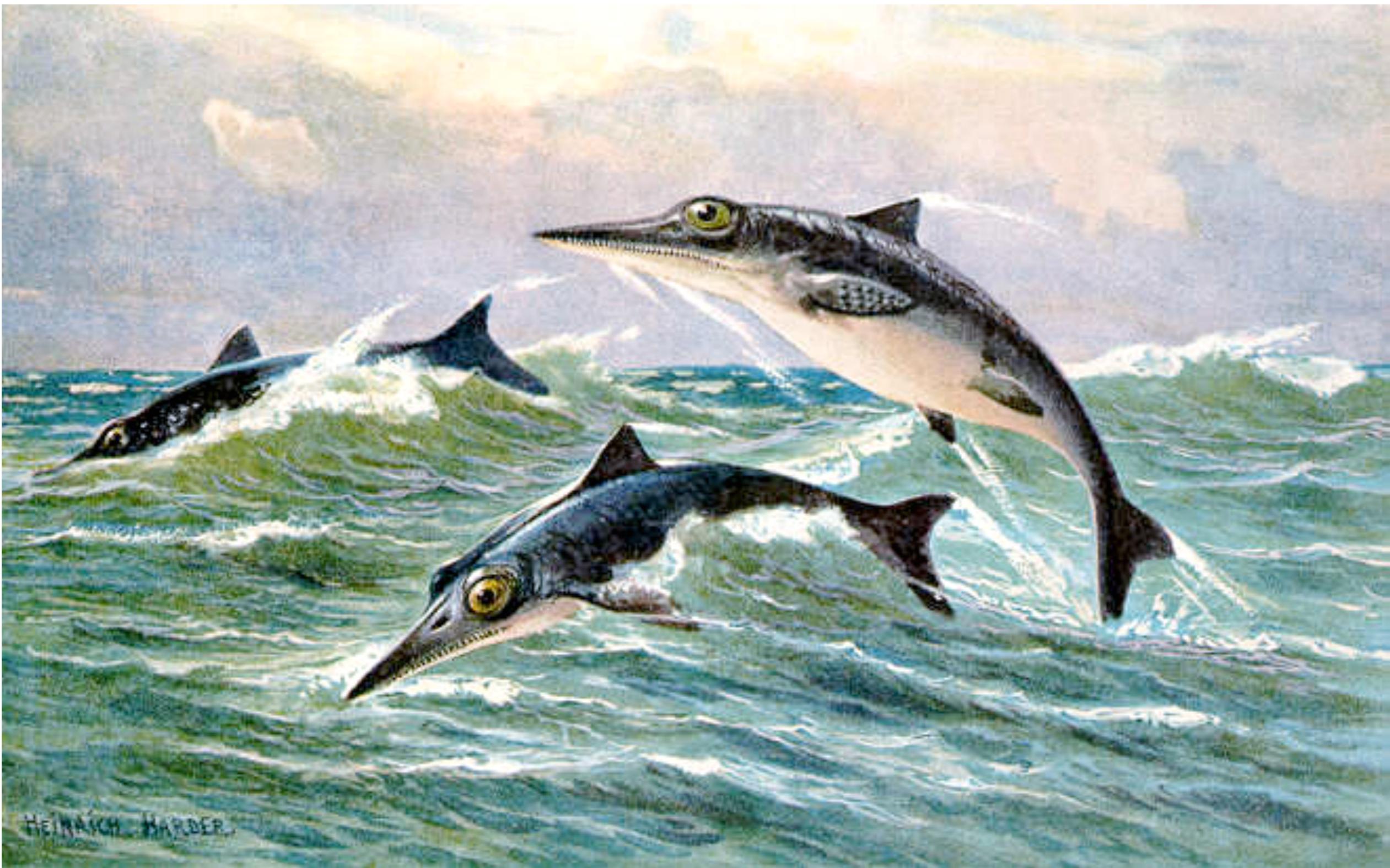
**Abstract** Reptiles have repeatedly invaded marine environments despite their physiological constraints to air breathing. Marine reptiles were especially prominent in the Mesozoic as major predators in the sea. There were over 100 distinct groups of marine reptiles in the Mesozoic, which far exceeded those of all groups, namely crocodylians (including plesiosaurs), ichthyosaurs, mosasaurs, and sea turtles. Mesozoic groups, such as Ichthyosaurus and Thalattoarchon, had about ten genera, whereas small groups, such as Hoplocephalus and Plesiosuchus, consisted of only two genera or less. Ichthyosaurs and Ichthyopterygia were the most longer surviving lineages, with 105 and 103 million years of taxonomical spans, respectively. Mesozoic marine reptiles evolved many unique evolutionary traits and traits. These traits included ribs, cephalopods, abdominal, and hind-limb appendages, whereas cutaneous features in the pectoral, stenopterygian, and Ichthyopterygia gave rise to running from the probably much faster ones. Ichthyosaurs, like sharks or dolphins, possessed the remarkable ability to turn sharply, whereas Ichthyopterygia, like plesiosaurs, had a more gradual turning in the same direction as the long forelimbs of their counterparts, reaching 20 meters in total length (Motani and Blaauw 2004), whereas the others were small, reaching only about 40 centimeters (Küller 2000). Some were adapted to catching big fishes (Motani 2003), but others were more suitable for hunting plesiosaurs (Motani 1998; IT Motani 2001).

**Keywords** Marine reptiles · Mesozoic · Plesiosaur · Ichthyopterygia · Ichthyosaur

R. Motani (✉)  
Department of Geobiology, University of California, Davis,  
One Shields Avenue,  
Davis, CA 95616-1236  
e-mail: rmotani@ucdavis.edu

Springer

# Aquatic Reptiles of the Mesozoic





## Mosasaurus

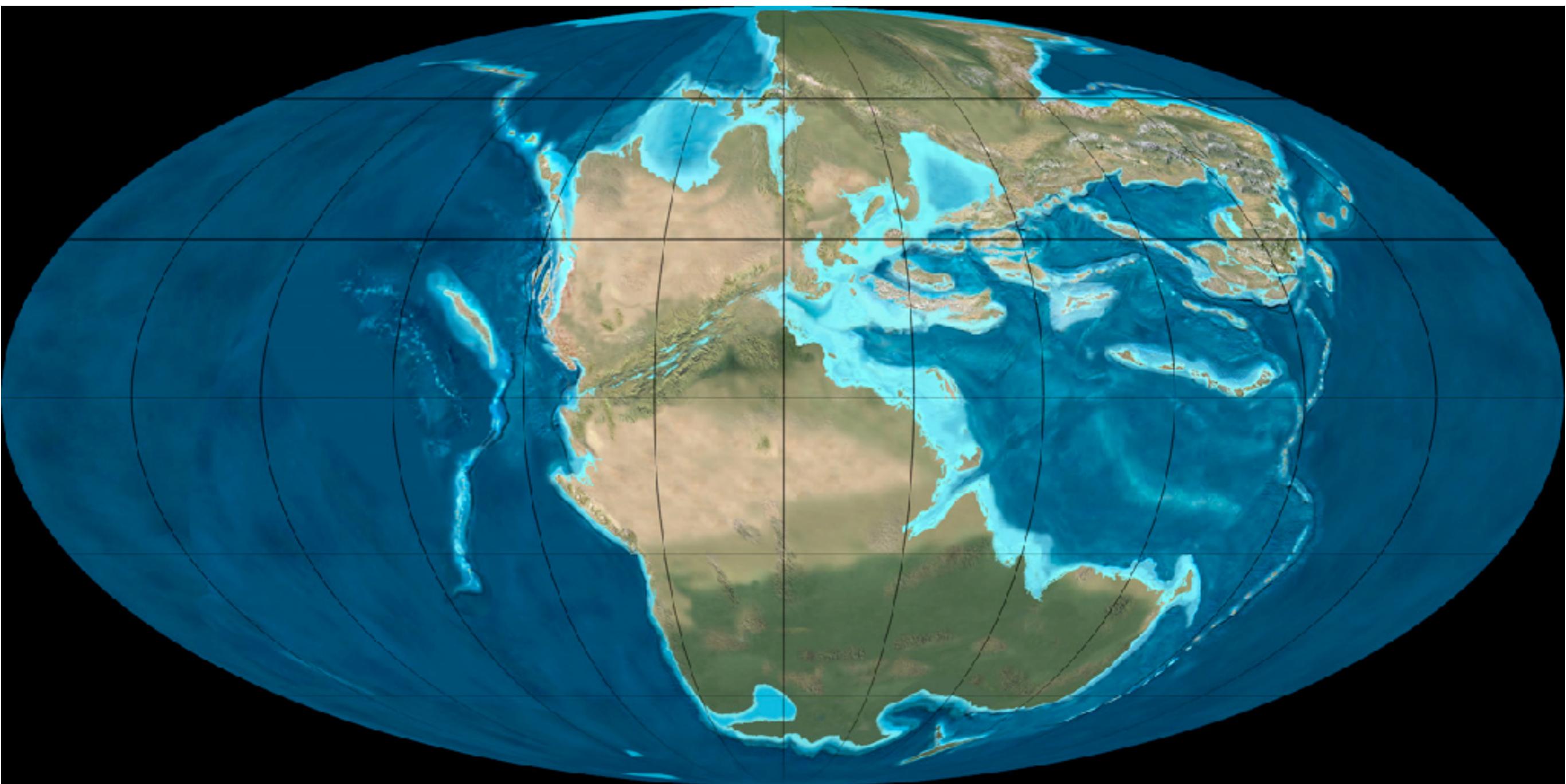
Preceded any dinosaur discoveries: unearthed in 1764 by quarry workers in the Dutch city, Maastrich

French Revolutionary Forces obtained the fossil after paying a 600 bottle of wine reward

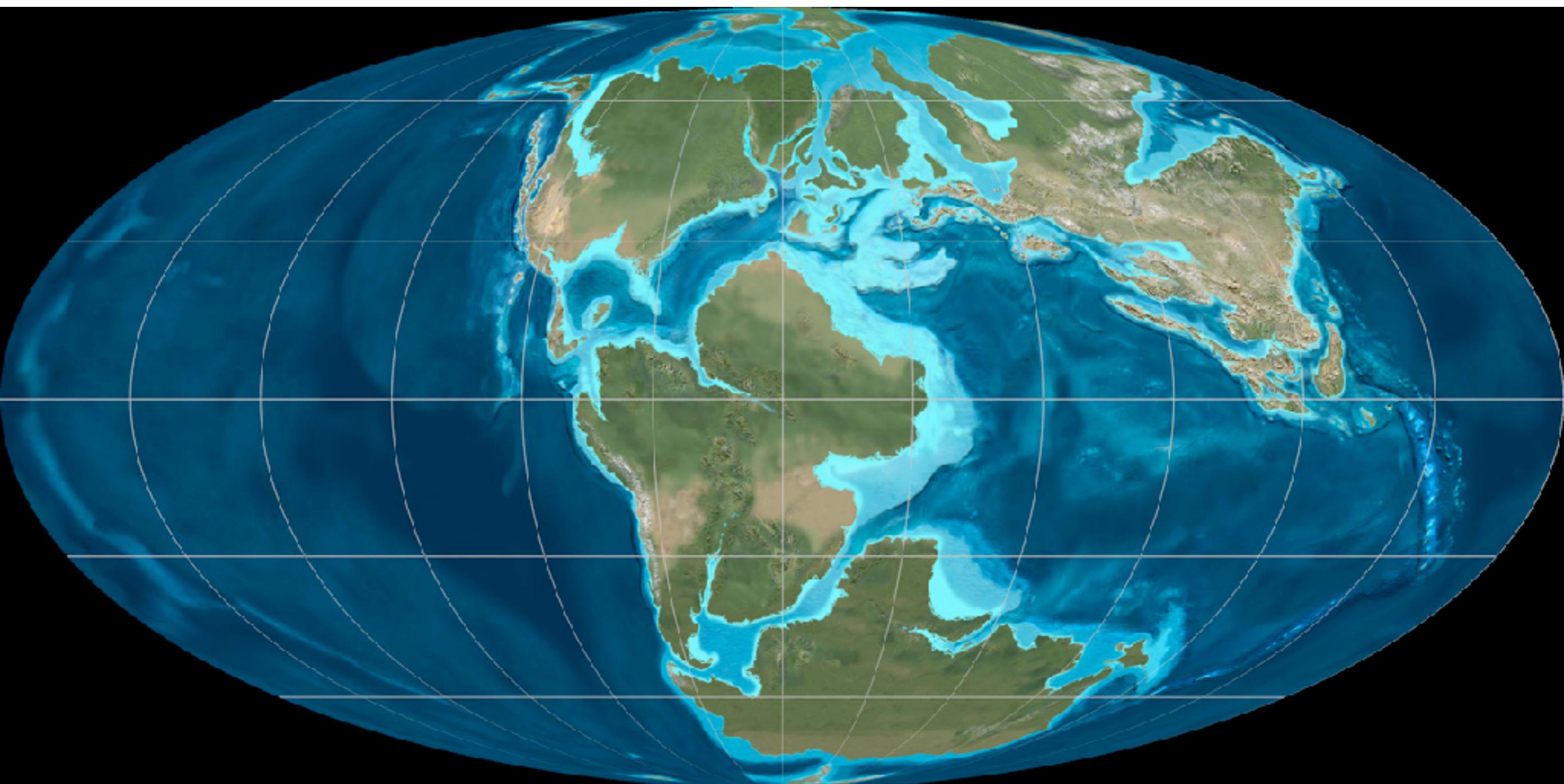
Wasn't recognized as reptilian until 1799



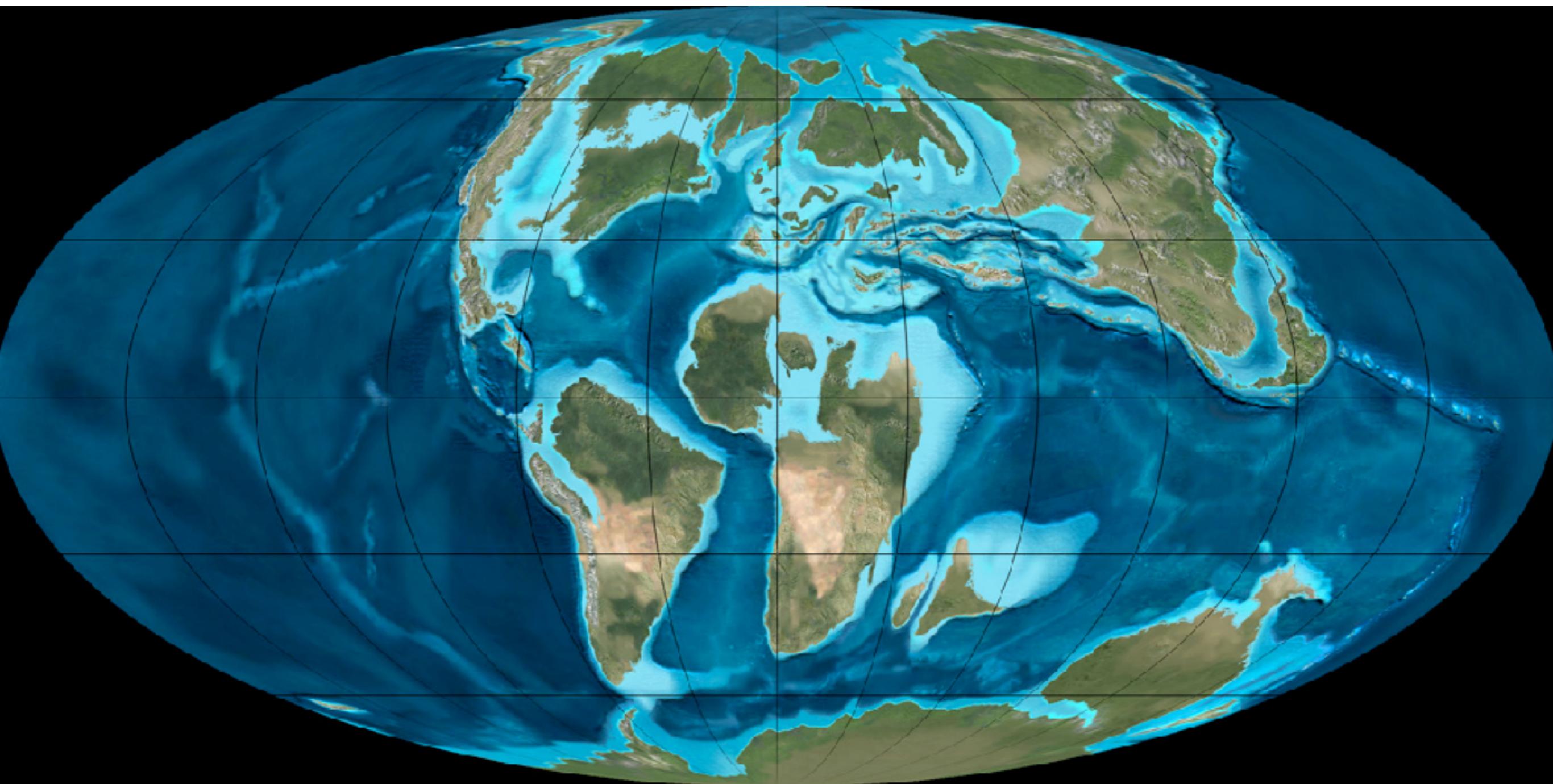
# Triassic Oceans

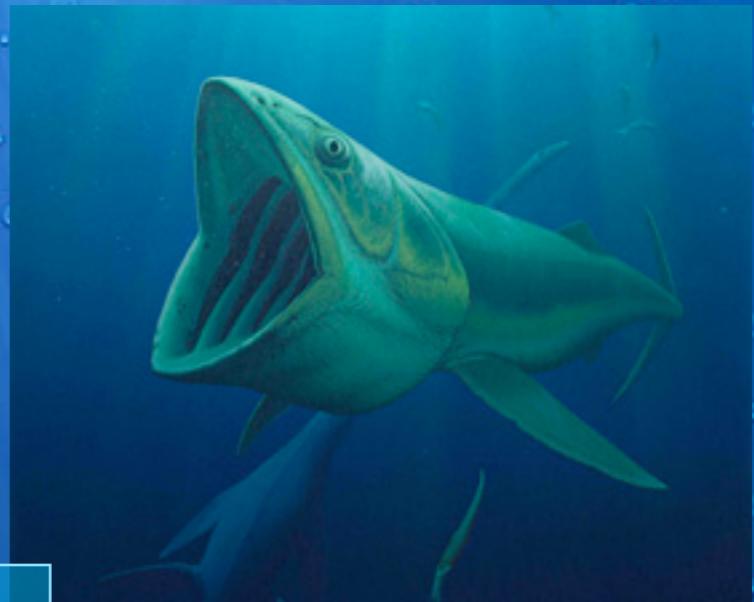
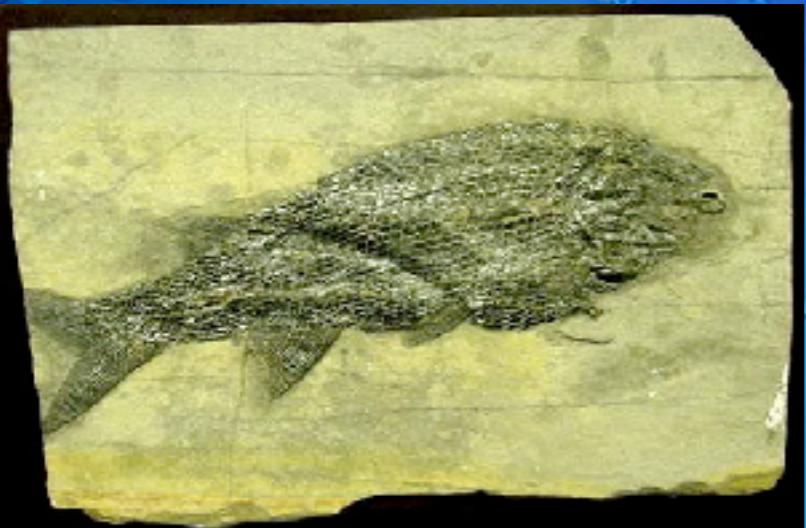


# Jurassic Oceans



# Cretaceous Oceans





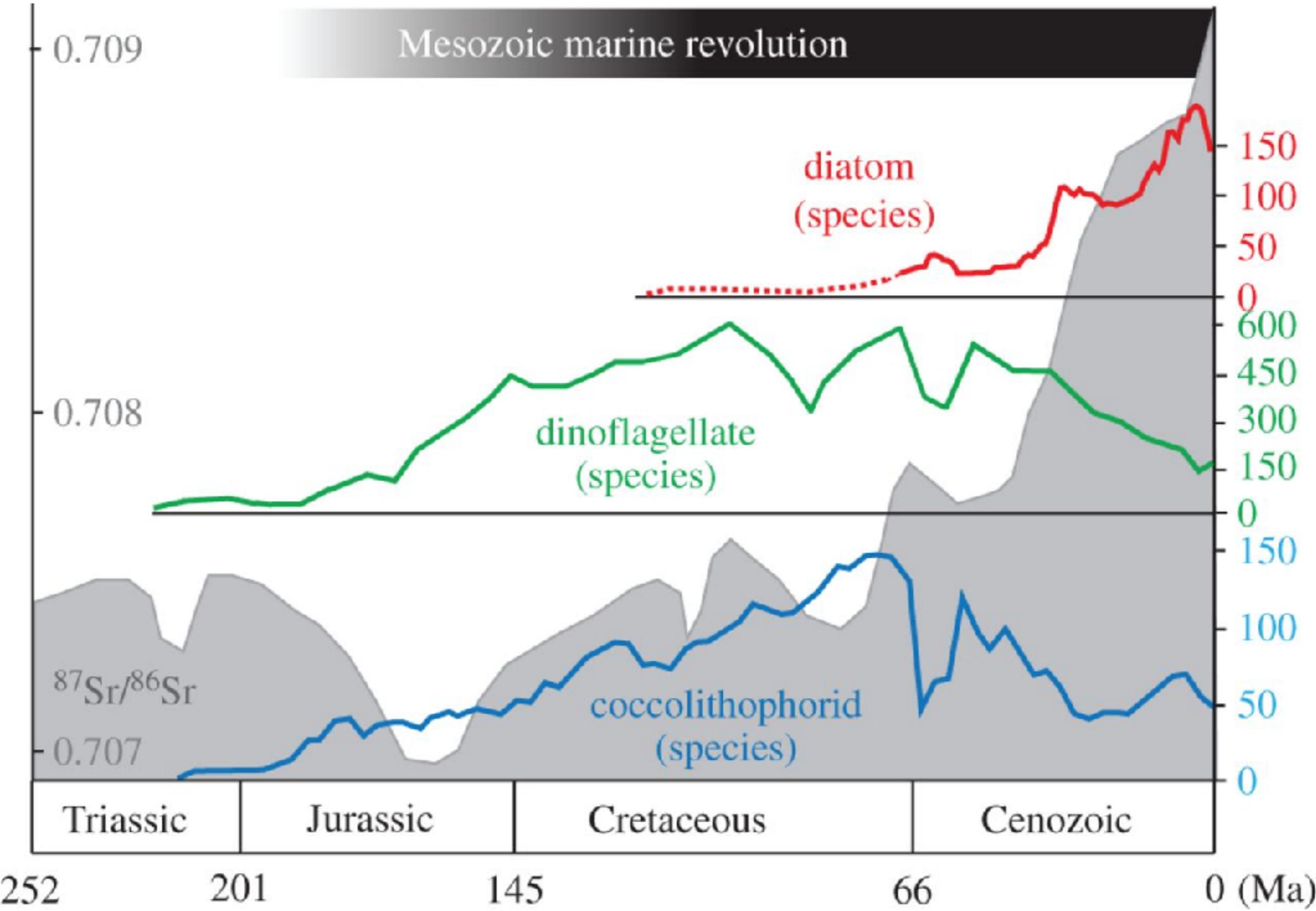
## 'Seafood Hypothesis'

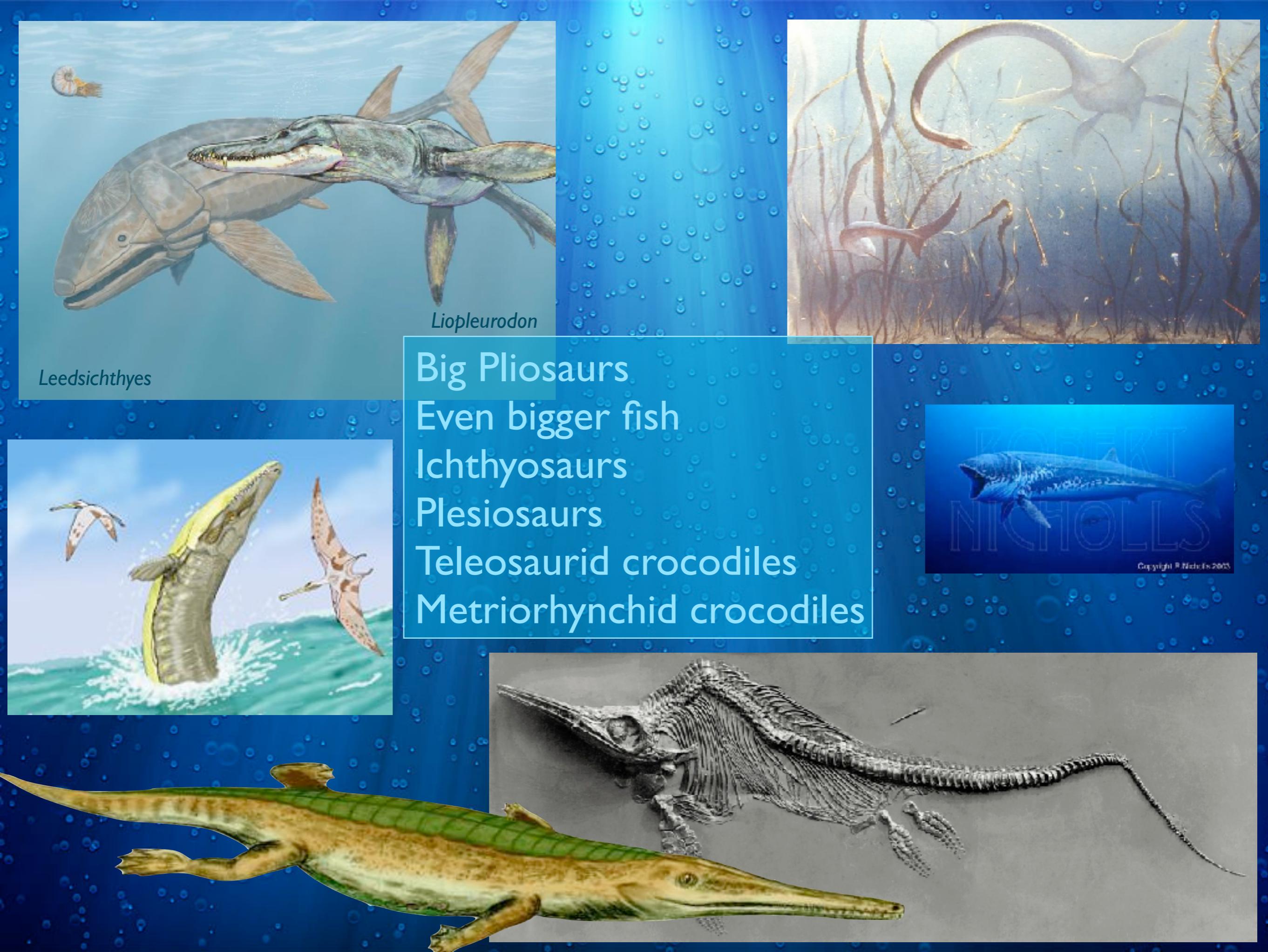
Fish of various sizes  
Enormous filter-feeding fish  
Rays  
Neoselachian sharks  
Ammonites  
Squid



"The radiation of mixotrophic dinoflagellates and the subsequent diversification of marine diatoms would have accelerated the transfer of primary production upward into larger size classes and higher trophic levels. Thus, phytoplankton evolution provides a mechanism capable of facilitating the observed evolutionary shift in Mesozoic marine animals."

## Mesozoic marine revolution





Leedsichthys

*Liopleurodon*

Big Pliosaurs  
Even bigger fish  
Ichthyosaurs  
Plesiosaurs  
Teleosaurid crocodiles  
Metriorhynchid crocodiles

Copyright R.Nicholls 2003

# Aquatic Reptiles of the Mesozoic

Major Groups:

Sauroptrygians

Nothosaurs and Placodonts

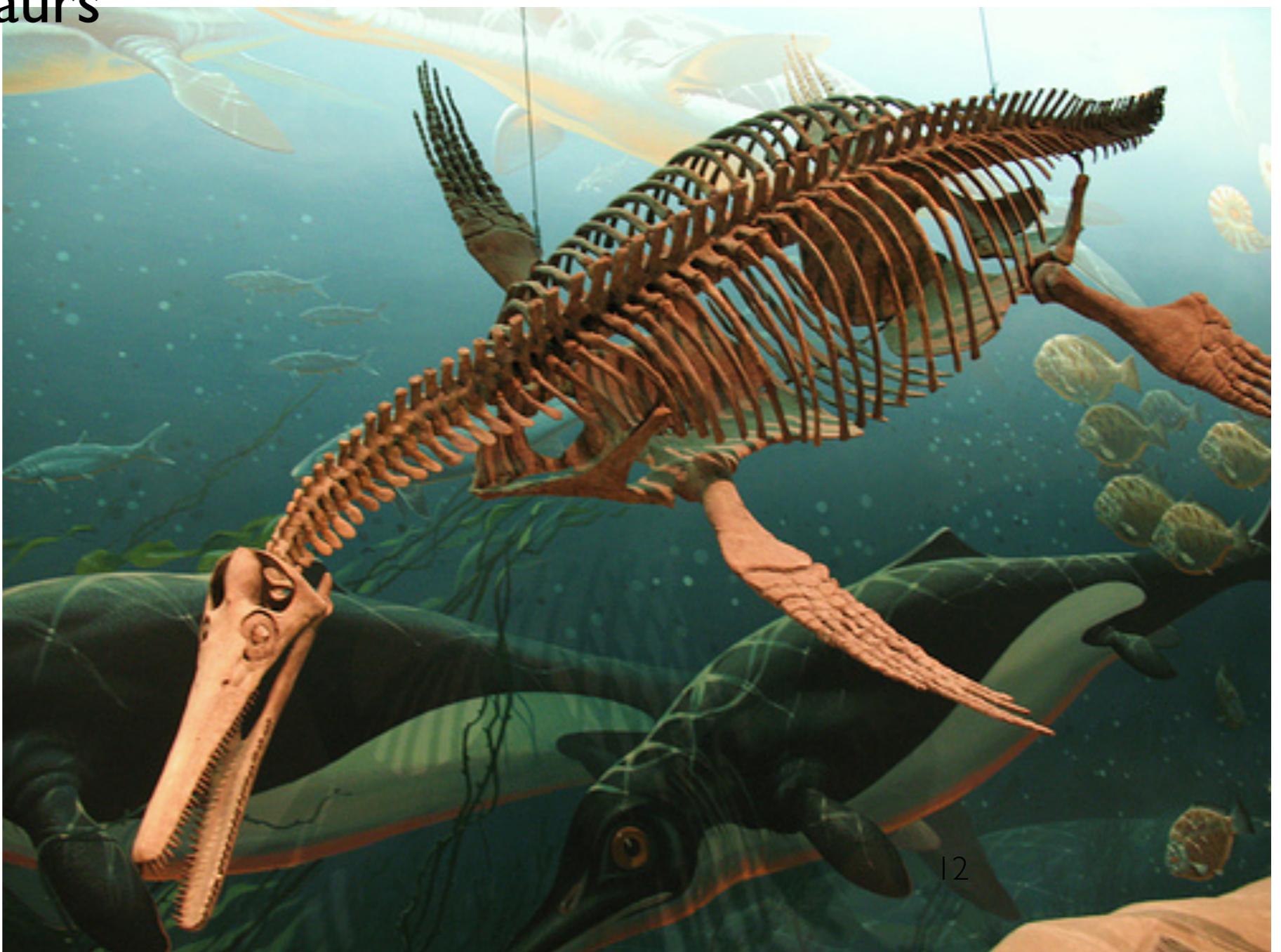
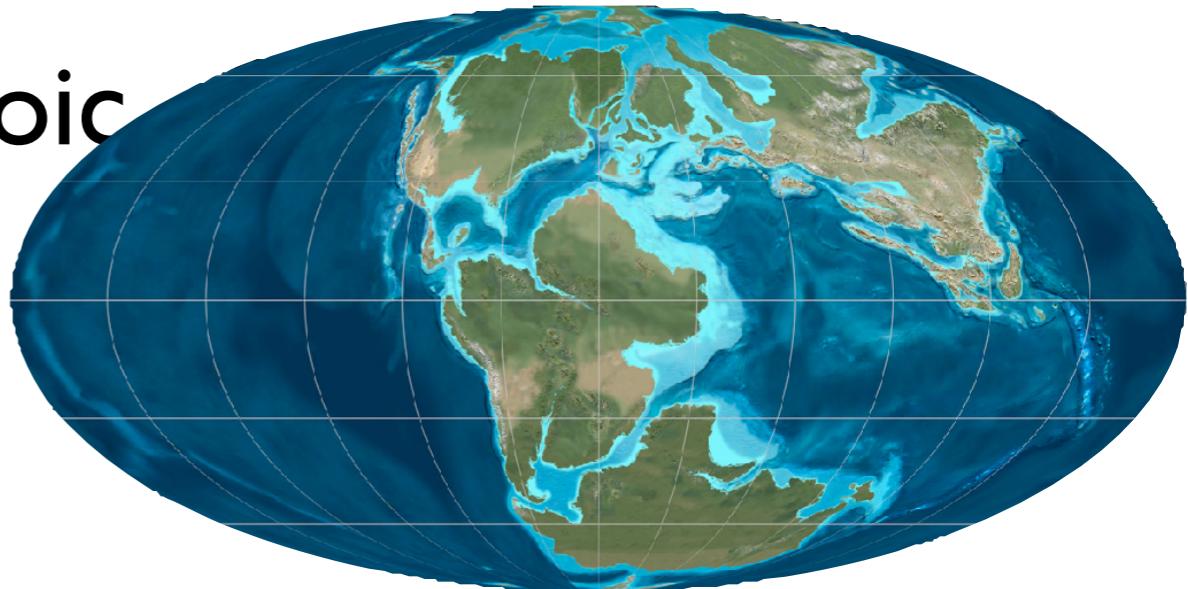
Plesiosaurs and Pliosaurs

Ictyosaurs

Mosasaurs

Turtles

Crocodiles



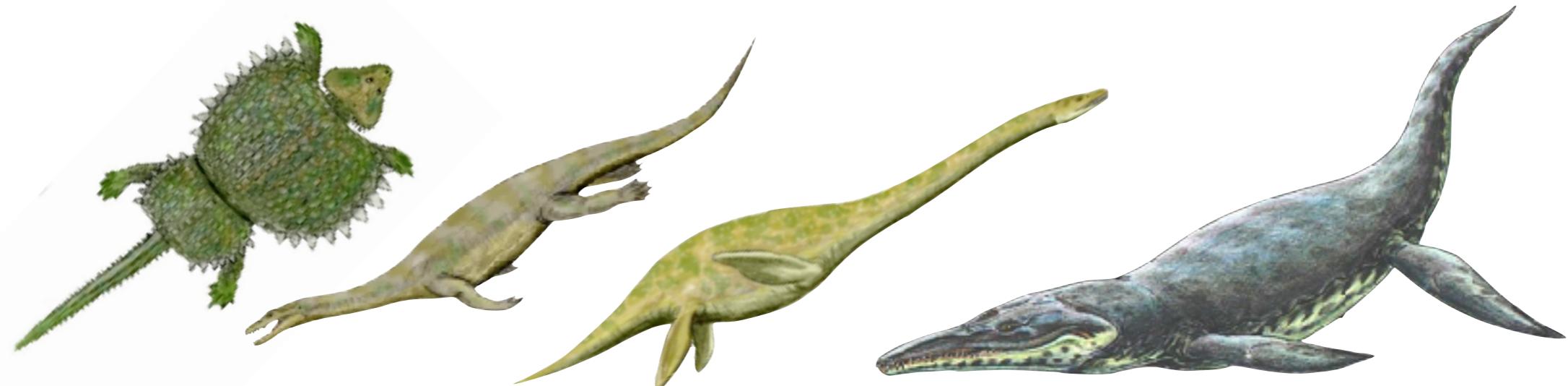
# Sauropterygians: Basal Diapsids

Diversified in the Triassic

Lepidosauria  
Sauropterygia



(Basal to Archosaurs)



**Placodonts**

Nothosaurs

Plesiosaurs

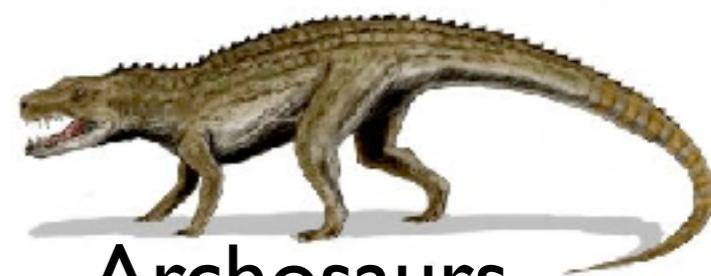
Pliosaurs

Icthyopterygia

Modern lizards

Lepidosauramorpha

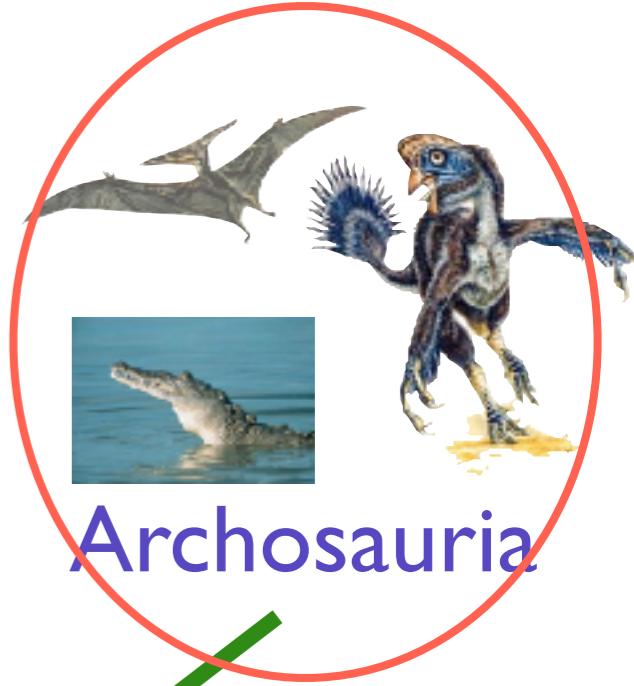
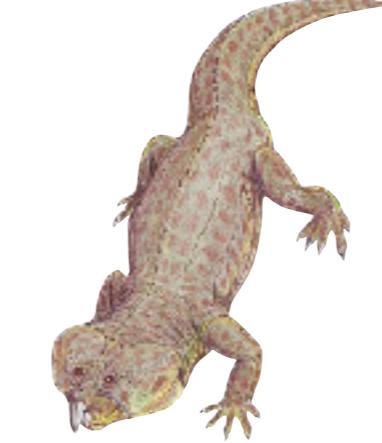
Sauropterygia



Archosaurs



**Synapsida**    **Anapsida**



Archosauromorpha

Diapsida

Eureptilia

Amniotes

# Placodonts = “Tablet Teeth”

Mid to late Triassic  
Several continents  
Shallow, coastal environments  
1-3 ft long  
Turtle shape, long tail

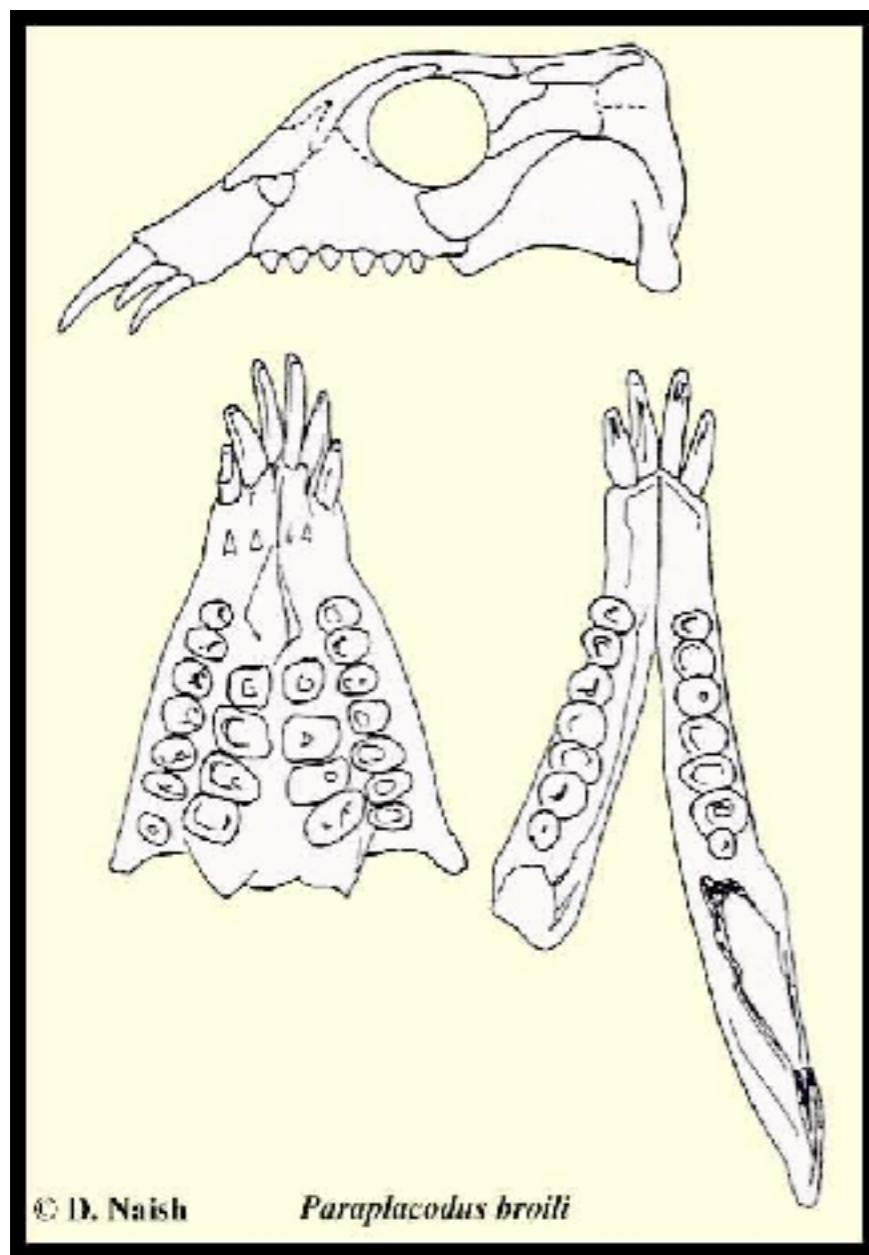


# Placodonts

Boxy skull

Tooth comb, crushing teeth

Mollusk-strainer?

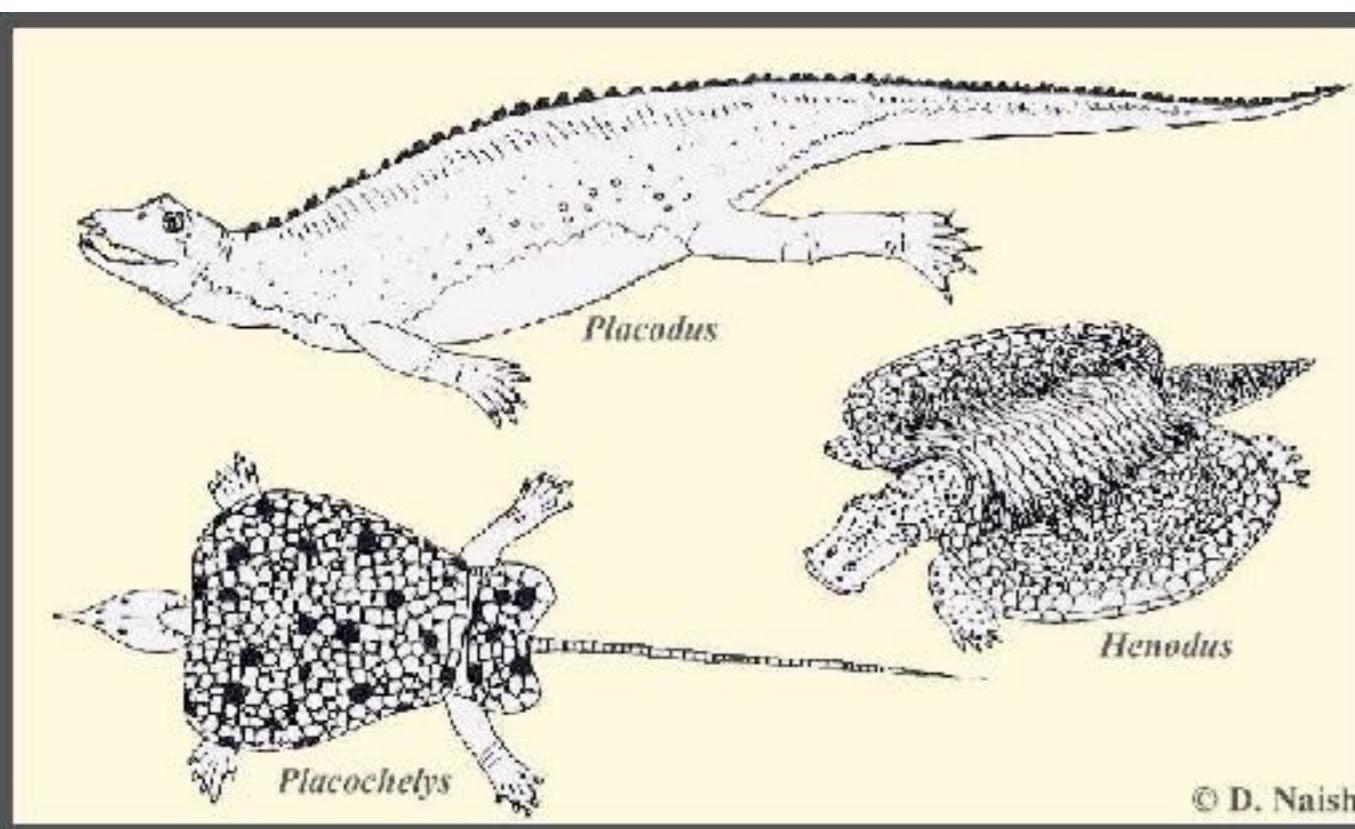


# Placodonts

2 Major groups:

Placodontoids: unarmored

Cyamodontoids: armored



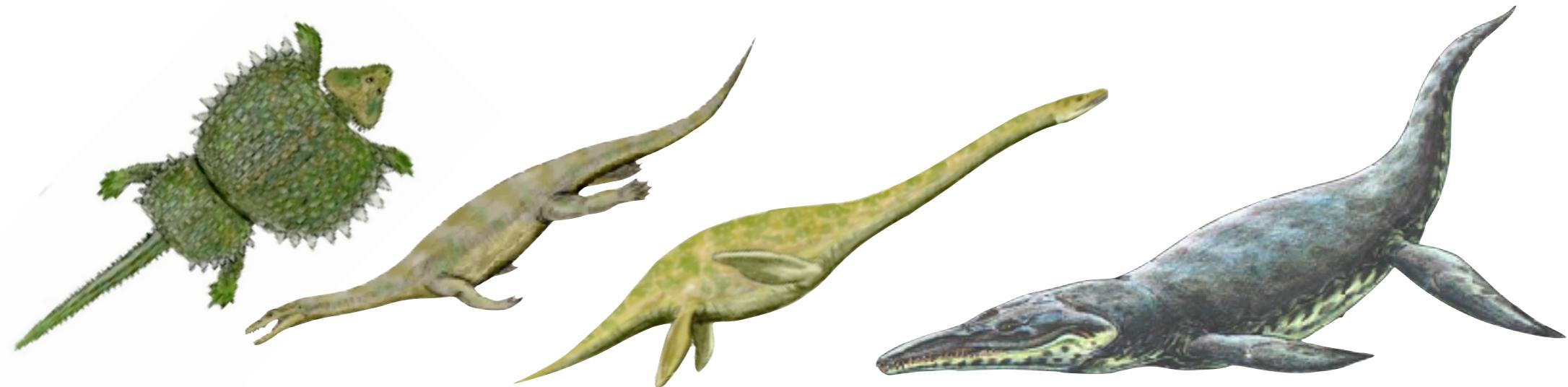
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Diversified in the Triassic

Lepidosauria  
Sauropterygia



(Basal to Archosaurs)



Placodons

**Nothosaurs**

Plesiosaurs

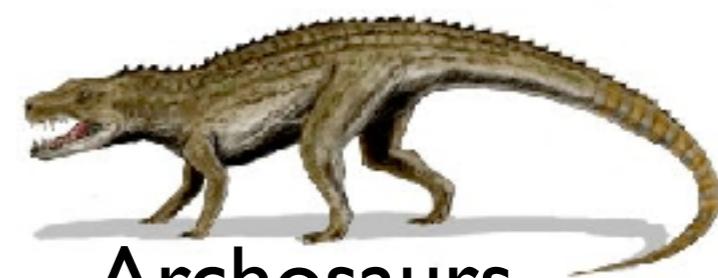
Pliosaurs

Icthyopterygia

Modern lizards

Sauropterygia

Lepidosauramorpha



Archosaurs

# Nothosaurs

## Triassic SEALS



### Attributes:

Mid Triassic of Eurasia

Coastal environments

~ 12 ft long as adults

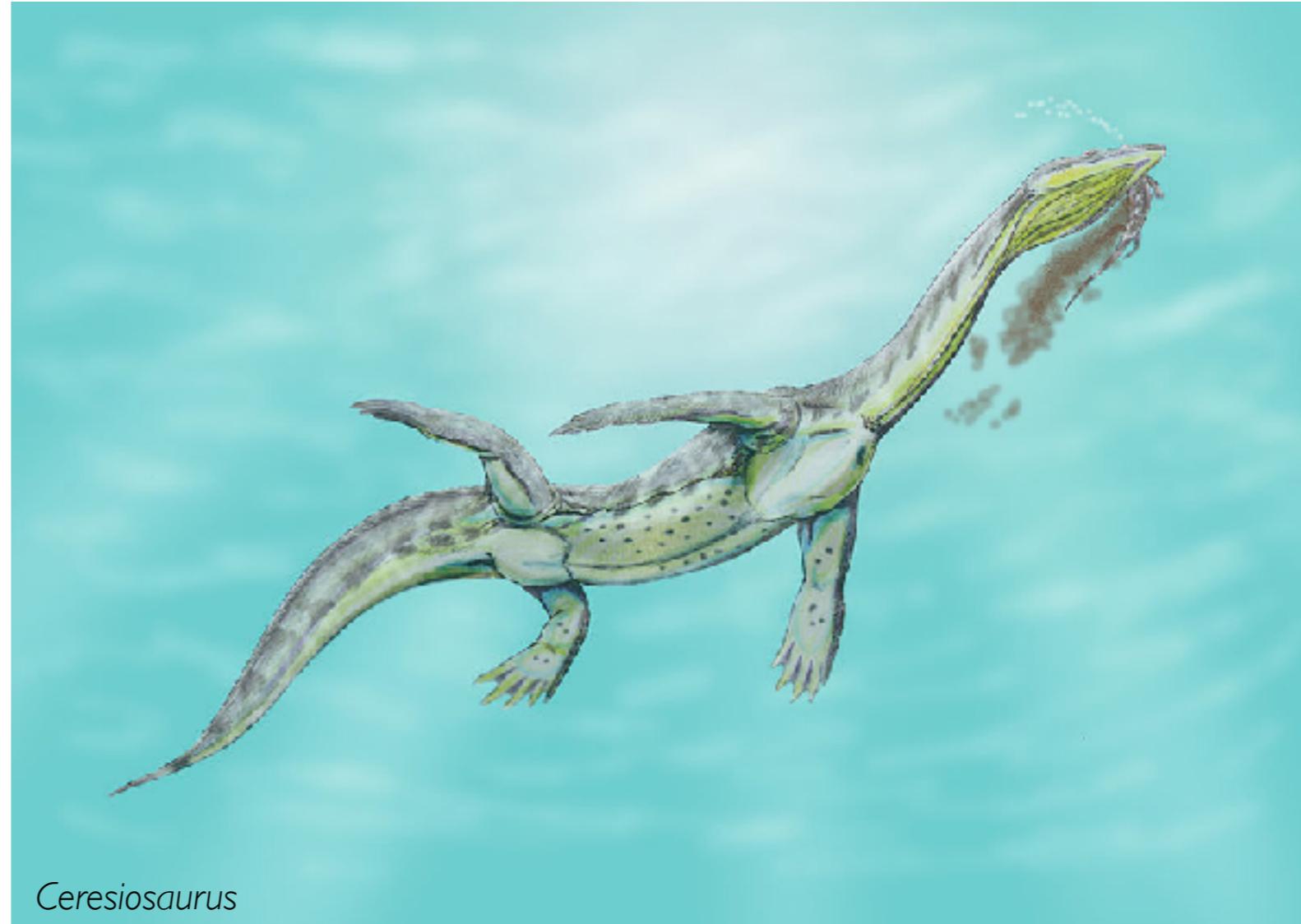
Long neck, streamlined body

Paddlelike forelimbs

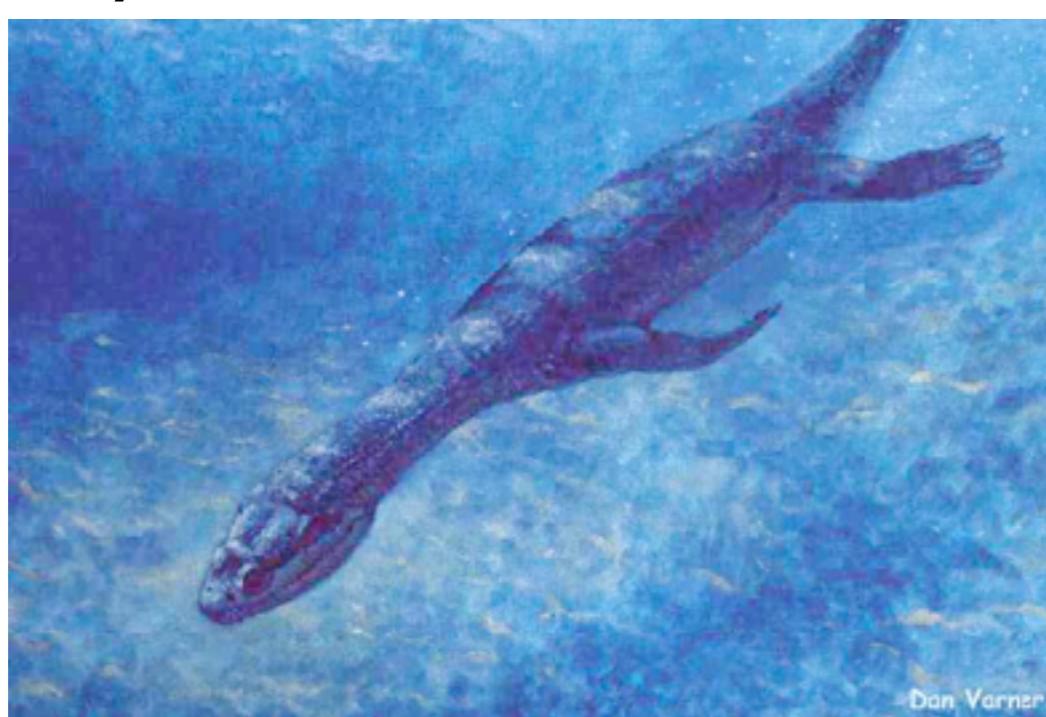
Reduced hindlimbs

Webbed feet

Small pointy teeth



*Ceresiosaurus*



Dan Varner



# Nothosaurs

## Triassic SEALS

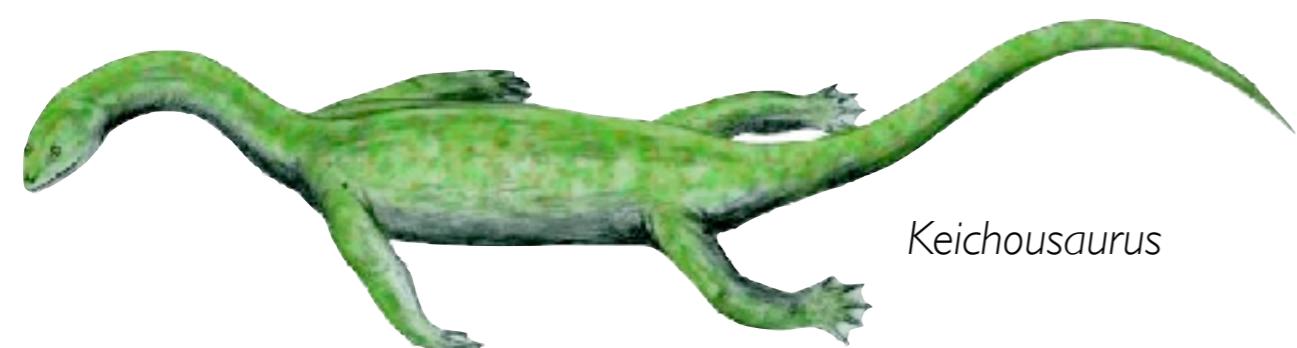
### Ecology:

Fish/squid-specialists

Foraged in water, but were dependent on rocks/beaches



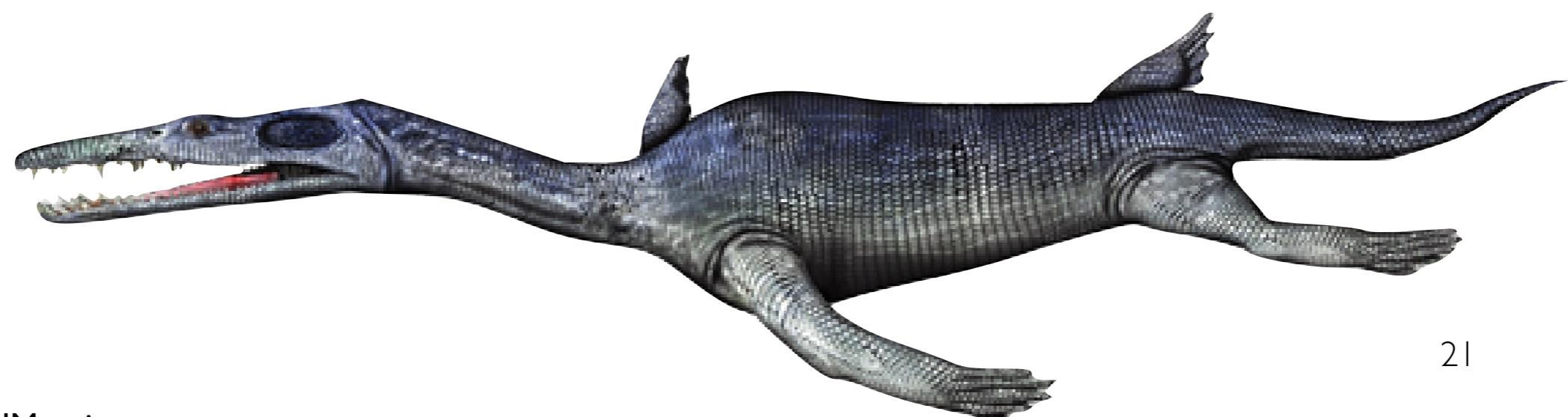
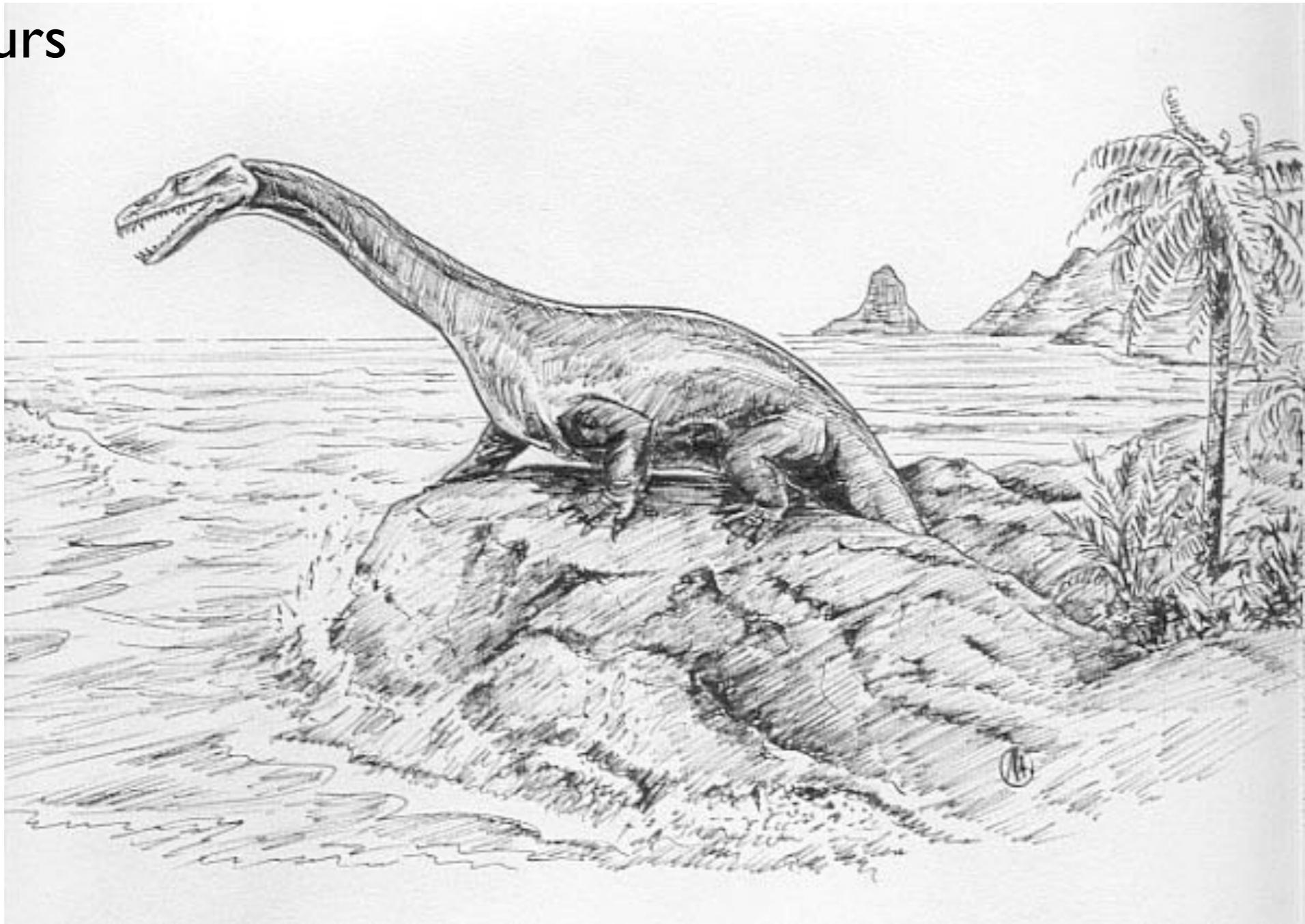
*Lariosaurus*



*Keichousaurus*



# Nothosaurs



21



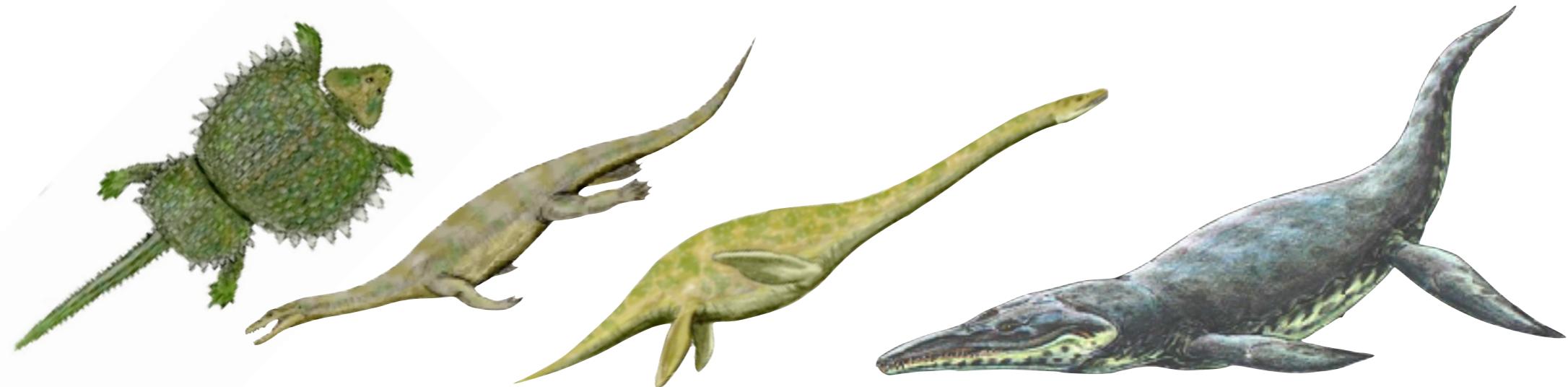
# Sauropterygians: Basal Diapsids

Diversified in the Triassic

Lepidosauria  
Sauropterygia



(Basal to Archosaurs)



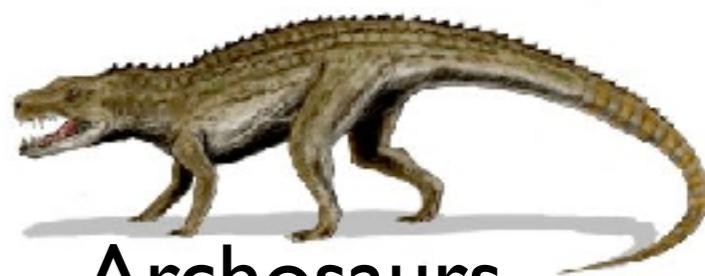
Placodons      Nothosaurs      Plesiosaurs      Pliosaurs

Icthyopterygia

Modern lizards

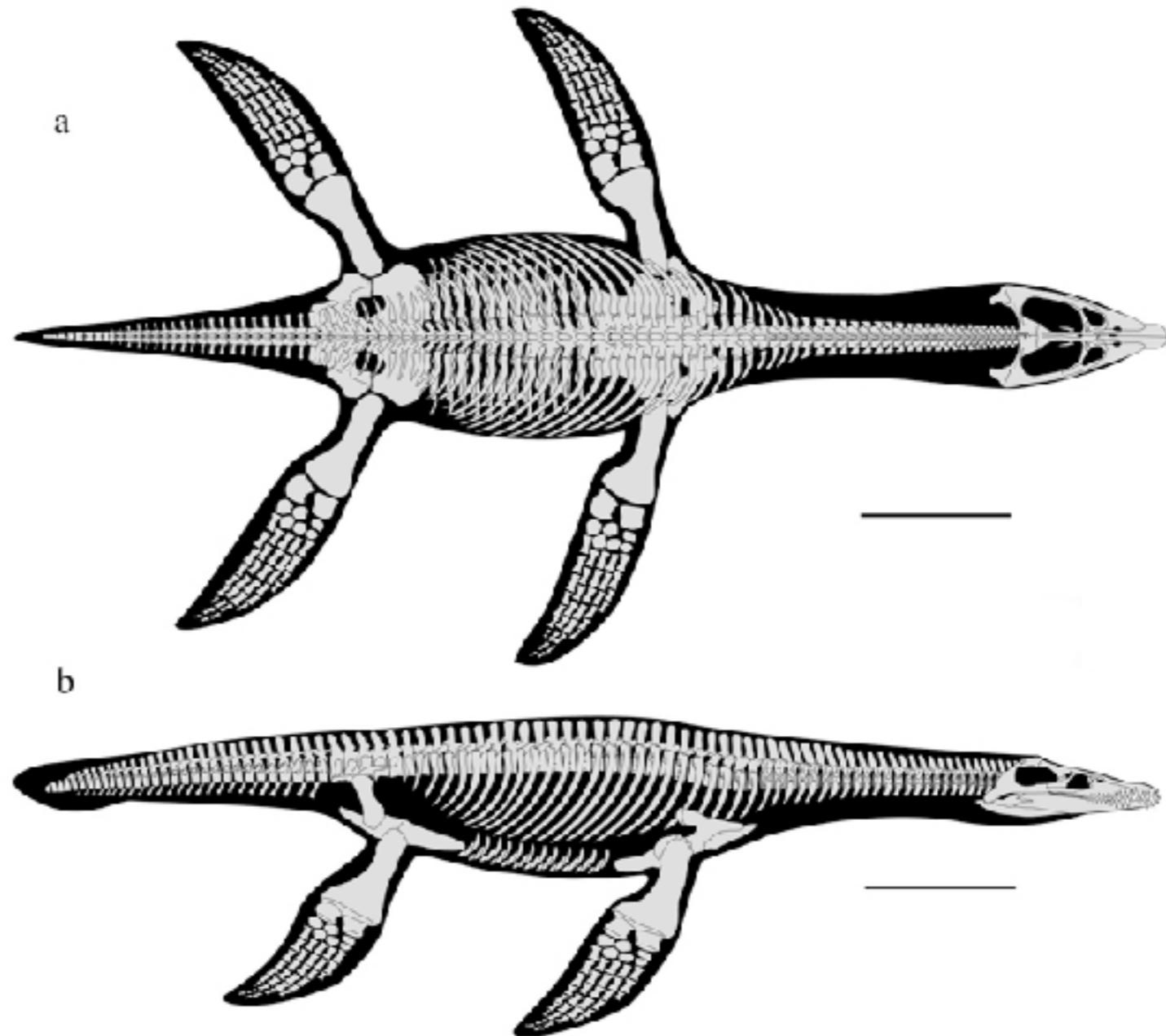
Lepidosauramorpha

Sauropterygia



Archosaurs

# Plesiosaurs



## Attributes:

Early Jurassic to Late Cretaceous

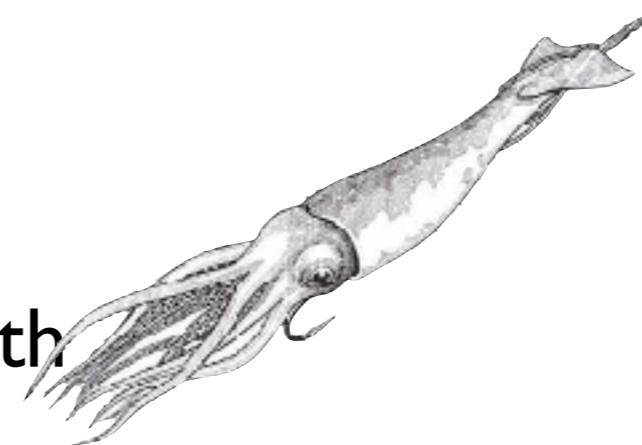
Several Continents

Front and hind limbs modified to flippers

Stiff trunk, strong pectoral and pelvic girdles

Short, boxy body with massive ventral ribs

Long necks, short tails, small head, sharp teeth



# Plesiosaurs

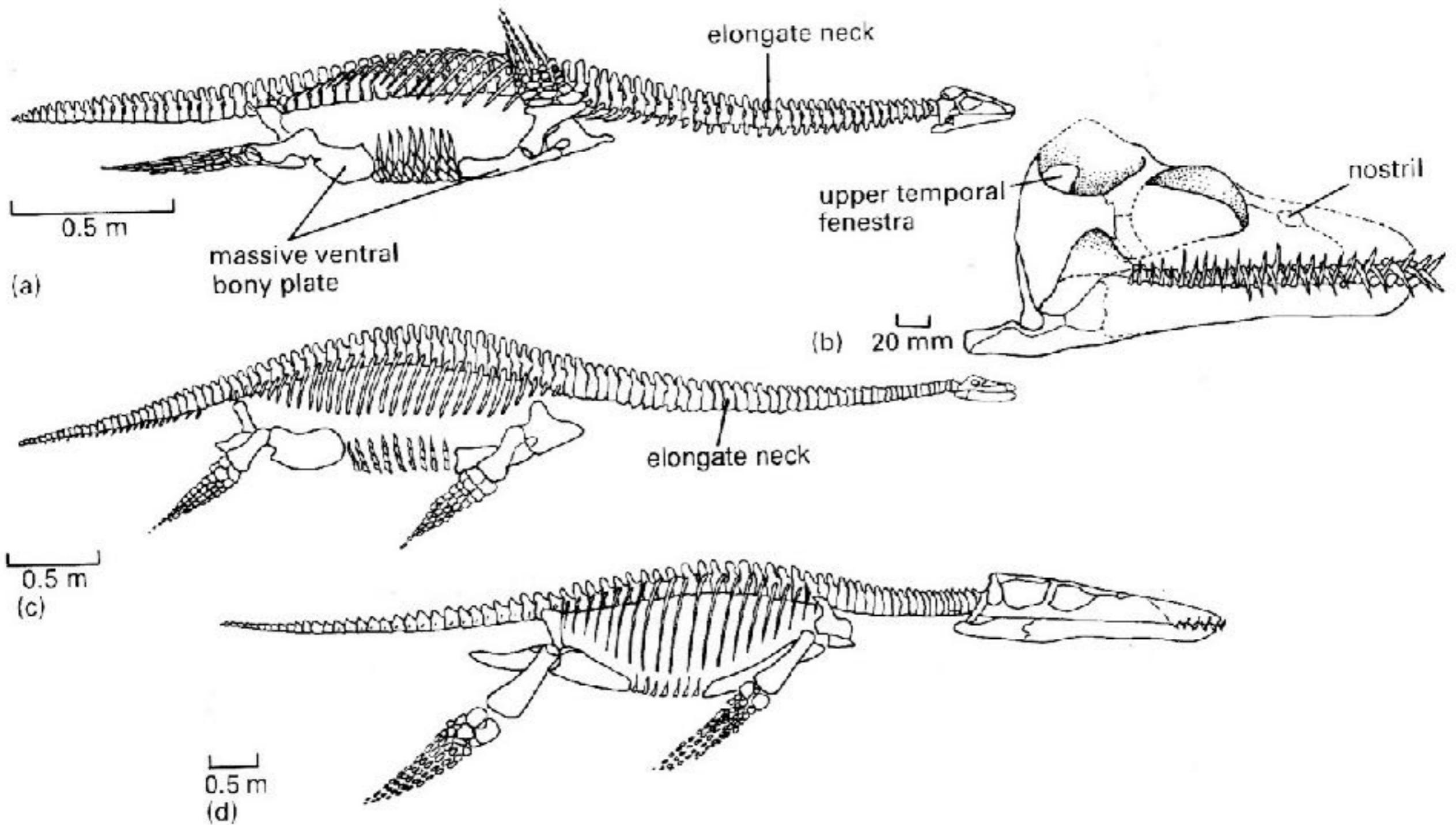
## Ecology:

Fully marine and deep water habitats

Fish/cephalopod specialists



*Elasmosaurus*



# Plesiosaurs

## Locomotion

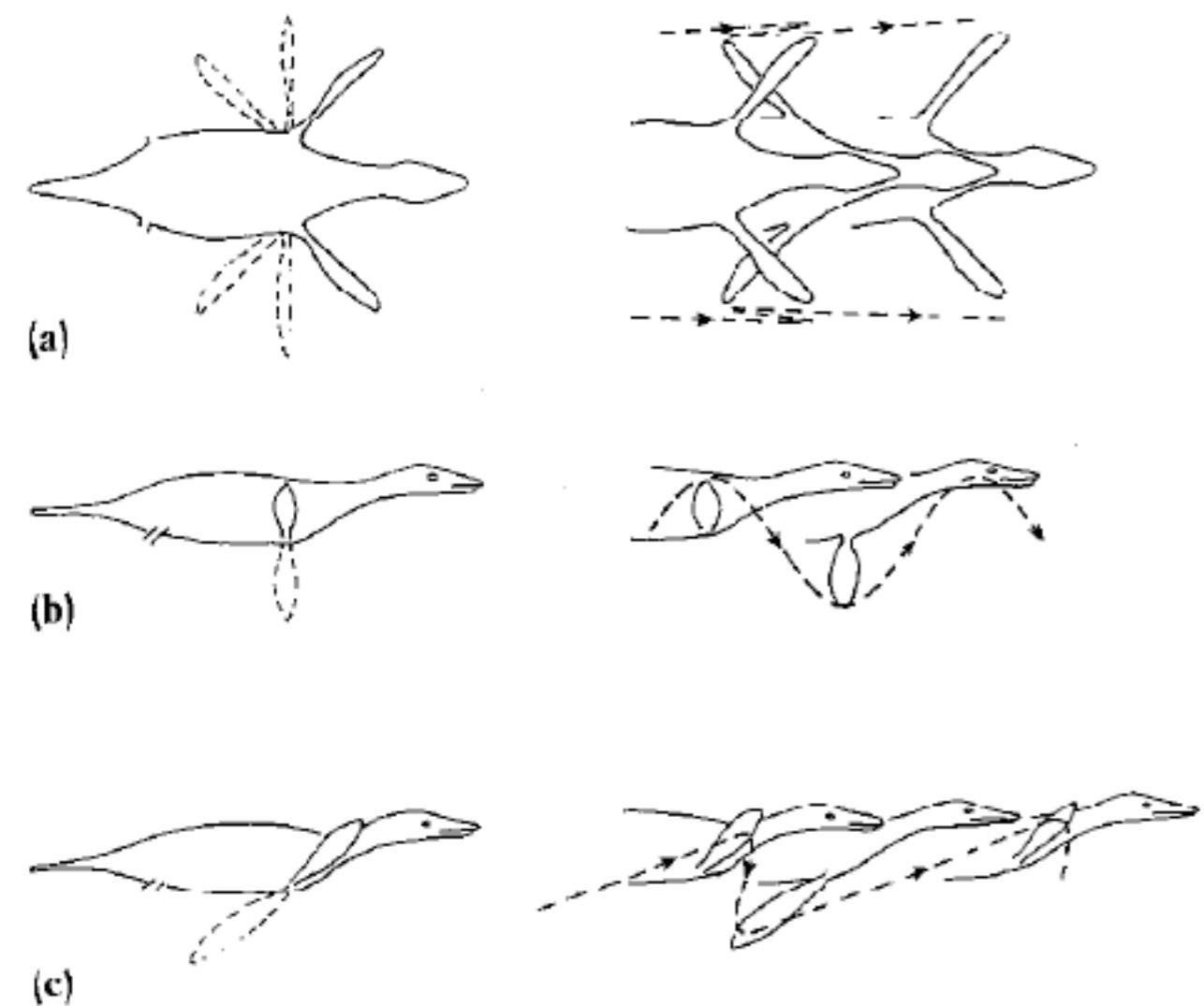


FIGURE 9.6 Three possible swimming techniques for plesiosaurs: (a) rowing; and (b) and (c) underwater flight. The diagrams on the left show how the flippers would have been moved relative to the body and those on the right show successive positions of the animal moving through the water. Only the foreflippers are shown.

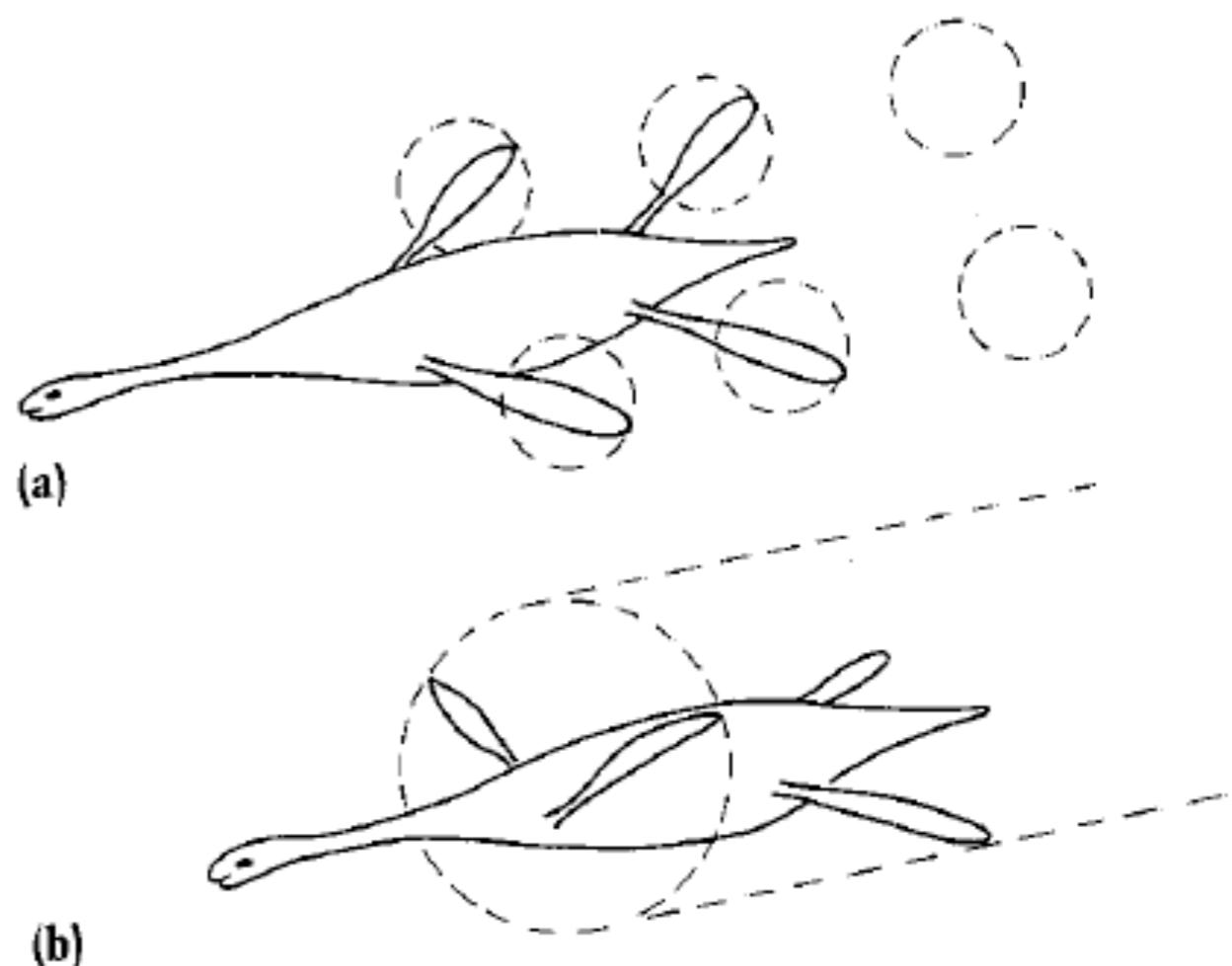
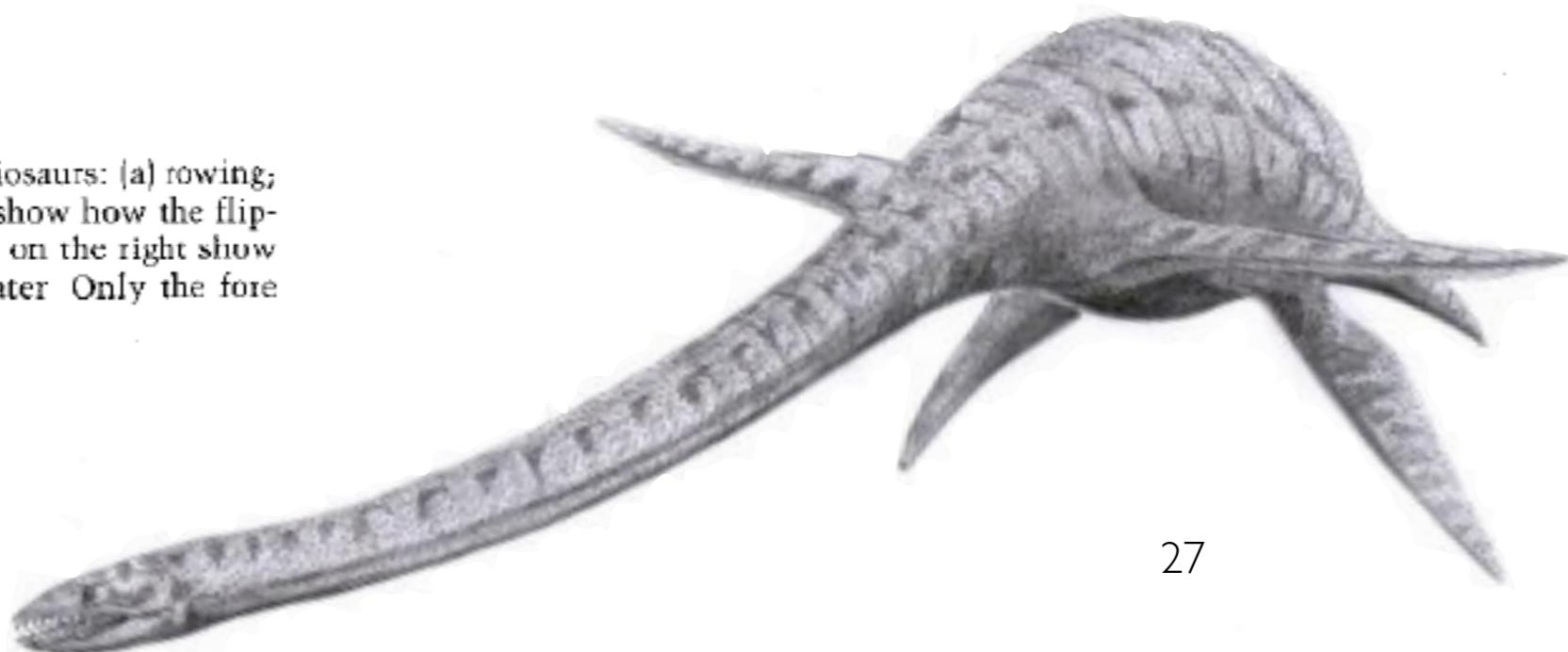


FIGURE 9.8. A plesiosaur (a) rowing and (b) "flying" under water. Broken out lines show the water driven backward by the swimming movements.

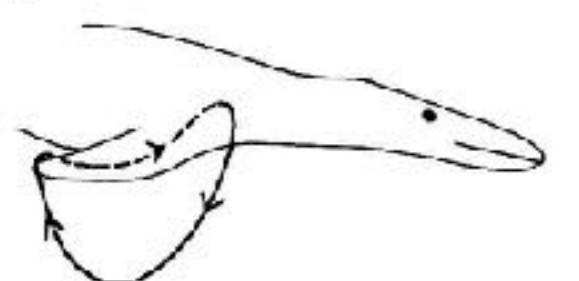




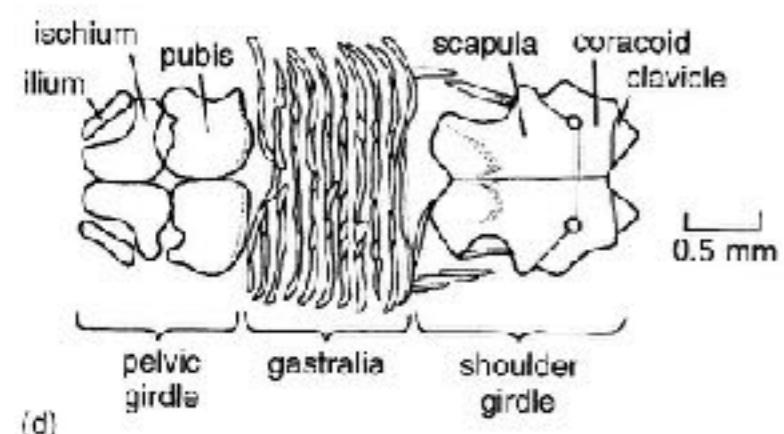
(a)



(b)



(c)



*Plesiosaur locomotion:* (a–c) three hypotheses: (a) rowing underwater like a duck, (b) flying underwater like a penguin, and (c) an intermediate style like a sealion; (d) ventral view of the heavy bony covering of the plesiosaur belly. [Figures (a–c) after Taylor 1986, copyright © 1986 Macmillan Magazines Ltd; (d) after Robinson, 1975.]

Birds

<http://www.youtube.com/watch?v=EahSpvyiFmw&feature=related>

Penguins

<http://www.youtube.com/watch?v=ErIhvelMk0k>

Sea Lions

<http://www.youtube.com/watch?v=br4IPNmfrOY&feature=related>









# Plesiosaurs

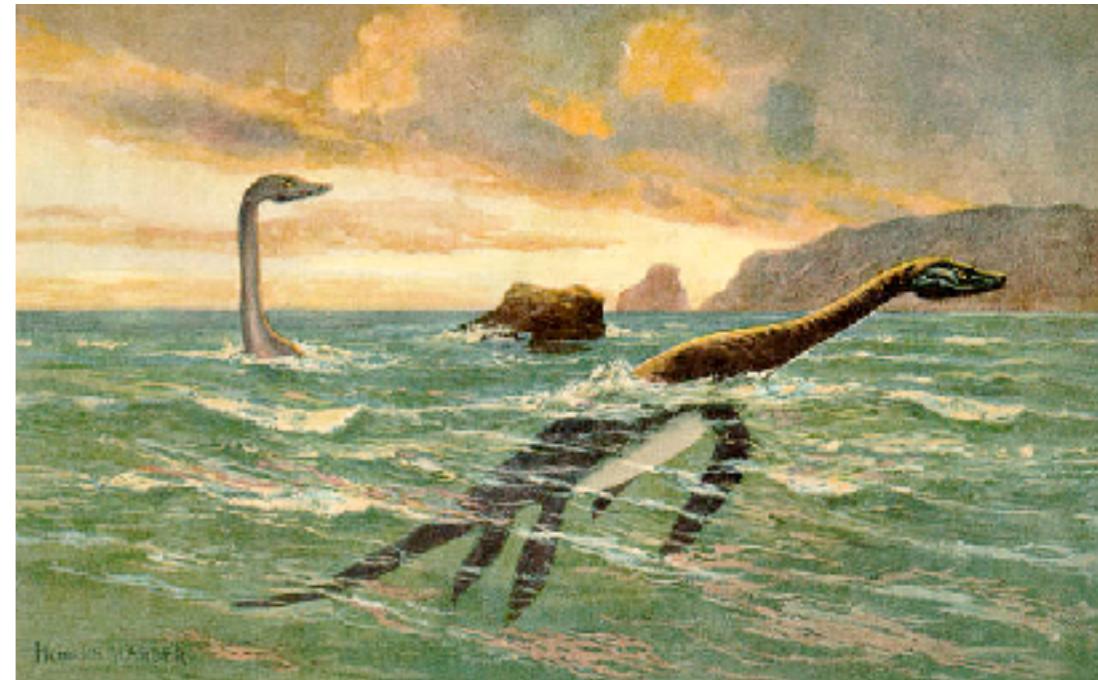
## Locomotion

Likely slow swimmers

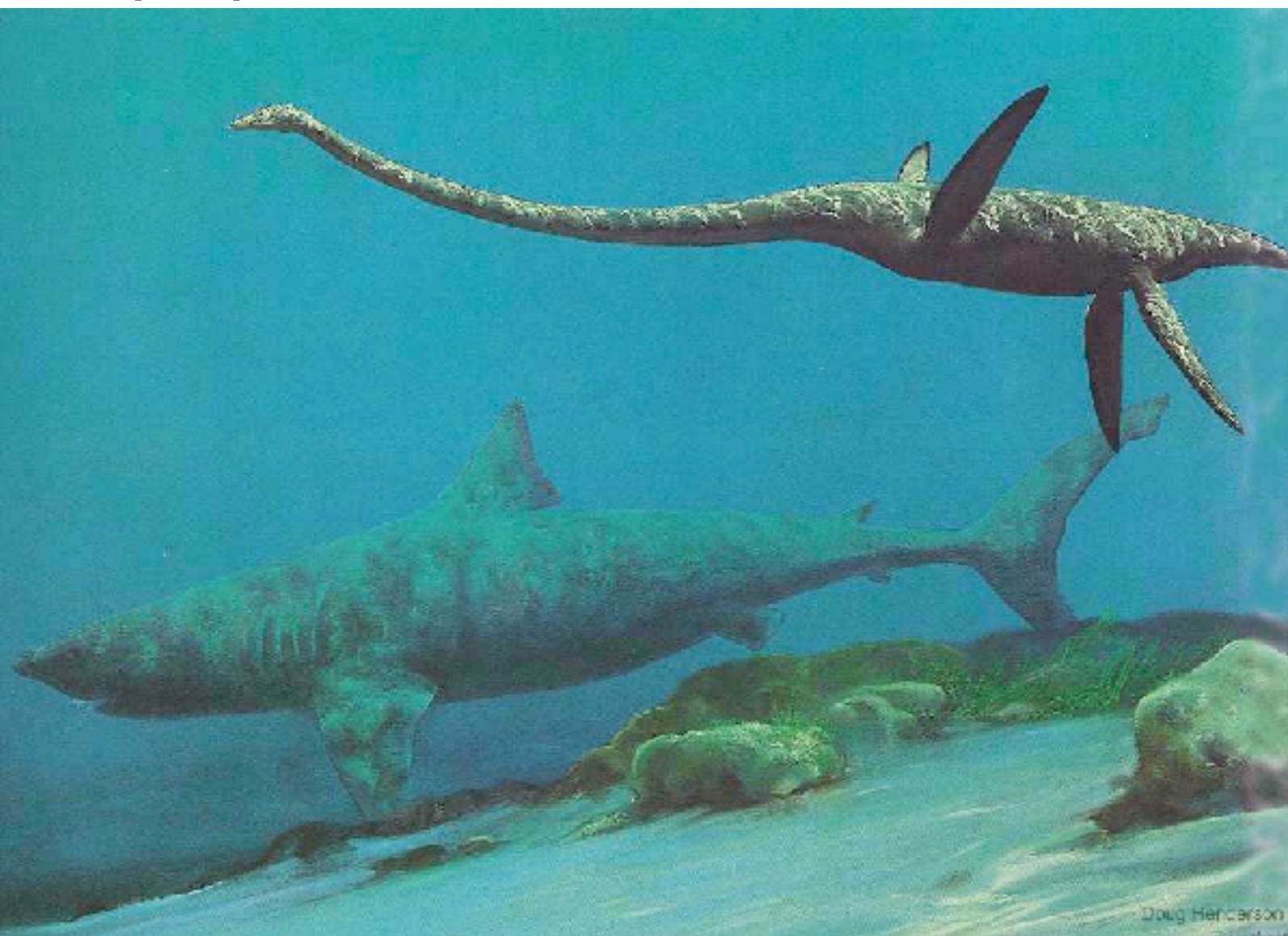
Cruised below the water surface and used long neck to grab prey from below

4-flipper setup would give them an amazing amount of maneuverability

Fins: propulsion



This would have been impossible



BBC One

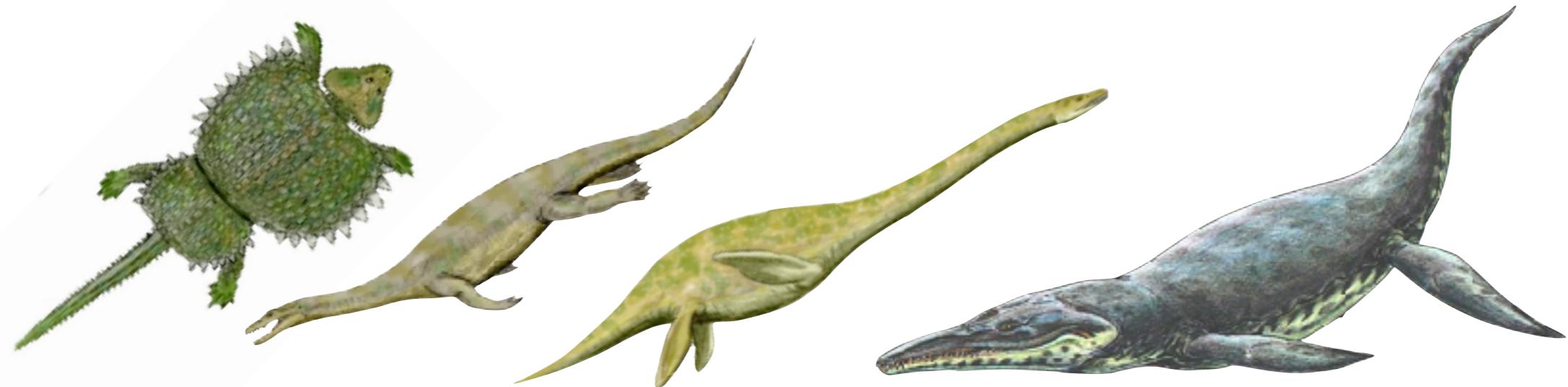
# Sauropterygians: Basal Diapsids

Diversified in the Triassic

Lepidosauria  
Sauropterygia



(Basal to Archosaurs)



Placodonts

Nothosaurs

Plesiosaurs

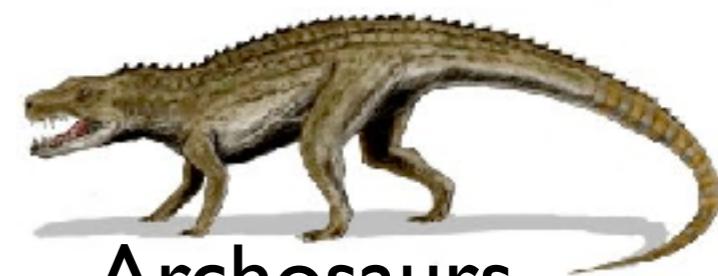
**Pliosaurs**

Icthyopterygia

Modern lizards

Lepidosauramorpha

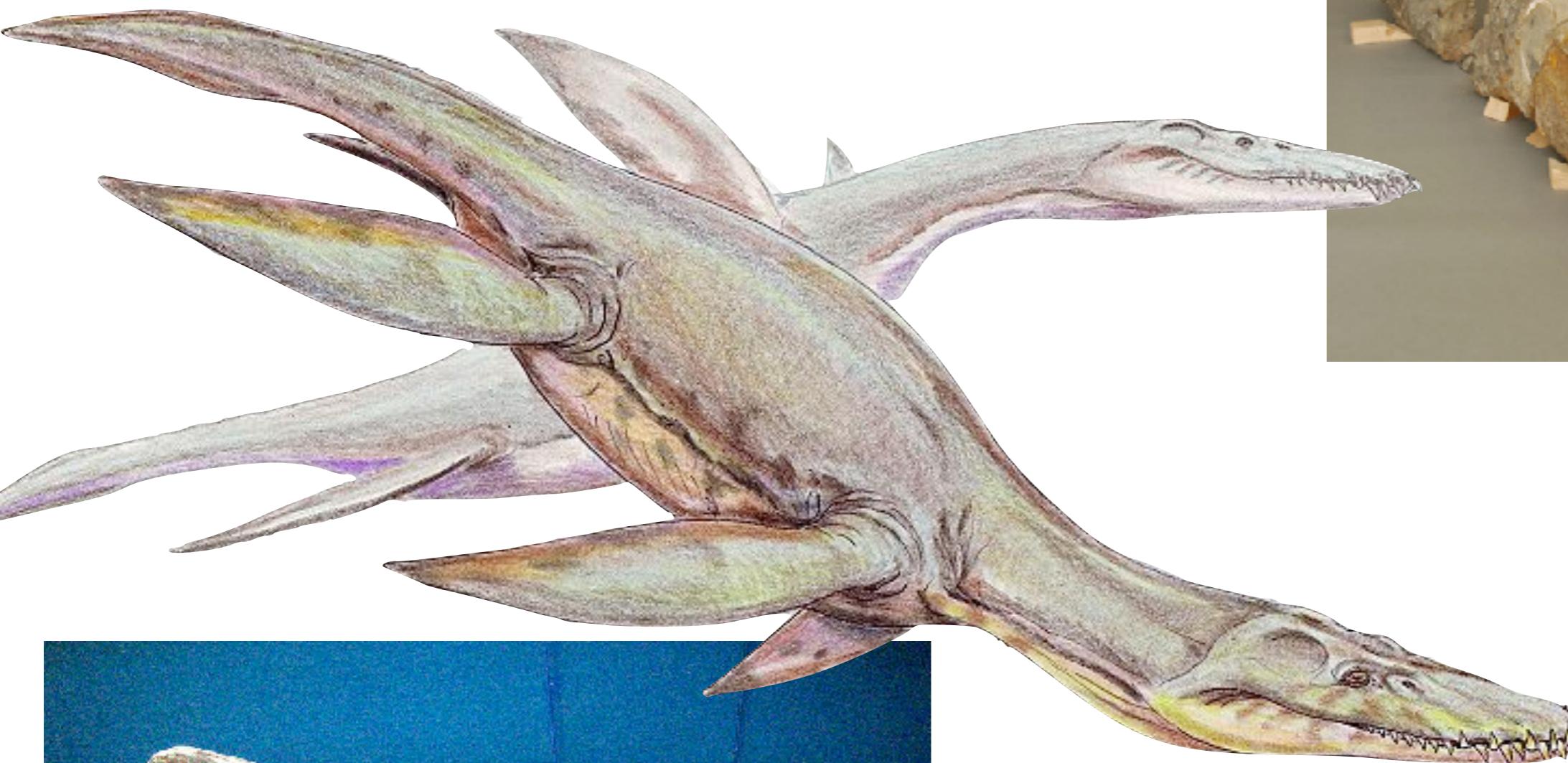
Sauropterygia



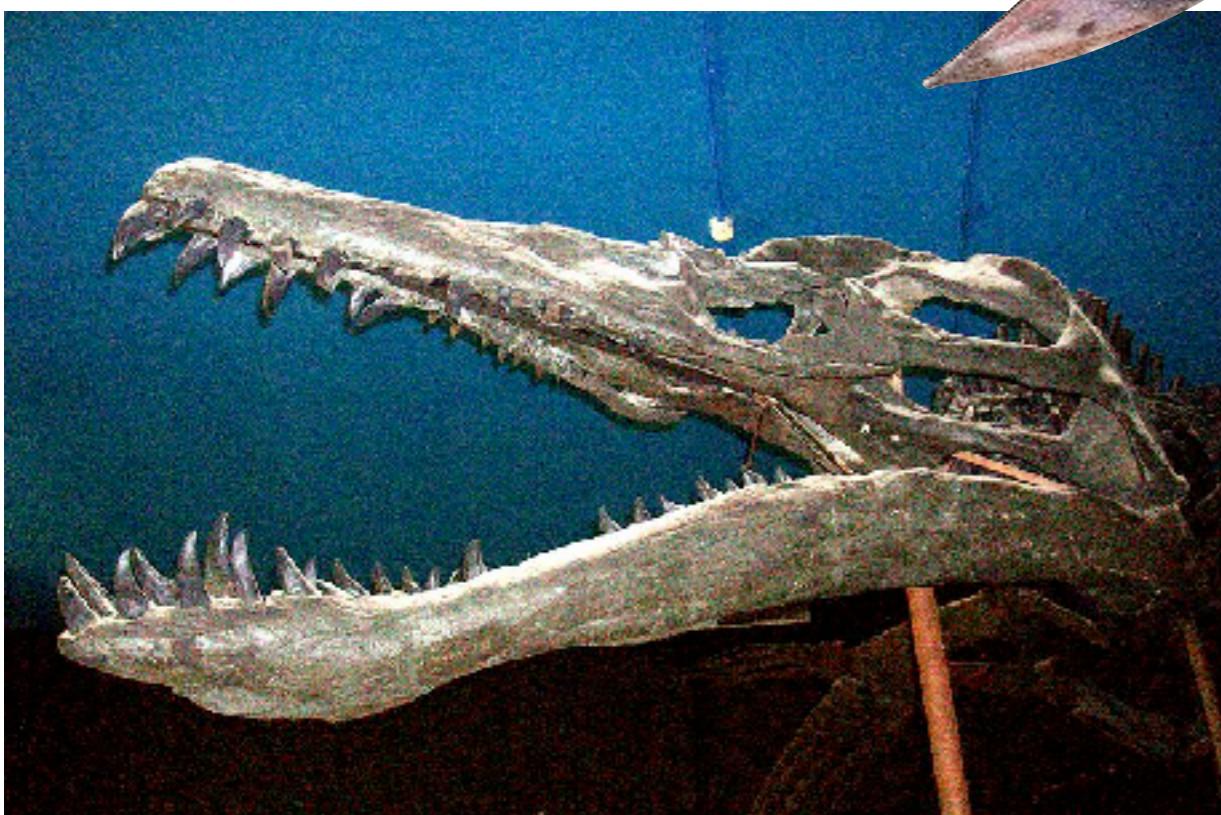
Archosaurs

# Pliosaurs

## APEX predators



A Pliosaur jaw



# Pliosaurs

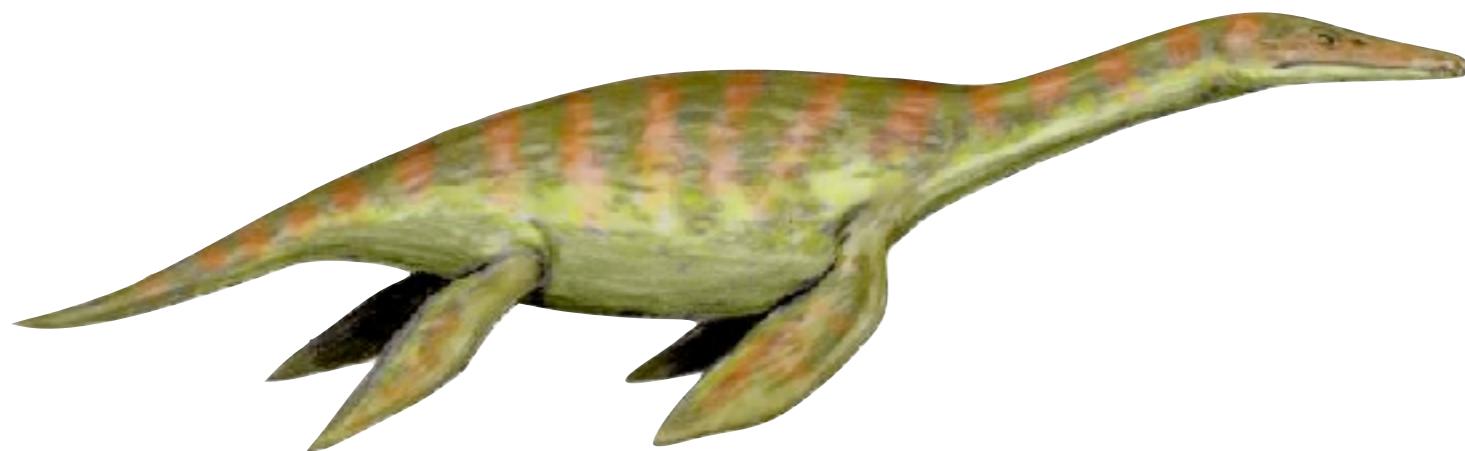
Whales of the Mesozoic!

Up to 40 feet in body length

The skull was 1/3 of this length!

Large and faster than Plesiosaurs

Large, conical teeth



TOR SONGA, BT

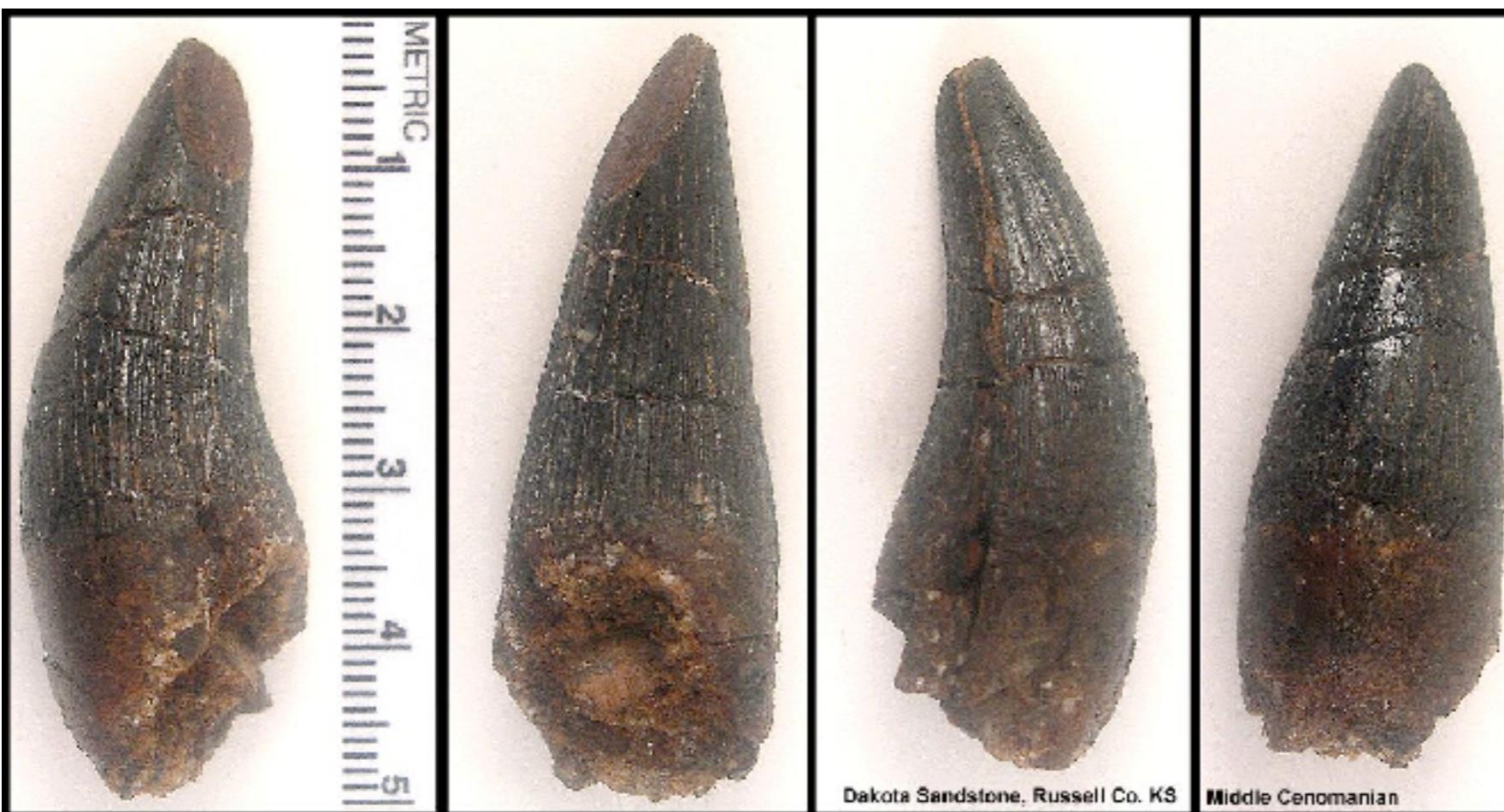
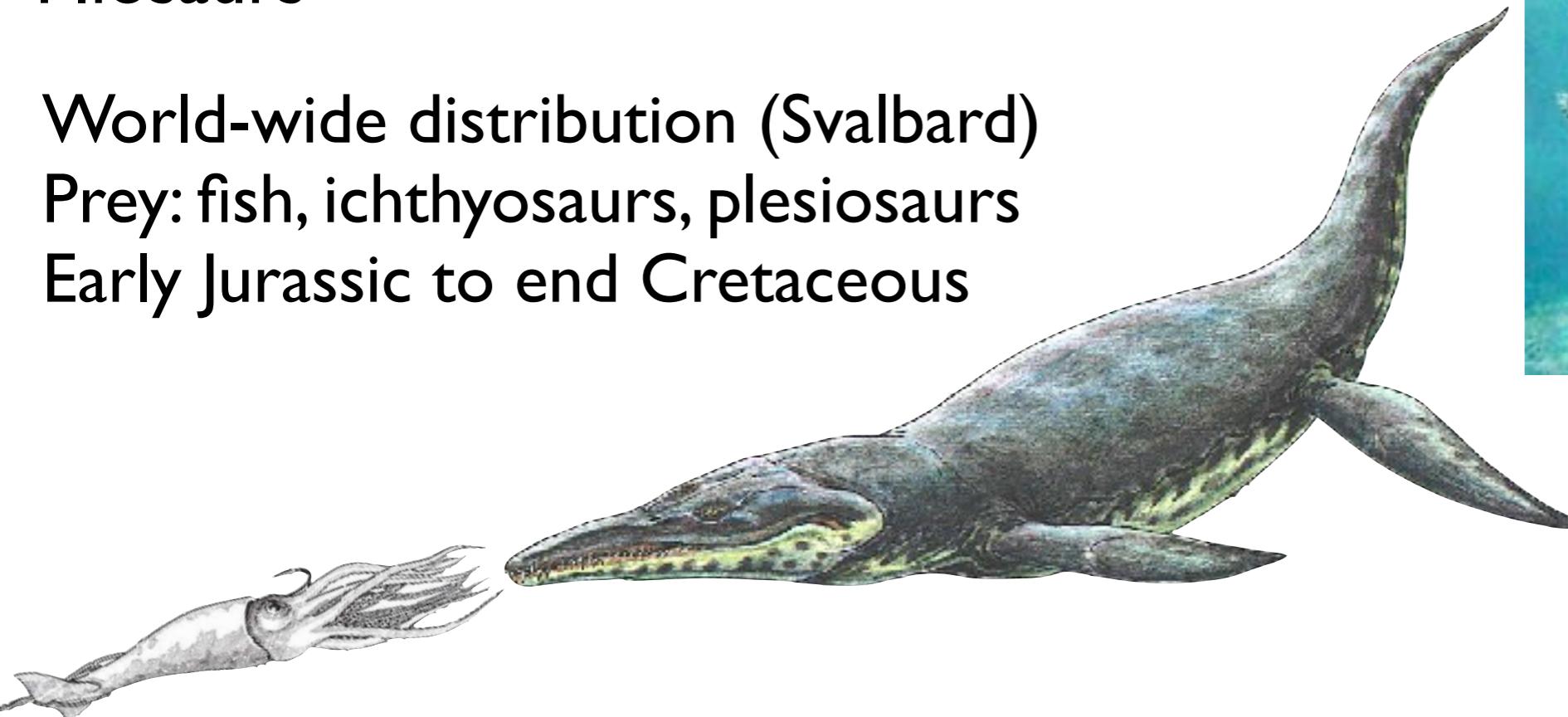


# Pliosaurs

World-wide distribution (Svalbard)

Prey: fish, ichthyosaurs, plesiosaurs

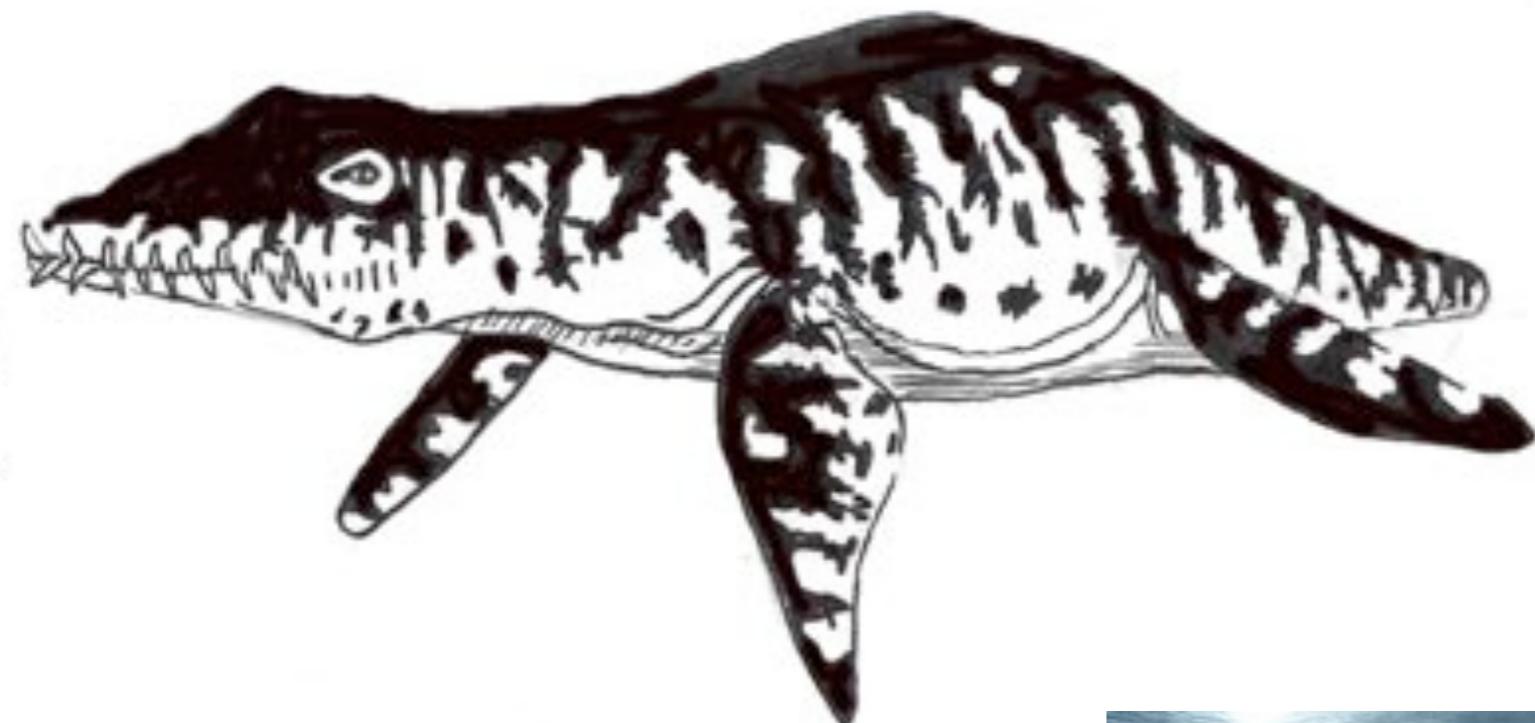
Early Jurassic to end Cretaceous



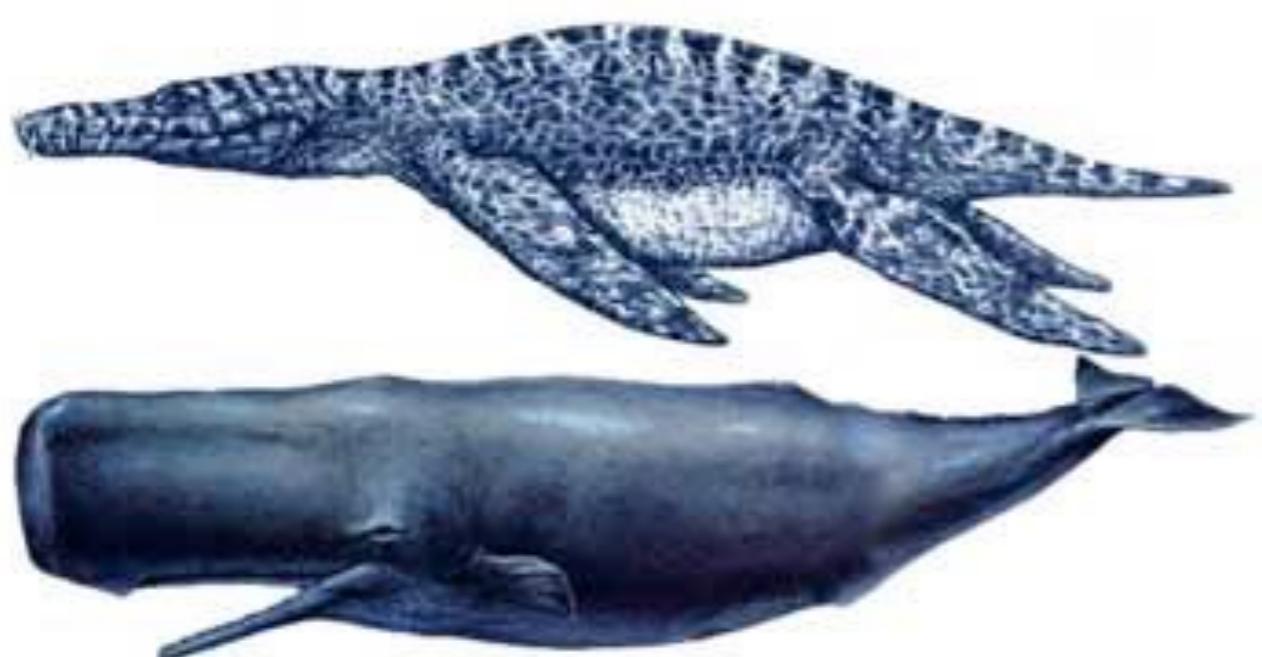
# Pliosaurs



# Liopleurodon



Serrated Portion.





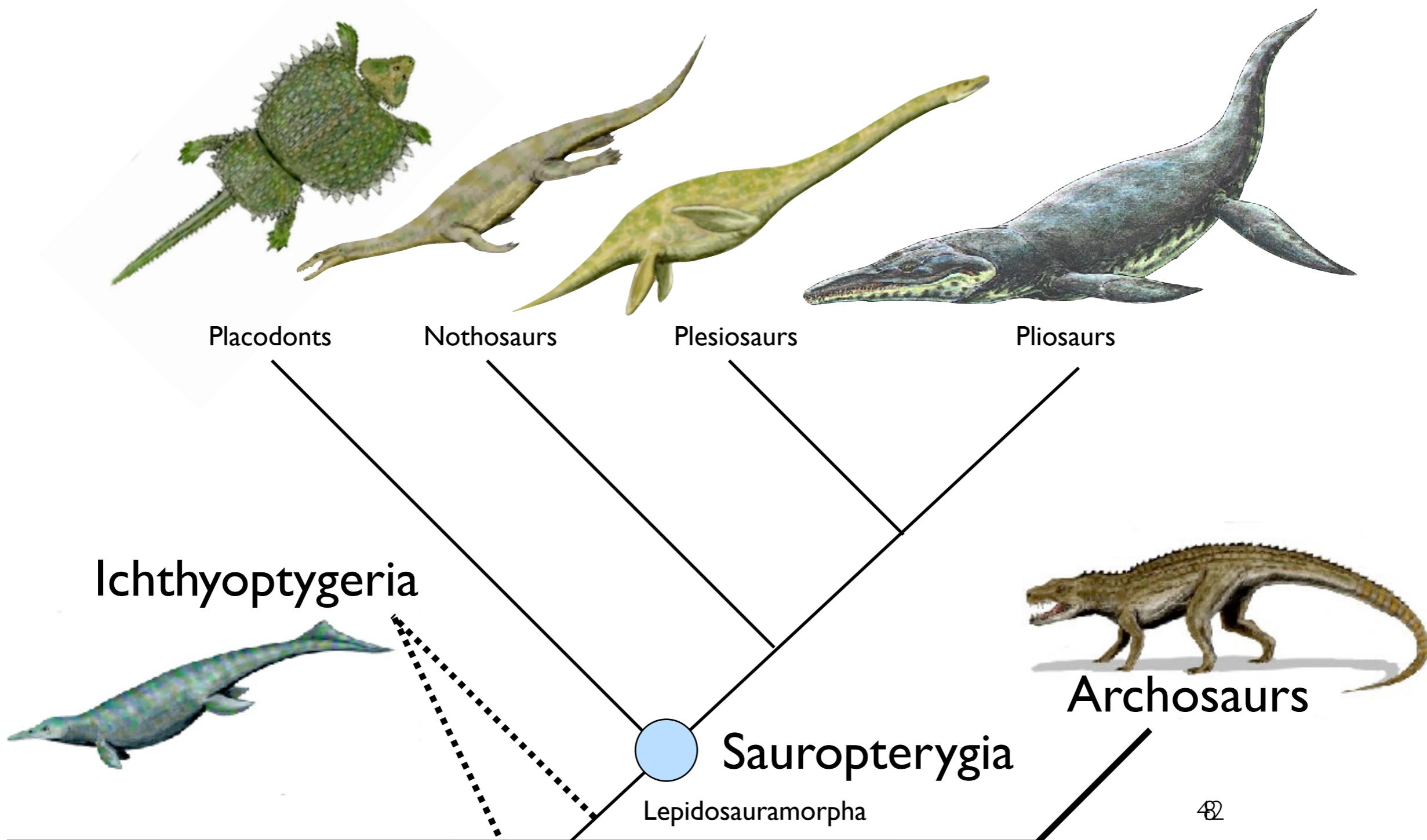


# Ichthyosaurs: Basal Lepidosaurs or sister taxa?

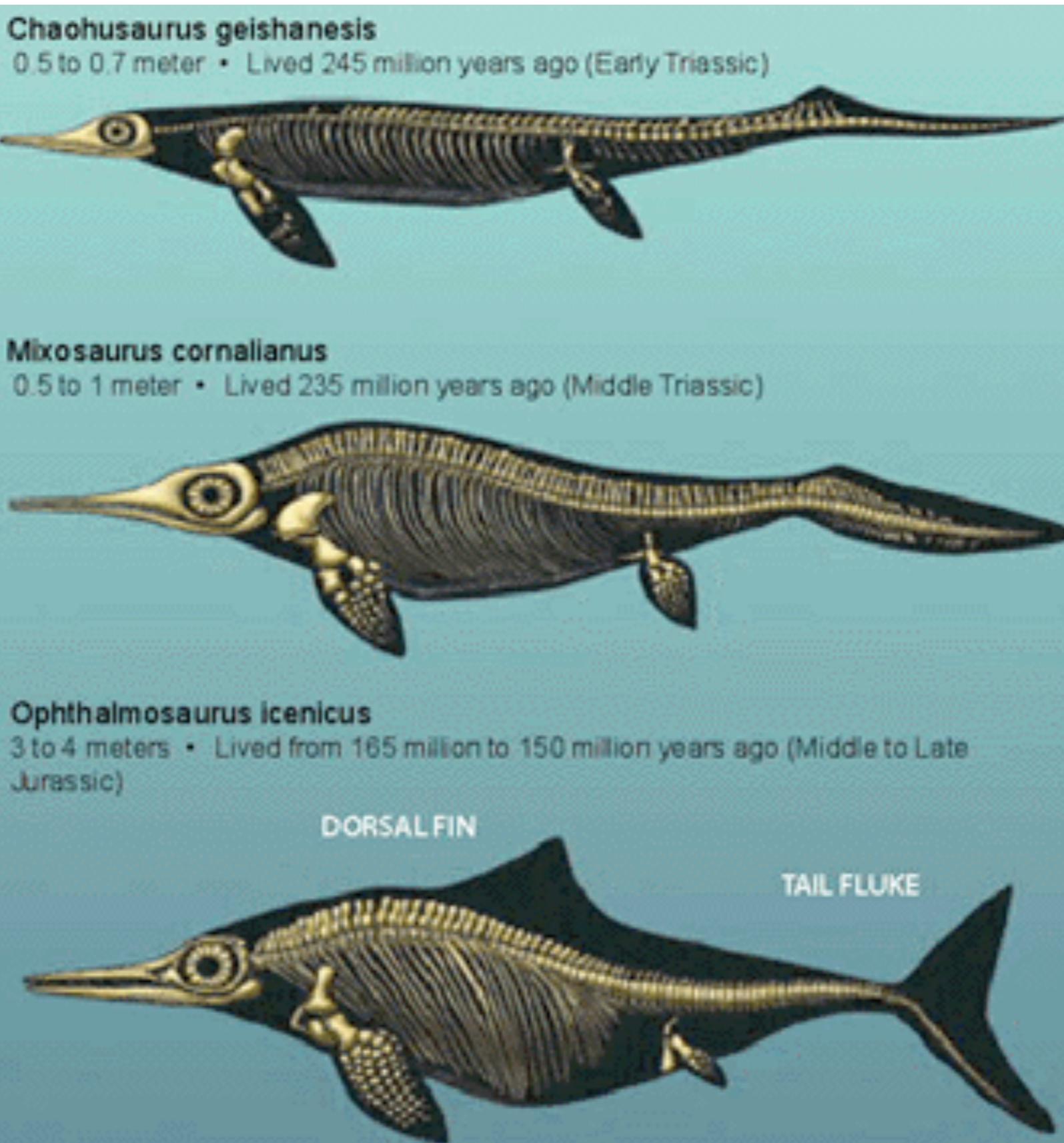
Lepidosaurs

Lepidosauria

Sauroptrygia

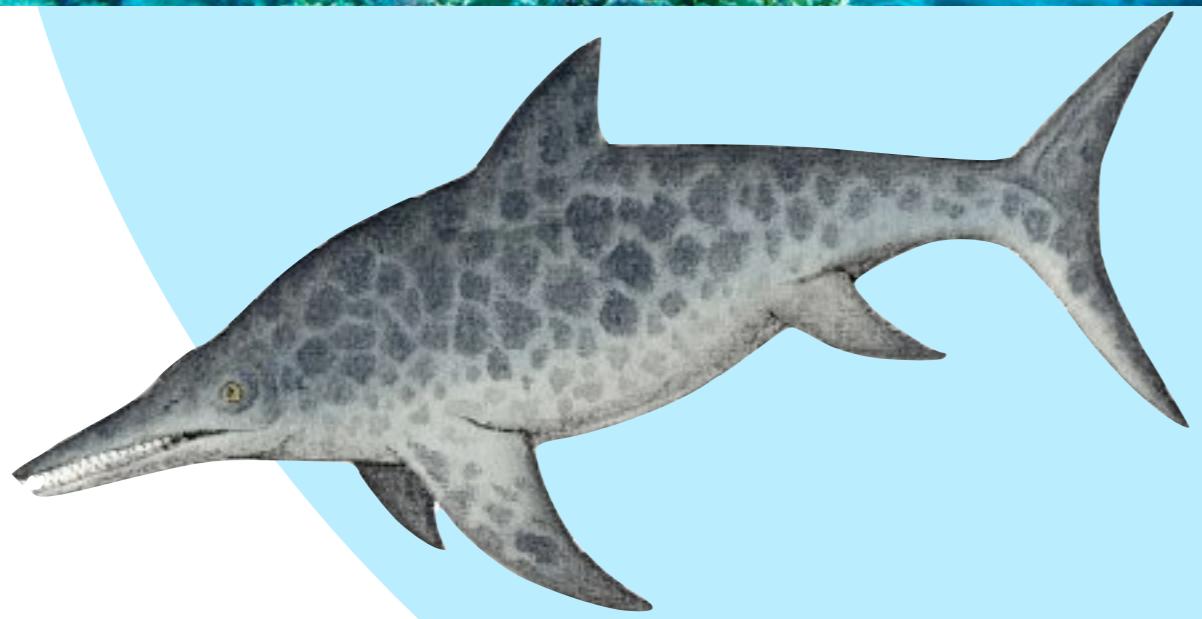
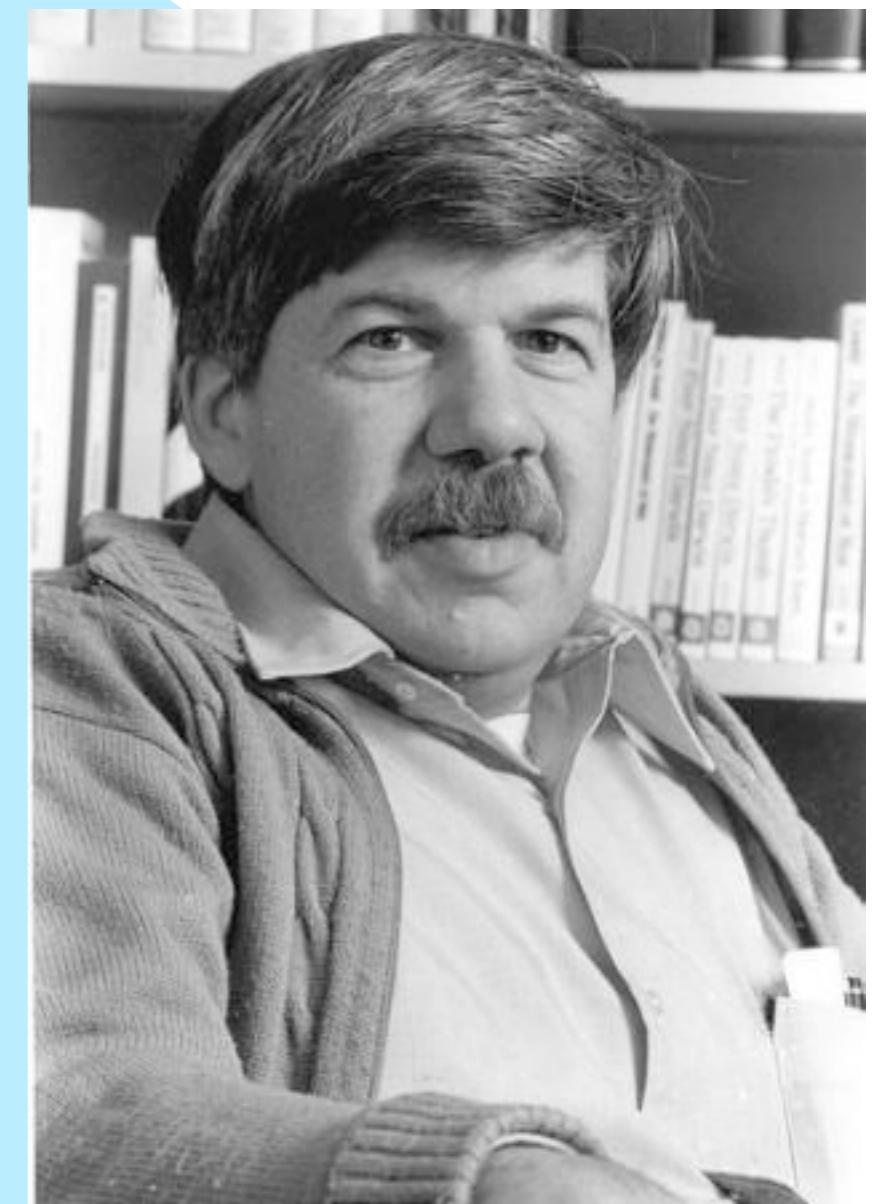


# Ichthyosaurs





©2009 Tahoe Art on Demand



Convergent Evolution!

The dorsal fin evolved in exactly the right place for maximal hydrodynamic efficiency in fish, ichthyosaurs, & dolphins... the power of selection

# Ichthyosaurs

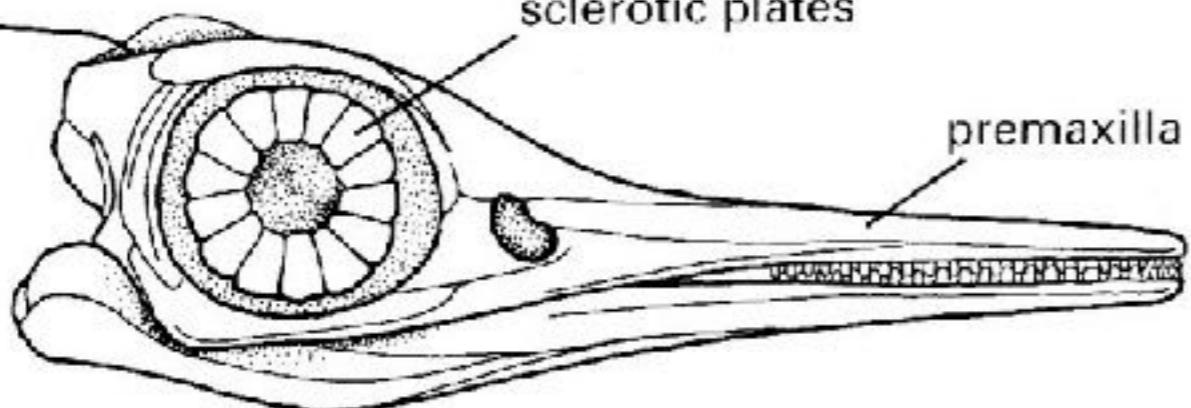
upper  
temporal  
opening

sclerotic plates

premaxilla

100 mm

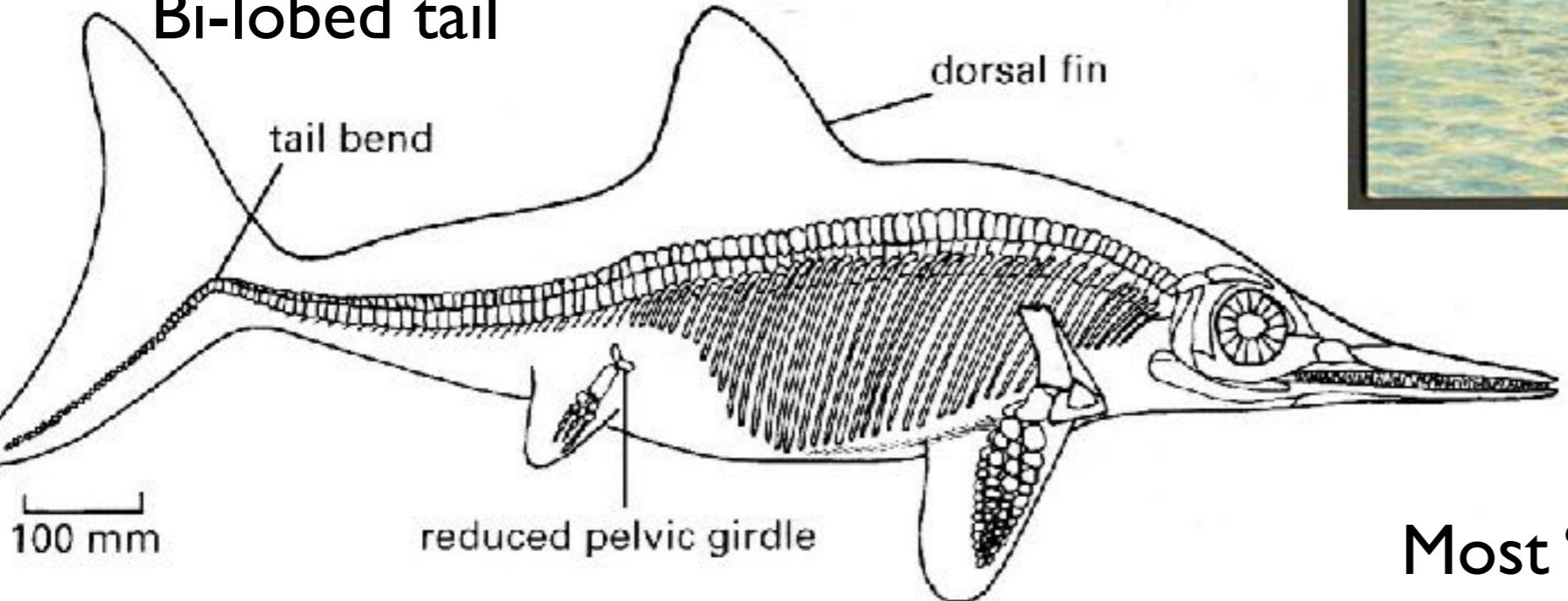
(a)



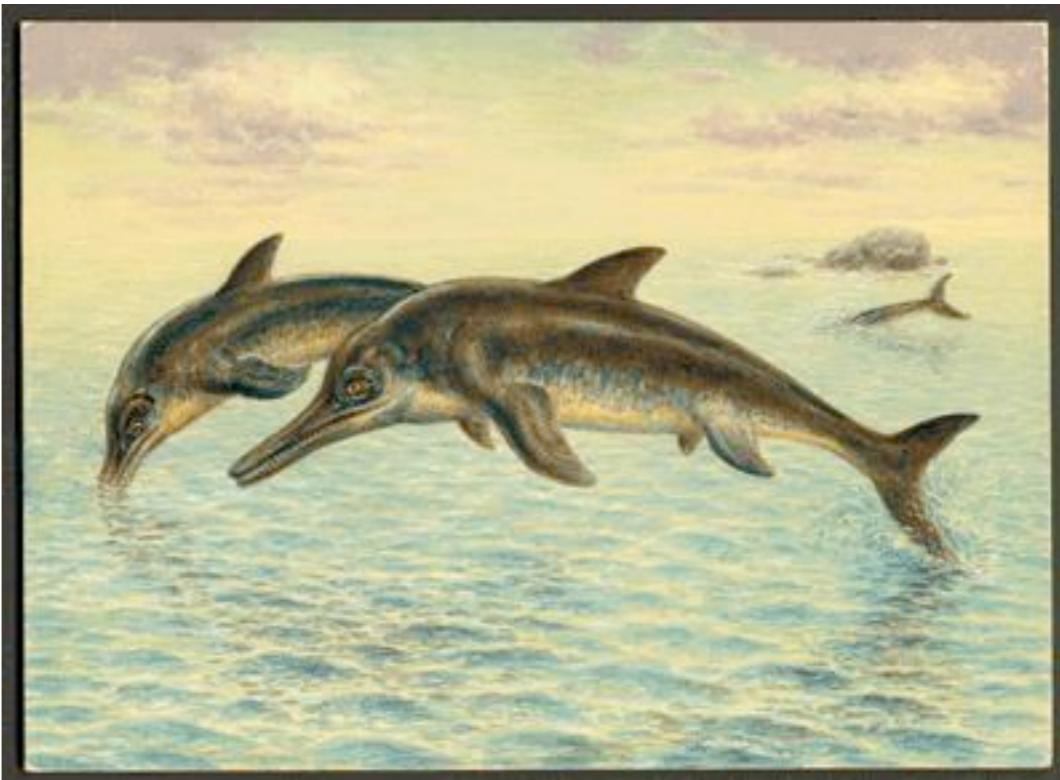
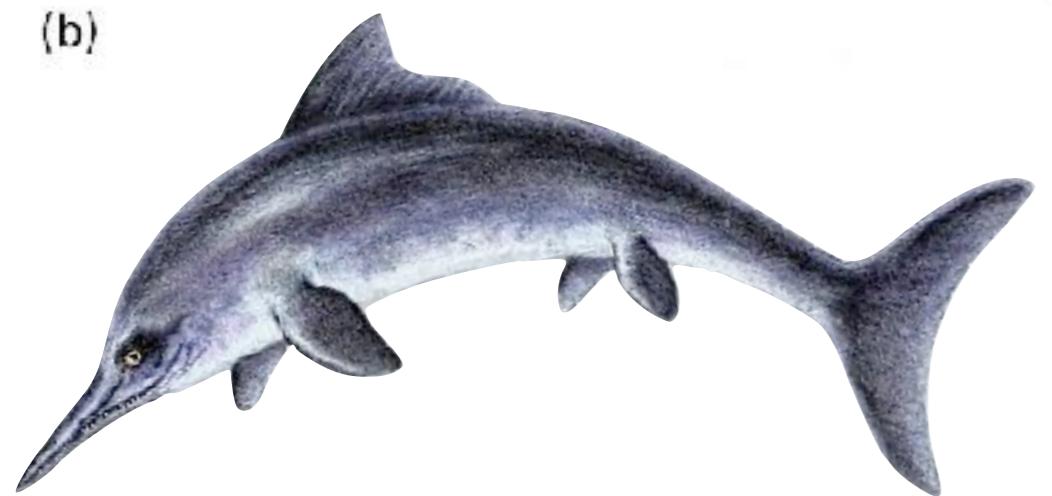
Bi-lobed tail

tail bend

dorsal fin



(b)



## Attributes:

Most 'fish-like' marine reptile

Earlier forms had longer bodies

Cretaceous forms are more dolphin-like

Up to 85 ft in length!

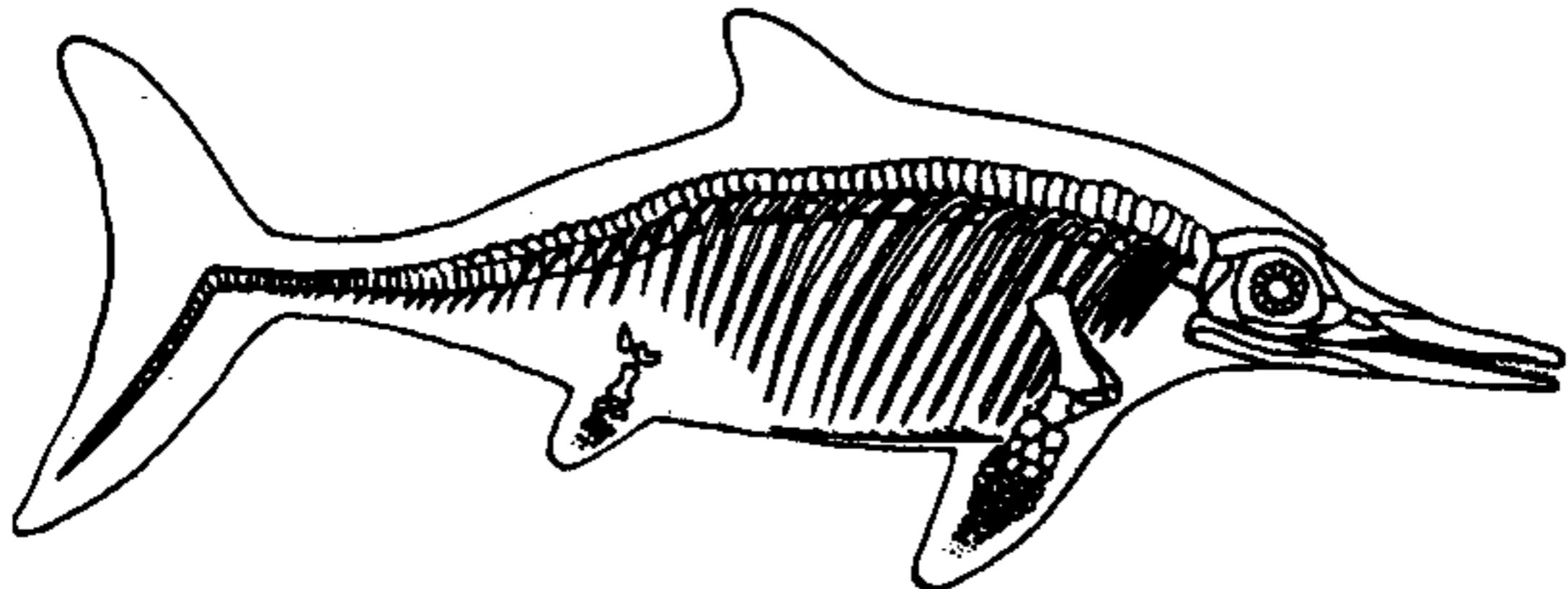
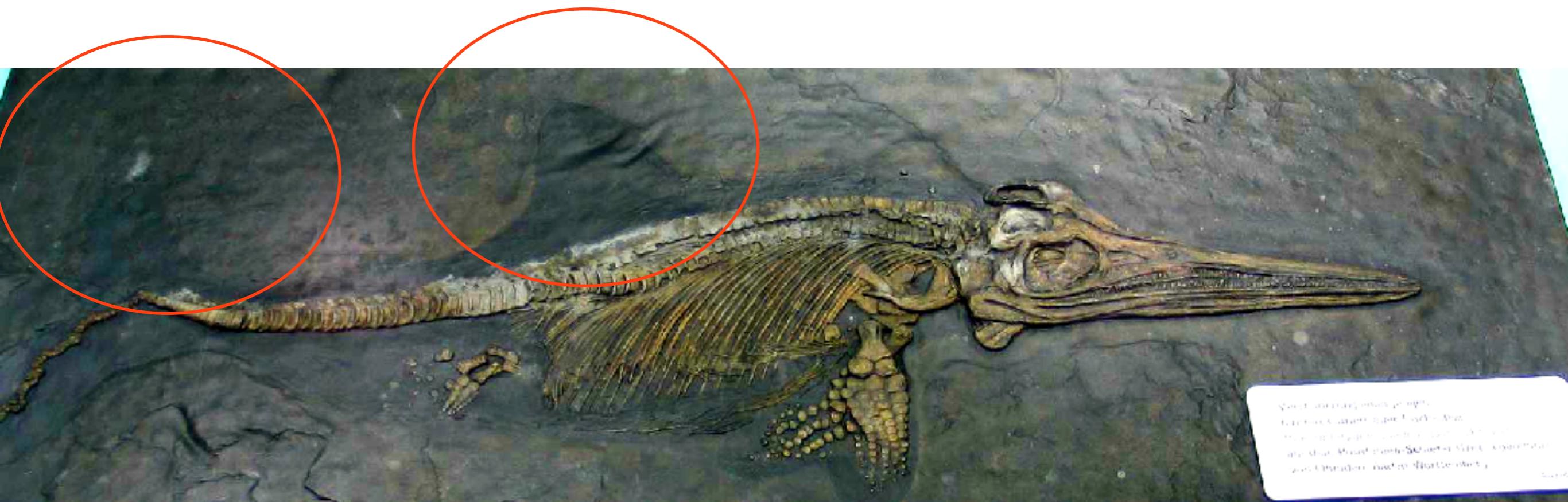
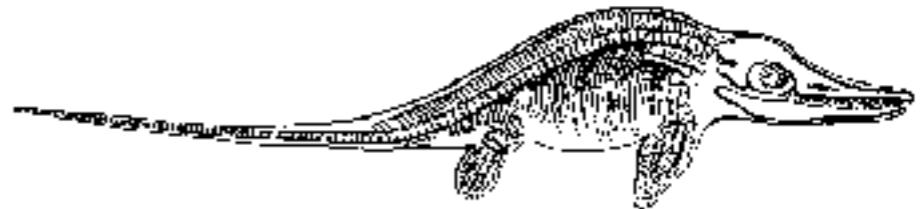
Forelimbs modified into flippers

Reduced hindlimbs, reduced pelvic girdle

Ventrally-tipped tail and dorsal fin

46

# Fossil evidence for soft anatomy: Germany



## Attributes:

World-wide distribution

Specialized pursuit predators

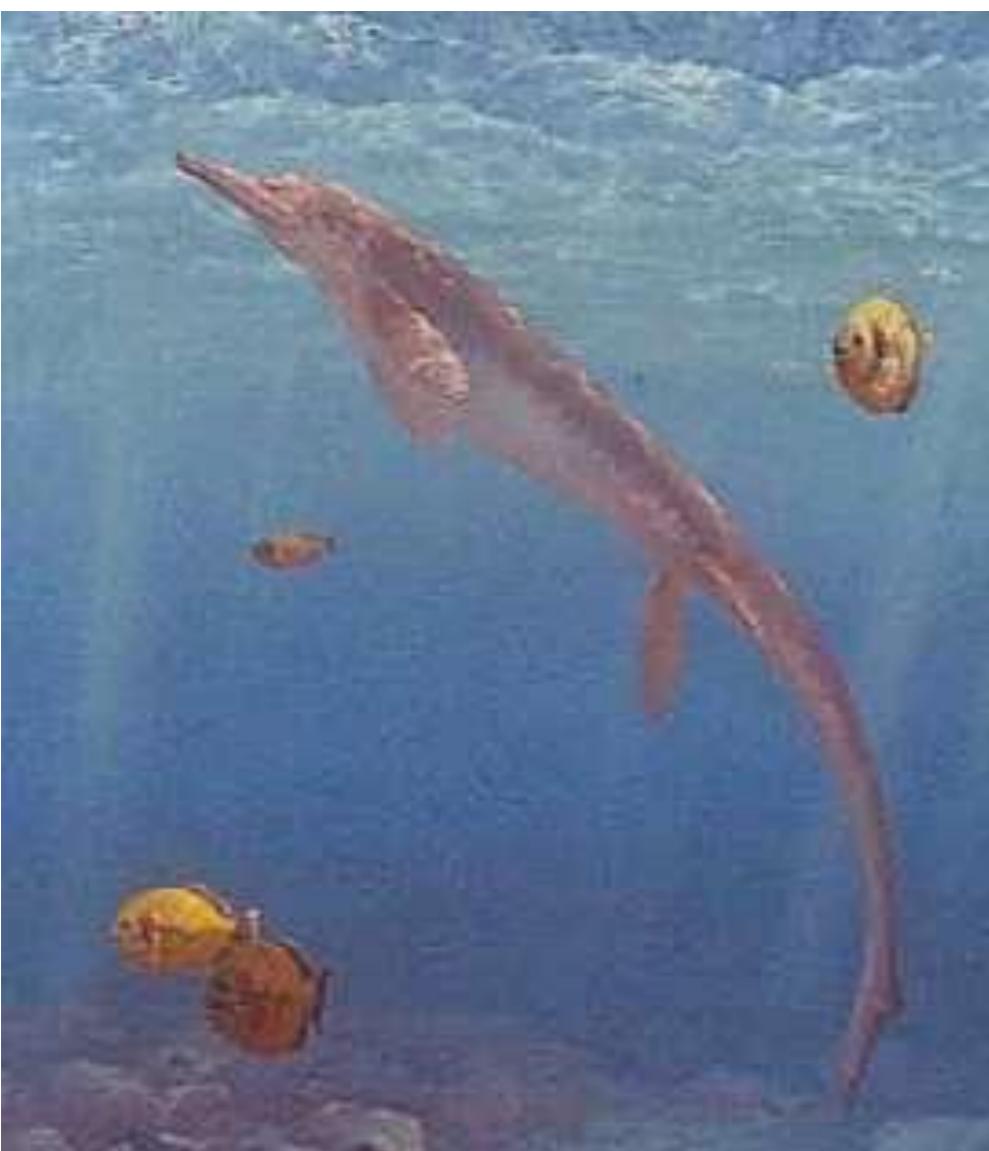
Likely a very similar ecology as modern dolphins

Fins were not used for propulsion, but for directional control & stability



2 main styles of locomotion:

I. Slow-moving, ambush predators

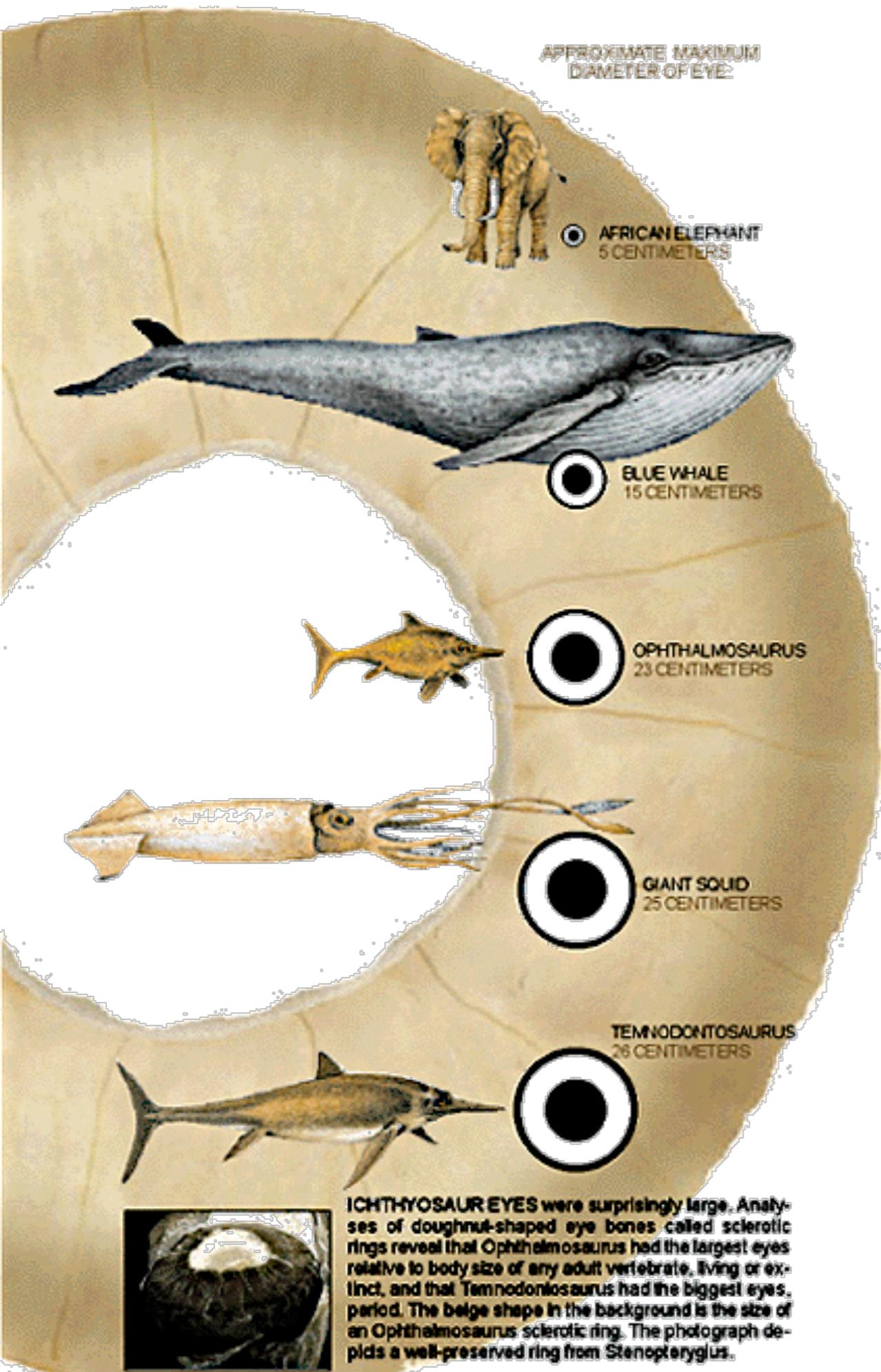


2. Fast-moving pursuit predators  
up to 25 mph





Their similarity with tuna, dolphins, suggests that they occupied a similar ecological niche. This has led some people to believe that they could have been endothermic (Tuna are also endothermic)



## Ichthyosaur EYES

- Largest eyes of any animal
- Eyes are sized by measuring the sclerotic rings
- Large eyes are needed for hunting prey at great depths~ probably similar to elephant seals and sperm whales



## Ichthyosaur Reproduction

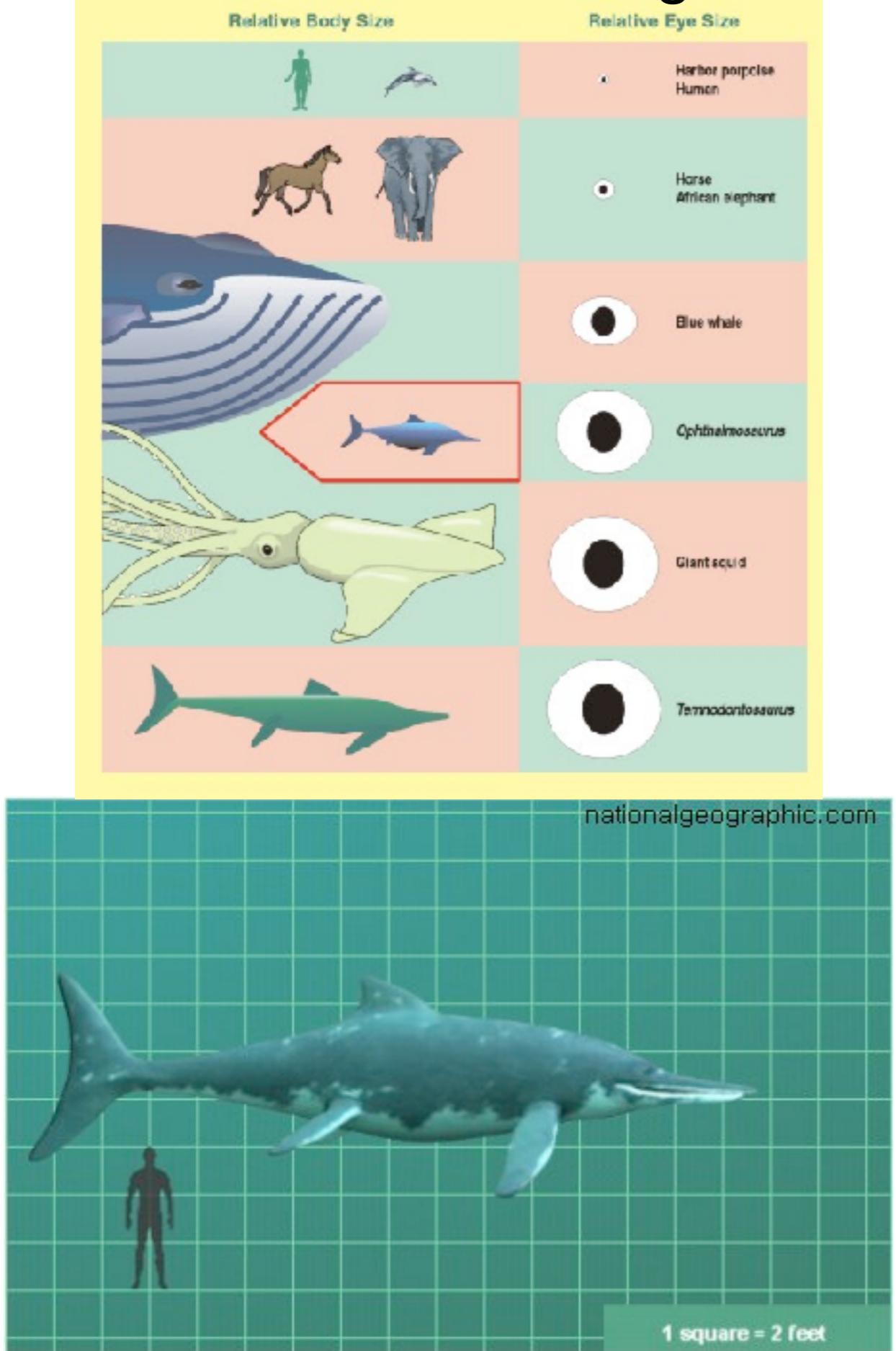
Although they evolved from egg-laying ancestors, Ichthyosaurs were **Viviporous** (gave birth to live young)

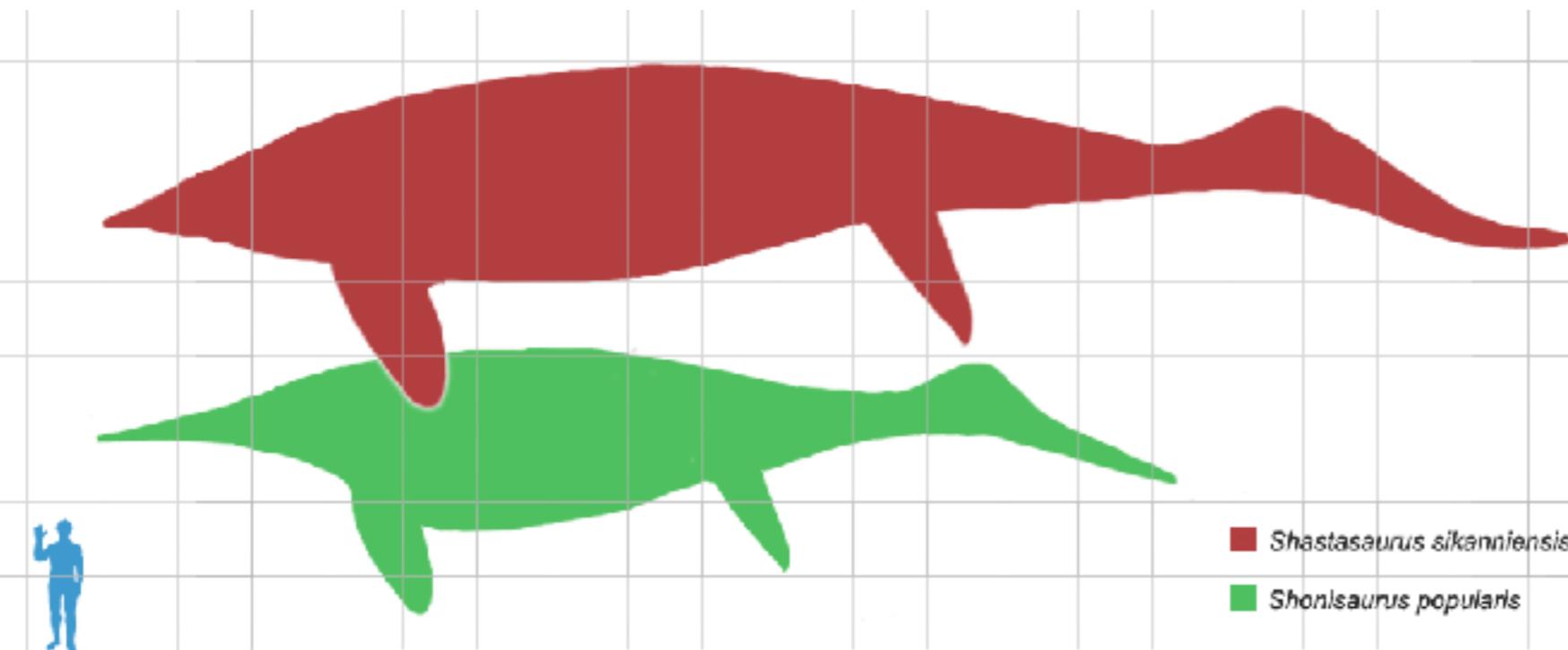
A divorce from the mainland was inevitable, given their marine adaptations



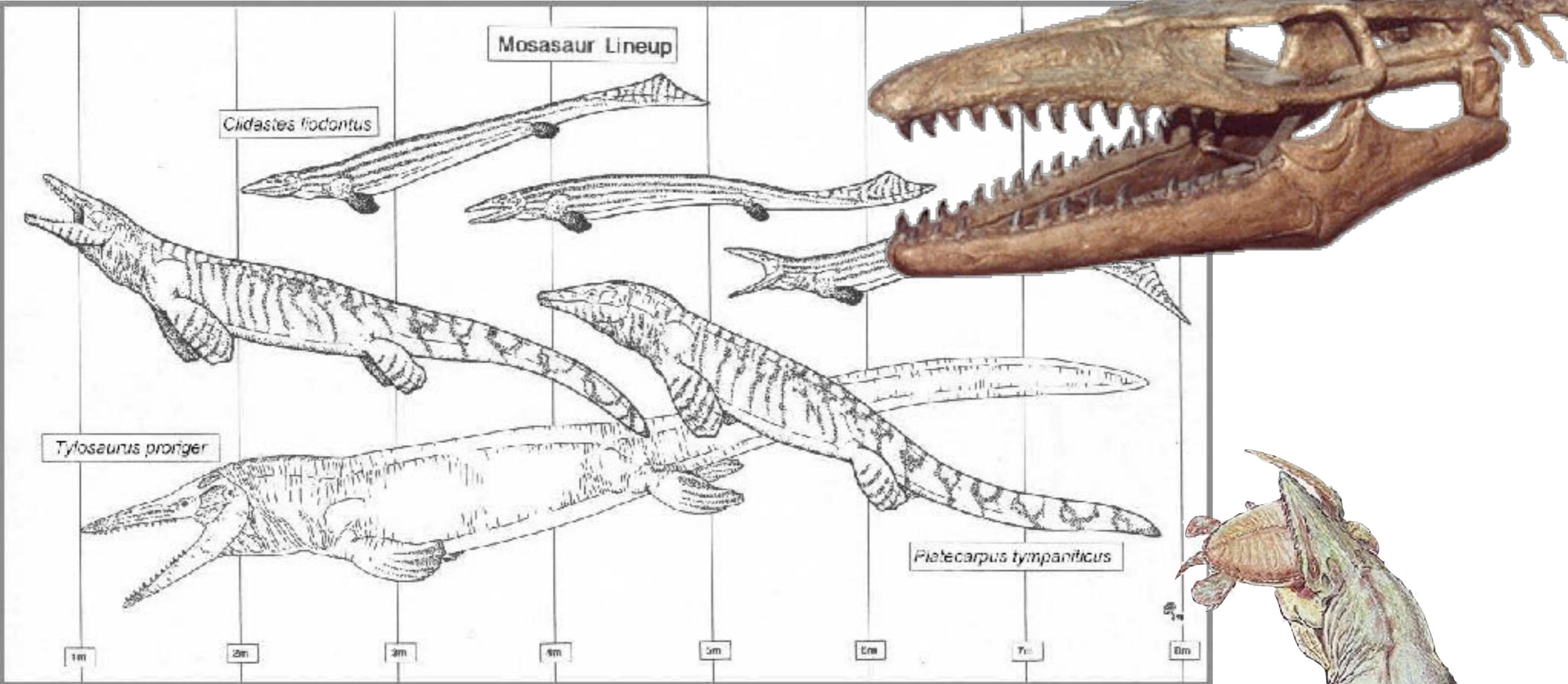
Young were born tail-first, similar to modern whales!

# *Temnodontosaurus*: the 'largest' Ichthyosaur

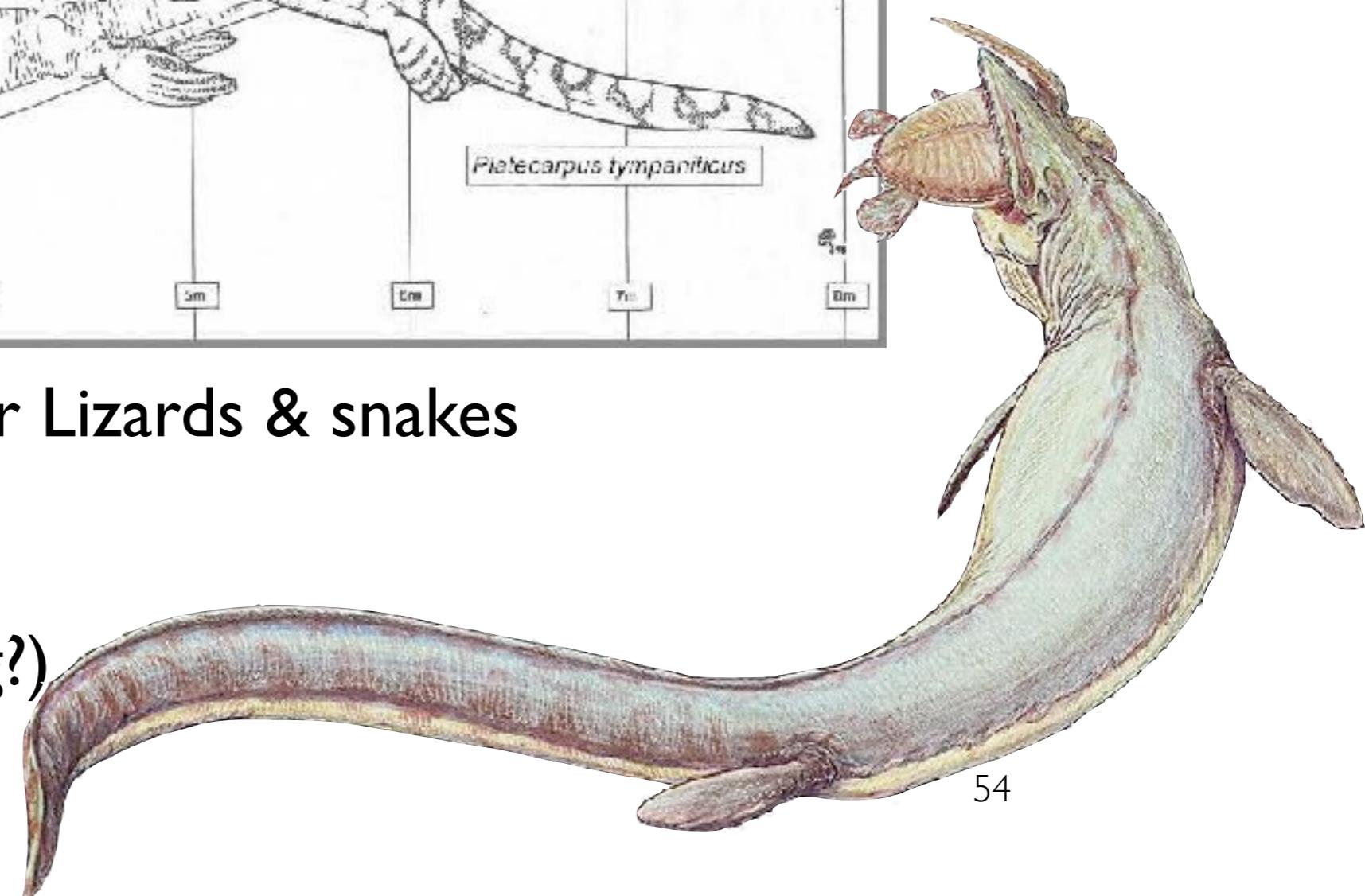




# Mosasaurs!



Closely related to Monitor Lizards & snakes  
5 to 45 feet long  
Long and slender  
Blunt snouts (for ramming?)  
Large eyes, stout teeth  
APEX predator

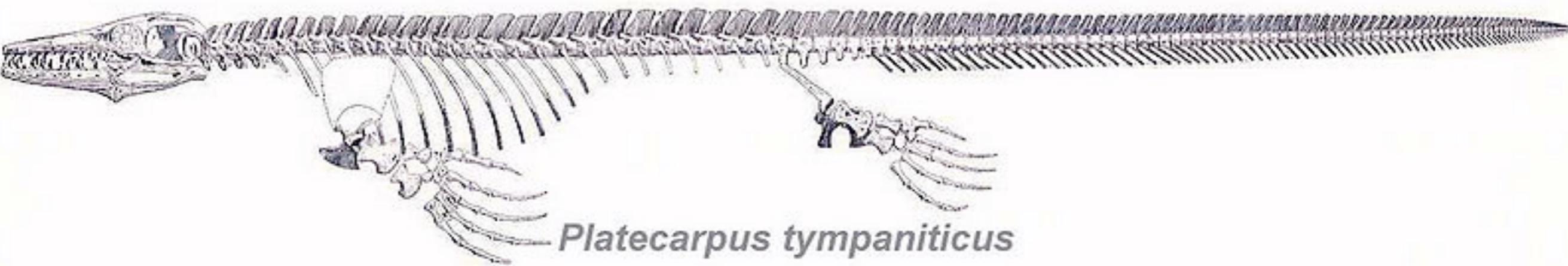


# Mosasaurs!

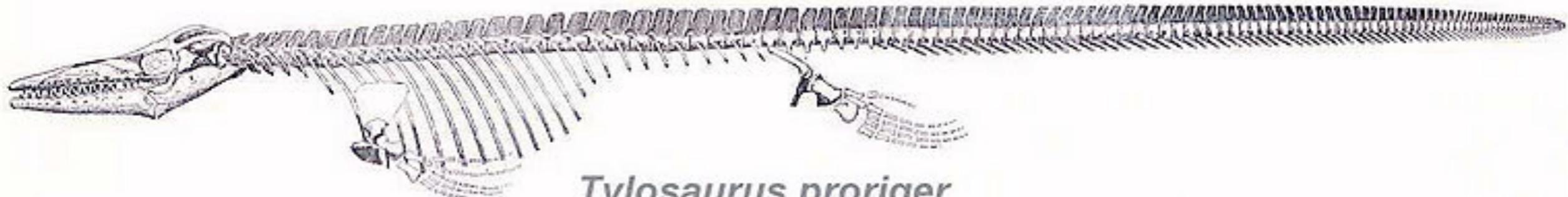
Early to late Cretaceous  
Superseded Ichthyosaurs and Pliosaurs as the  
dominant Apex Predators



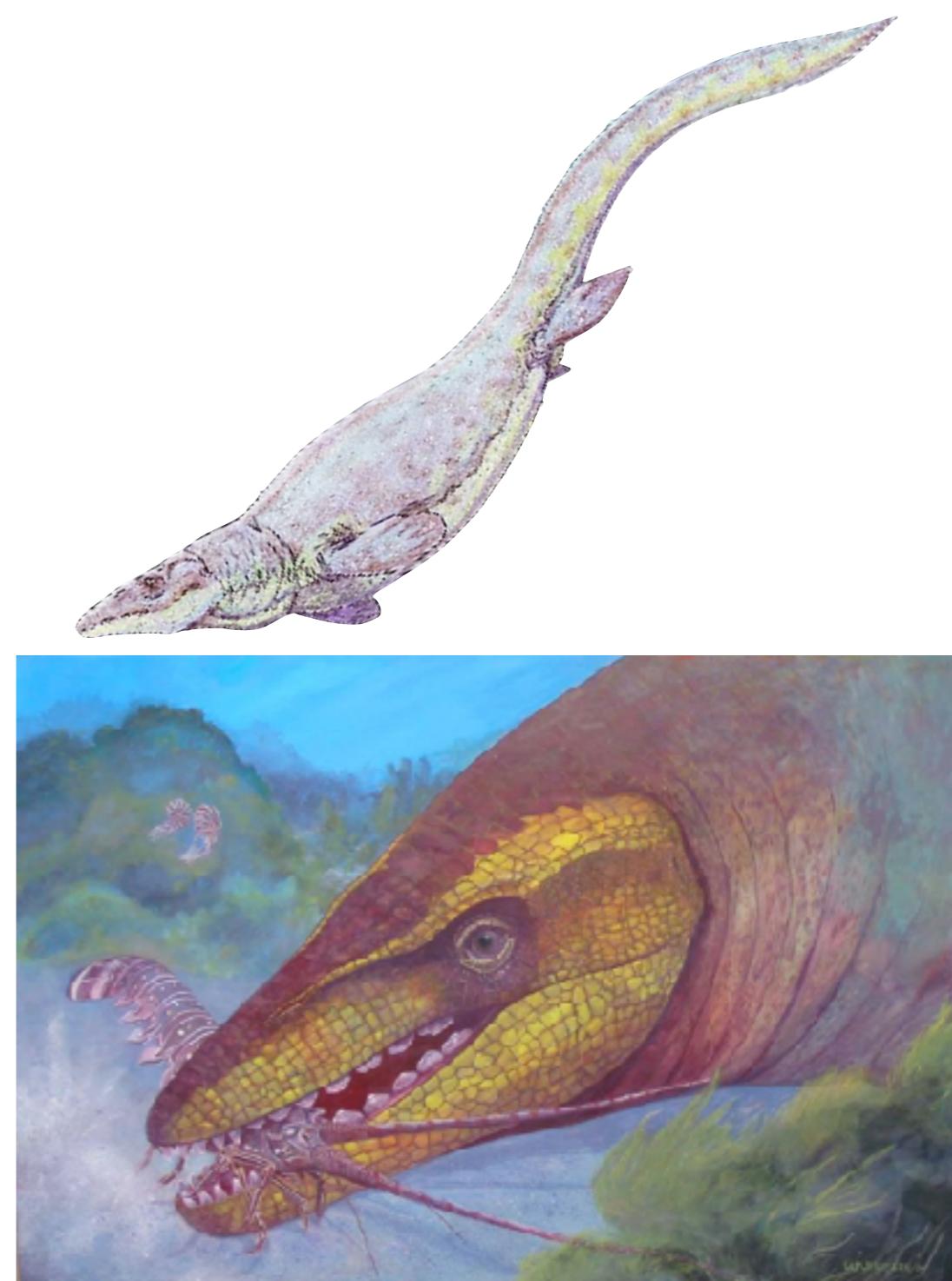
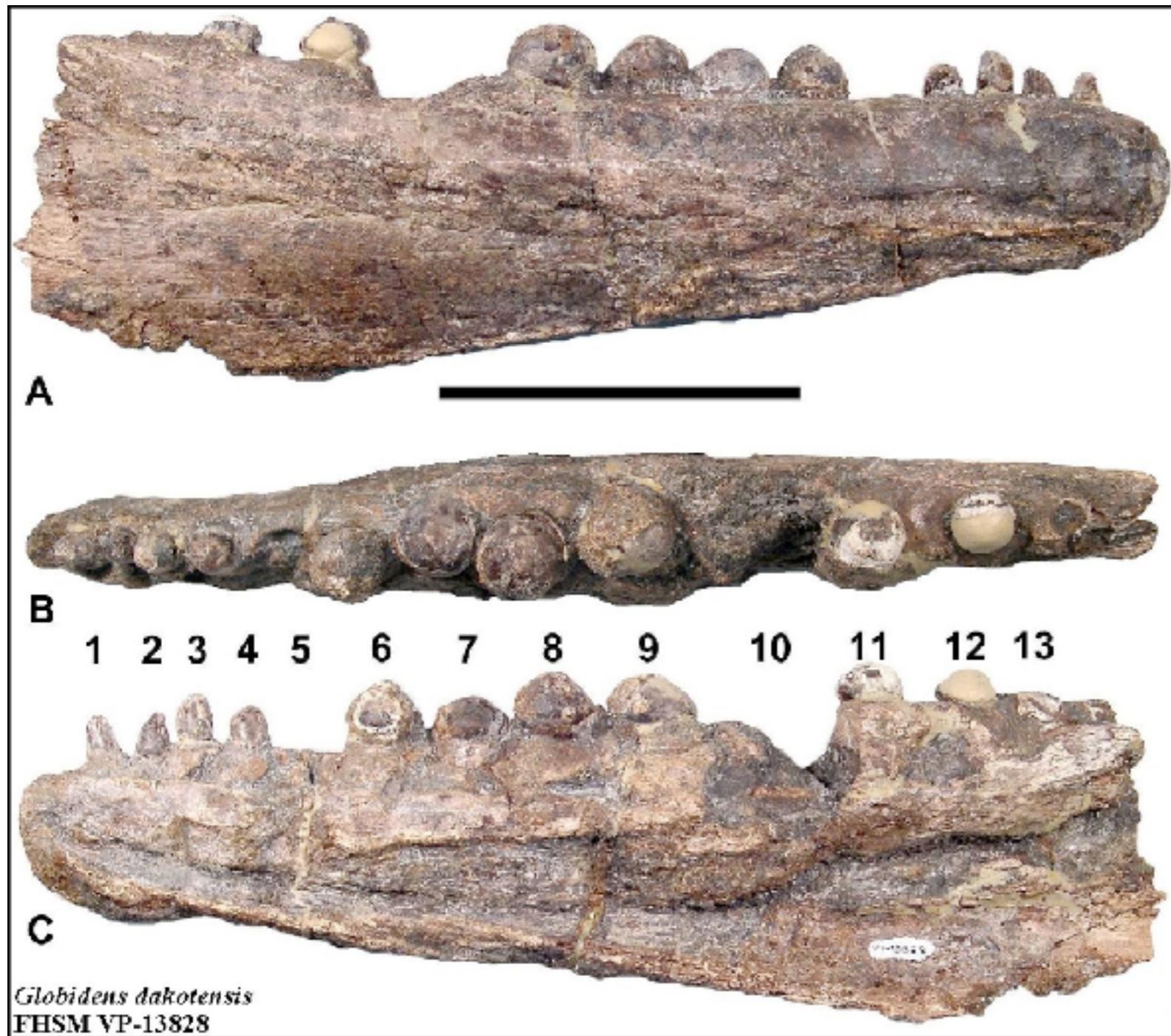
*Clidastes propython*



*Platecarpus tympaniticus*



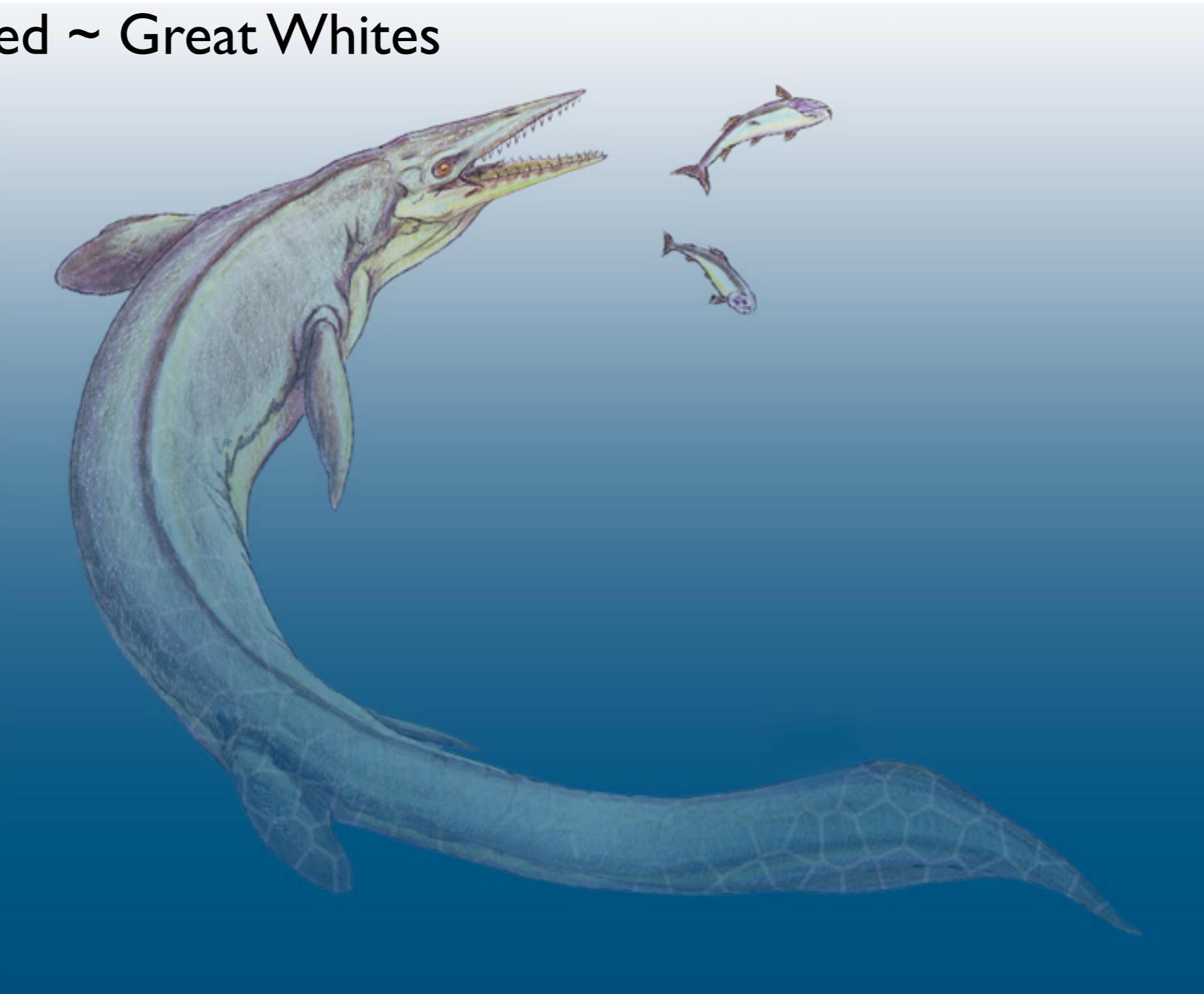
*Tylosaurus proriger*



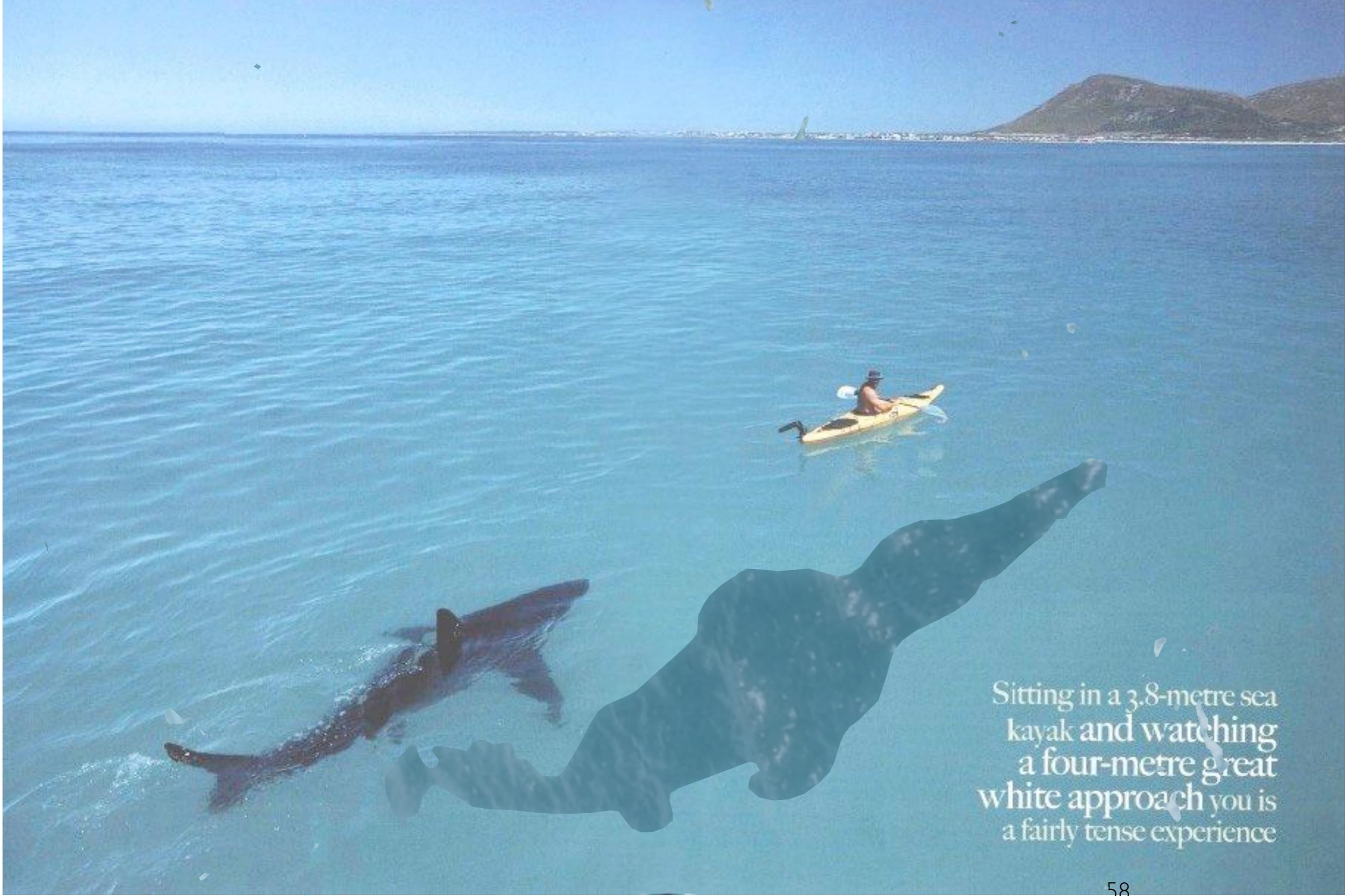
*Carinodens & Globidens*: smallest, earliest mosasaurs (11 ft)  
 Likely ate mollusks, small to medium arthropods  
 ~ Shell crackers (blunt teeth)

# Mosasaurs!

Its body plan suggests that it stalked prey, attacking in short, powerful bursts of speed ~ Great Whites

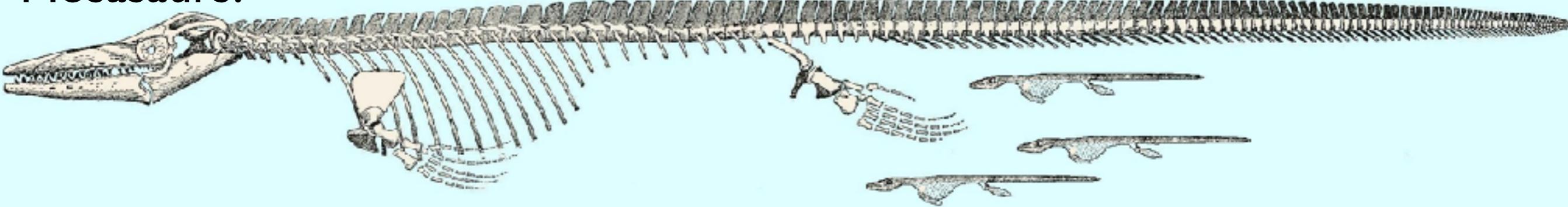


# Mosasaurs!



Sitting in a 3.8-metre sea kayak and watching a four-metre great white approach you is a fairly tense experience

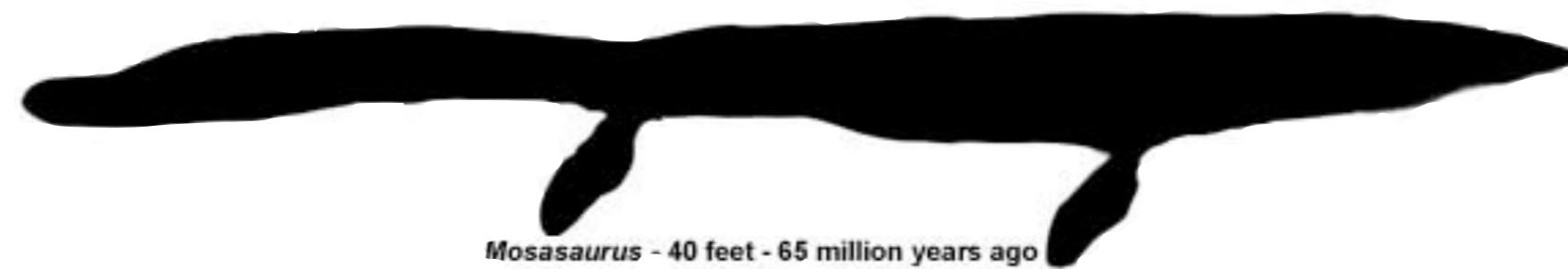
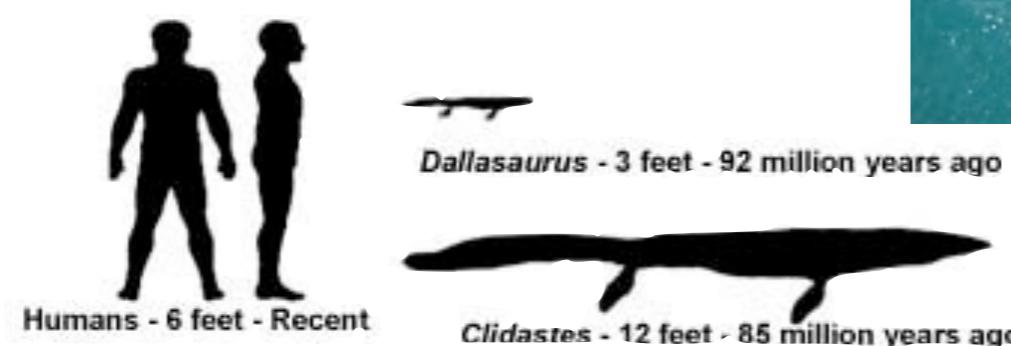
# Mosasaur!



*Derived Mosasaurs had double-hinged jaws ~ allowed them to swallow prey whole*

*Mosasaur have been found with large sharks in their 'stomachs'*

*Covered in overlapping scales; keeled scales on the upper body and smooth scales on the lower body*



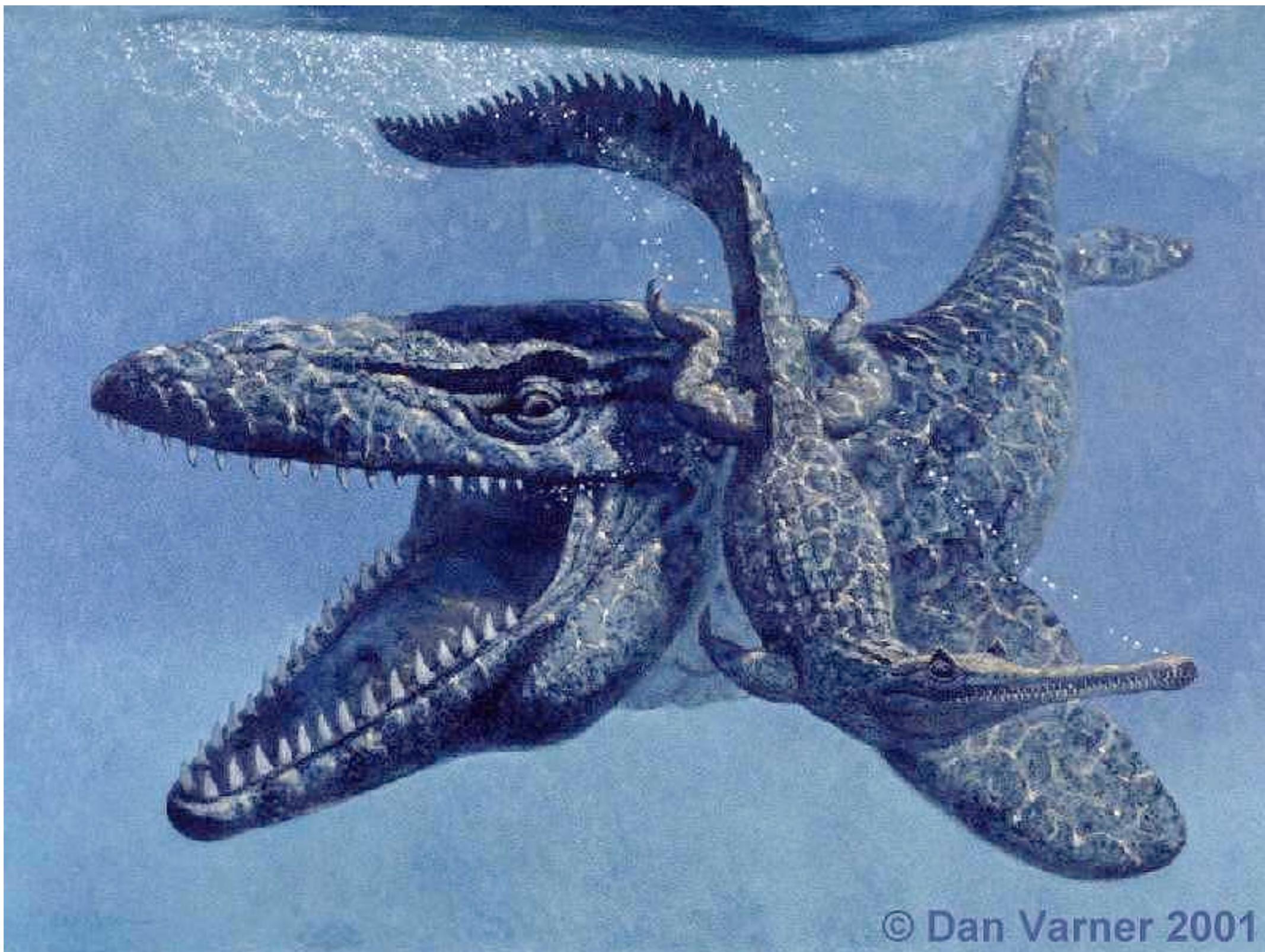
# Mosasaurs!





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# Turtles & Crocodiles



© Dan Varner 2001

# Turtles

## Triassic - Present



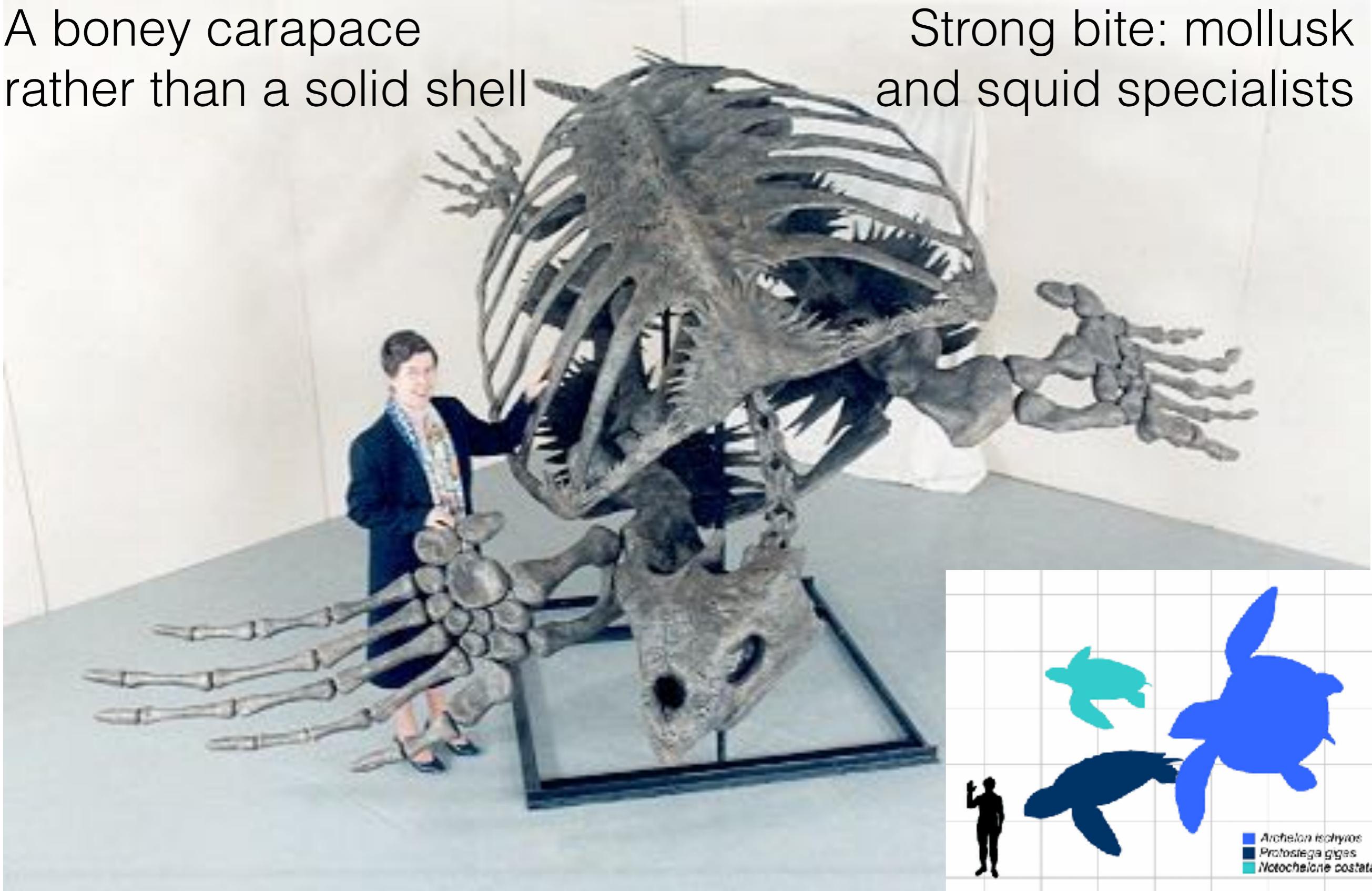
*Odontochelys*  
Had teeth  
Aquatic  
Did not yet have a solid carapace, as do modern turtles



*Proganochelys*  
First fully shelled turtle, Late Triassic

A boney carapace  
rather than a solid shell

Strong bite: mollusk  
and squid specialists



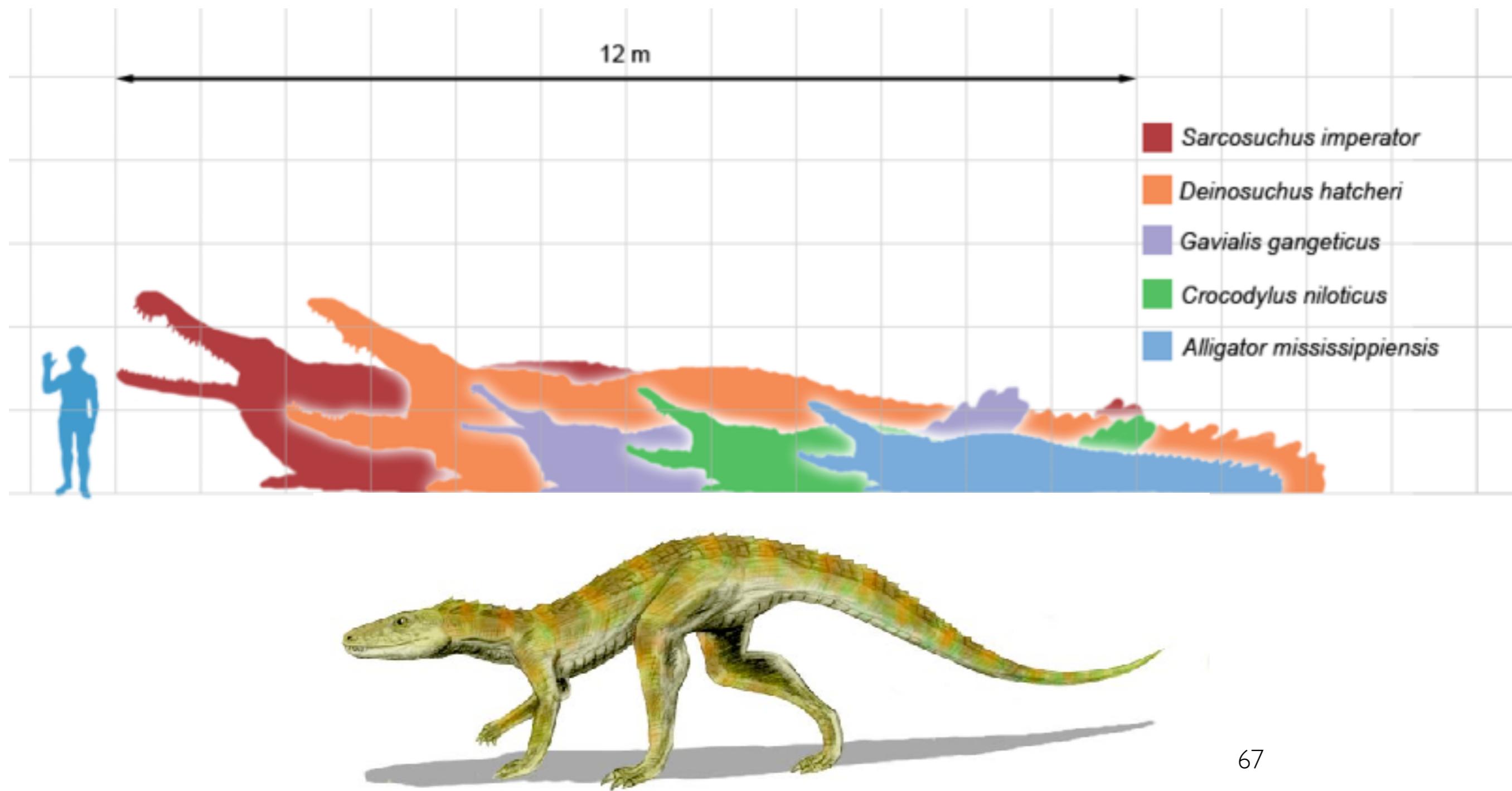
Archelon (late Cretaceous)



True Crocodiles:  
Late Cretaceous to present

Marine Crocs:  
Teleosaurids  
Metriorynchids

Crocodylomorpha (Archosaurs)  
mid-Triassic to present





A modern croc  
most haven't  
heard of: *Gavialis*

Indian subcontinent &  
Java, Malay Archipelago

*"Their jaws are too thin and delicate to grab larger prey, especially people. They catch fish by lying in wait for fish to swim by, and then catch the fish by quickly whipping their heads sideways and grabbing it in their jaws. They herd fish with their bodies against the shore, and stun fish using their underwater jaw clap. They do not chew their prey, but swallow it whole."*

## Teleosaurid Crocs

Early Jurassic to Early Cretaceous

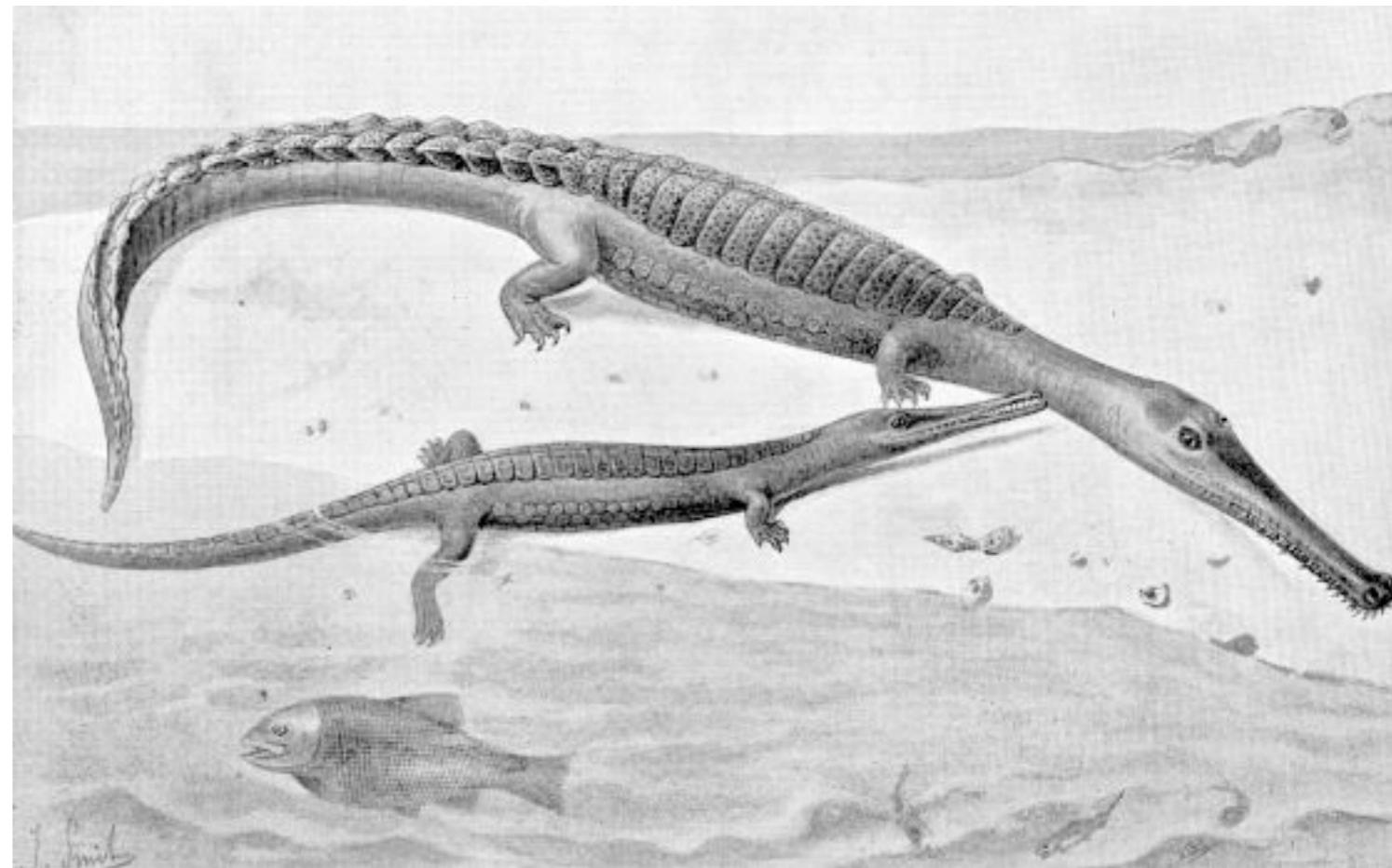
Long snouts (Piscivores)

Very crocodile-like

Worldwide distribution



*Mystriosuchus*



*Teleosaurus*



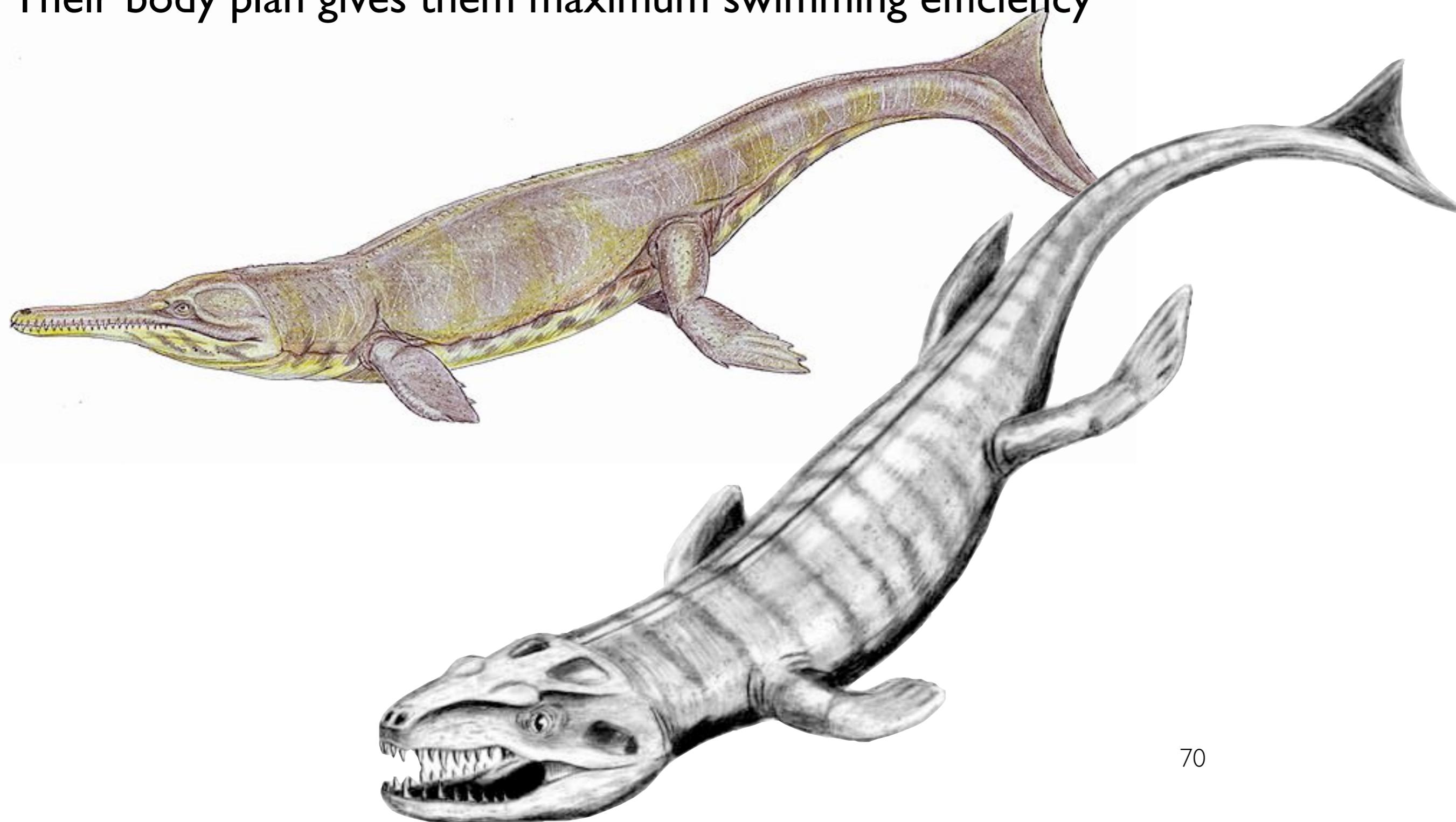
## Metriorynchid Crocs

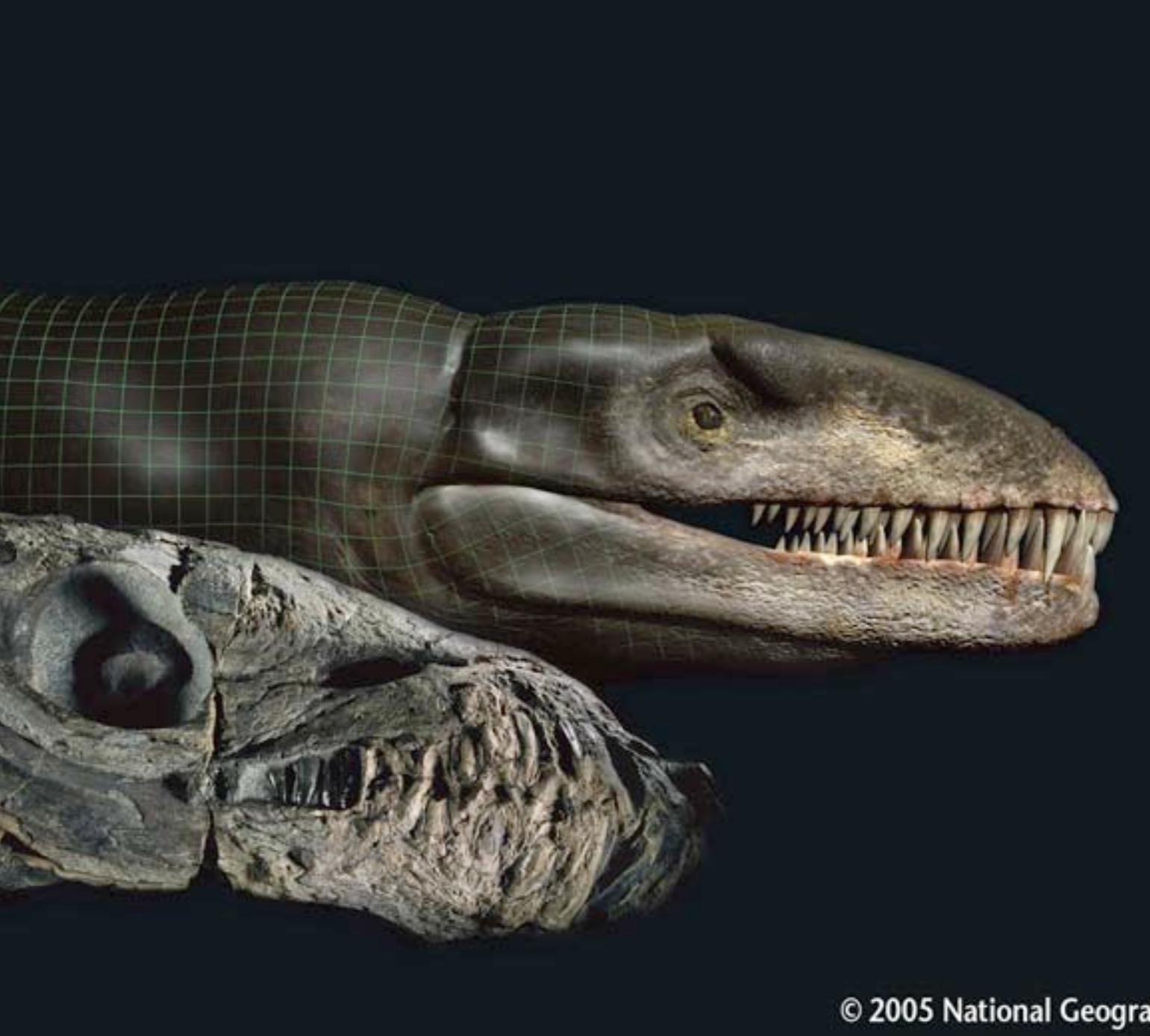
Mid Jurassic to Early Cretaceous

Fully aquatic- evolved fish-like fins

Lost their osteoderms

Their body plan gives them maximum swimming efficiency





© 2005 National Geogra

Flattened, serrated teeth  
Teeth analogous to Killer Whales  
Had salt glands in skull to deal with  
ocean water

*Dakosaurus*

# Freshwater Crocodylomorphs

'Super Croc'

*Sarcosuchus*

Early-Mid Cretaceous

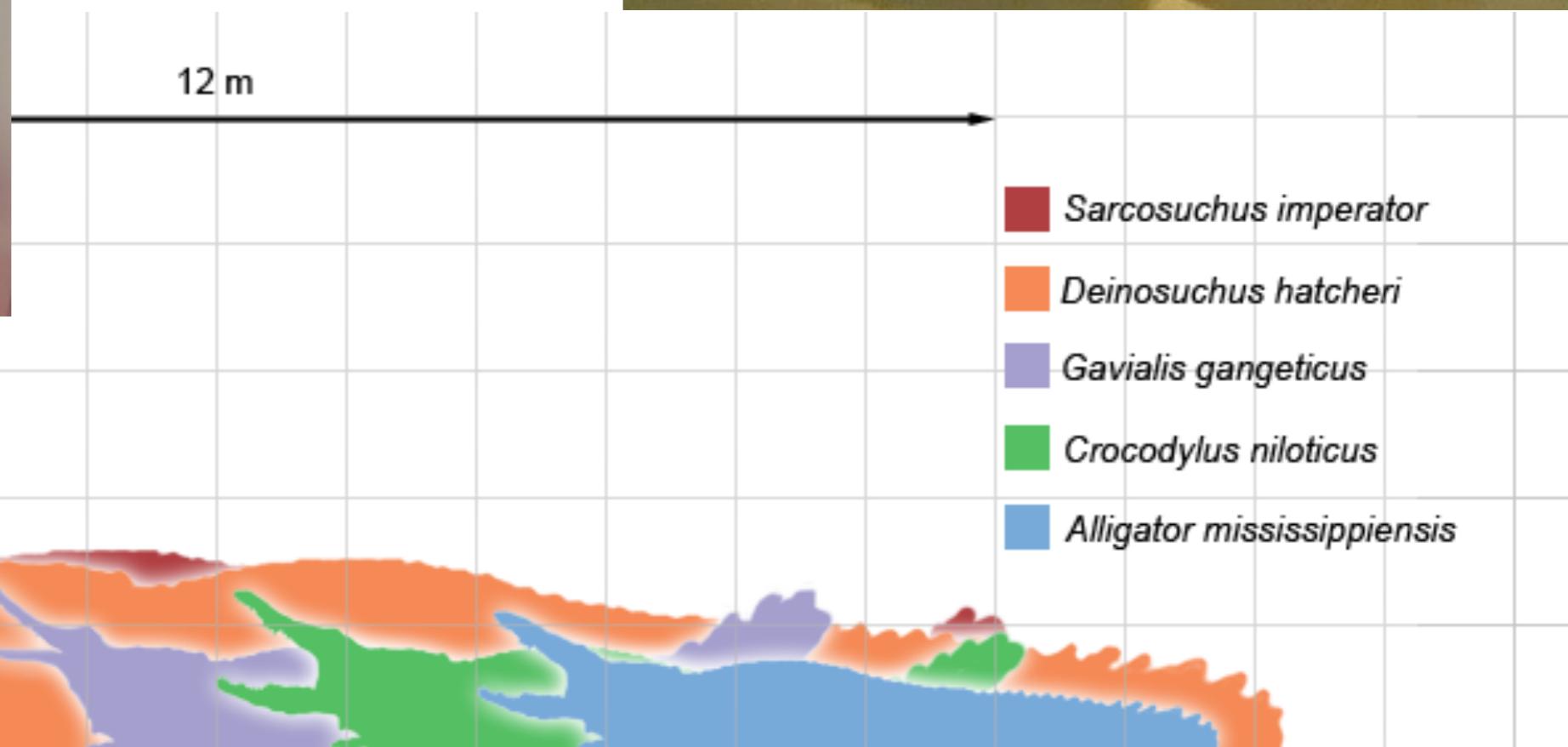
40 ft long; 6 ft long skull

Thinner snout than *Deinosuchus*

Prey: large fish, turtles, small Dinosaurs



12 m





# Freshwater Crocodylomorphs

'Dreadful Croc'

*Deinosuchus*

Early-Mid Cretaceous

35-40 ft long

Robust skull, teeth: built for crushing/tearing

Prey: large Dinosaurs (hadrosaurids: tooth marks on tail vertebrae)



Food





