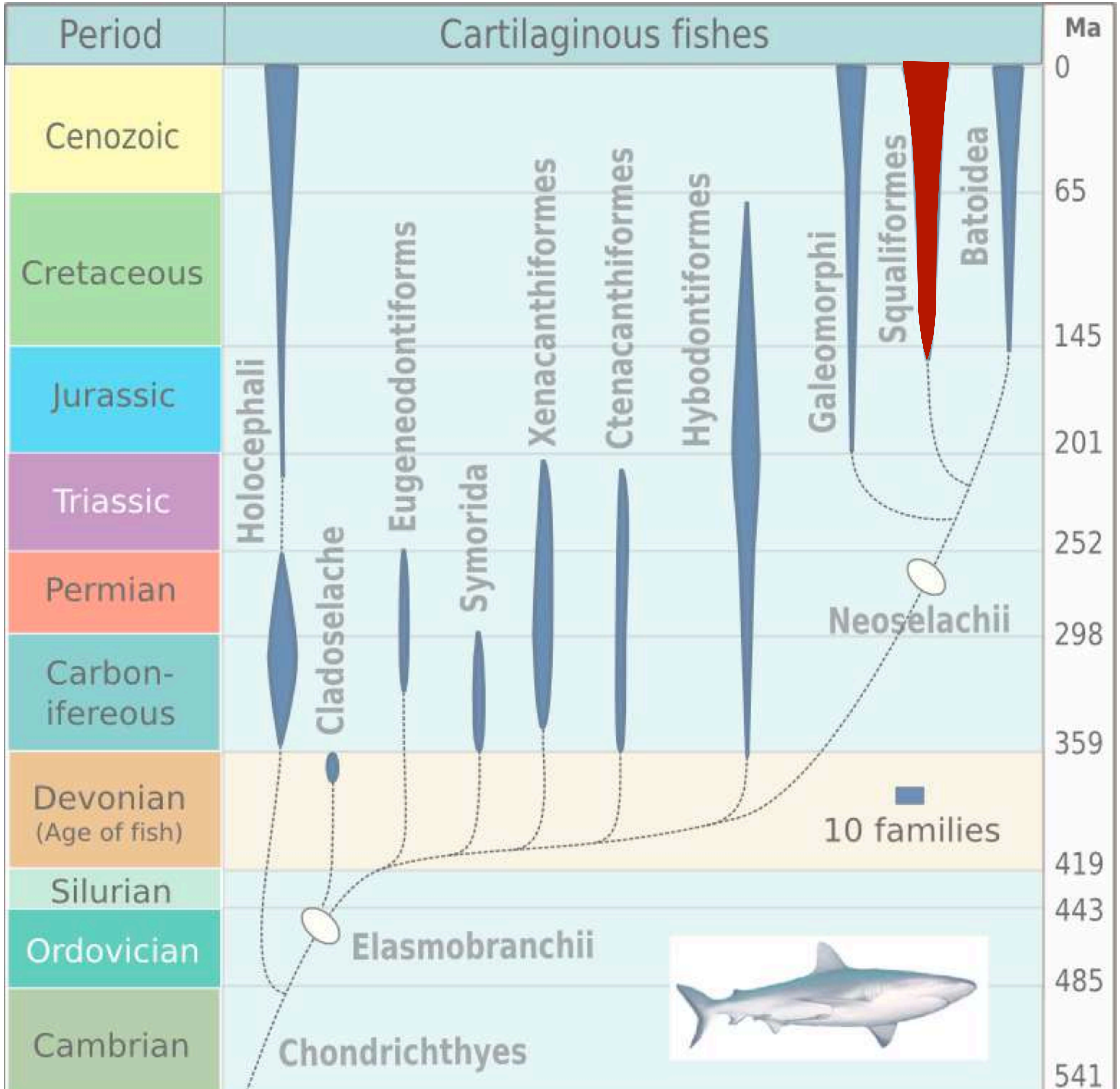
Past and present biographical patterns of a deep-sea shark

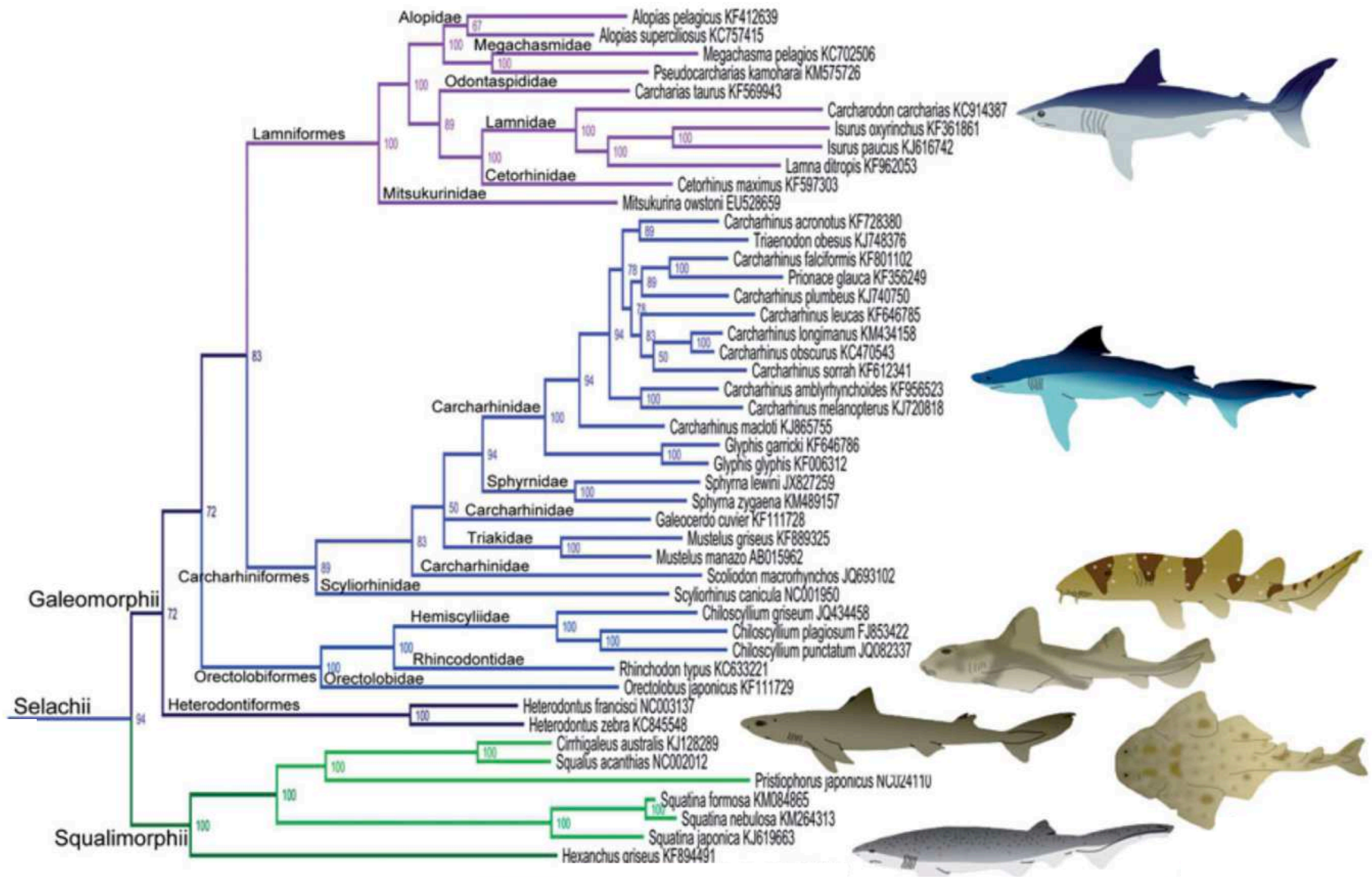
Regina L. Cunha

CCMAR, Faro, Portugal

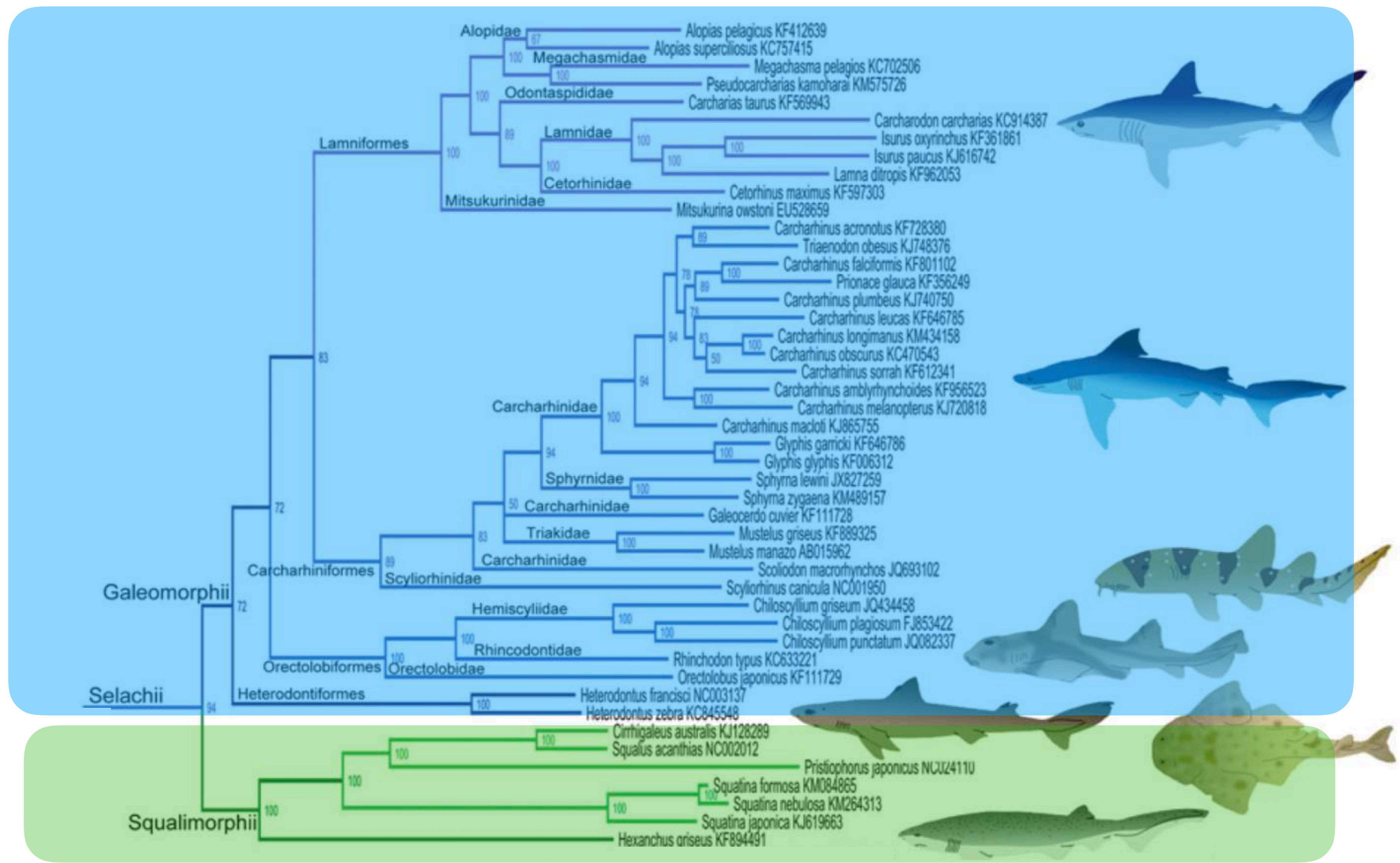
WebPage: http://rcastilho.pt/R2C2/R.L.Cunha.html



Period
Cartilaginous fishes
Ma
Cenozoic
Cretaceous
Jurassic
Triassic
Permian
Carbon-
ifereous
Devonian
(Age of fish)
Silurian
Ordovician
Cambrian
0
65
145
201
252
298
359
419
443
485
541
Holocephali
Cladoselache
Eugeneodontiforms
Symorida
Xenacanthiformes
Ctenacanthiformes
Hybodontiformes
Galeomorphi
Squaliformes
Batoidea
Neoselachii
10 families
Elasmobranchii
Chondrichthyes



Amaral et al. 2018. Mitochondrial DNA Part A.

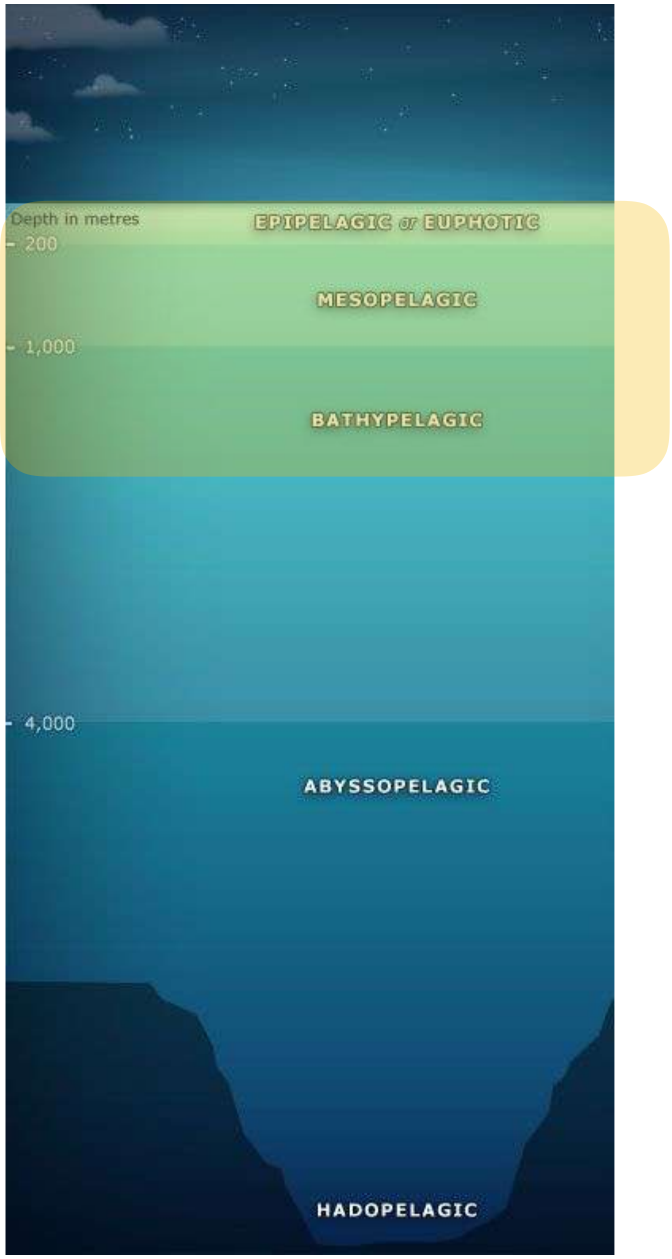


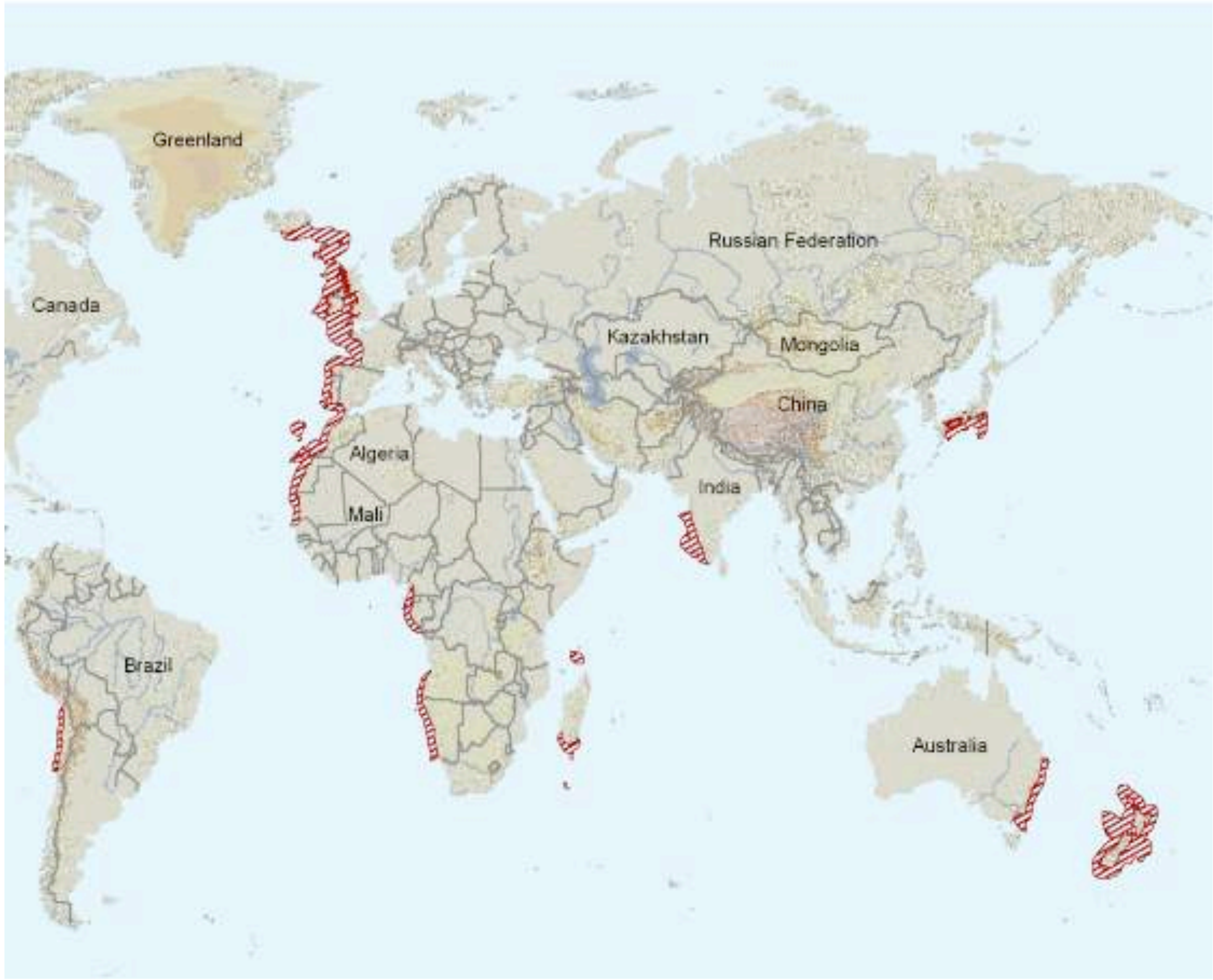
Amaral et al. 2018. Mitochondrial DNA Part A.

Longnose velvet dogfish shark, *Centroscymnus crepidater*

https://www.iucnredlist.org/species/46864/11087086

Longnose velvet dogfish shark, *Centroscymnus crepidater*





Longnose velvet dogfish shark, *Centroscymnus crepidater*

maximum length: 130 cm

maximum reported age: **54** years

sexual maturity: ~ **20** years

R-Strategies vs. K-strategies

Characteristic	R-strategy	K-Strategy
Life Span	Short	Long
Number of Offspring	Many	Few
Growth	Quickly	Slowly
Onset of Maturity	Early	Late – after a long period of parental care
Body Size	Typically Small	Typically Larger
Reproduction	Once during lifetime	More than once during lifetime
Parental Care	None	Very likely and in depth
Environment	Unstable	Stable

K selected species






R selected species






Sharks are in crisis

GLOBAL THREATS TO SHARKS

SHARK BUSINESS

Longline fishing
Industrial fleets use fishing line hundreds of meters in length containing as many as 2500 hand baited hooks to target sharks"

TARGETED SHARK FISHING

The global growth of shark fishing has had devastating consequences for shark populations around the world. Although anti-finning measures were introduced in an attempt to stop the barbaric practice of removing fins from live animals, there is little evidence to suggest that global landings are in decline. Unlike many other fish, sharks are slow to reach sexual maturity and have few young, making them especially vulnerable to modern industrial fishing techniques. Put simply we are killing sharks quicker than they are able to reproduce

Shark fins
Due to massive consumer demand for their fins and other shark related products, some species are being targeted and caught at an alarming and unsustainable rate

Baited hooks
Food is attached to individual hooks that are connected to the main line and held in the water column using small anchors

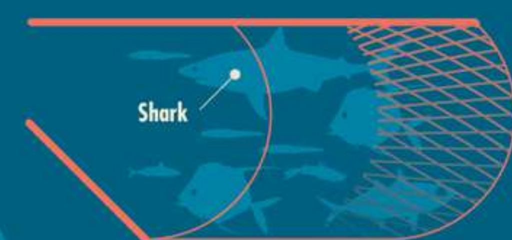
Many other marine species also fall victim to the long line hooks

While it is impossible to know exactly how many sharks are killed in what is a largely unregulated fishery, the best scientific estimates suggest the number is as high as

100 Million each year

BY-CATCH

Millions of tons of marine life are unintentionally caught every year including tens of millions of sharks. Despite methods existing for fishing fleets to decrease the by-catch of sharks, there is little incentive for them to do so



Trawling nets Trawls are highly indiscriminate and capture all species in their path. Many fish that end up in these nets will be thrown back to sea dying or already dead

HABITAT DEGRADATION

Habitat degradation and loss have been linked to negative effects on elasmobranchs including decreased condition and population declines. Sharks depend on a healthy ecosystem to survive and find prey

The destruction of mangrove forests and reefs reduces breeding and nursery areas making it more difficult for juvenile sharks to reach maturity

GREENHOUSE GAS EMISSIONS

Scientific research is revealing that higher water temperatures and CO2 levels in our oceans are having a detrimental effect on many species of marine life. We are only just beginning to understand the long term implications of this phenomenon but a recent study has shown that ocean acidification not only degrades sharks habitats but also reduces their growth rate and ability to hunt effectively

DETRIMENTAL EFFECT ON MARINE LIFE

Higher water temperatures | Carbon dioxide (O_2, C)

Coral bleaching
Sharks rely on healthy reefs, but if the water is too warm corals expel the algae living in their tissues causing them to turn completely white and die

POLLUTION

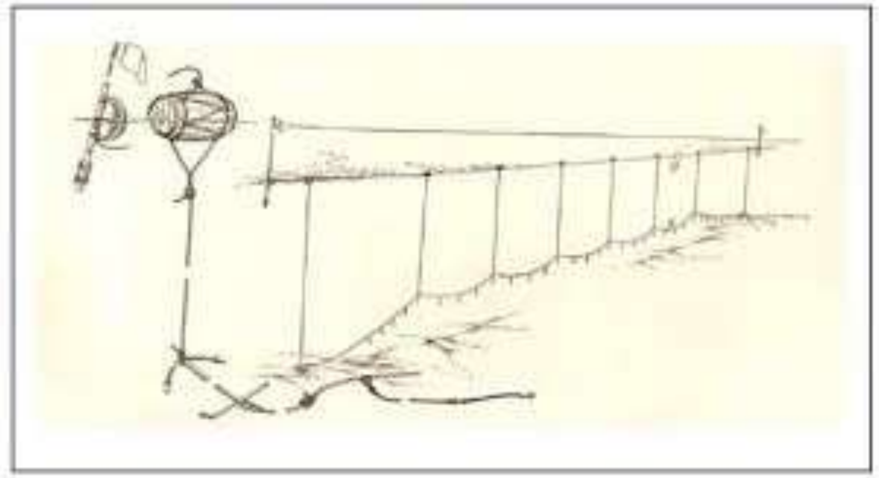
Like most large marine species, sharks are very susceptible to pollution and environmental contamination. Sharks can live for decades and in that time may accumulate many highly toxic chemicals from the environment and their prey

Plastic products
These materials slowly degrade and enter the food chain where they are consumed by sharks and other marine animals, slowly poisoning them. Larger items can also cause injuries and entanglement

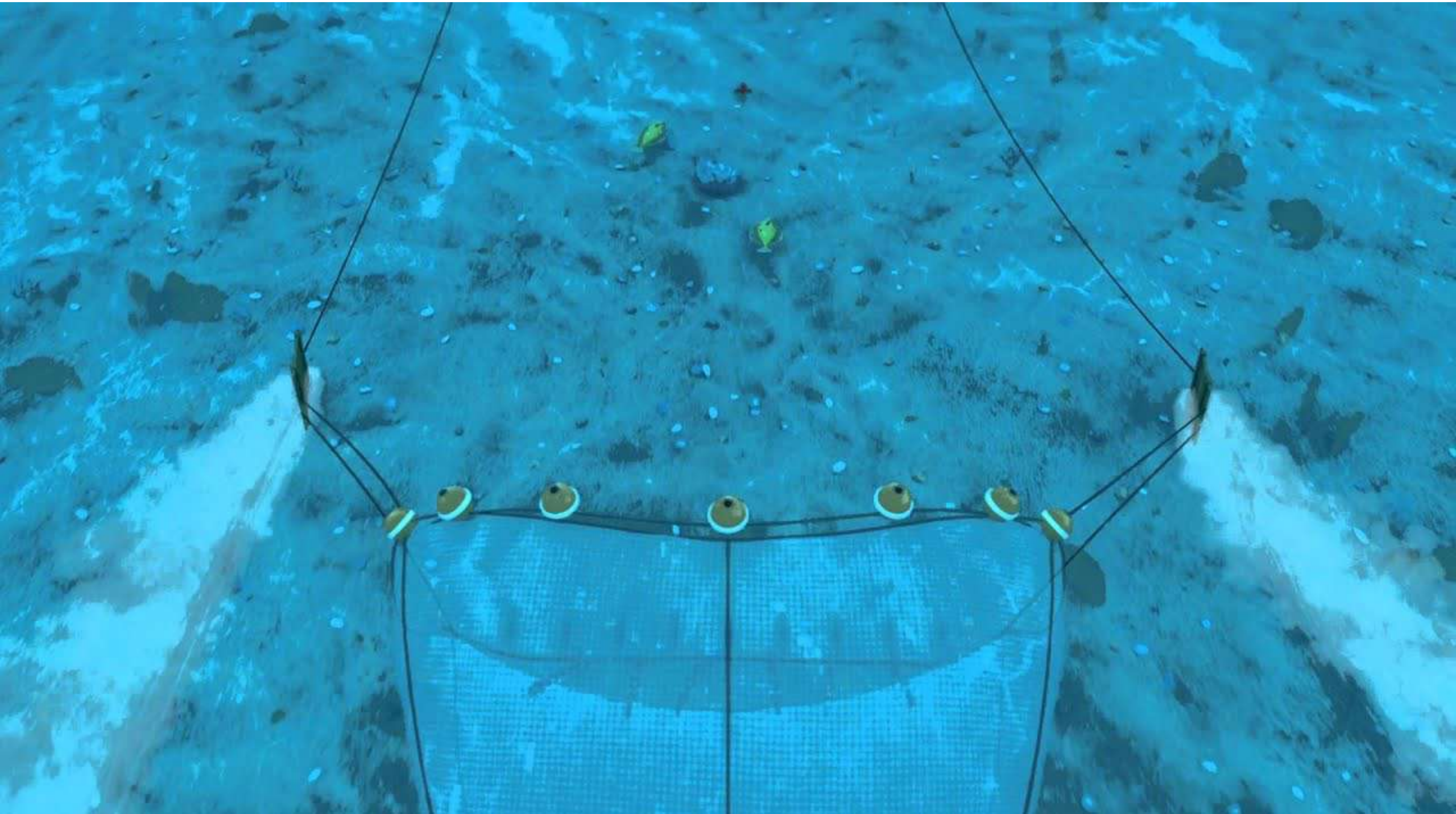
Sharks' anthropogenic threats

livers are rich in squalene (oil)
used in food supplements

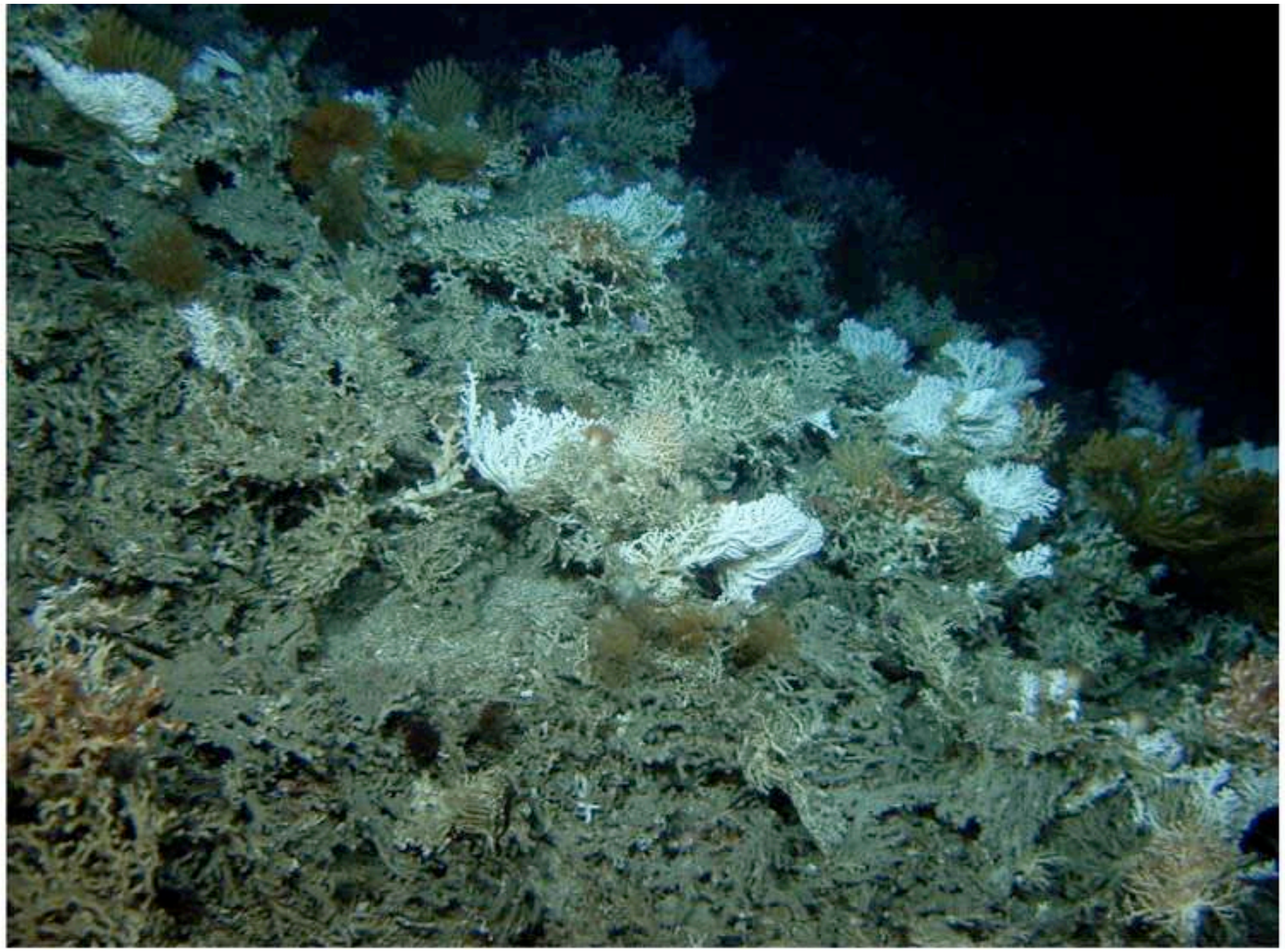
Deep-Sea Fisheries



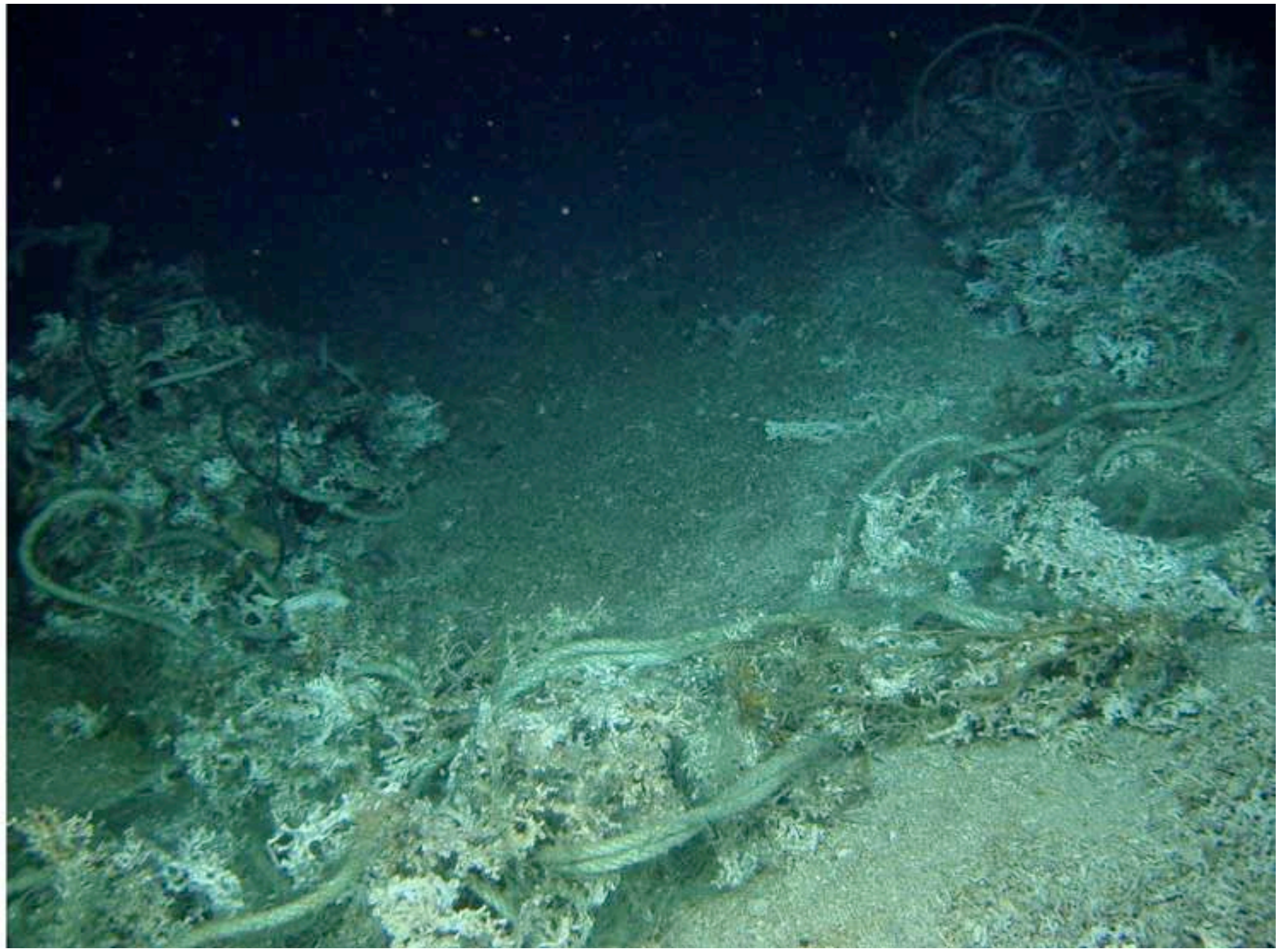
Bottom-Trawling



Before trawling



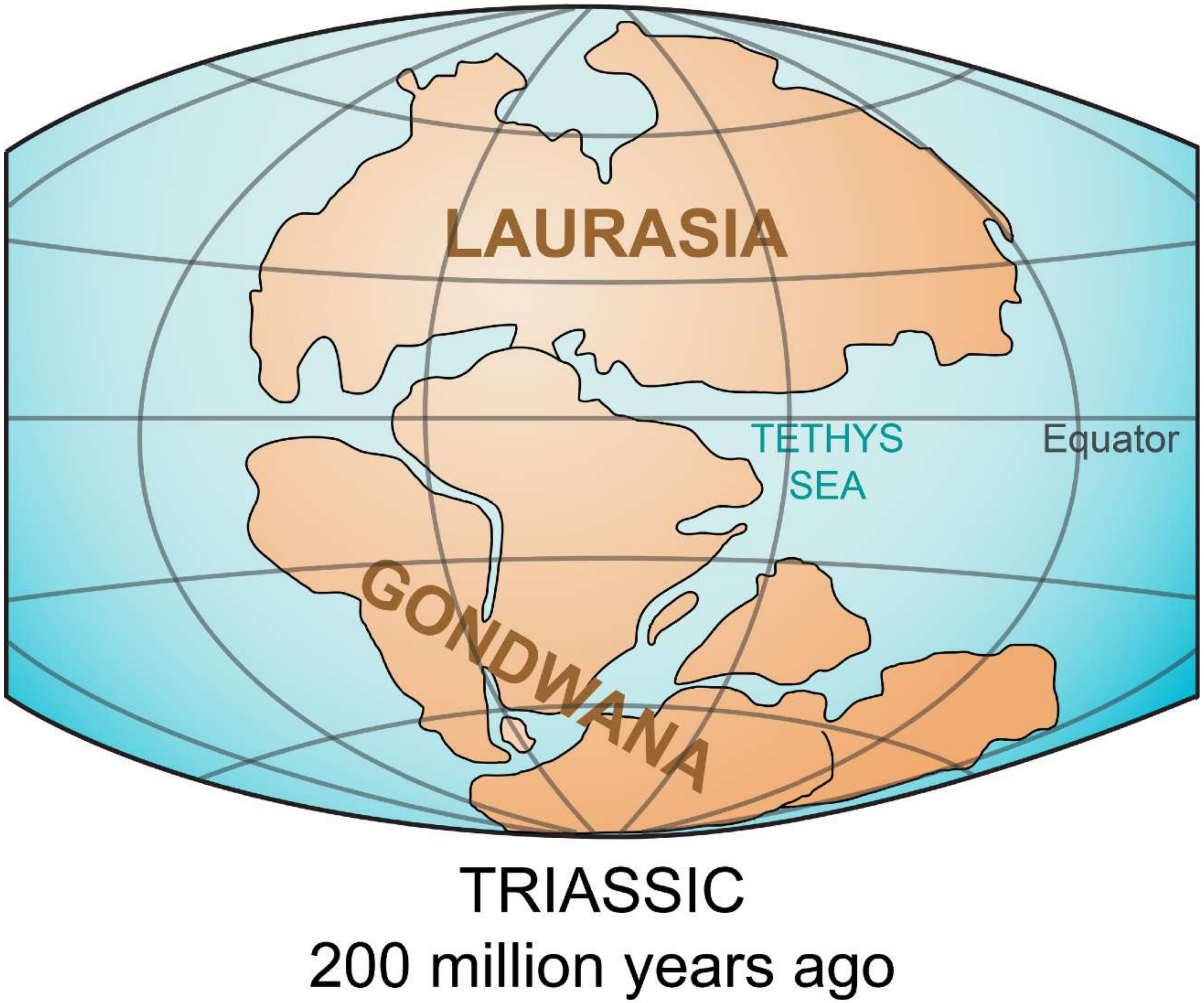
After trawling

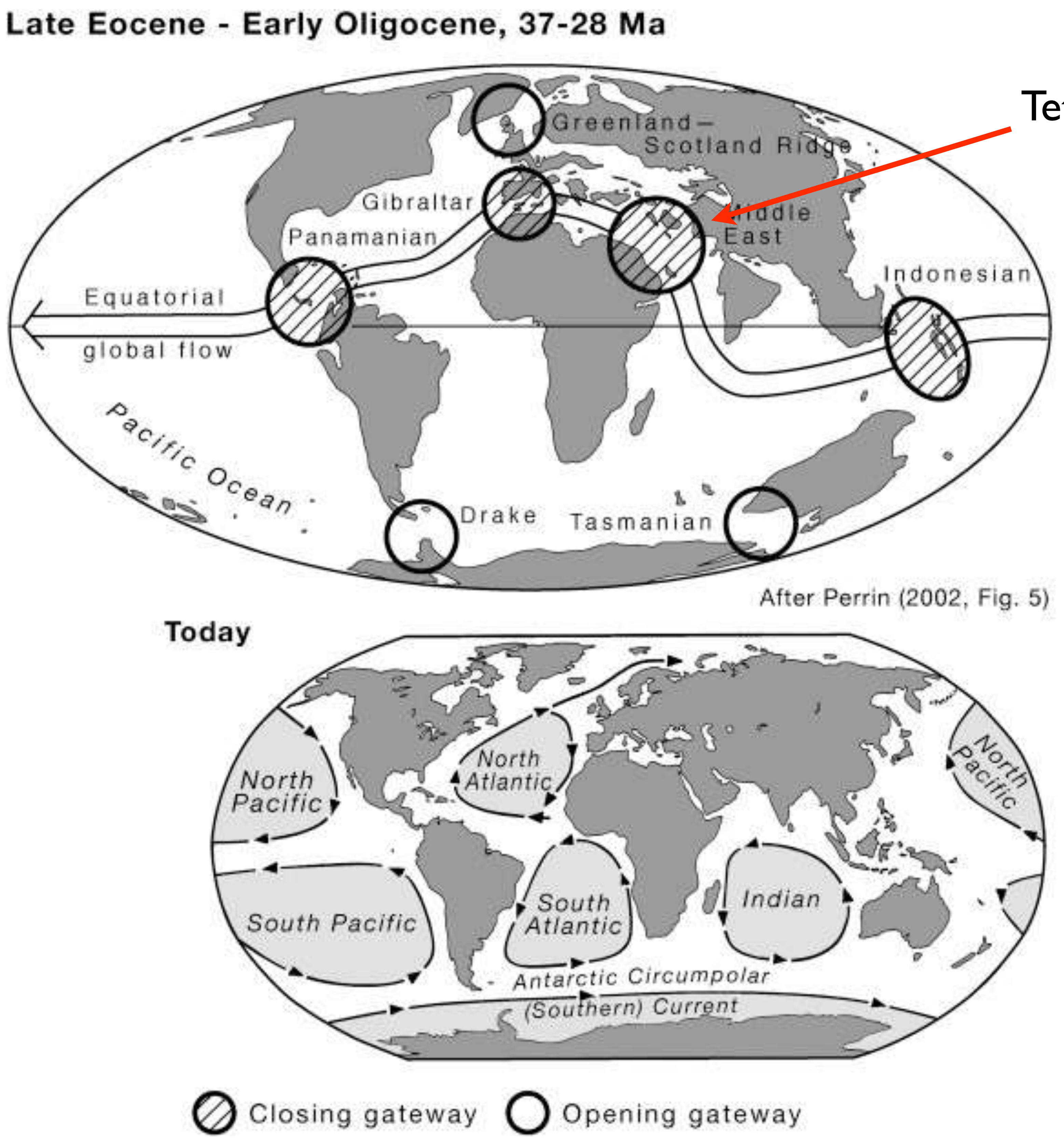


Deep-sea sharks

C. crepidater

Paleogeography

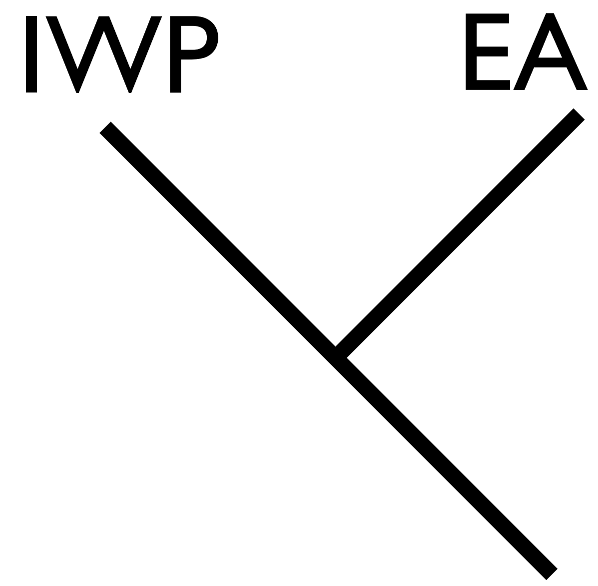

LAURASIA
TETHYS
SEA
Equator
GONDWANA
TRIASSIC
200 million years ago



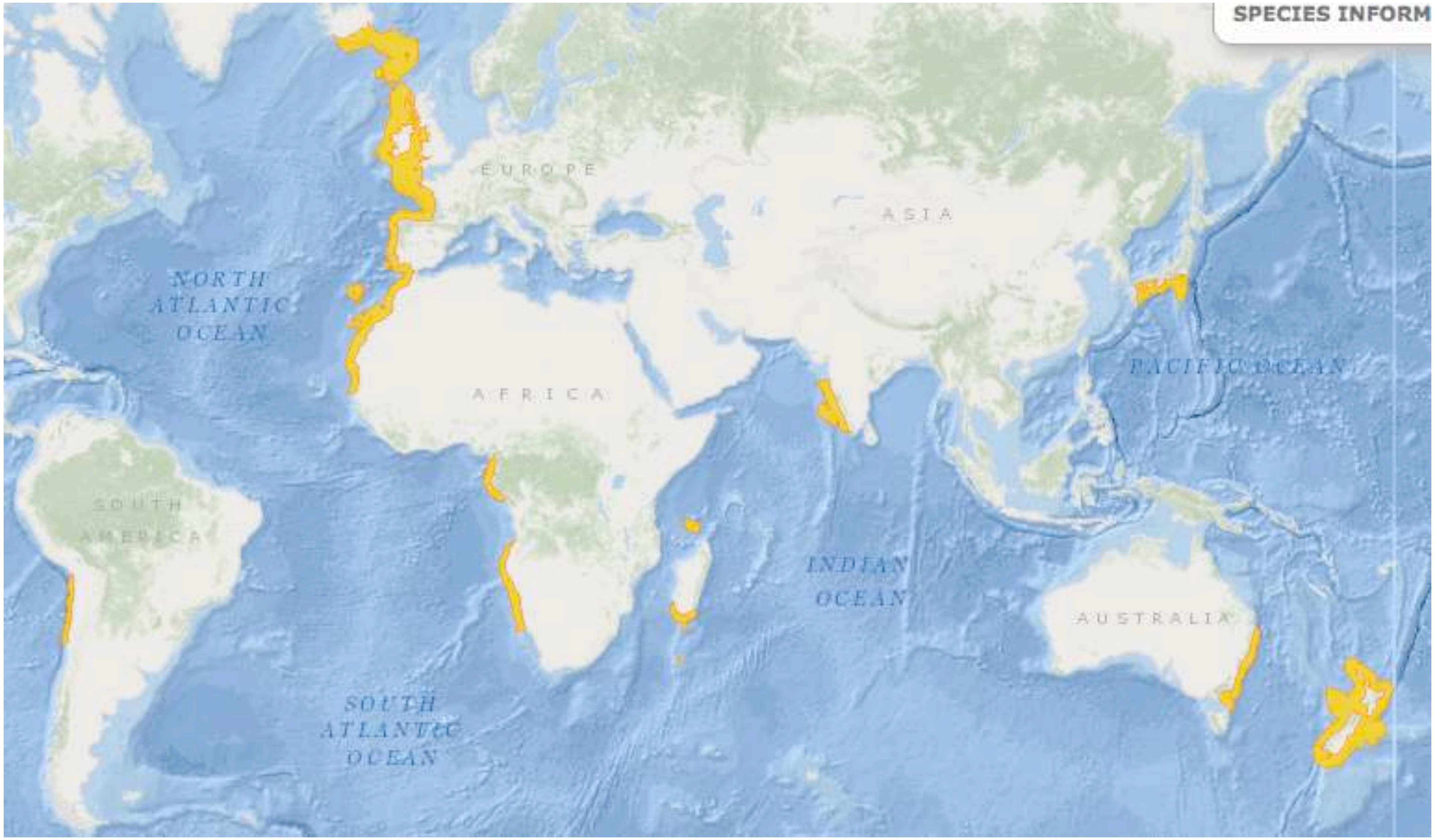
Tethys seaway

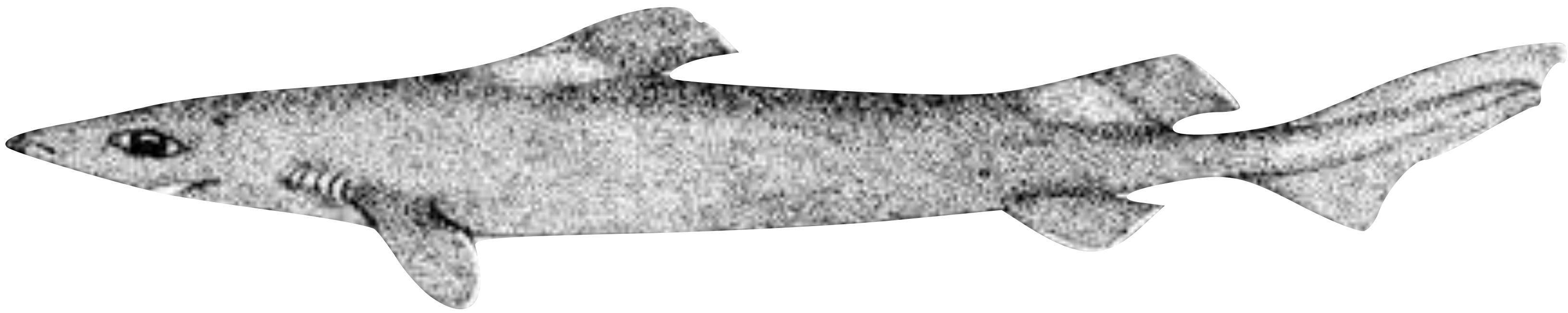
[18-6 Myr]

Expected phylogeographic pattern due to the Tethys closure



Centroscymnus crepidater geographic distribution



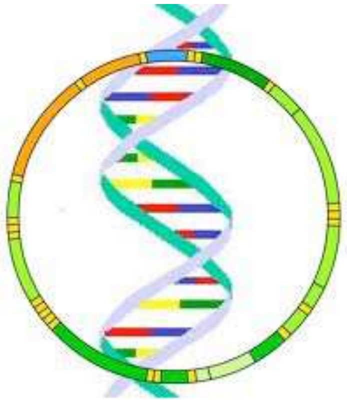
Evaluate the genetic structure of *C. crepidater*

Test if Tethys closure triggered lineage splitting events within *C. crepidater*

Analyse connectivity within Atlantic populations and between the Atlantic and Southern Pacific

Phylogeographic patterns of *Centroscymnus crepidater*

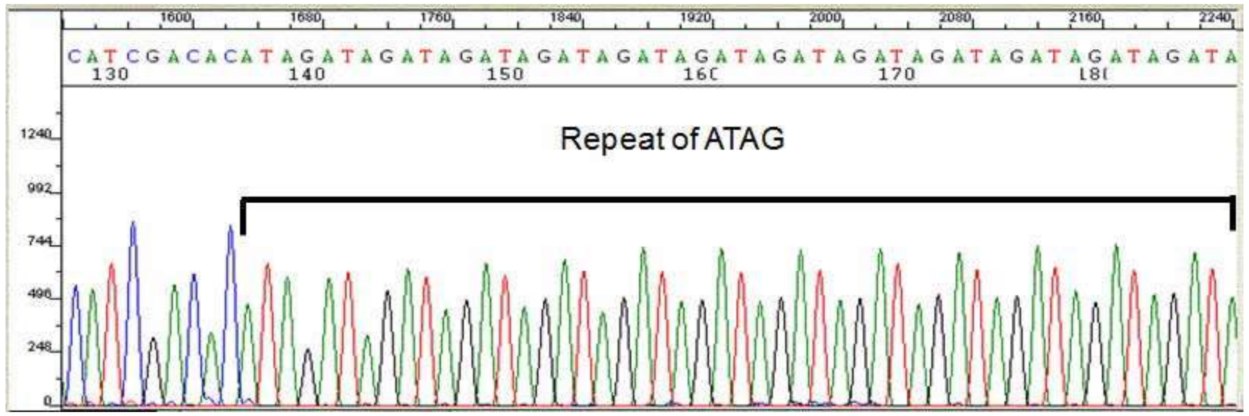
mitochondrial DNA



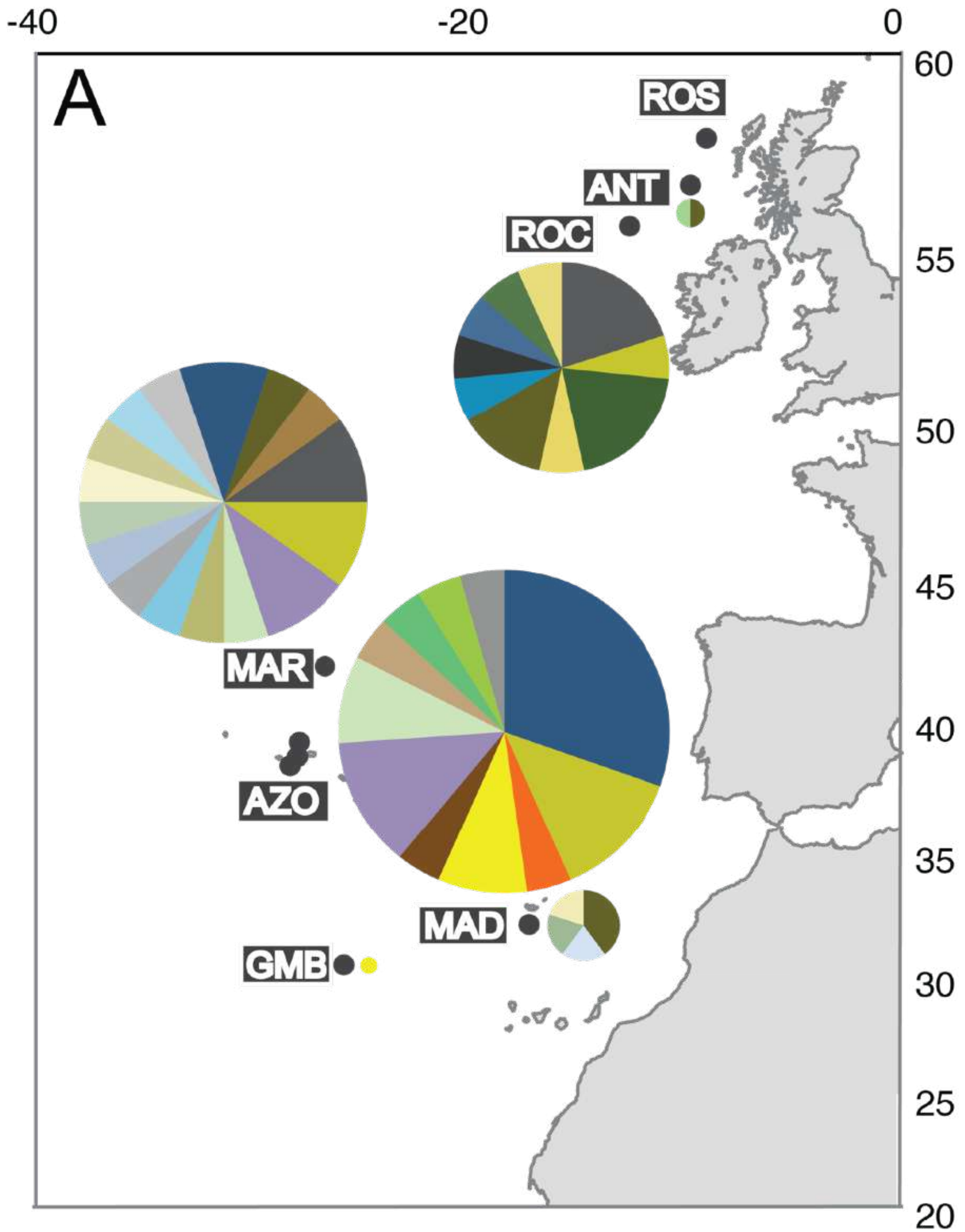
868 bp-fragment of the control region (CR)

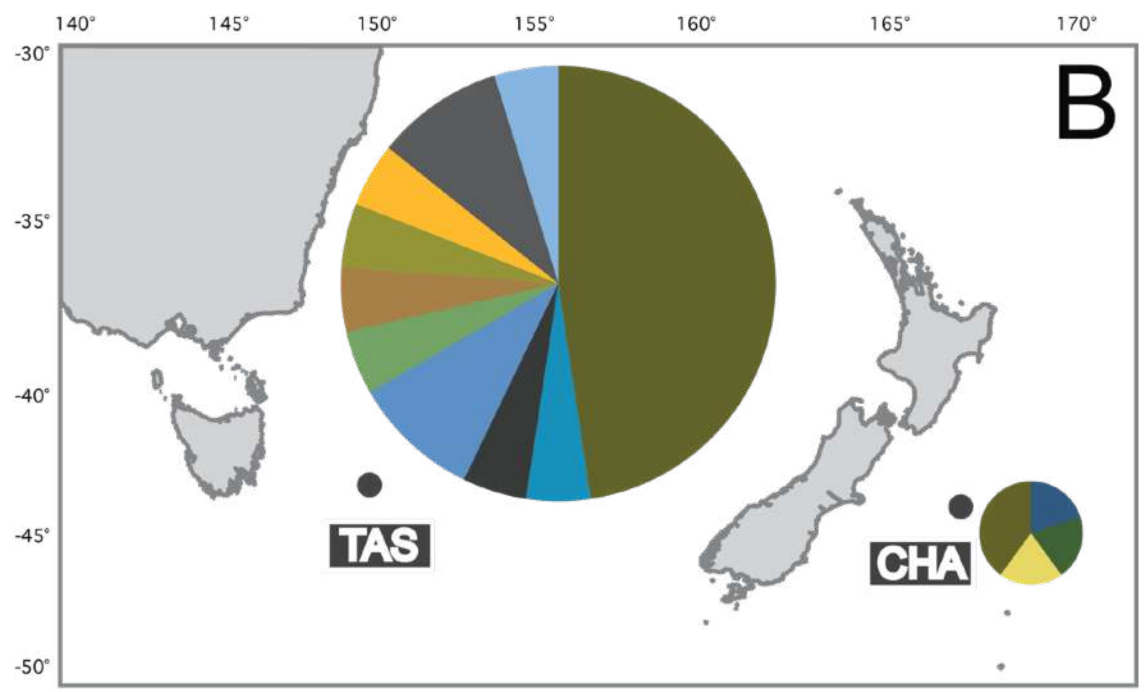
Genetic diversity and connectivity within the Atlantic populations and between the Atlantic and southern Pacific

7 microsatellite loci to analyse 160 individuals



Sampling locations and Haplotype frequencies





Sampling locations:

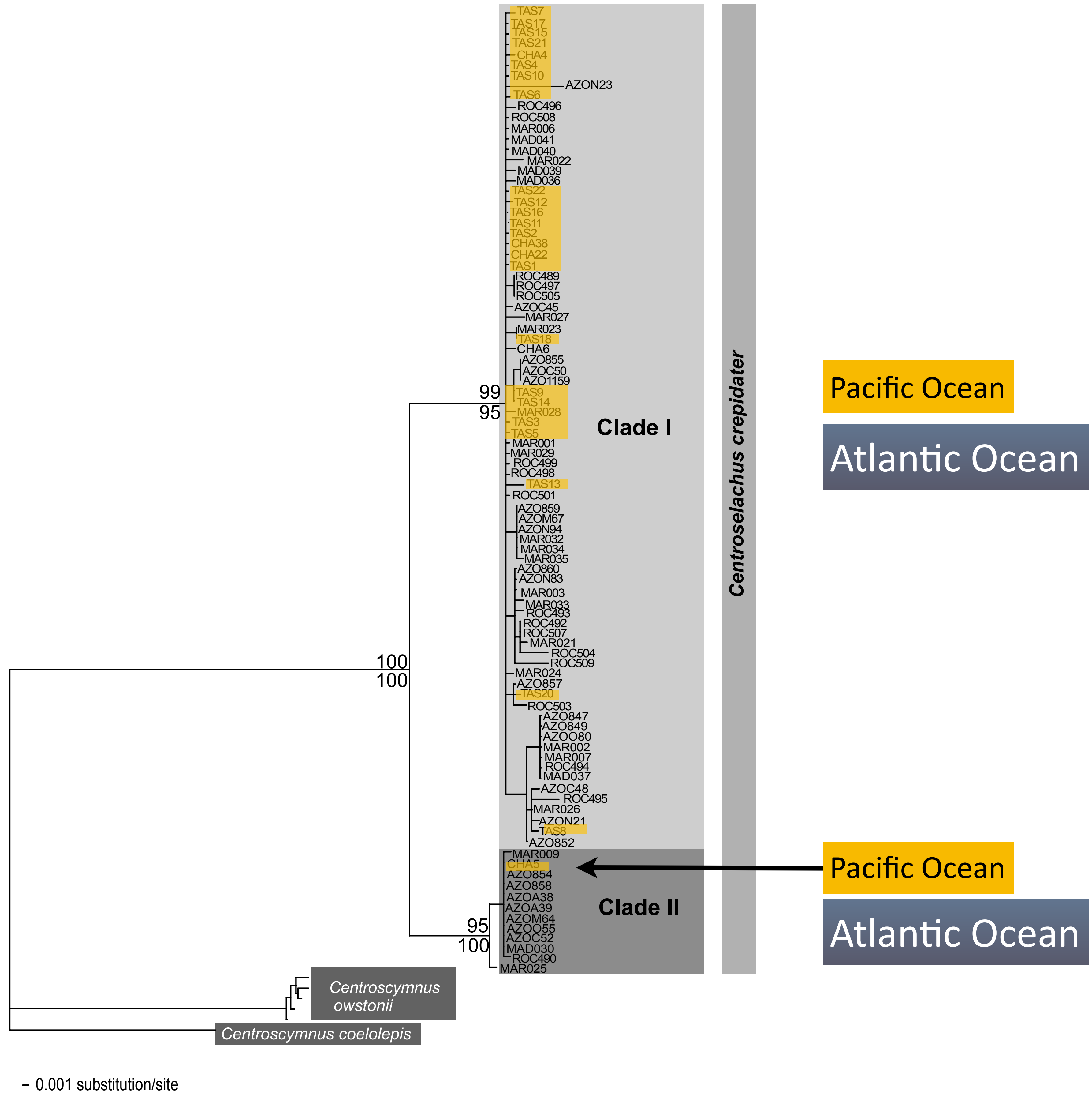
southern Pacific

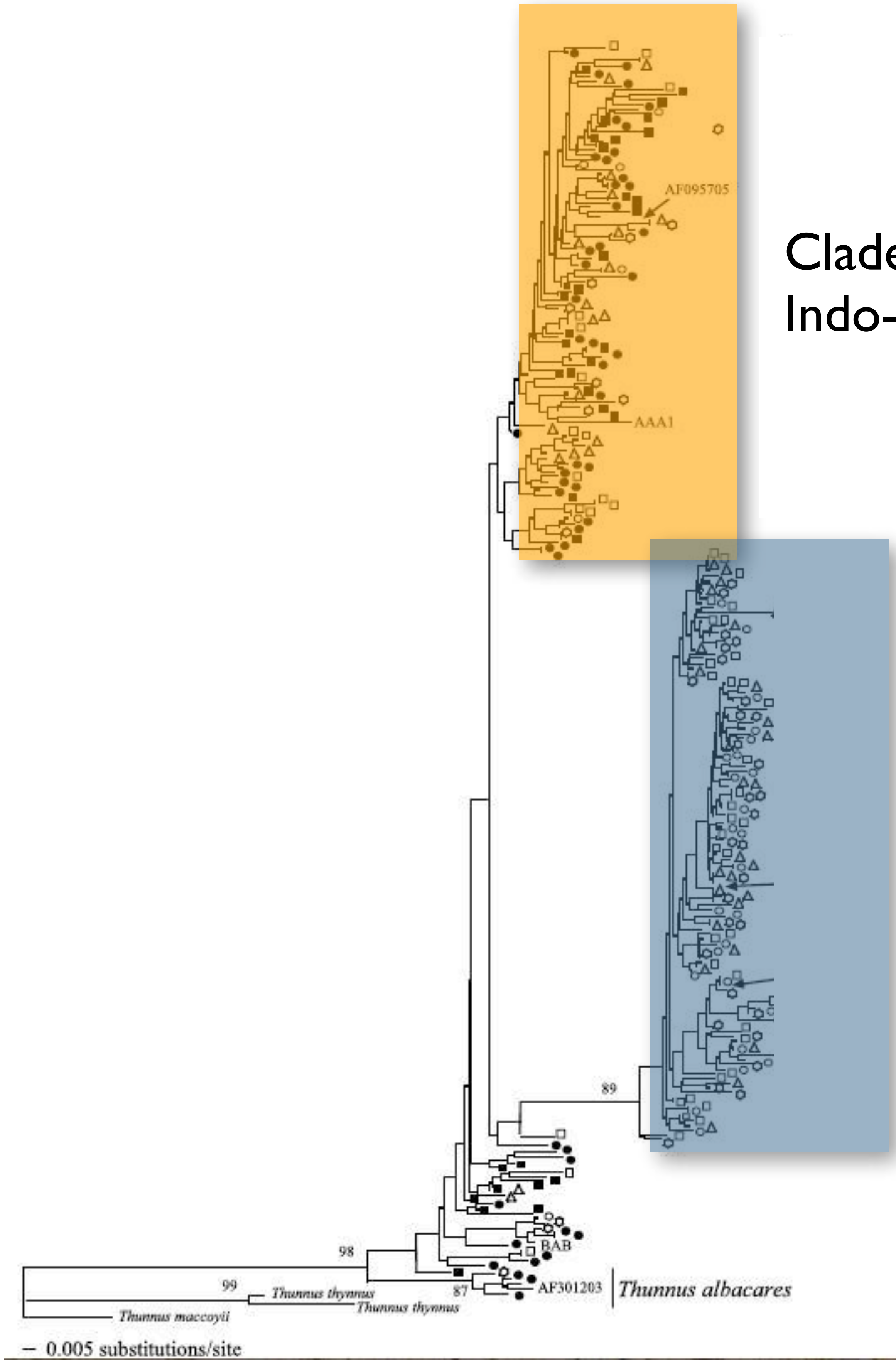
Tasman Sea
Chatham Rise

Atlantic

Azores, AZO
Rosemary Bank, ROS
Rockall Trough, ROC
Madeira, MAD
Anton Dohrn Seamount, ANT
Mid-Atlantic Ridge, MAR
Great Meteor Bank, GMB

ML - 868bp of mtDNA CR





Clade I
Indo-Pacific+Atlantic Ocean

Clade II
Atlantic Ocean

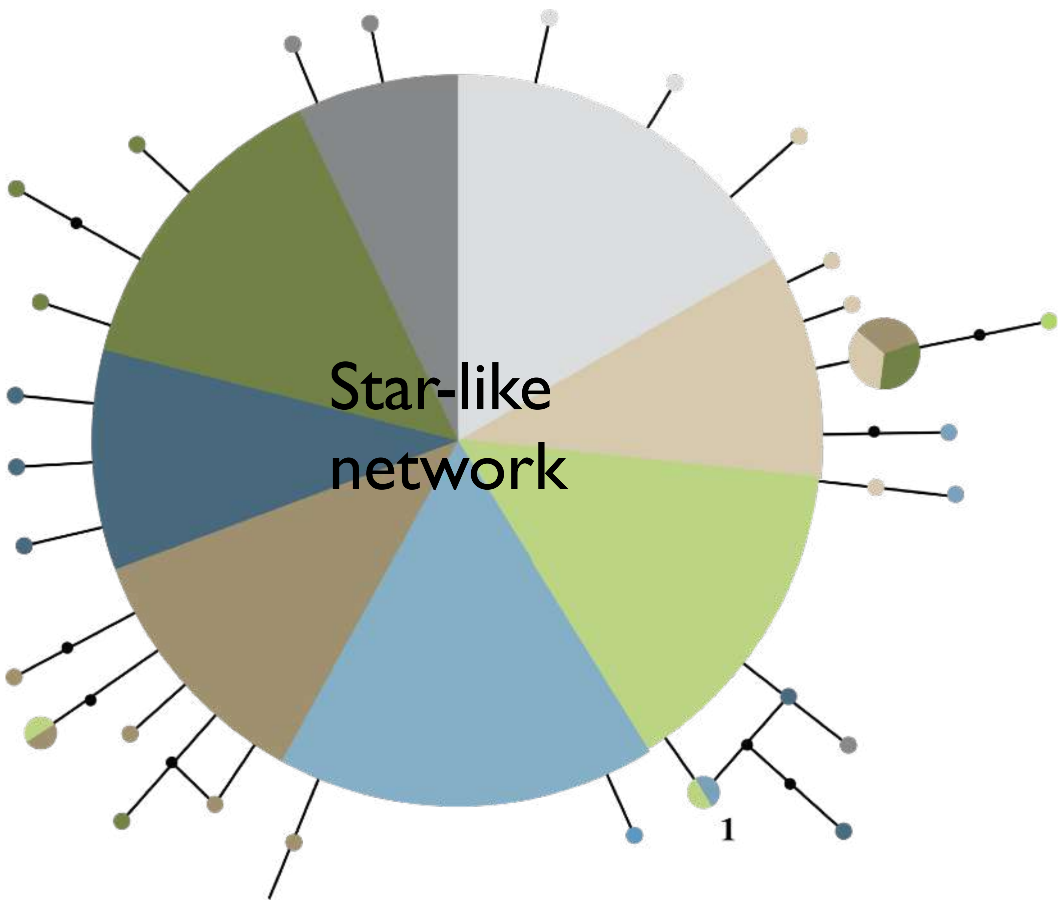
Bigeye Tuna

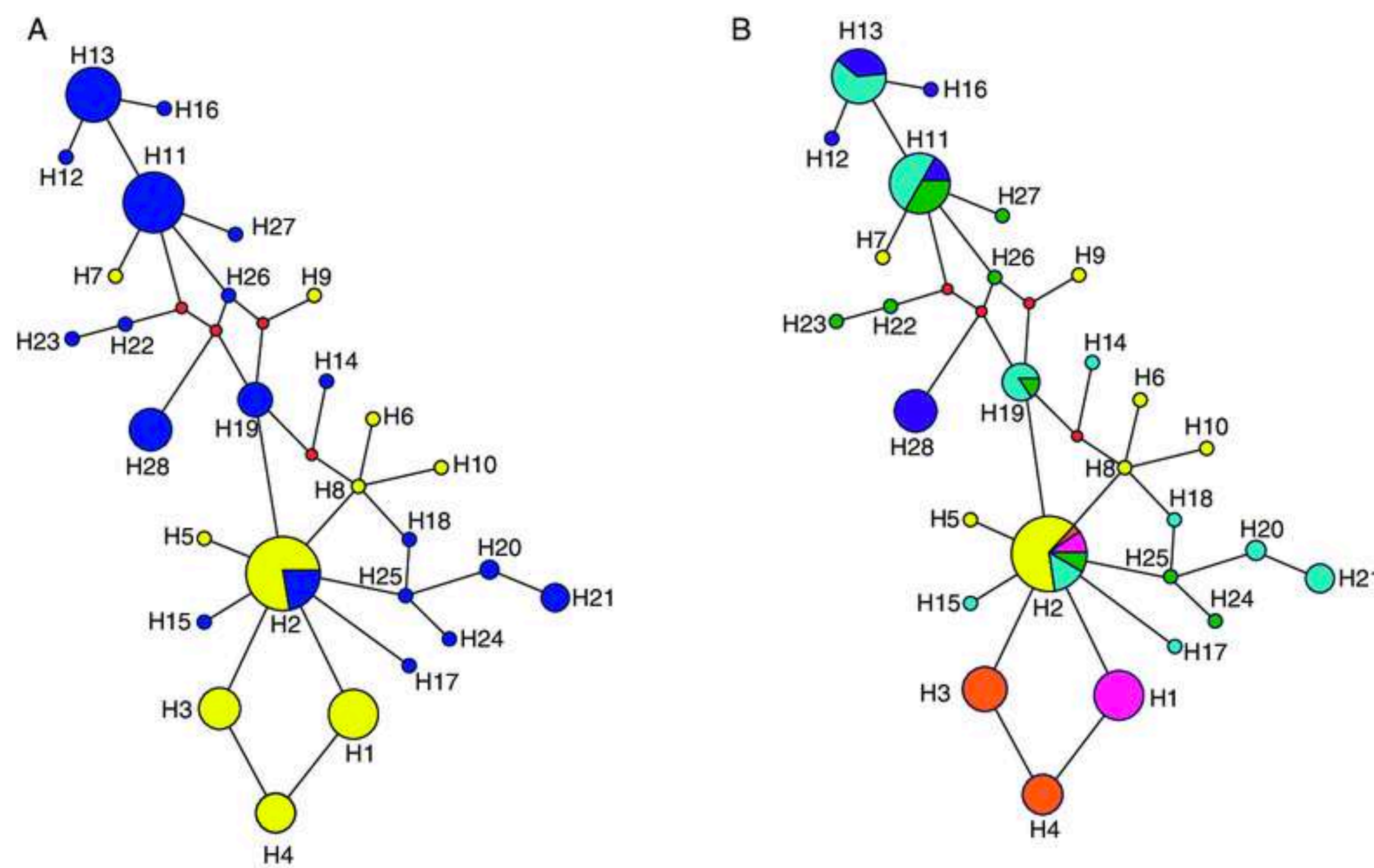
Martinez et al. 2006

Median-joining networks based on mtDNA

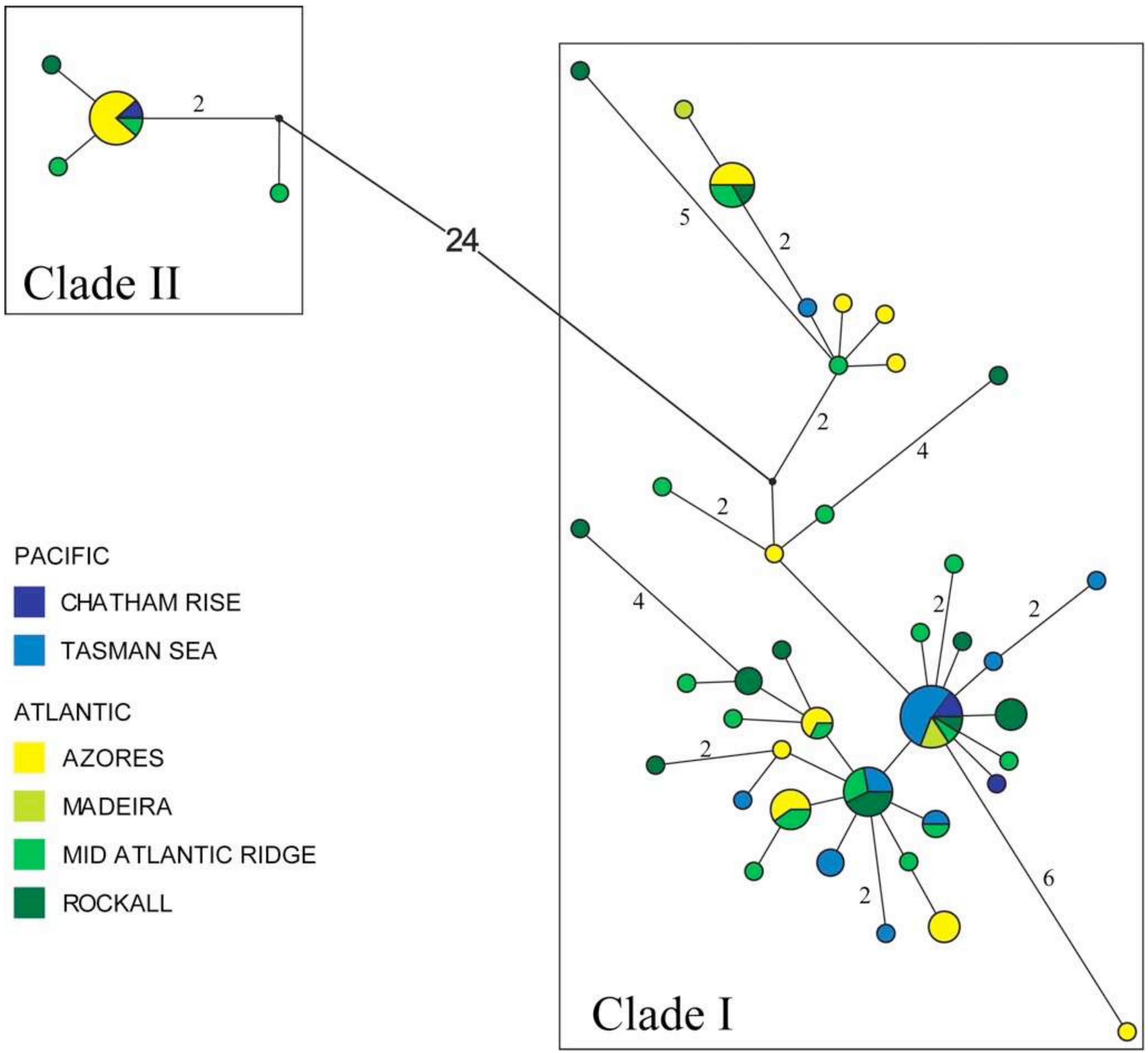
Pleistocene glaciation
>> recent population

Tethis closure >>
older and stable population

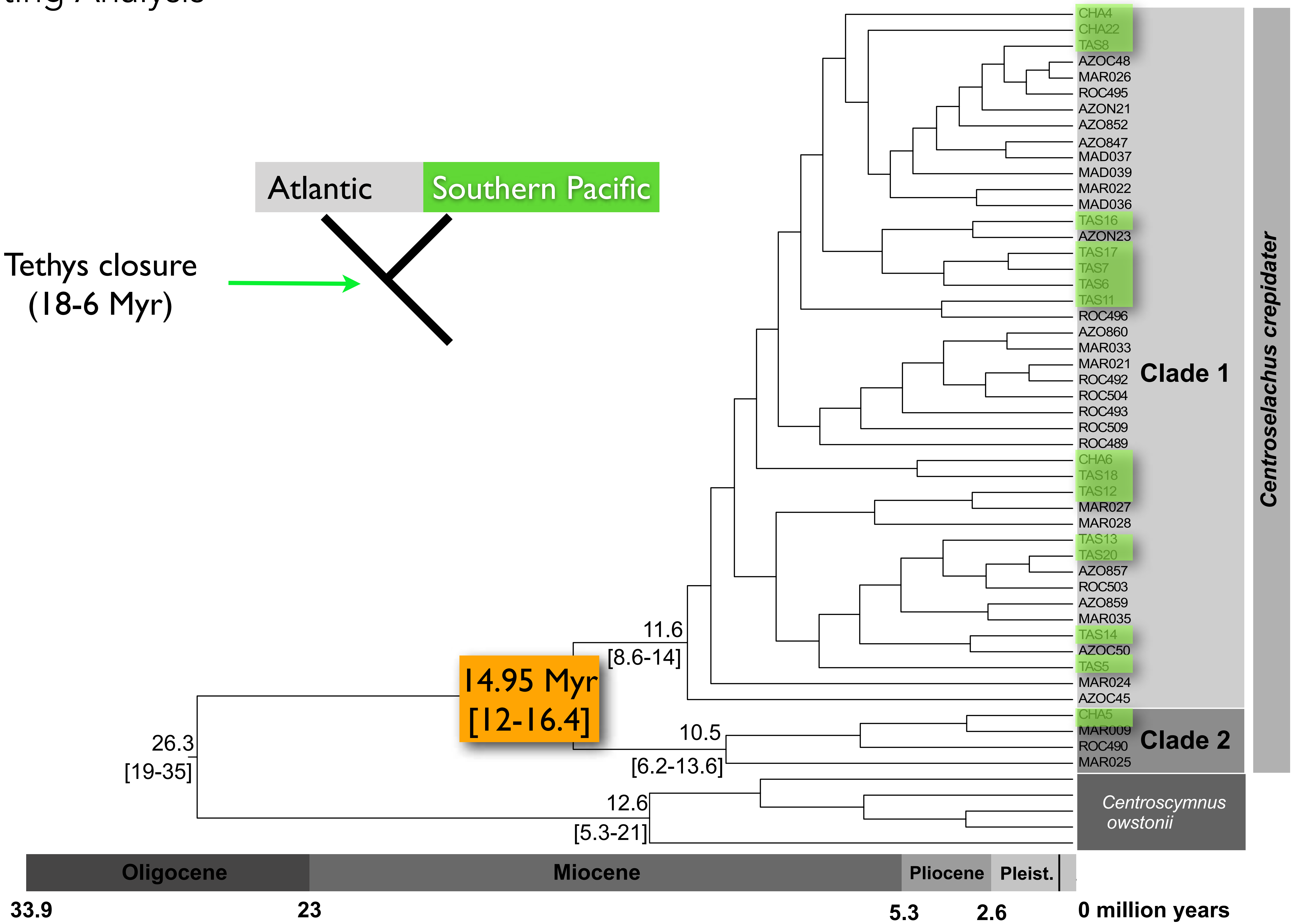




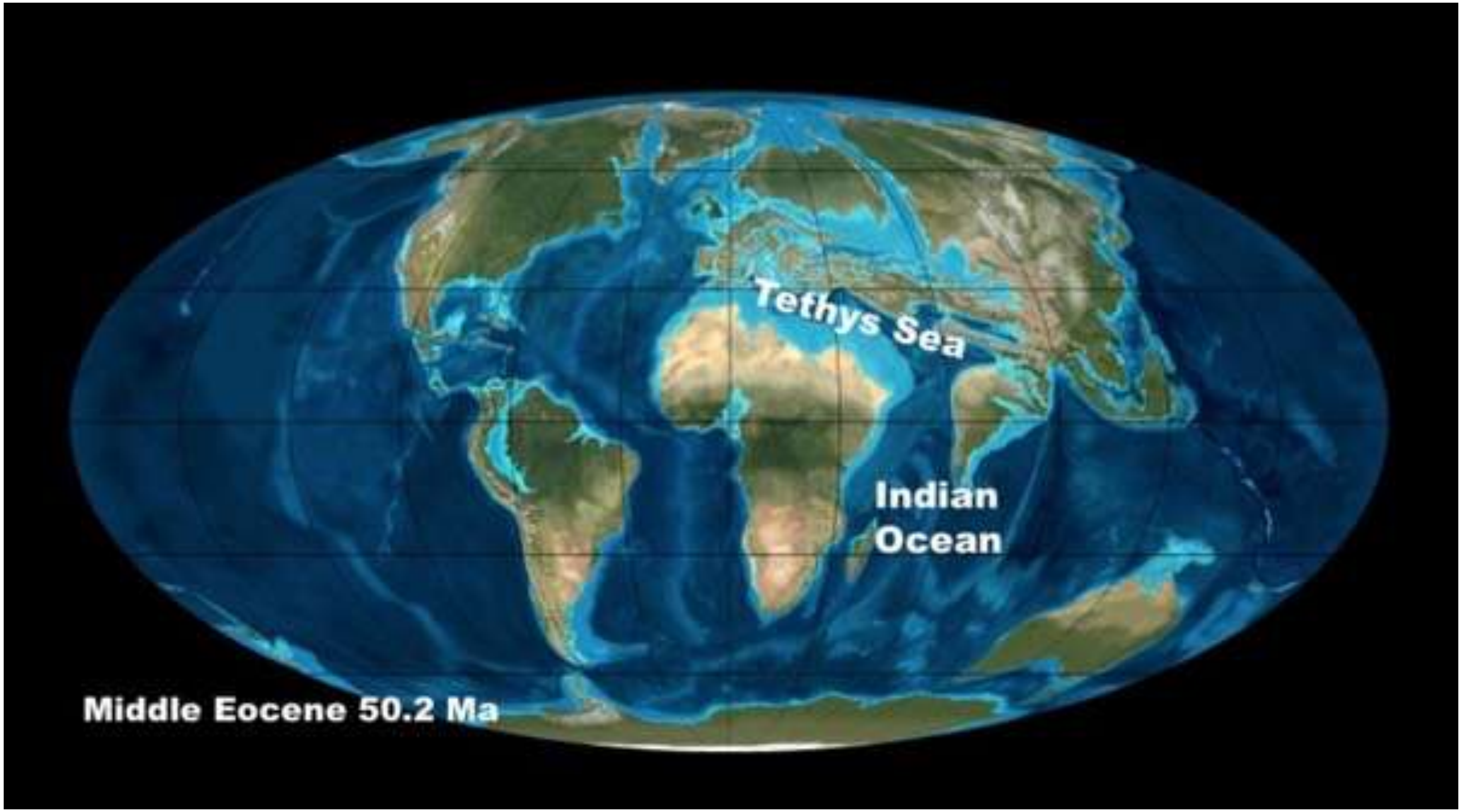
Median-Joining Network



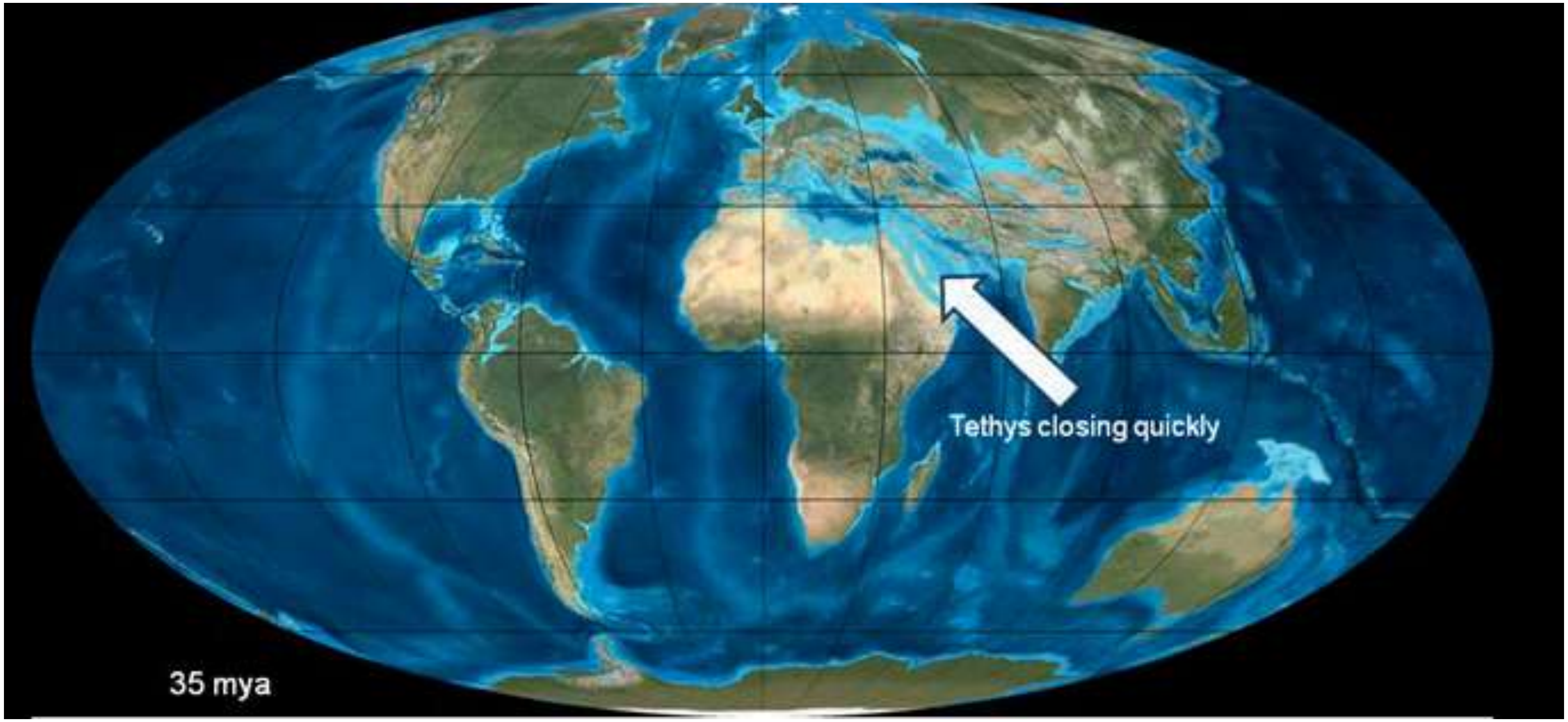
Dating Analysis

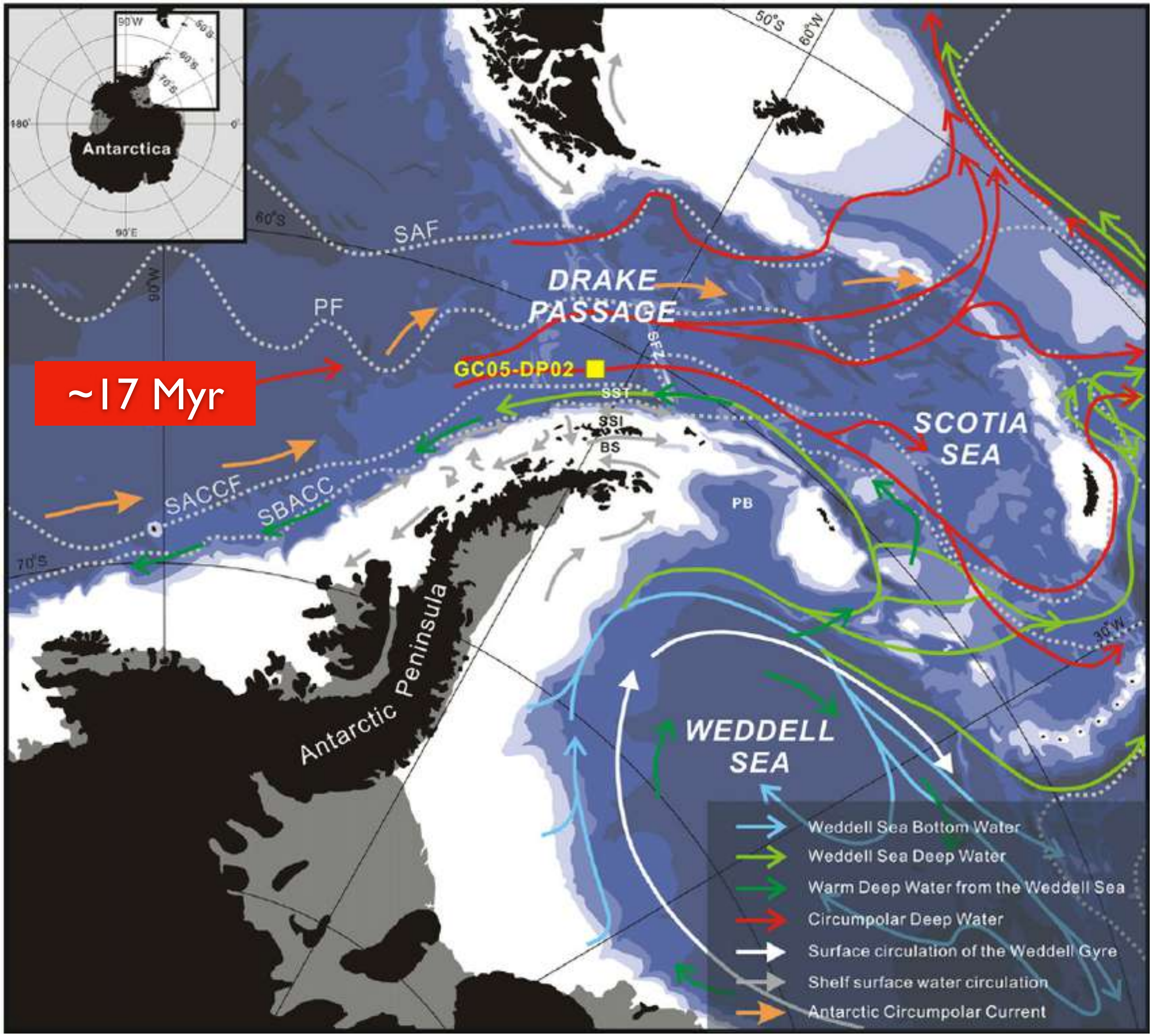


The ancestral lineage of *C. crepidater* was most likely distributed throughout the Atlantic and Pacific oceans



The Tethys closure caused a decrease in the ocean's temperature

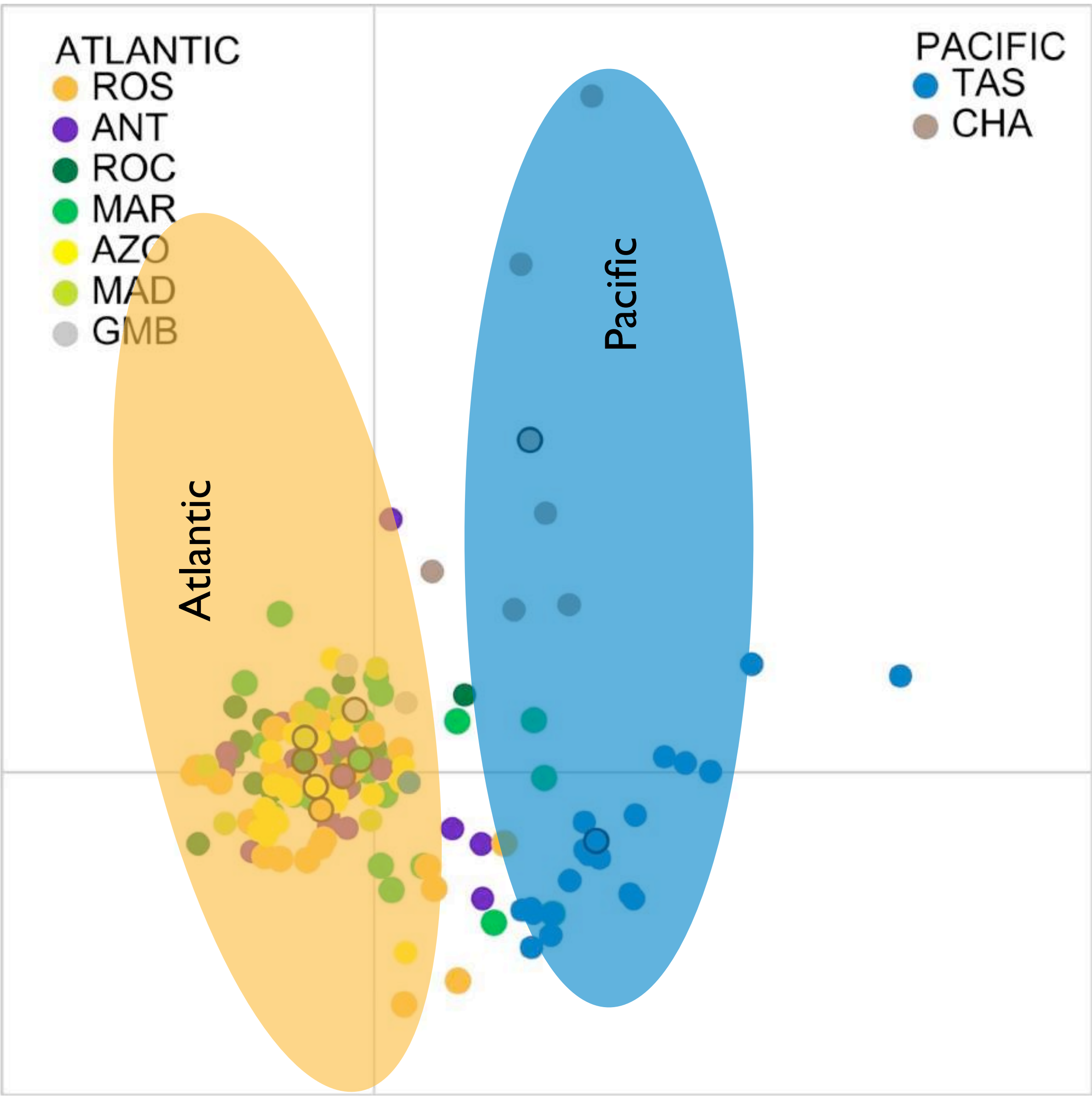




Ocean cooling promoted divergence between the Atlantic and the Pacific lineages. Each population from each basin retracted for more northward locations where there were more food resources

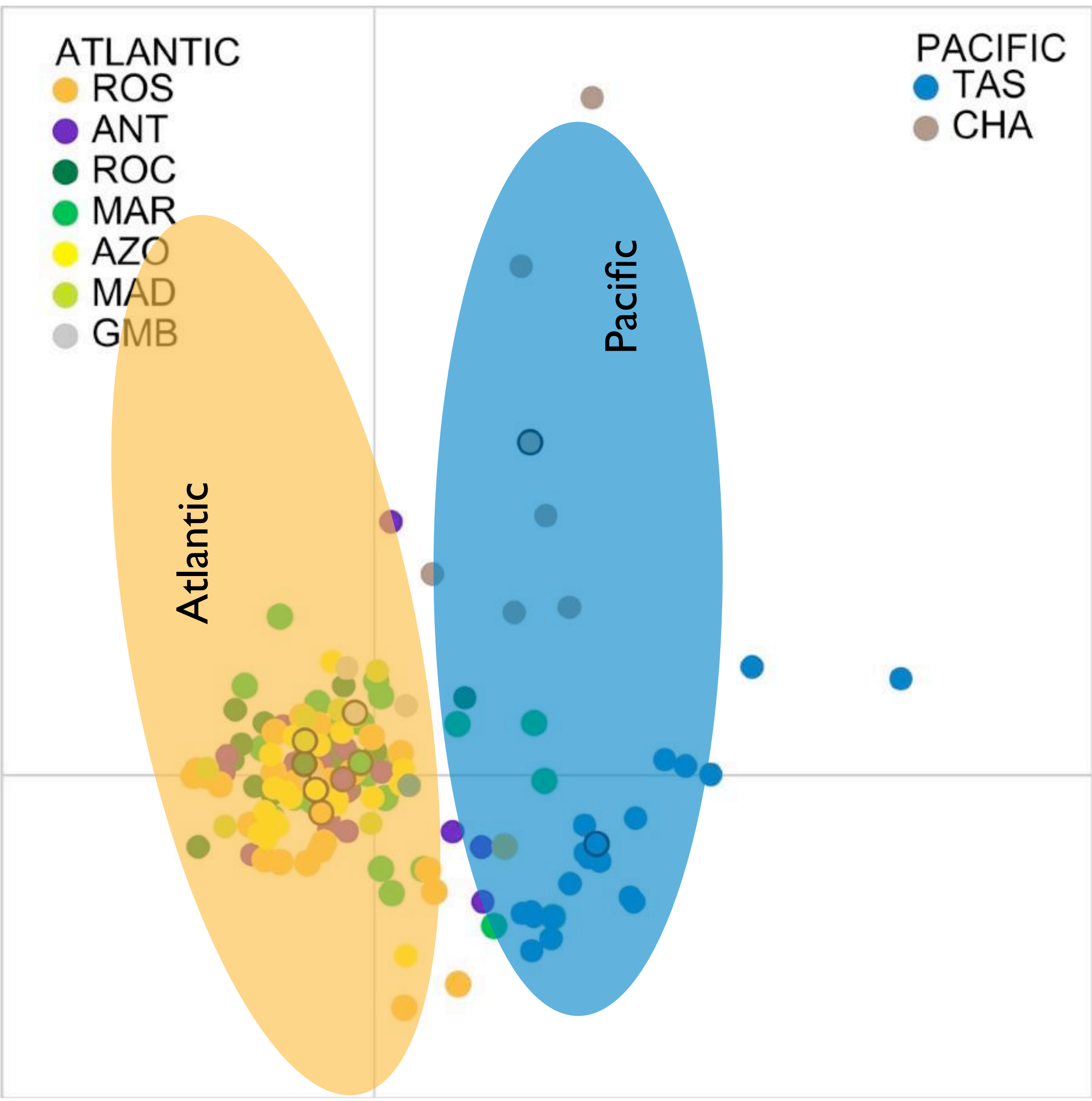
Some IWP lineages might have migrated into the North Atlantic, which explains the shared haplotypes

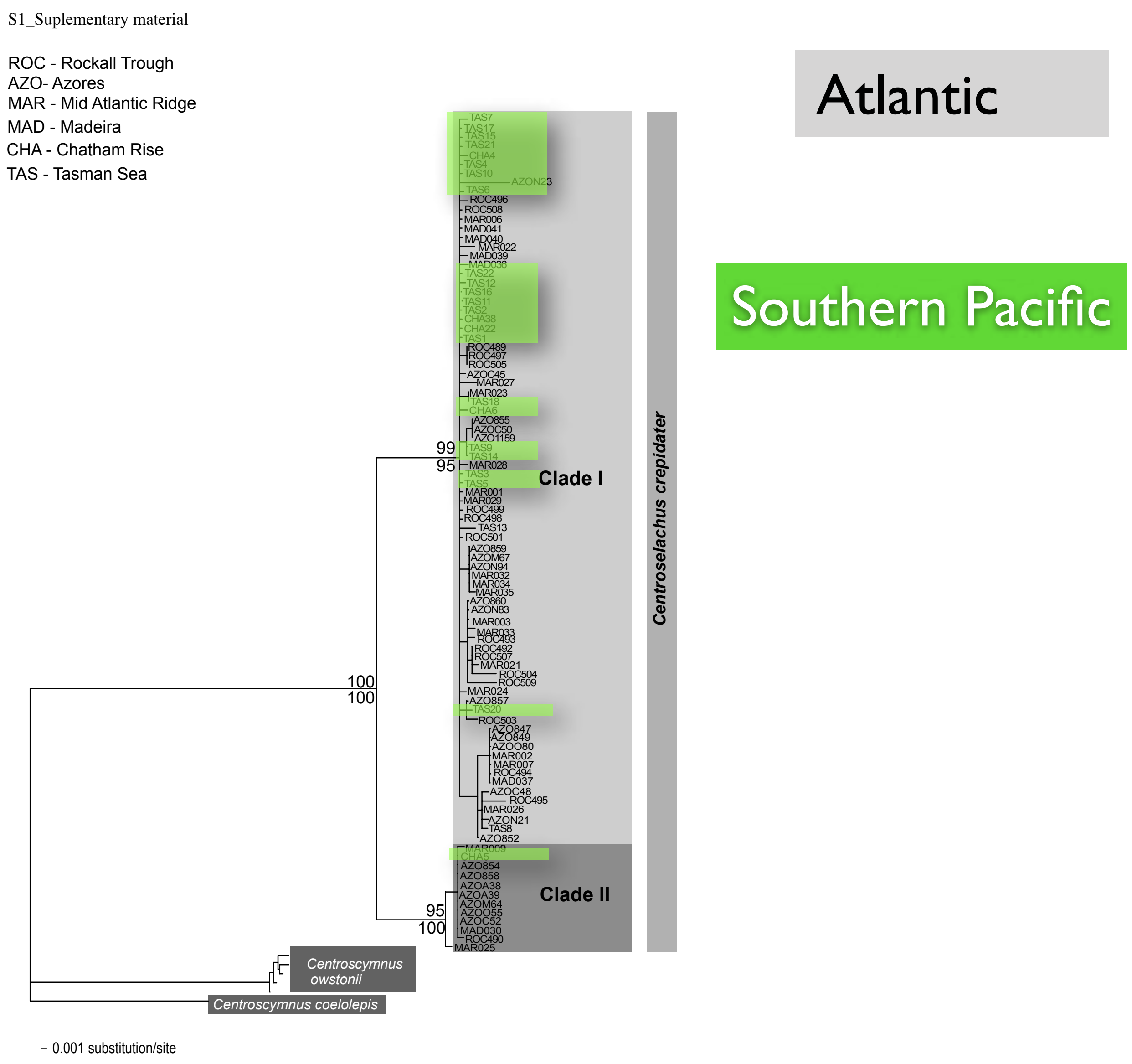
Discriminant Analysis of Principle Components (DAPC)



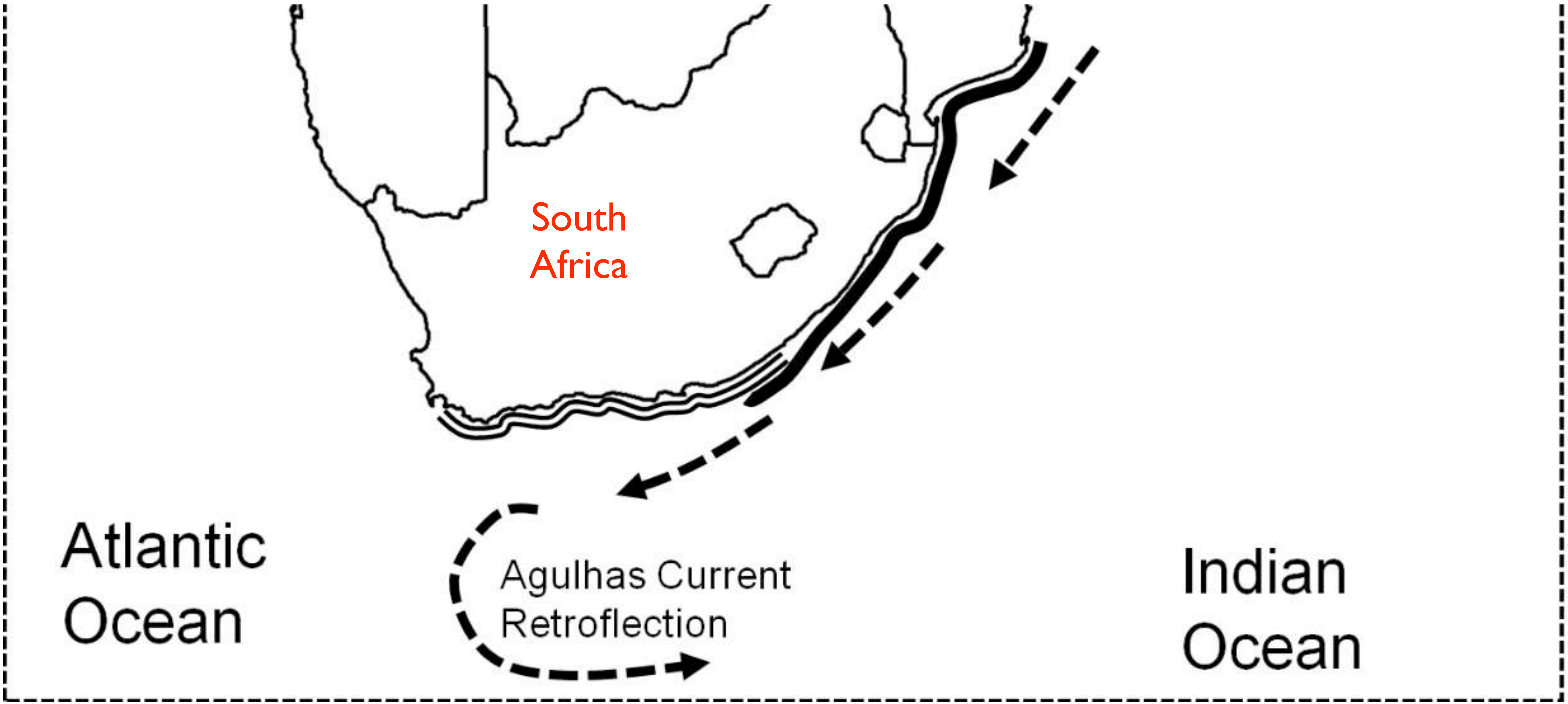
Present-day results

Historical results





Present-Day Oceanographic conditions



Summary

~17 Myr

Ocean cooling caused by the closure of the Tethys and the opening of the Drake's passage promoted divergence between the Atlantic and the Pacific lineages. Each population from each basin retracted for more northward locations where there were more food resources

Summary

~17 Myr

Some IWP lineages might have migrated into the North Atlantic, which explains the shared haplotypes

Summary

~5 Myr

–The formation of Agulhas Current creates a filter to the displacement of small fish between ocean basins which are an important component of Centroscymnus diet, which seems to restrict migrations.

OPEN ACCESS Freely available online

PLOS | ONE

Ancient Divergence in the Trans-Oceanic Deep-Sea Shark *Centroscymnus crepidater*

Regina L. Cunha[1*], Ilaria Coscia[2], Celine Madeira[1], Stefano Mariani[3], Sergio Stefanni[4], Rita Castilho[1]

1 CCMAR-CIMAR, Universidade do Algarve, Faro, Portugal, 2 Institute of Biological, Environmental and Rural Sciences (IBERS), Aberystwyth University, Aberystwyth, Ceredigion, United Kingdom, 3 School of Environment and Life Sciences, University of Salford, Manchester, United Kingdom, 4 IMAR / DOP, Department of Oceanography and Fisheries, University of the Azores, Horta, Azores, Portugal

PLoS ONE 2012; 7(11): e49196. doi:10.1371/journal.pone.0049196