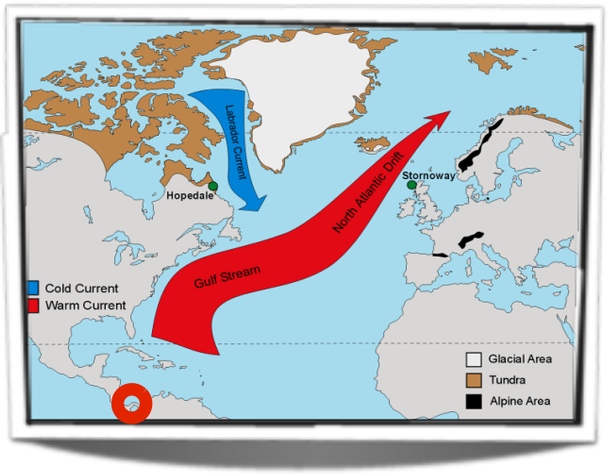
Fossil Sharks

Catalina Pimiento

- the isthmus that changed the world



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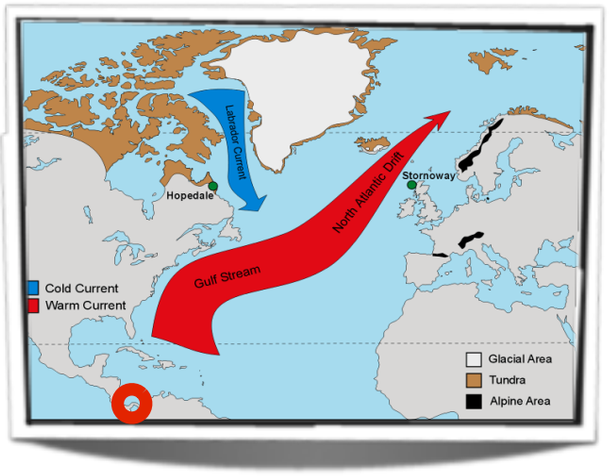

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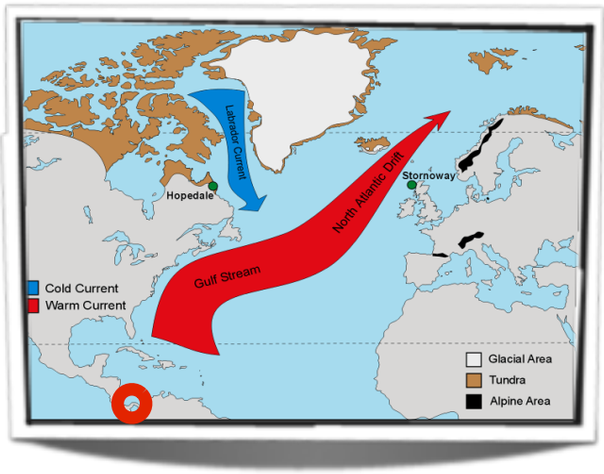

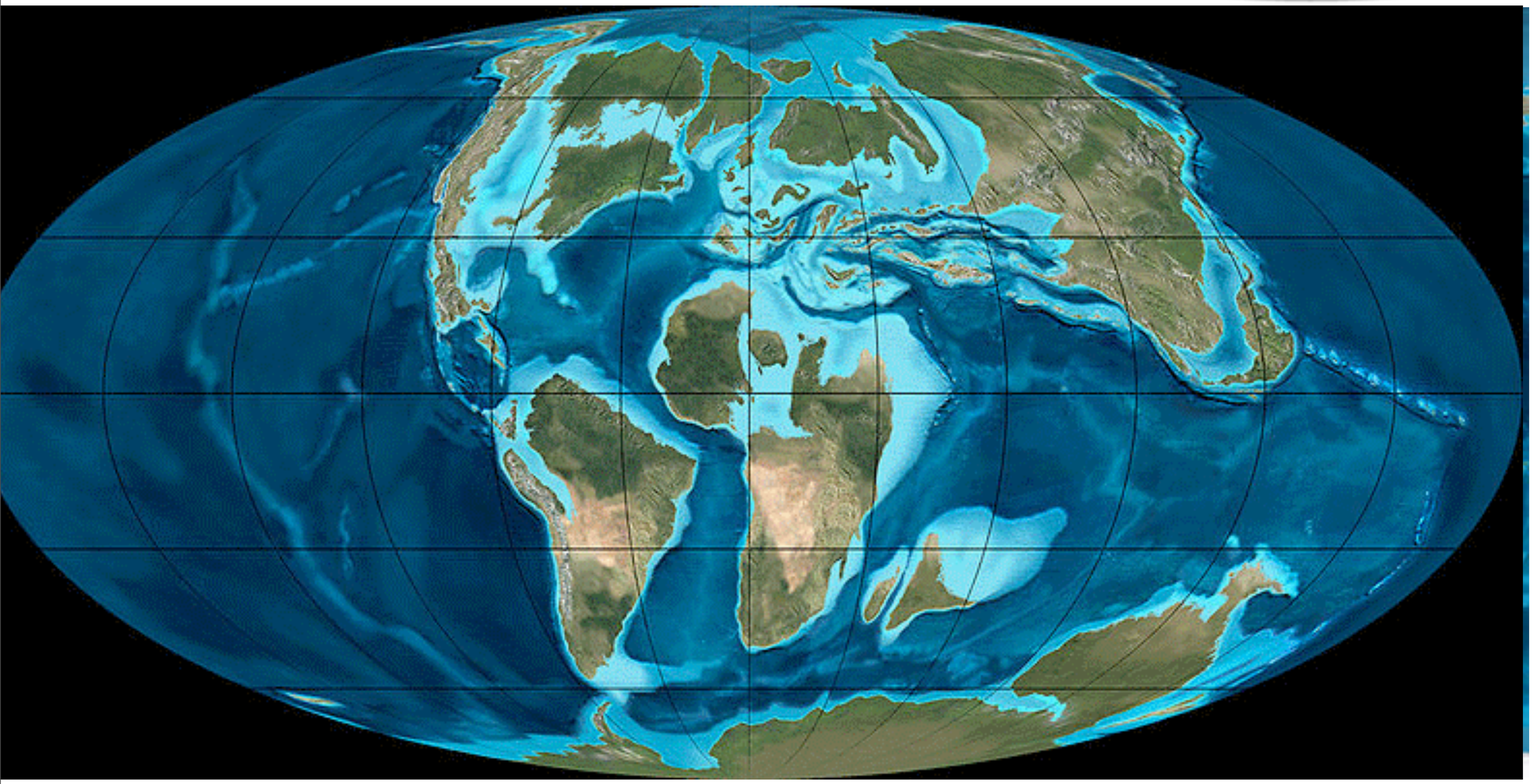

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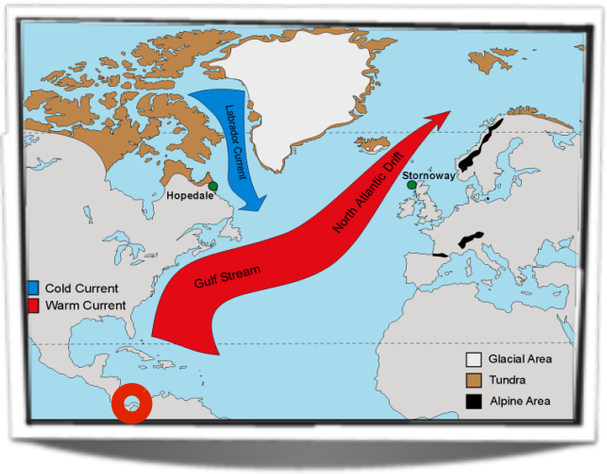

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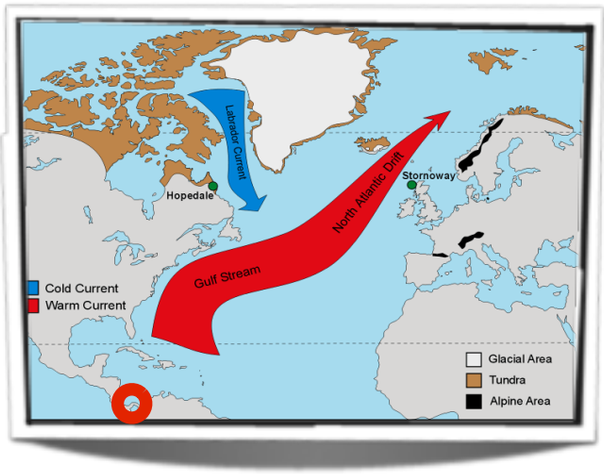
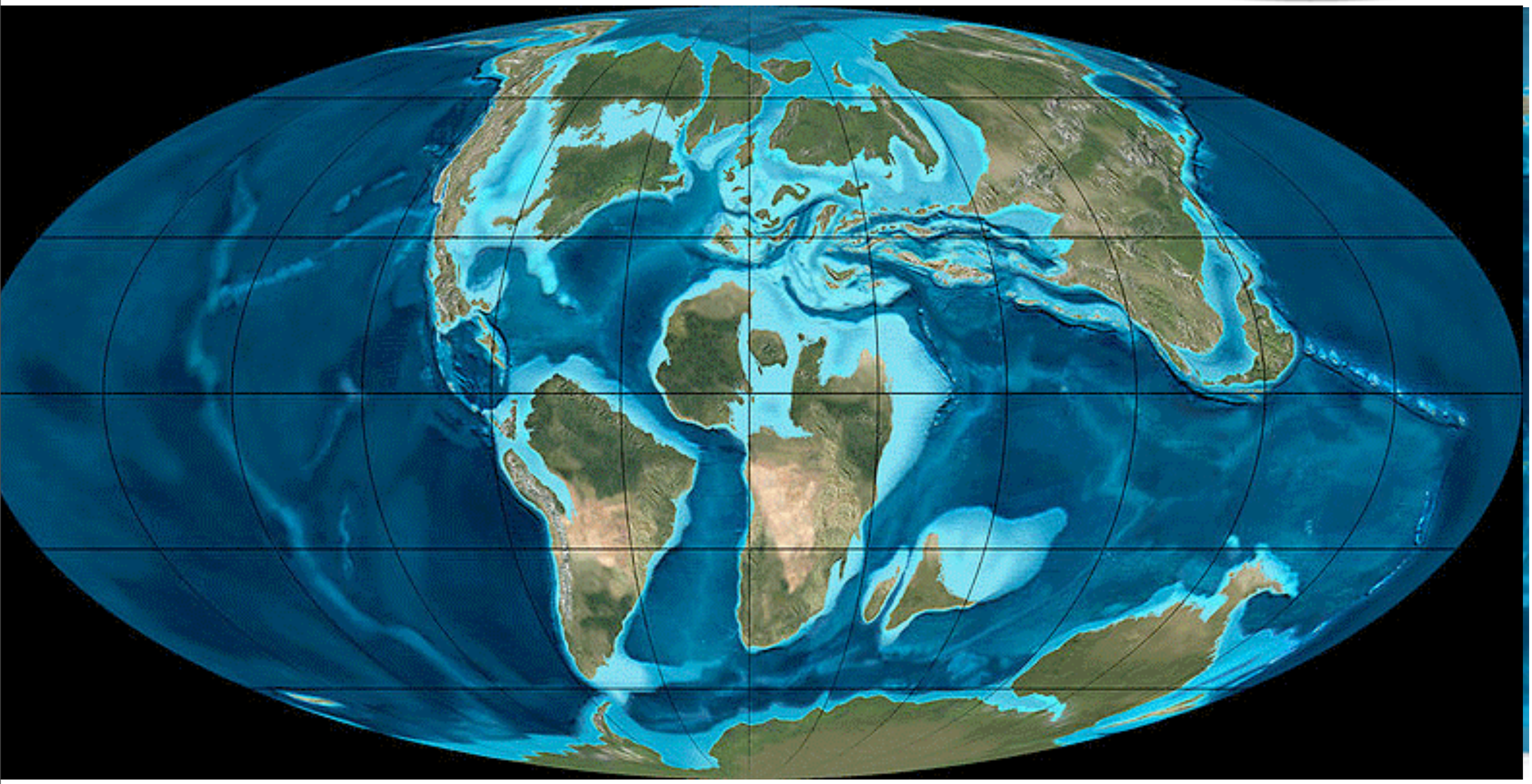
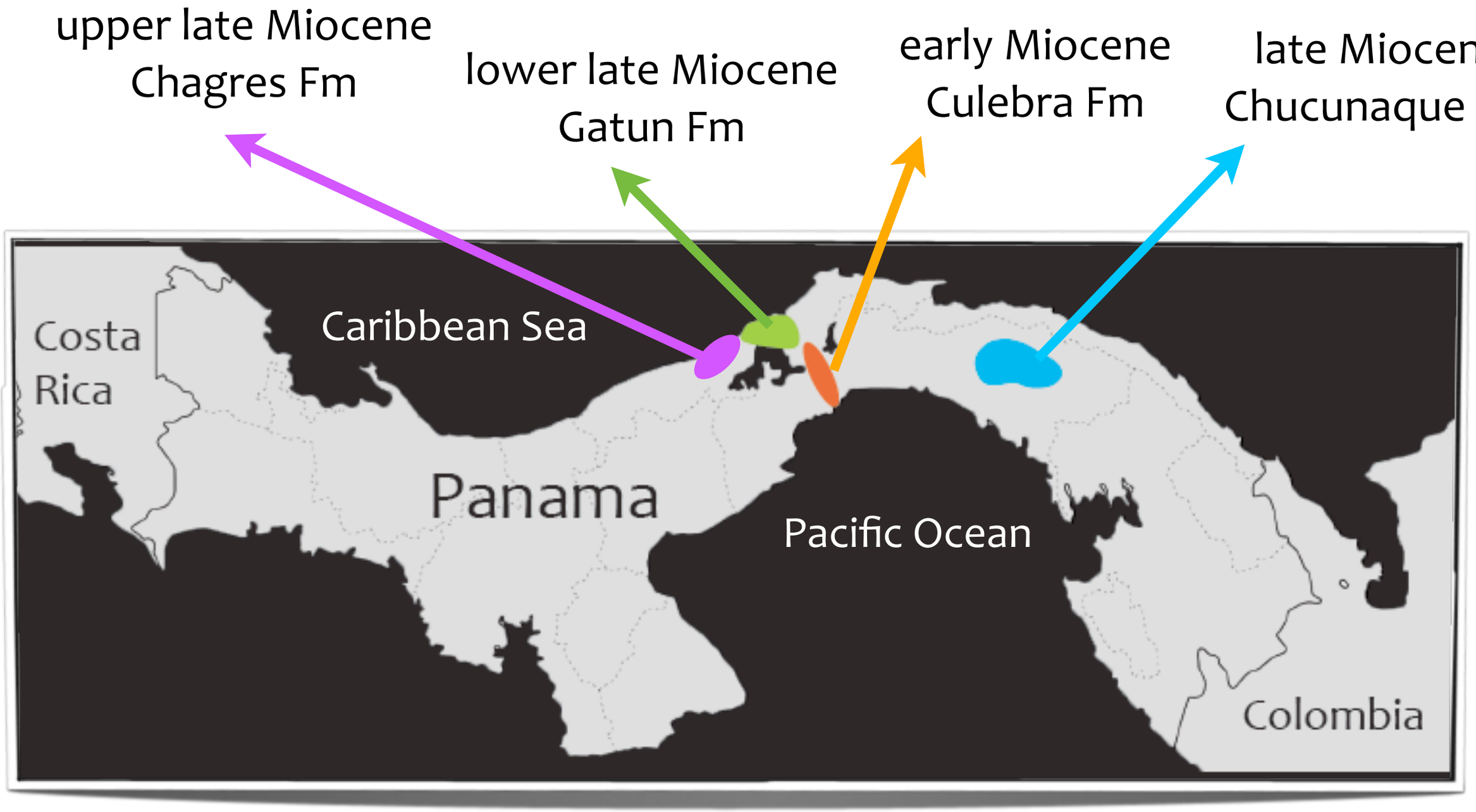




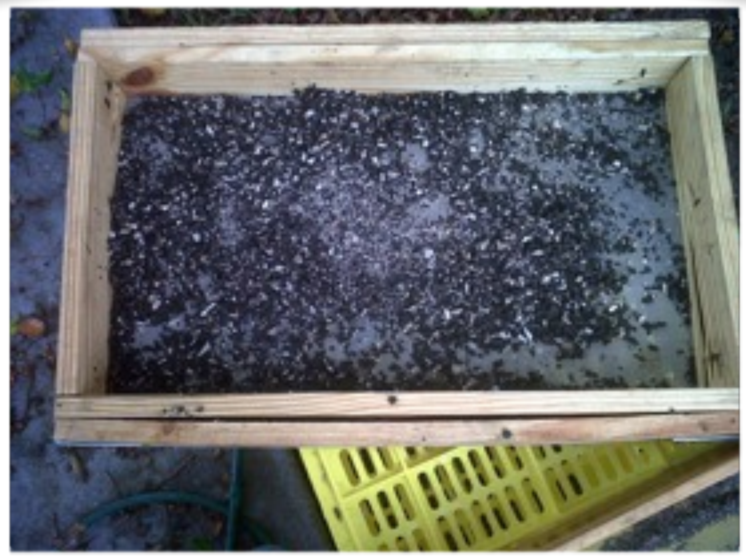
Miocene fossil shark localities



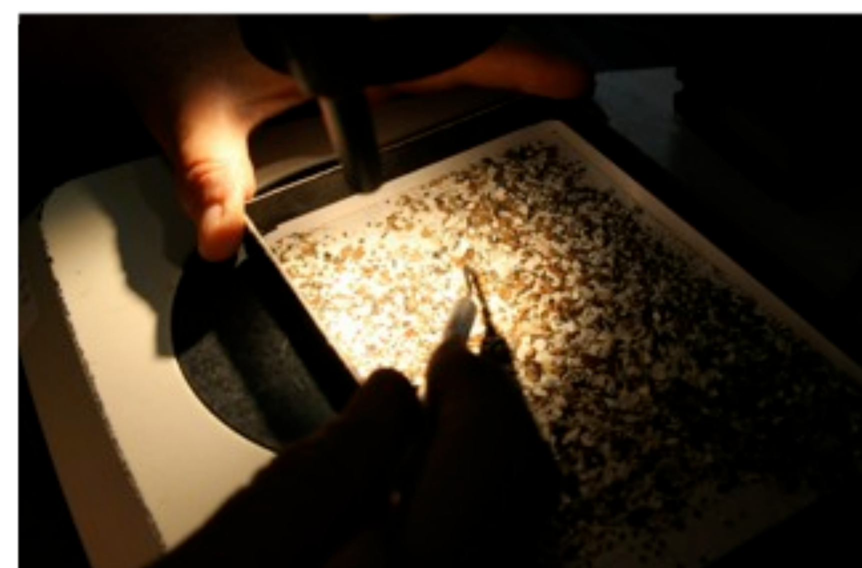
- Miocene fossil shark localities



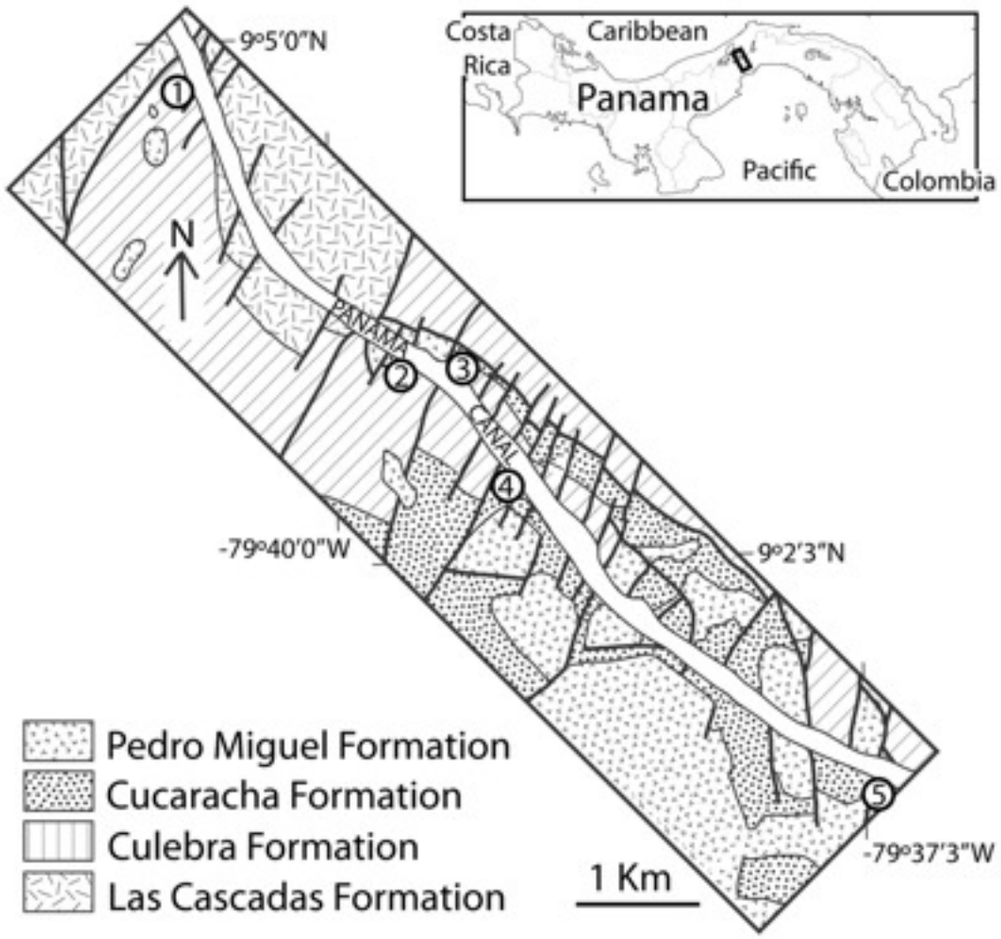

HCL
HCL
ADDED



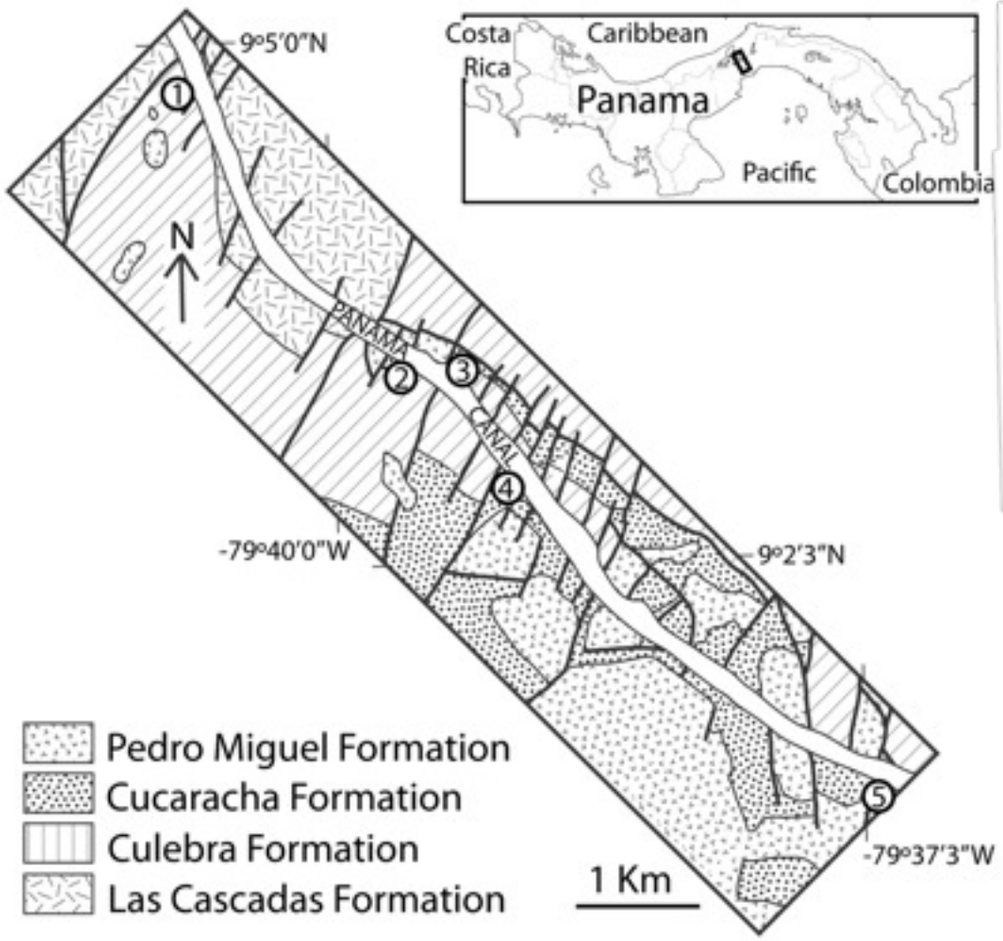

San Judas, Gatun Fm



- early Miocene Culebra Formation



- early Miocene Culebra Formation



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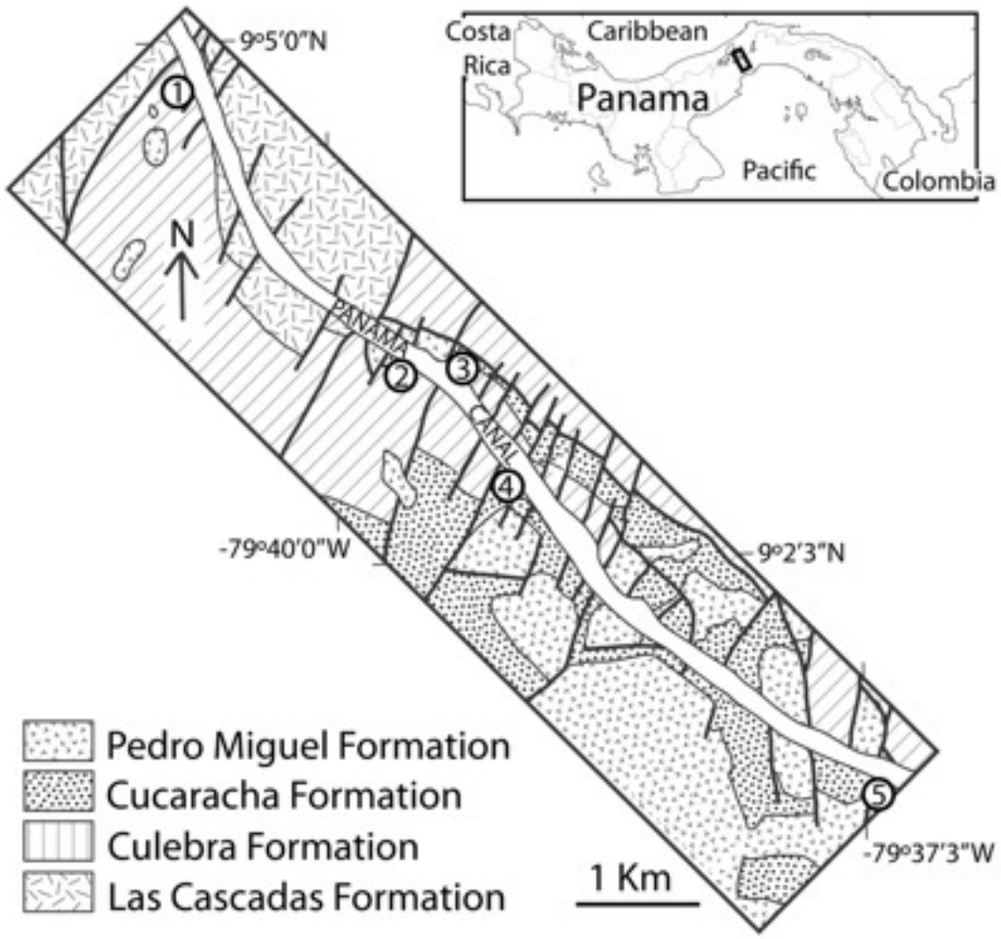

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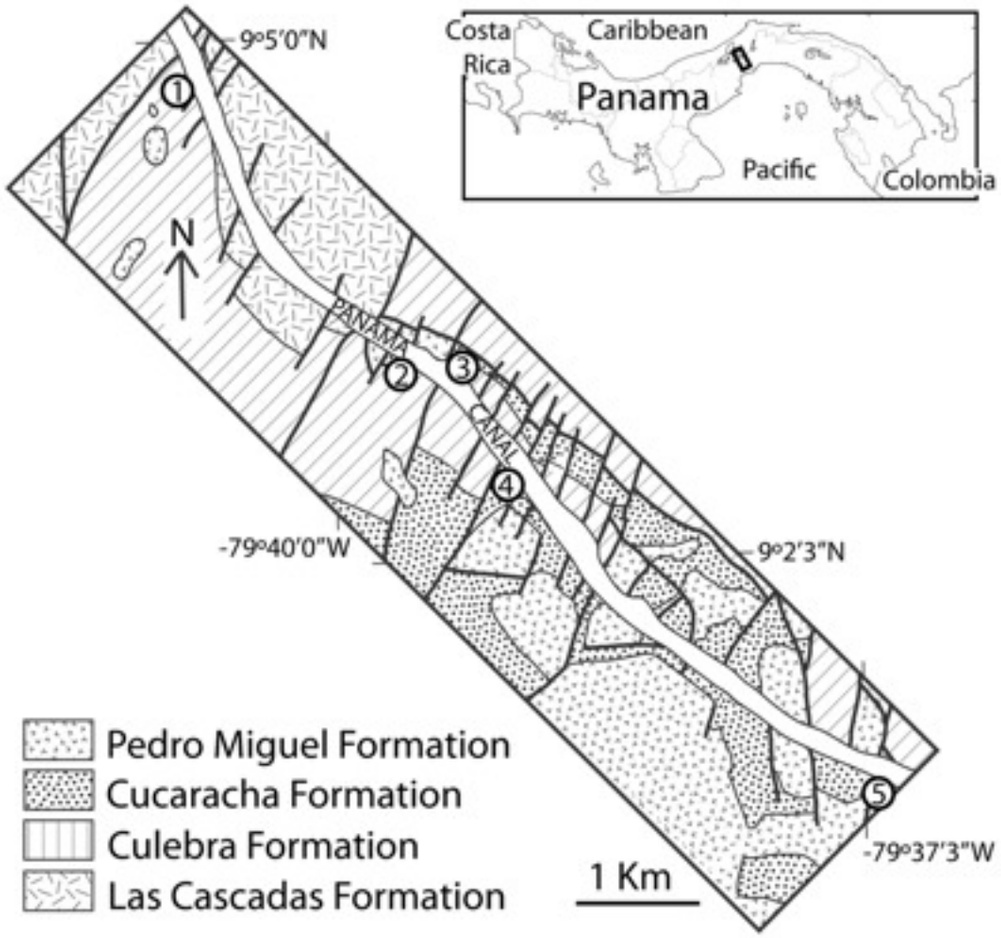
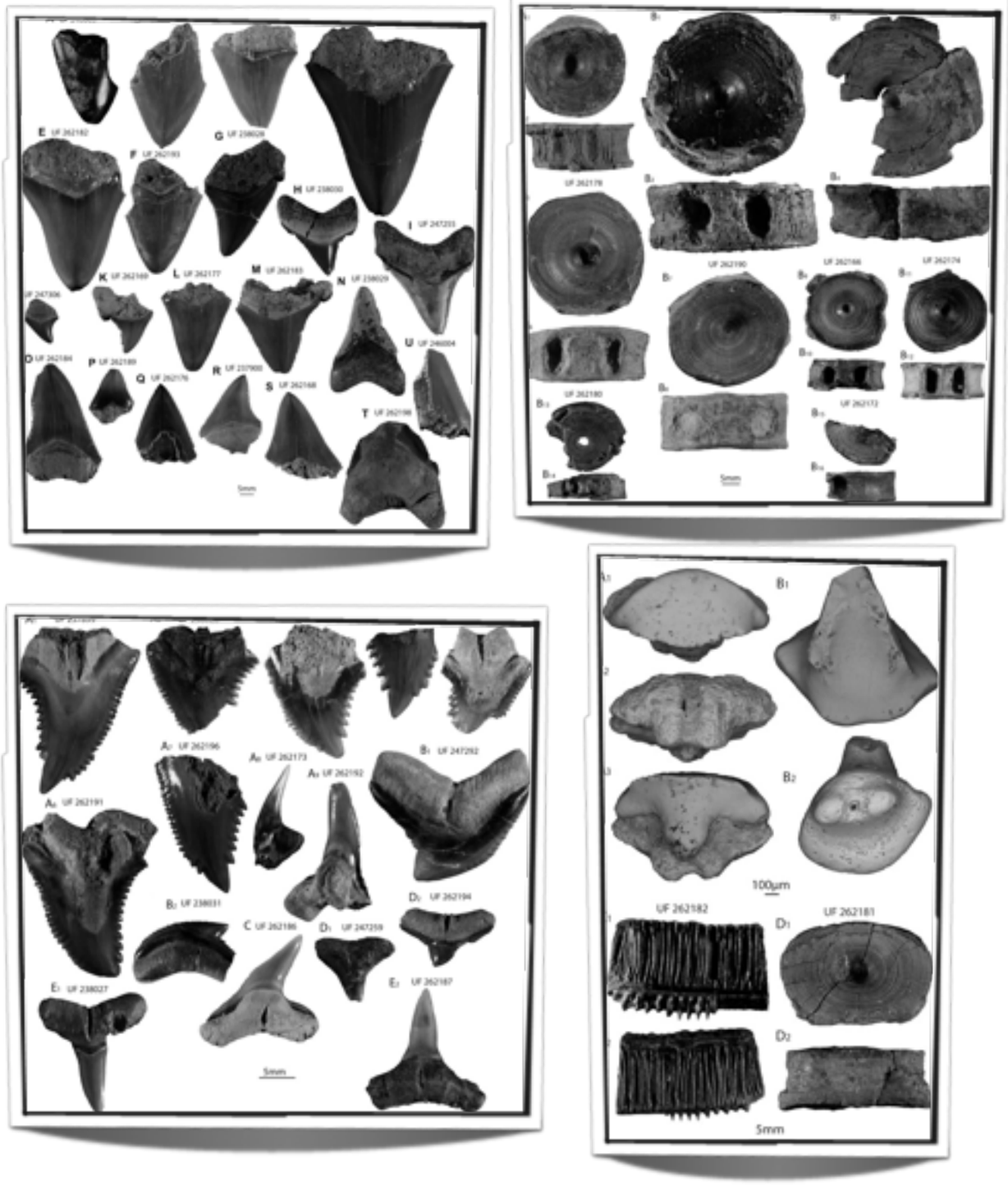
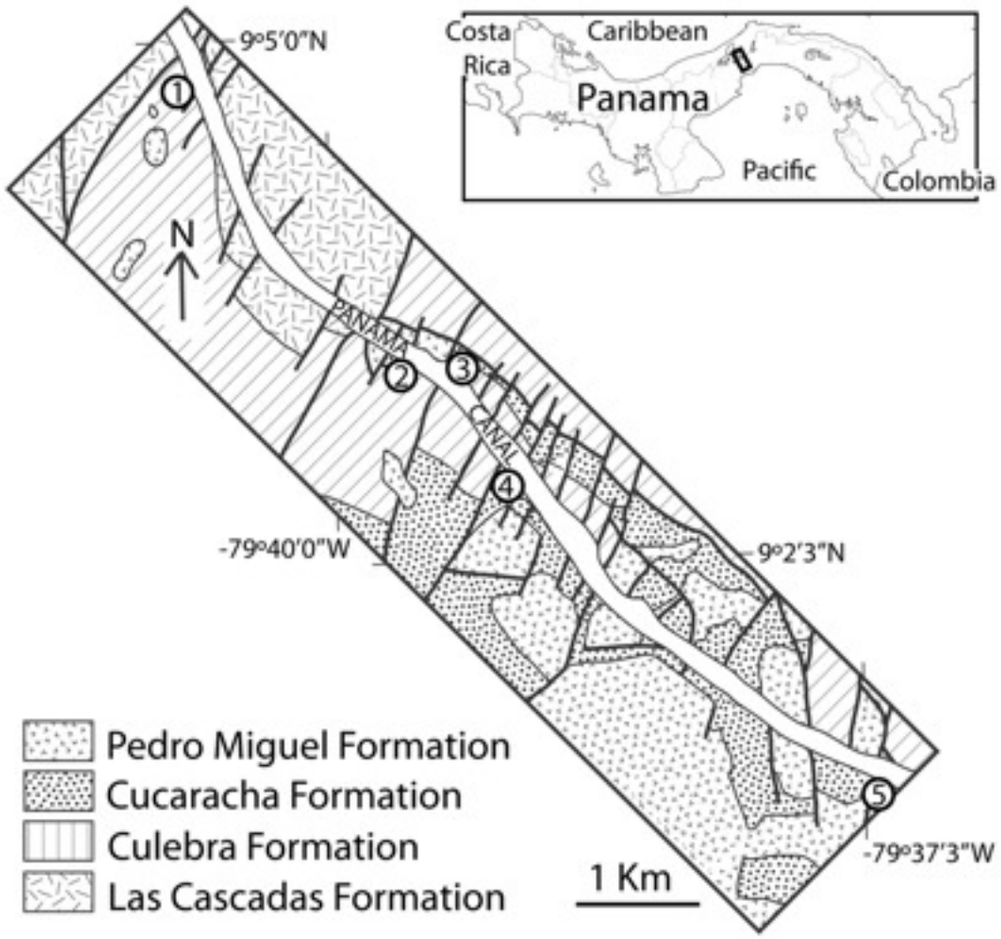


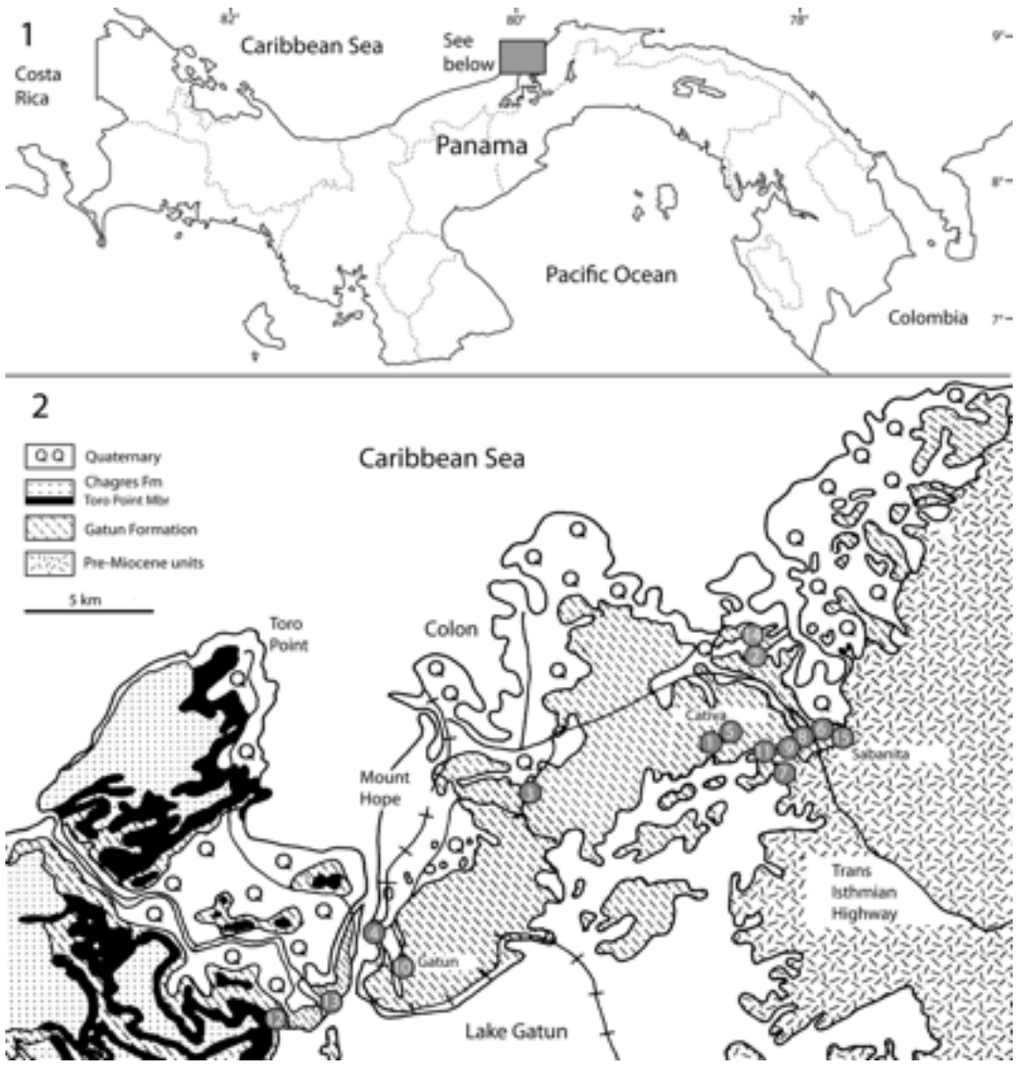


Pimiento et al. 2013

- early Miocene Culebra Formation

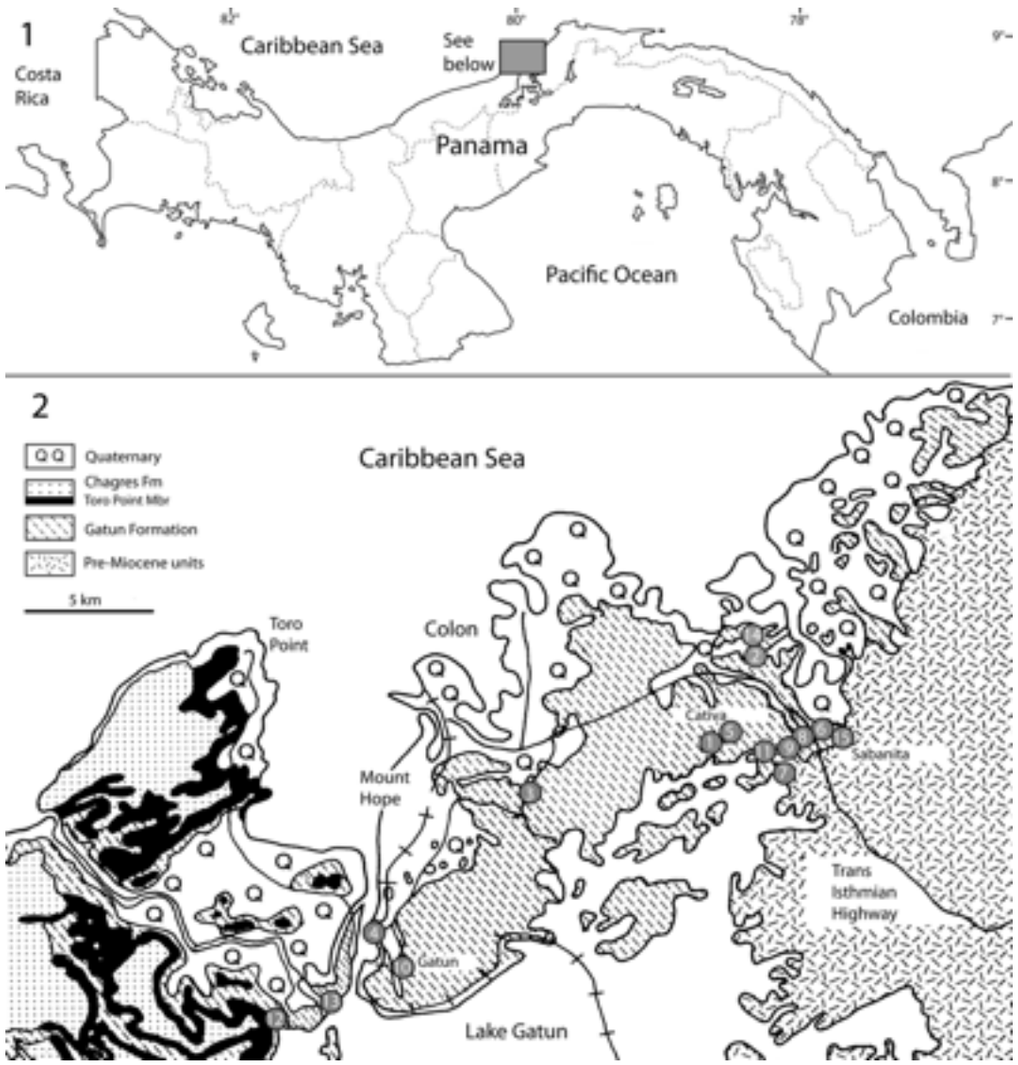


late Miocene Gatun Formation



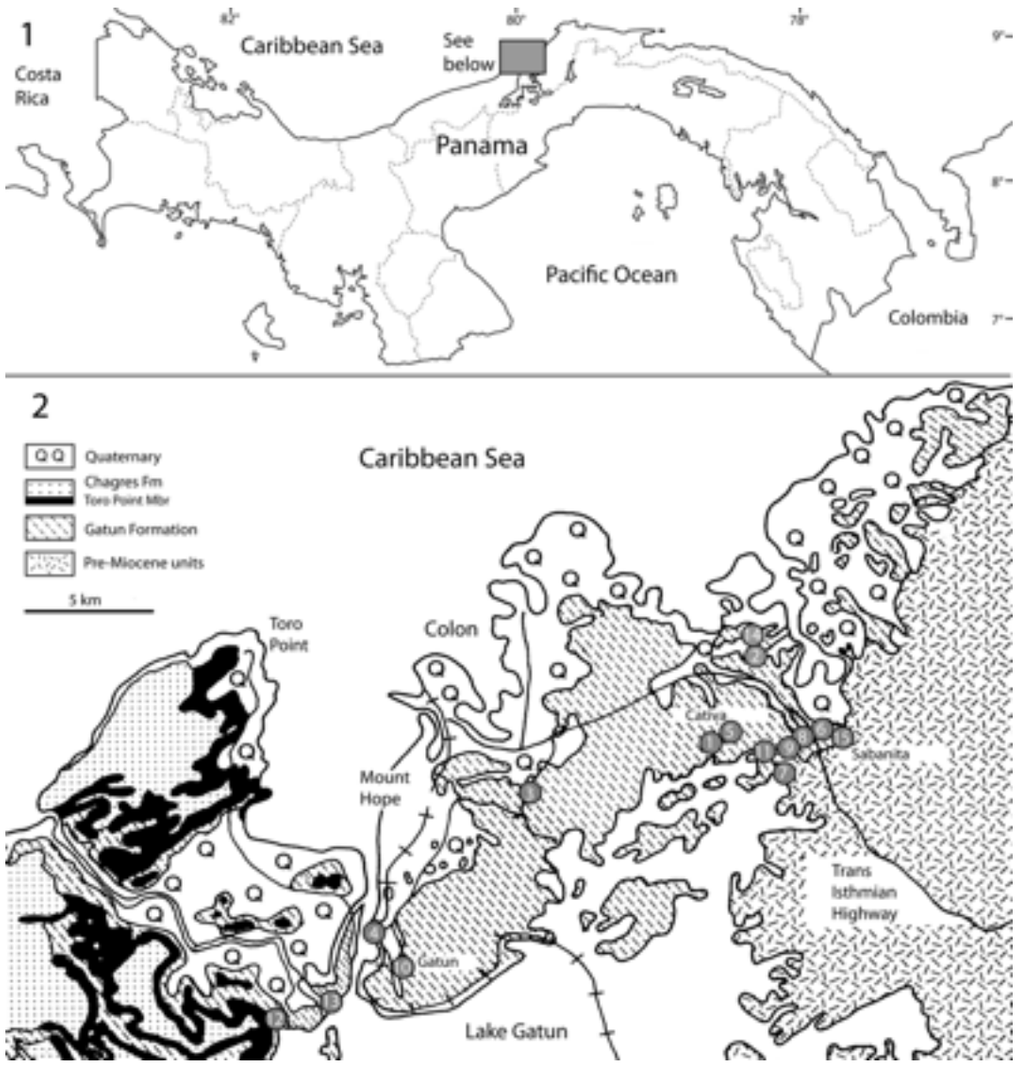
Pimiento et al. In press

late Miocene Gatun Formation



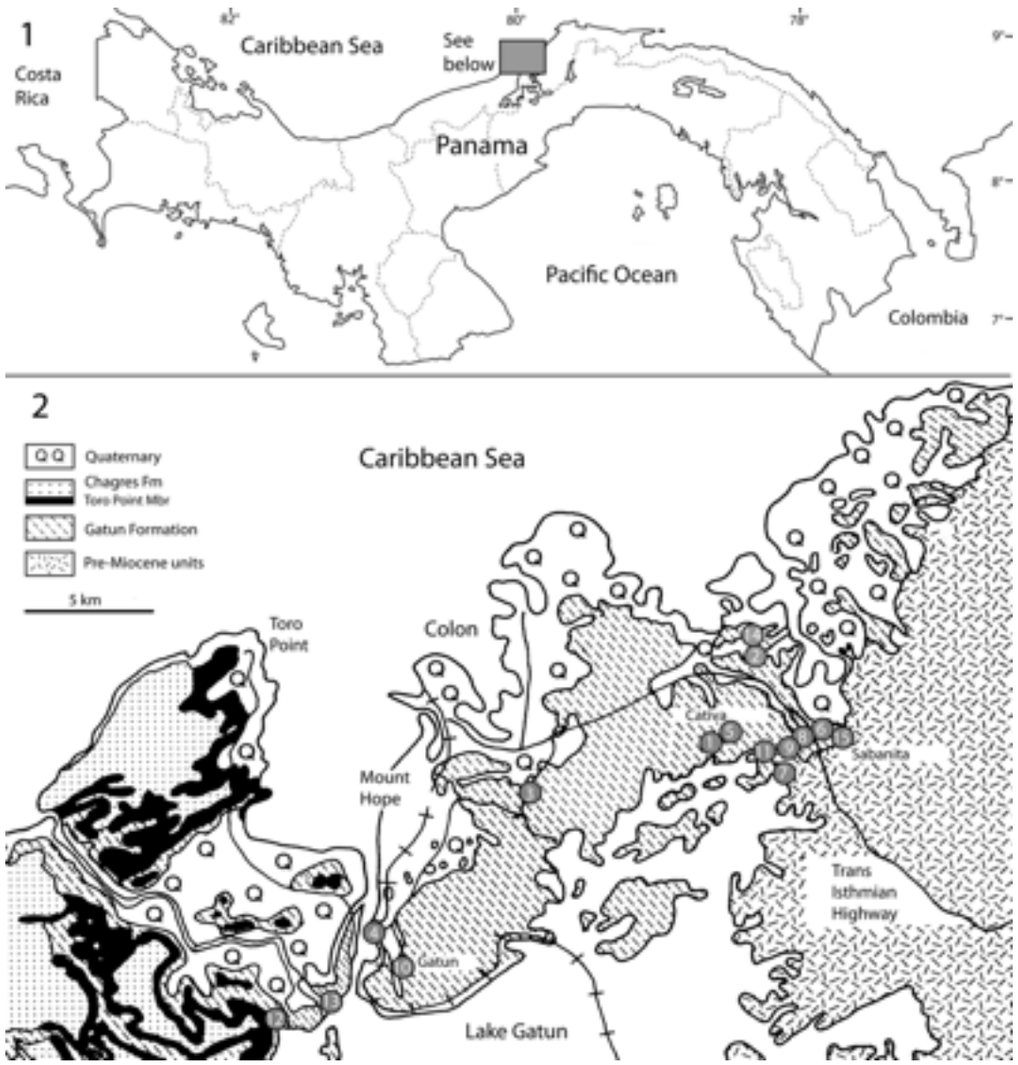
Pimiento et al. In press

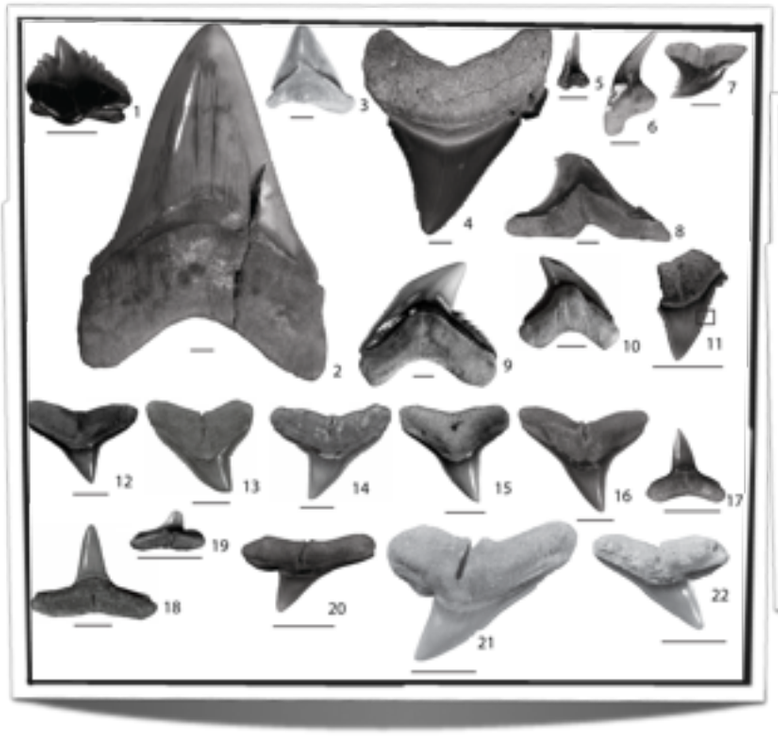
late Miocene Gatun Formation

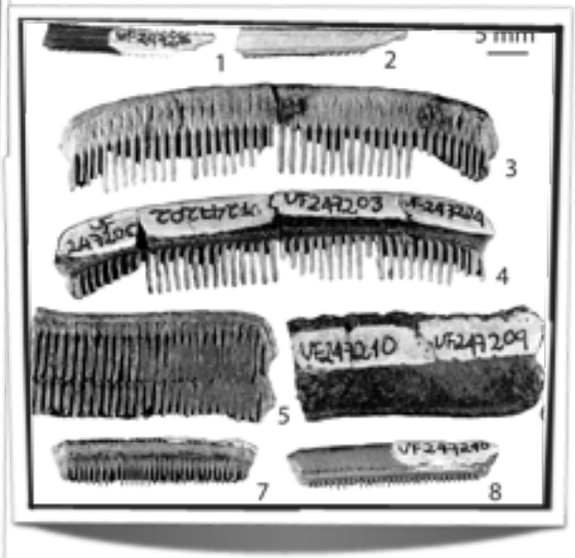


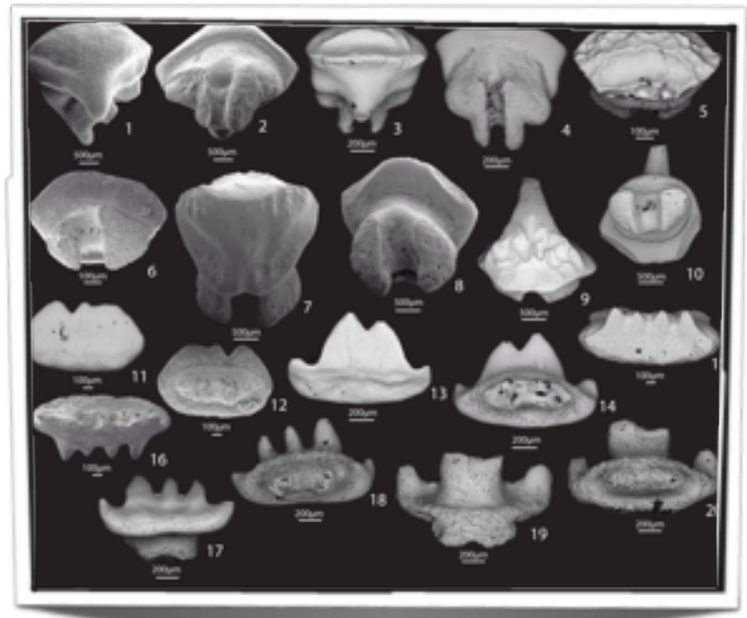
Pimiento et al. In press

late Miocene Gatun Formation



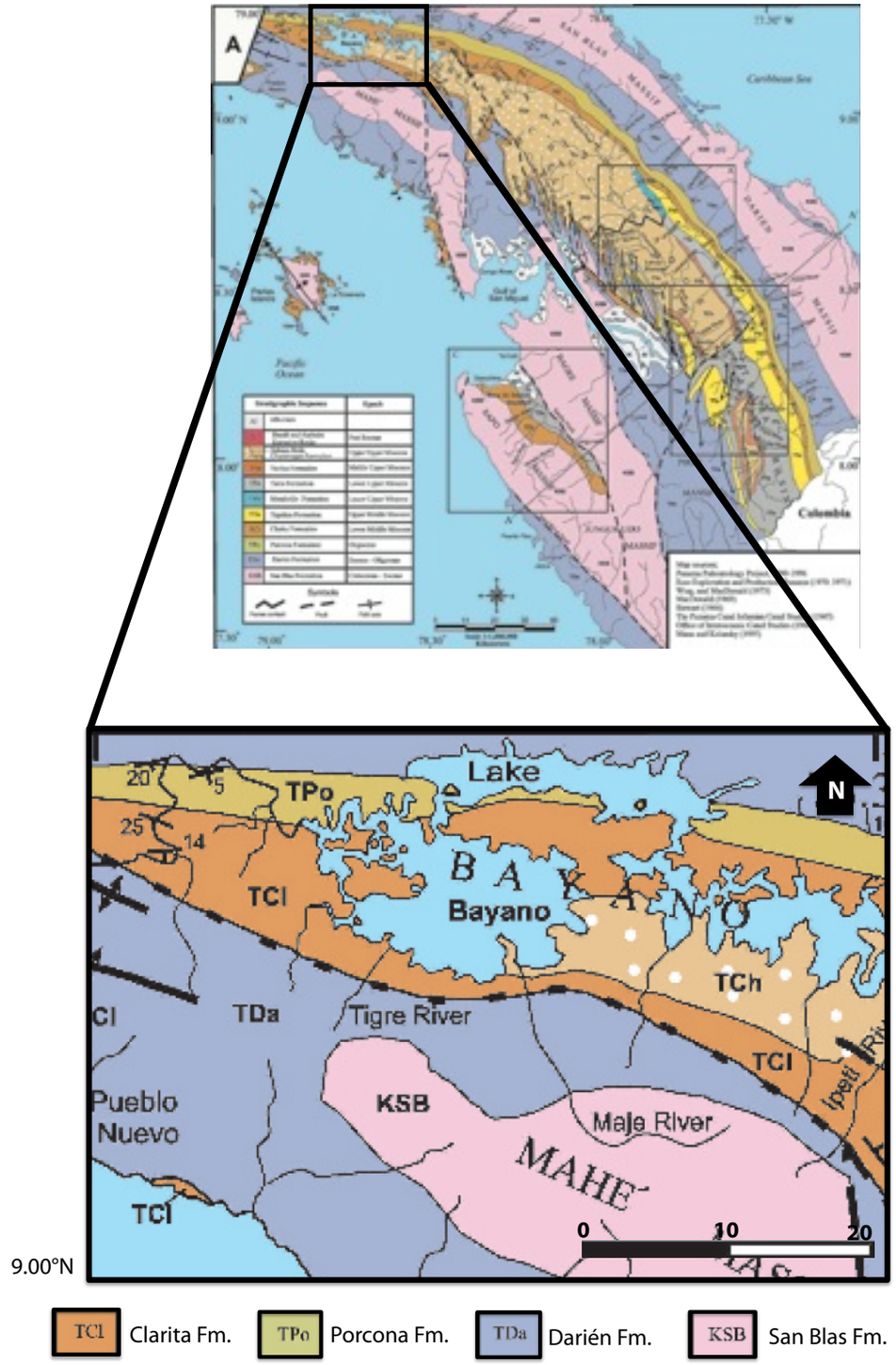






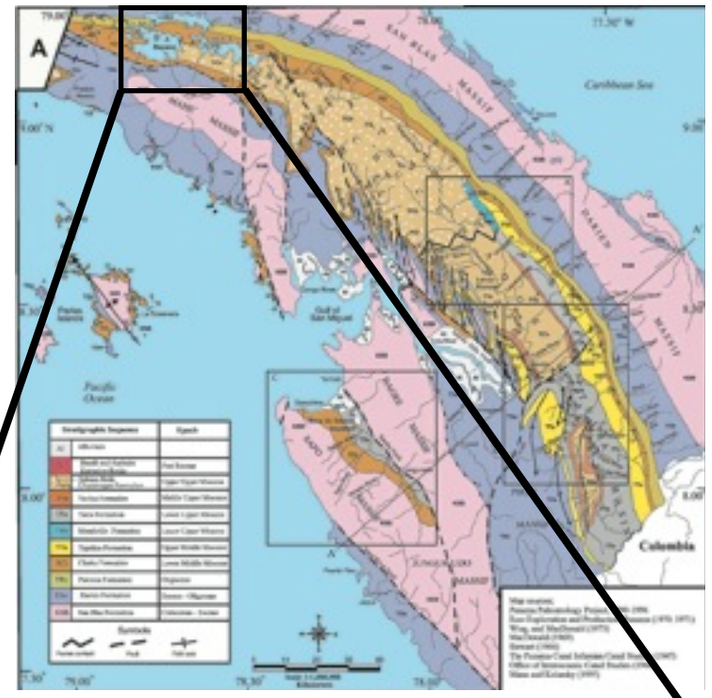
Pimiento et al. In press

- late Miocene Chucunaque Formation



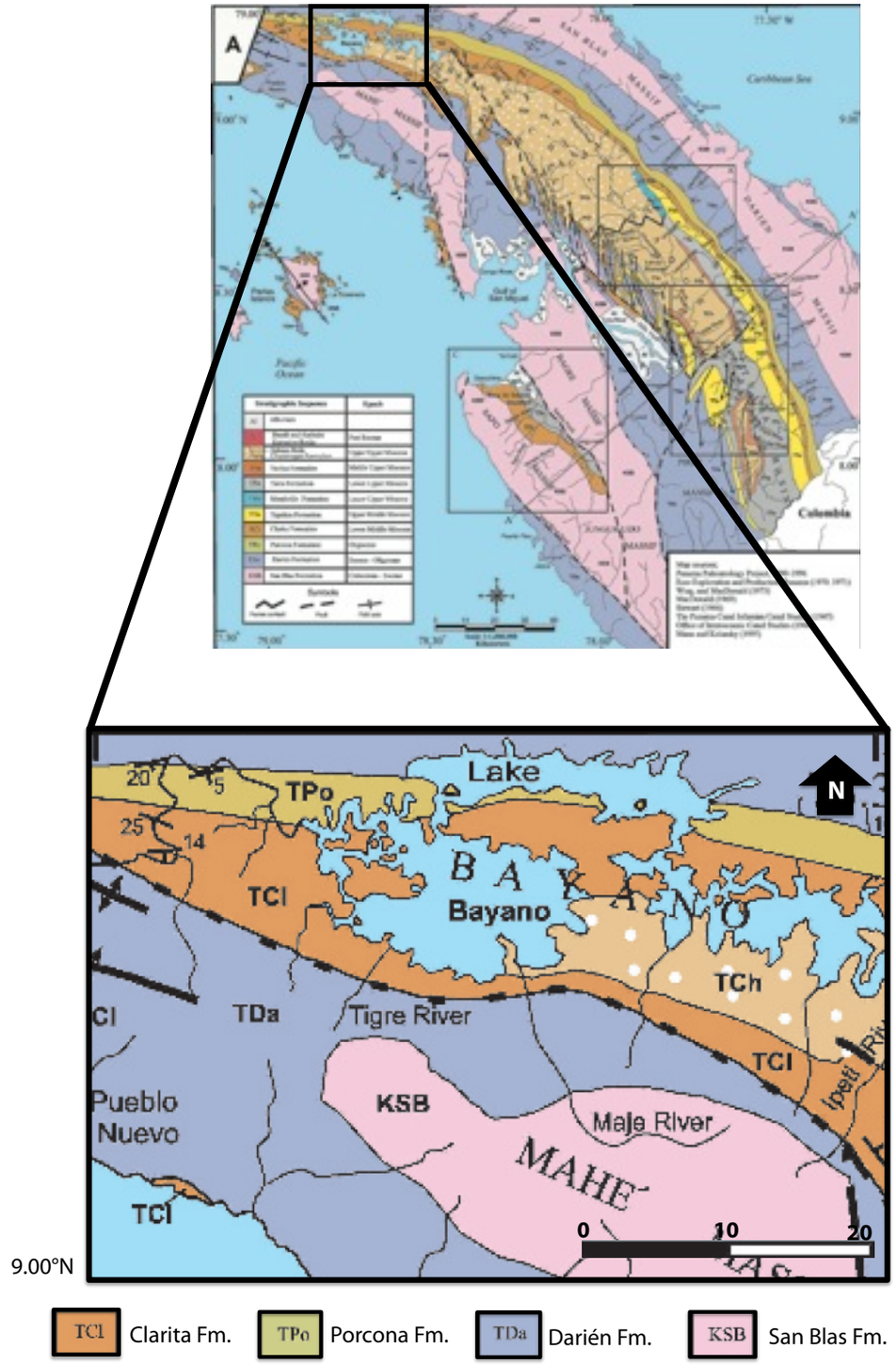
Coates et al. 2004

late Miocene Chucunaque Formation



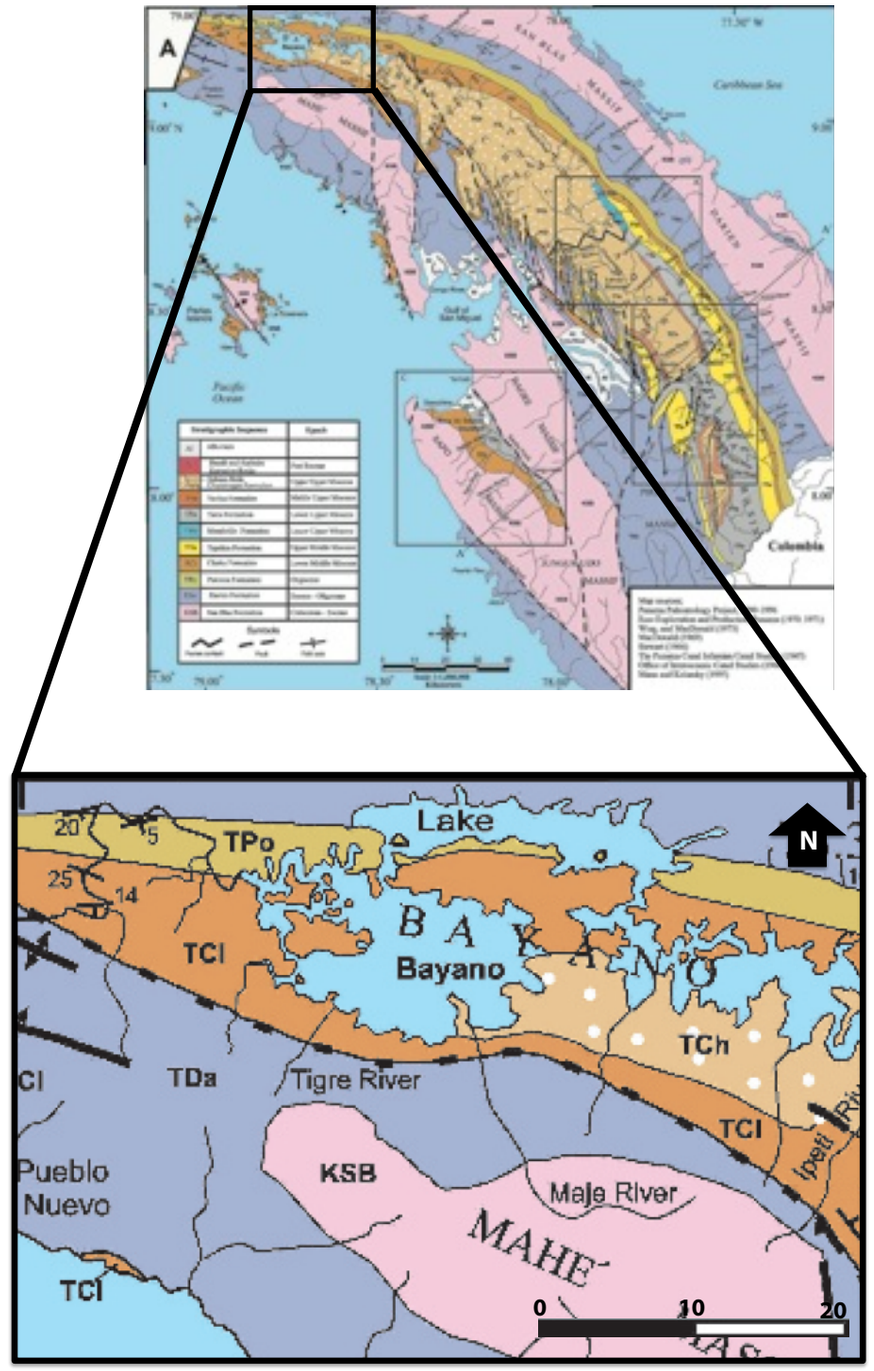
Coates et al. 2004

- late Miocene Chucunaque Formation



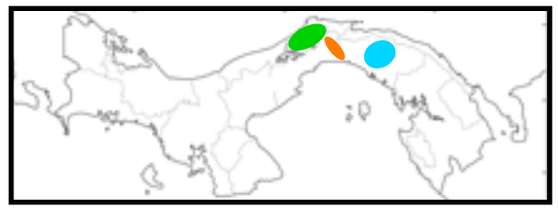
Coates et al. 2004

- late Miocene Chucunaque Formation



Coates et al. 2004

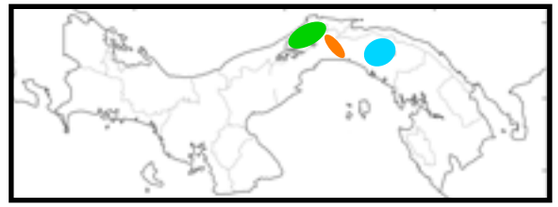
Miocene shark faunas: Biodiversity



late
late
early

At least 32 taxa so far...
Only 4 are extinct

Miocene shark faunas: Biodiversity



At least 32 taxa so far...
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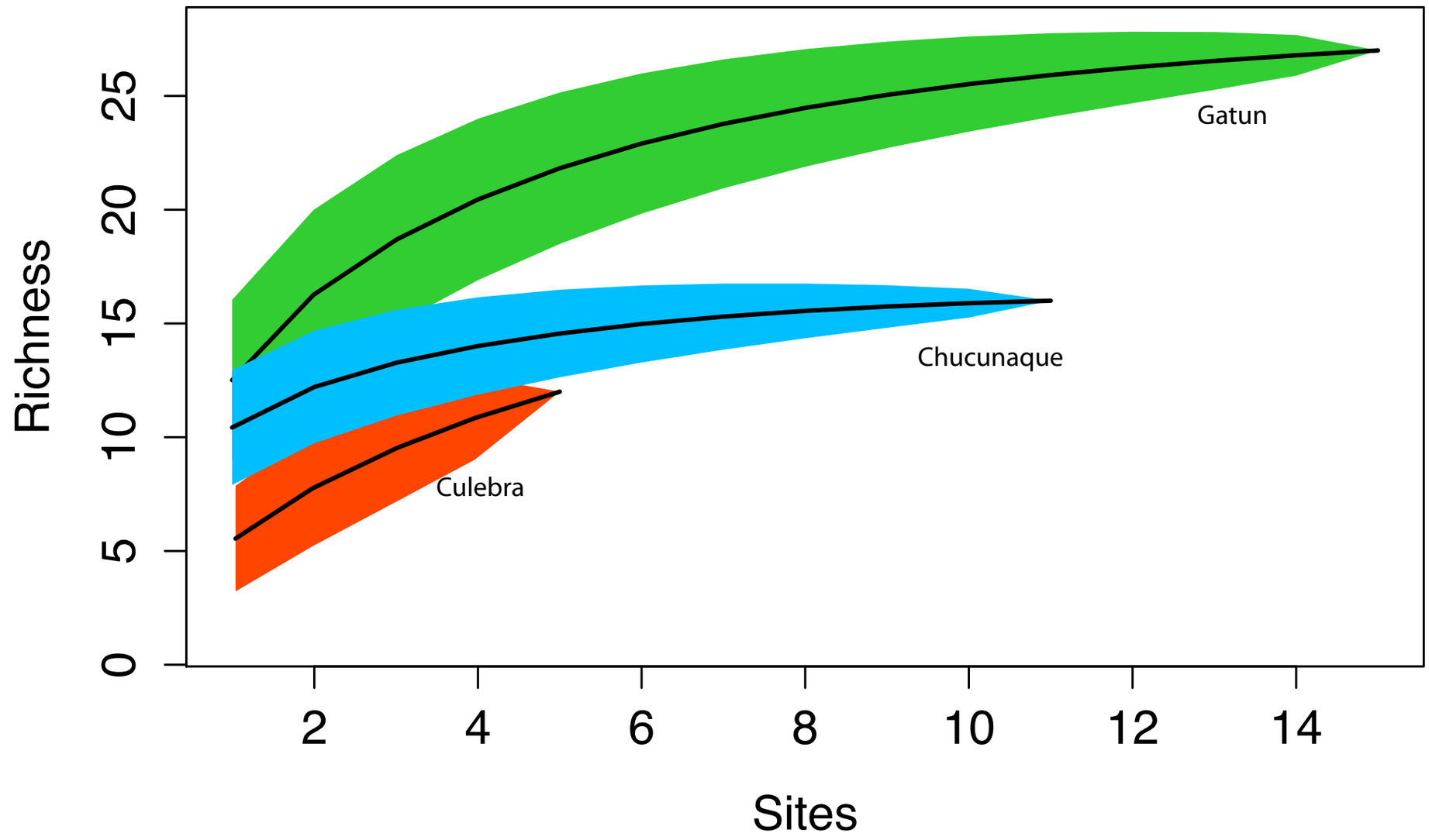
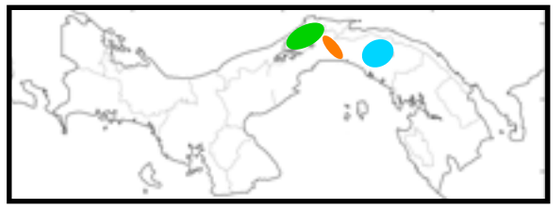
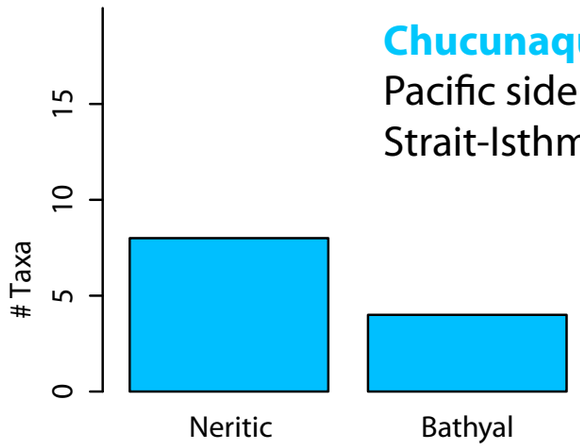


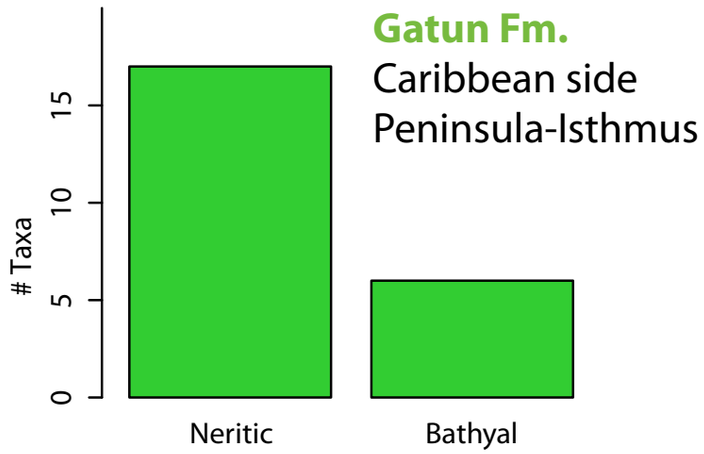
Miocene shark faunas: Environment

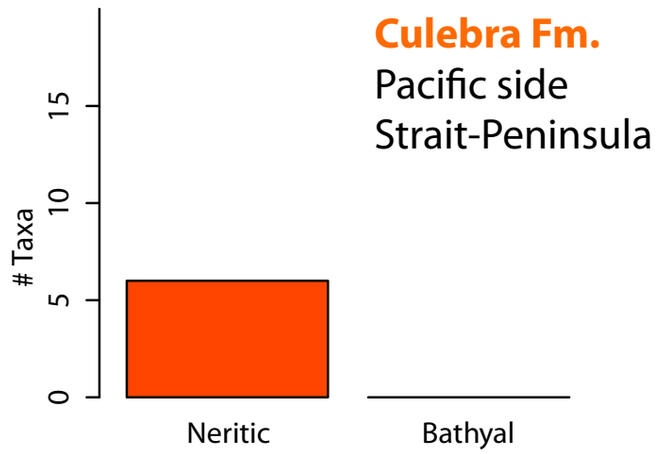


late
late
early

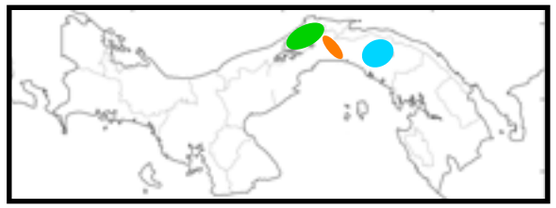
Depth





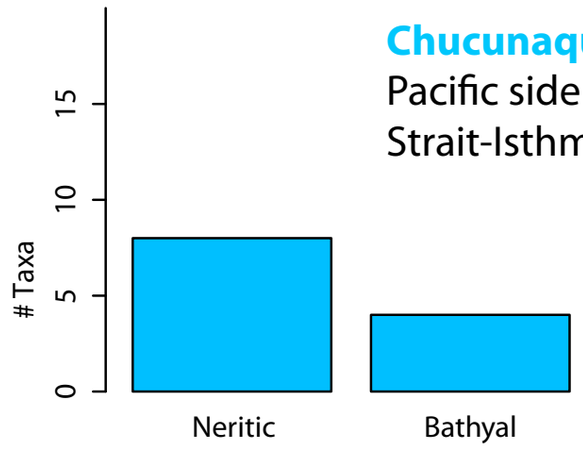


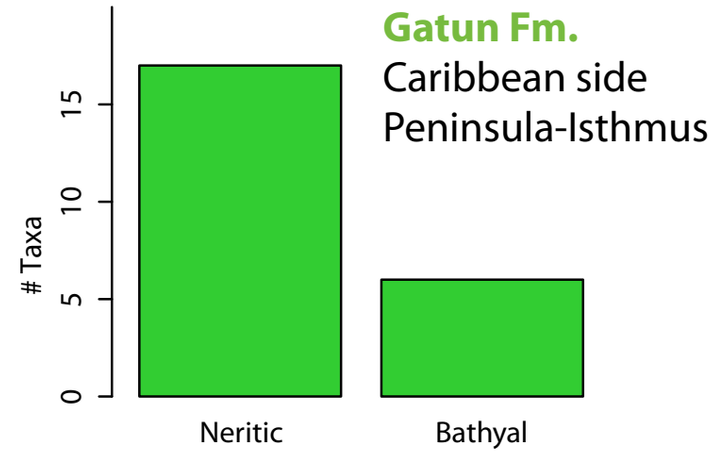
Miocene shark faunas: Environment

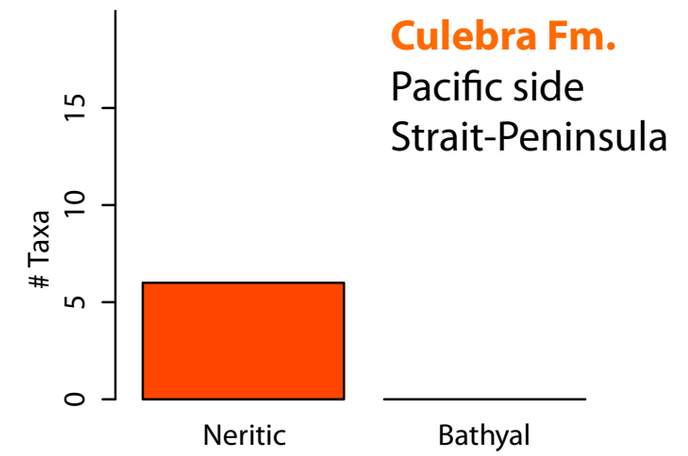


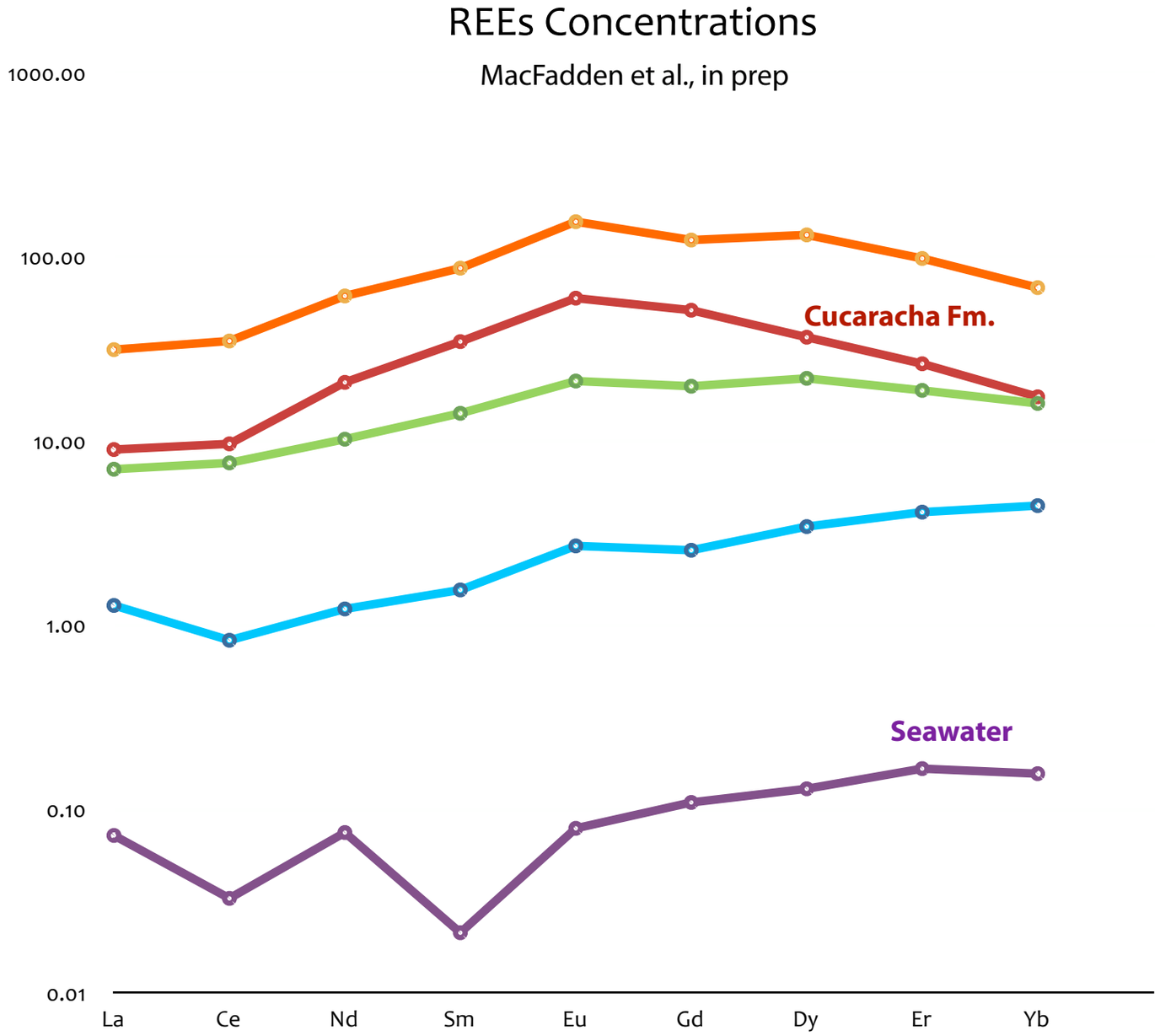
late
late
early

Depth

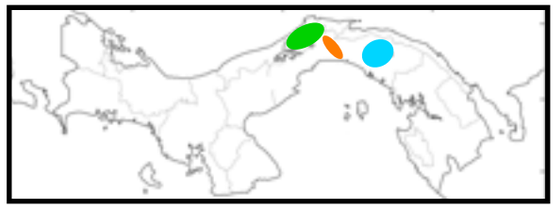








Miocene shark faunas: Biogeography

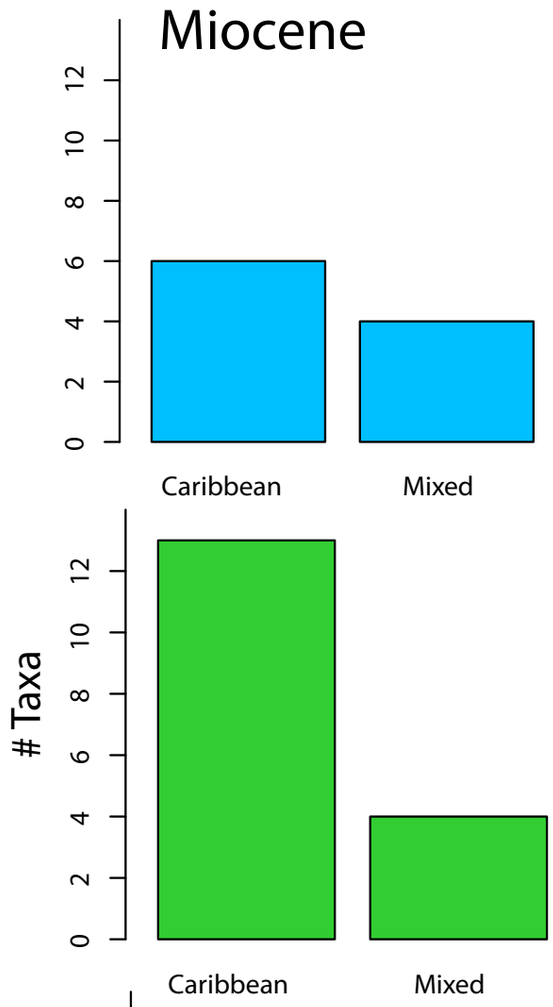


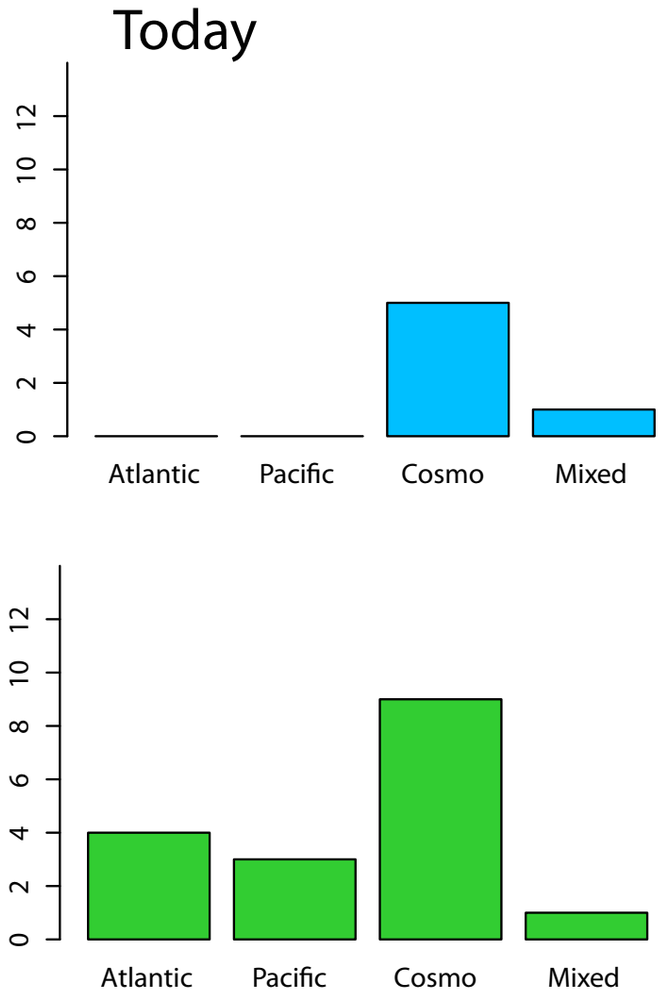
late
late
early

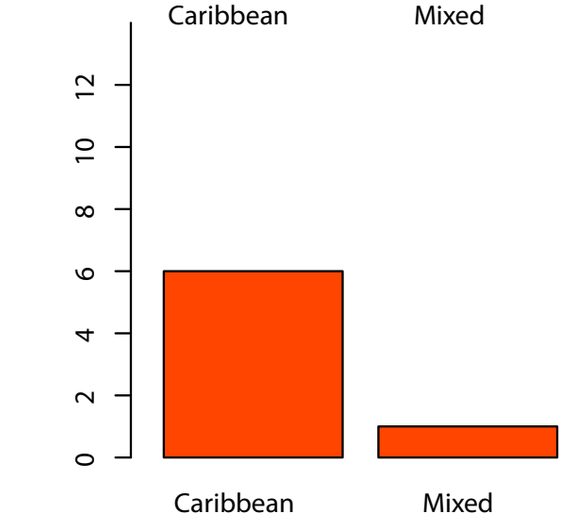
Chucunaque Fm.
Pacific side
Strait-Isthmus

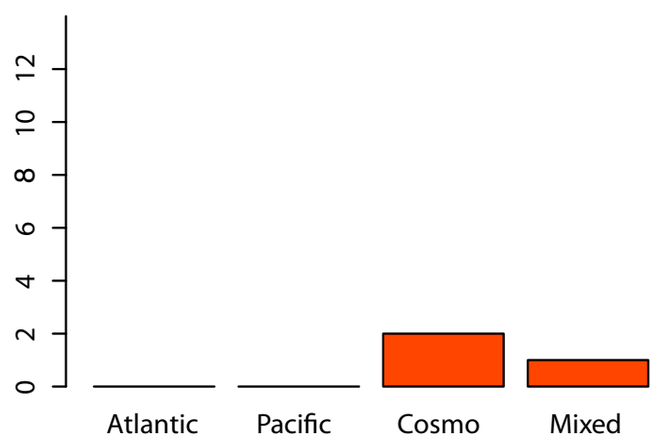
Gatun Fm.
Caribbean side
Peninsula-Isthmus

Culebra Fm.
Pacific side
Strait-Peninsula

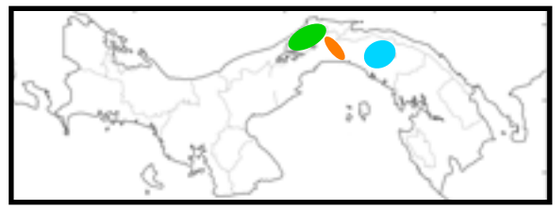








Miocene shark faunas: Biogeography



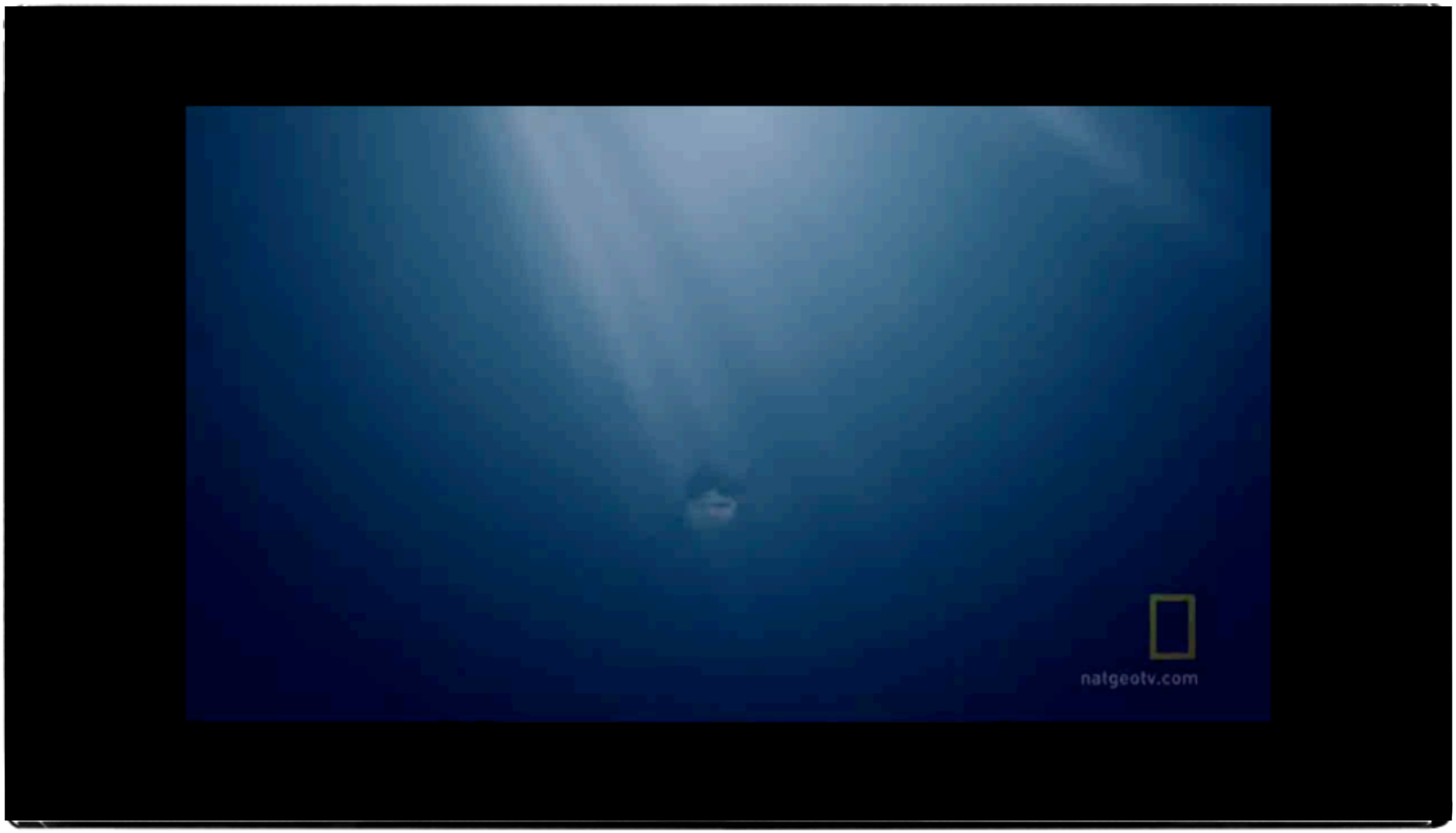
late
late
early

Miocene

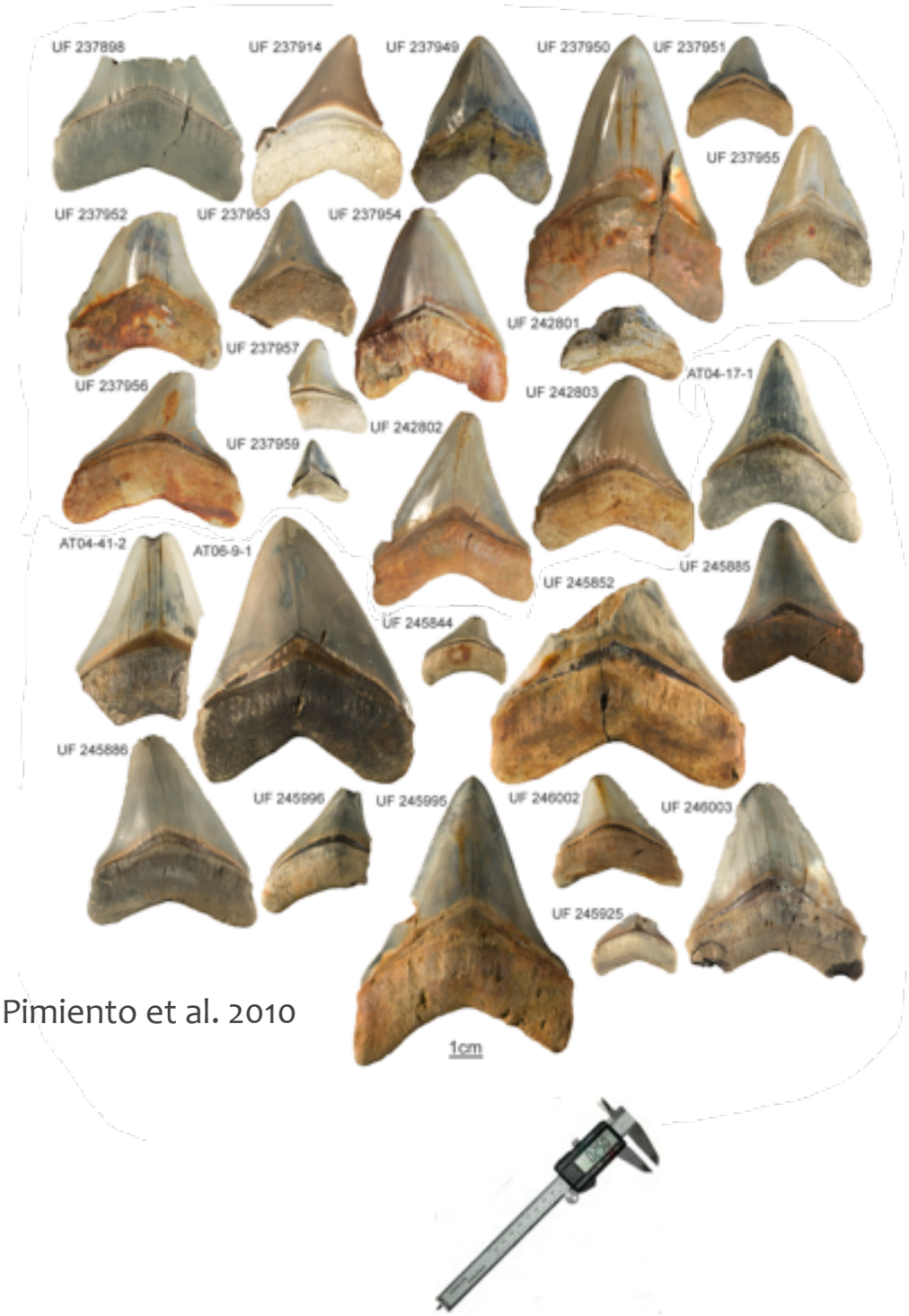
Today

Largest marine predator of all time

Megalodon



nursery area for Megalodon

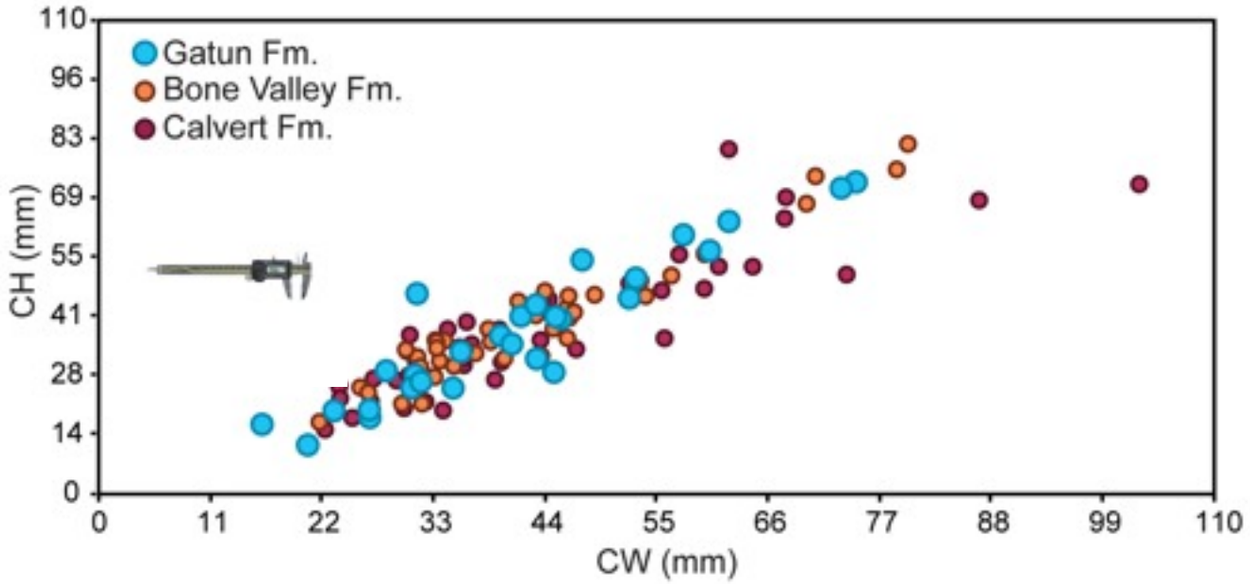


Pimiento et al. 2010

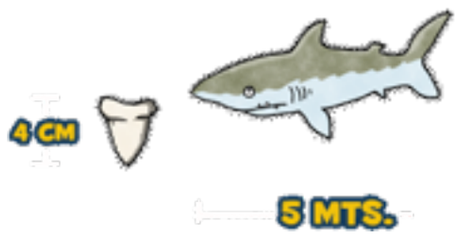
Nursery Habitats

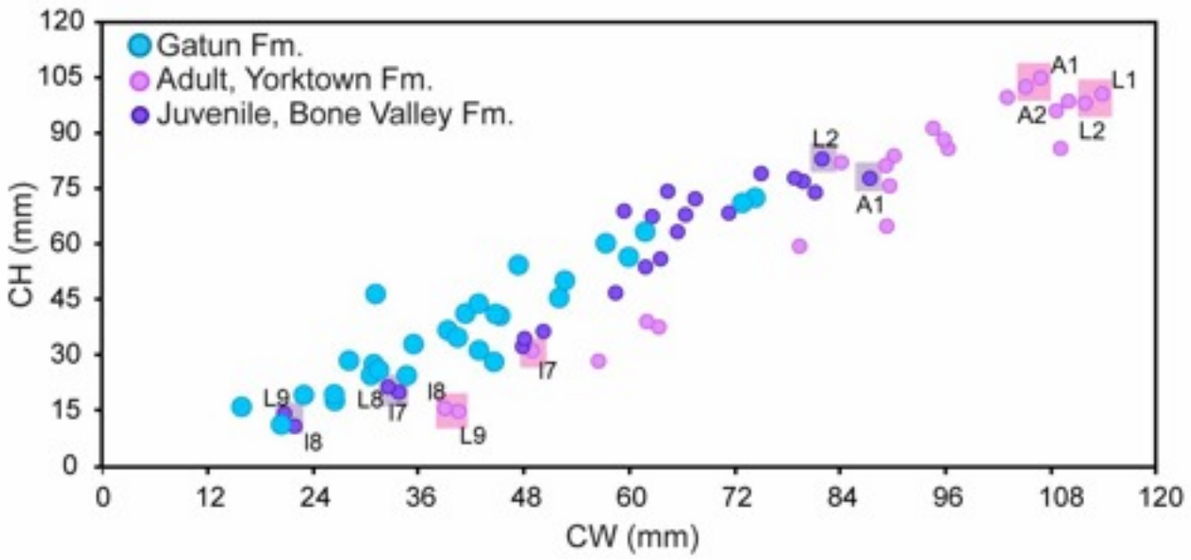
- Essential habitats for sharks survival
- Juveniles y neonates
- Food + Protection = Productive + Shallow waters

nursery area for Megalodon



White Shark

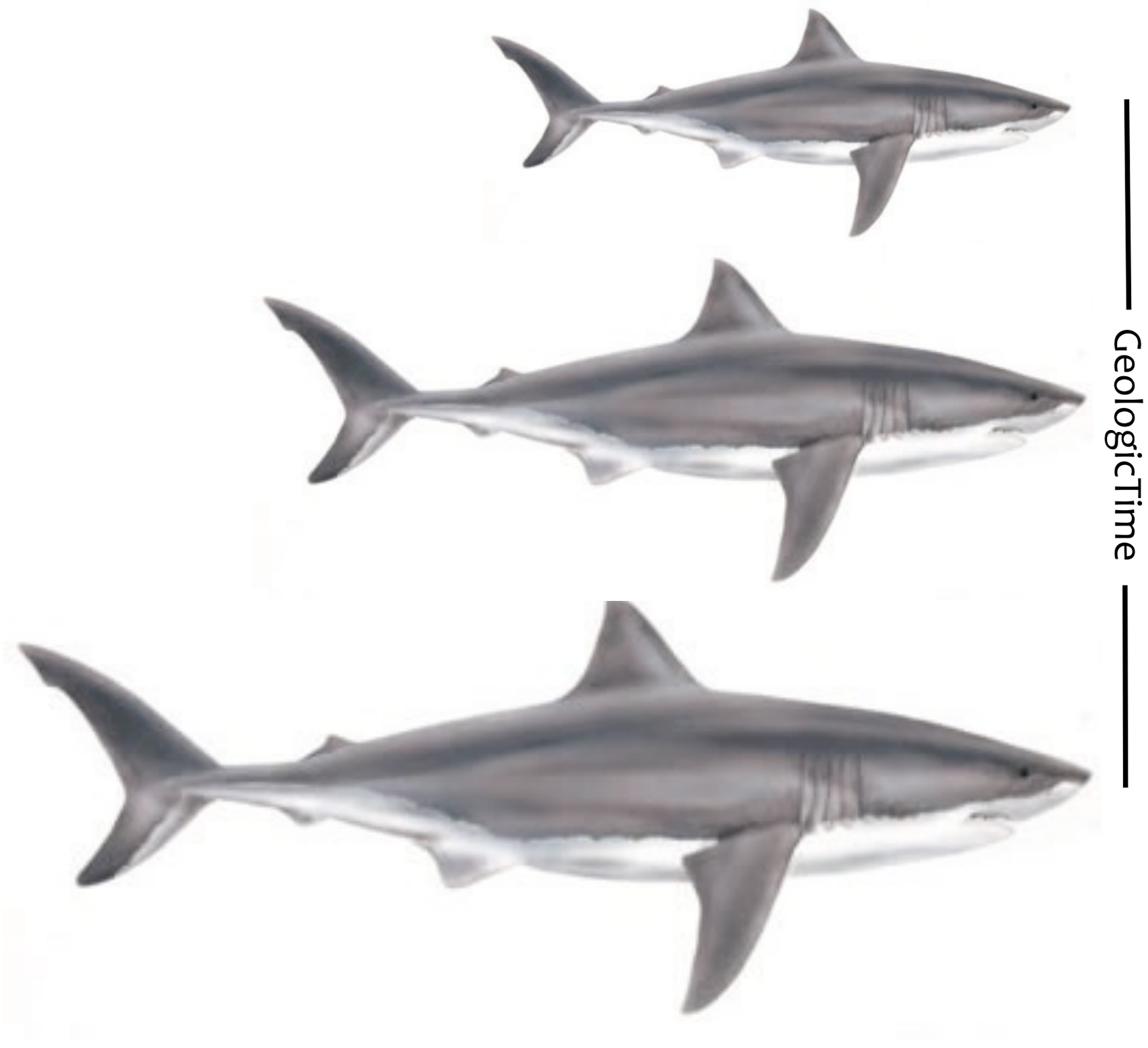




Megalodon

Pimiento et al., 2010

future plans



- future plans

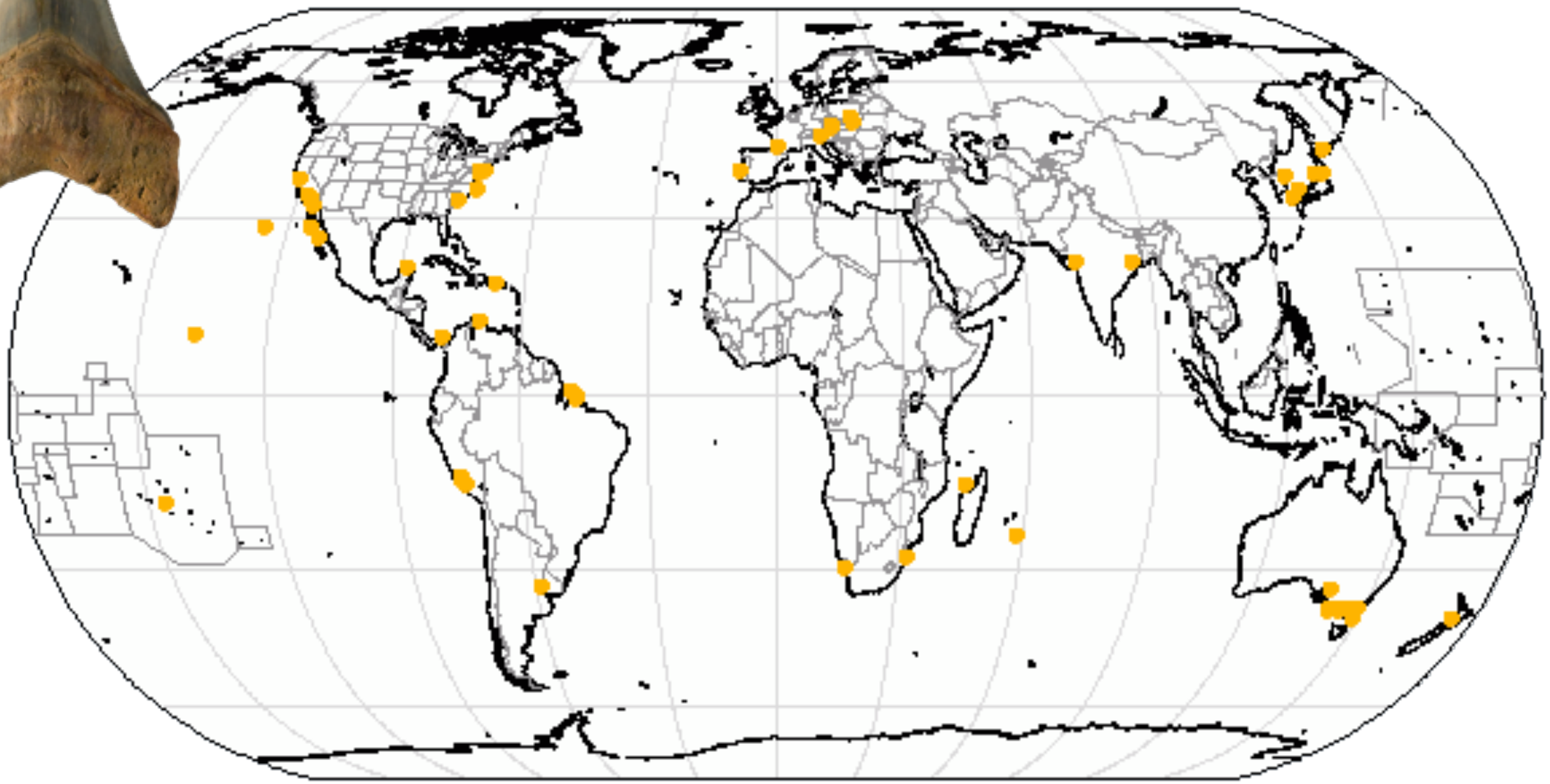
body size

future plans

Ocean	Lat.	Country	Formation	Age	Collection
Atlantic	Central	Venezuela	Cantaure	E. Miocene (18Ma)	Various
	North	US (MA)	Calvert	M. Miocene (14Ma)	USNMNH
	North	US (VA)	St. Marys	M. Miocene (14Ma)	FLMNH
	North	US (NC)	Pungo River	L. Miocene (12Ma)	USNMNH
	South	Argentina	Paraná	M. Miocene (12Ma)	NHM BsAs/La Plata
	Central	Panama	Gatun	L. Miocene (10Ma)	FLMNH
	North	US (NC)	Yorktown	E. Pliocene (6Ma)	USNMNH
	North	US (FL)	Bone Valley	E. Pliocene (5Ma)	FLMNH
	Central	Venezuela	Paraguaná	L. Pliocene (3.5Ma)	Various
Pacific	North	USA (CA)	Rosarito	E. Miocene (18Ma)	SDNHM
	North	USA (CA)	Temblor	M. Miocene (14Ma)	UCMP, SDNHM
	South	Peru	Pisco (Ica)	M. Miocene (12Ma)	NHM Lima
	South	Peru	Pisco (El Jahuay)	L. Miocene (10Ma)	NHM Lima
	North	USA (CA)	St.Margarita, St.Mateo	L. Miocene (10Ma)	UCMP, SDNHM
	South	Peru	Pisco (Sud Sacaco)	L. Miocene (7Ma)	NHM Lima
	South	Chile	Bahía Inglesa	L. Miocene (7Ma)	NHM Santiago
	South	Chile	Bahía Inglesa	E. Pliocene (4Ma)	NHM Santiago
	Central	Ecuador	Onzole	E. Pliocene (4Ma)	British Mus.
Indian	Central	Australia	Batesford, Gippsland	E. Miocene (18Ma)	Victoria Mus.
	Central	Australia	Port Campbell	M. Miocene (11Ma)	Victoria Mus.
	Central	Australia	Black Rock	L. Miocene (8Ma)	Victoria Mus.
	Central	Australia	Whaler's Bluff, Loxton Sand	E. Pliocene (4Ma)	Victoria Mus.
	Central	Australia	Grange Burn, Cameron Inlet	L. Pliocene (3.5Ma)	Victoria Mus.

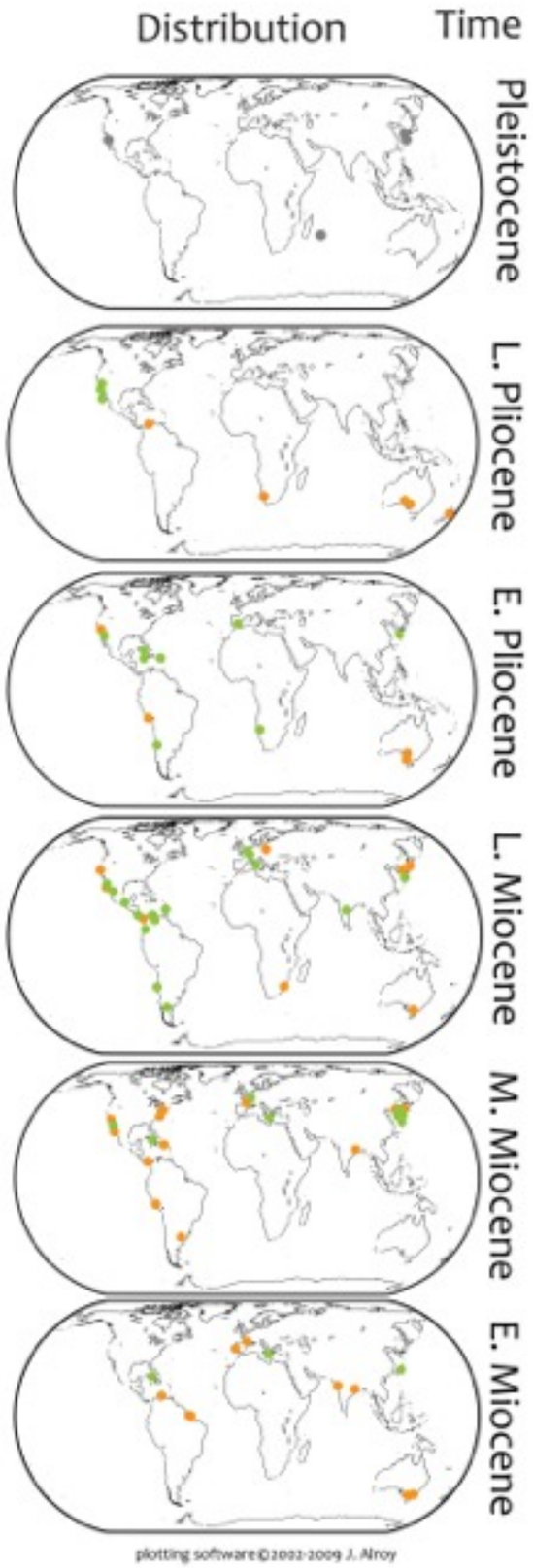
body size

geographic distribution size in deep time



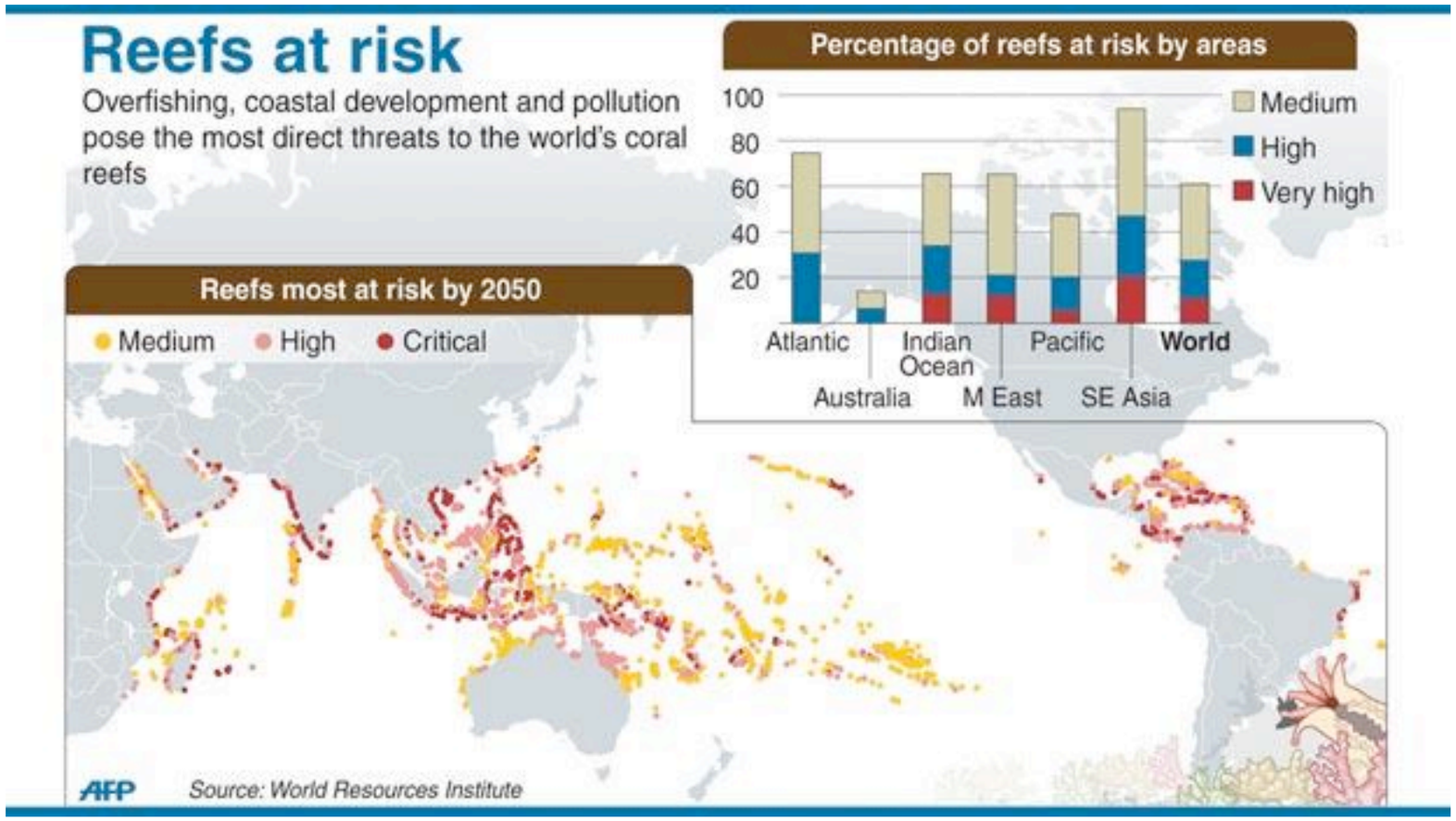
plotting software 2002-2012 J. Alroy

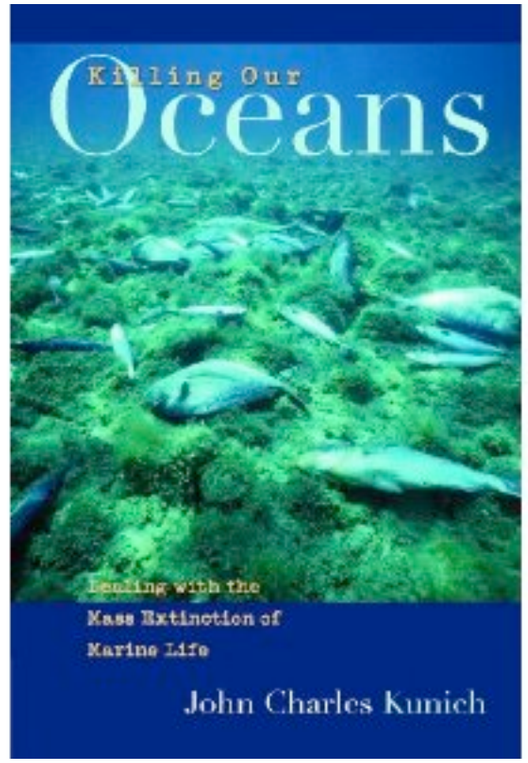
patterns of extinction



- What are the patterns of Megalodon extinction?
  - ✓ Distribution
- Why Megalodon became extinct?
  - ✓ Climate
  - ✓ Oceanography
  - ✓ Preys
  - ✓ Competitors

why is this important?





Implications: Conservation

Approximately 17% of sharks and their relatives are threatened, an additional 13% are considered Near Threatened, and a high proportion (47%) are Data Deficient. IUCN 2010

Trophic Downgrading of Planet Earth

James A. Estes,[1*] John Terborgh,[2] Justin S. Brashares,[3] Mary E. Power,[4] Joel Berger,[5] William J. Bond,[6] Stephen R. Carpenter,[7] Timothy E. Essington,[8] Robert D. Holt,[9] Jeremy B. C. Jackson,[10] Robert J. Marquis,[11] Lauri Oksanen,[12] Tarja Oksanen,[13] Robert T. Paine,[14] Ellen K. Pikitch,[15] William J. Ripple,[16] Stuart A. Sandin,[10] Marten Scheffer,[17] Thomas W. Schoener,[18] Jonathan B. Shurin,[19] Anthony R. E. Sinclair,[20] Michael E. Soulé,[21] Risto Virtanen,[22] David A. Wardle[23]

Until recently, large apex consumers were ubiquitous across the globe and had been for millions of years. The loss of these animals may be humankind's most pervasive influence on nature. Although such losses are widely viewed as an ethical and aesthetic problem, recent research reveals extensive cascading effects of their disappearance in marine, terrestrial, and freshwater ecosystems worldwide. This empirical work supports long-standing theory about the role of top-down forcing in ecosystems but also highlights the unanticipated impacts of trophic cascades on processes as diverse as the dynamics of disease, wildfire, carbon sequestration, invasive species, and biogeochemical cycles. These findings emphasize the urgent need for interdisciplinary research to forecast the effects of trophic downgrading on process, function, and resilience in global ecosystems.

Science (2011)

Review

Cell PRESS

Conservation paleobiology: putting the dead to work

Gregory P. Dietl[1] and Karl W. Flessa[2]

[1] Paleontological Research Institution, 1259 Trumansburg Road, Ithaca, NY 14850, USA
[2] Department of Geosciences, University of Arizona, Tucson, AZ 85721, USA

TREE (2010)

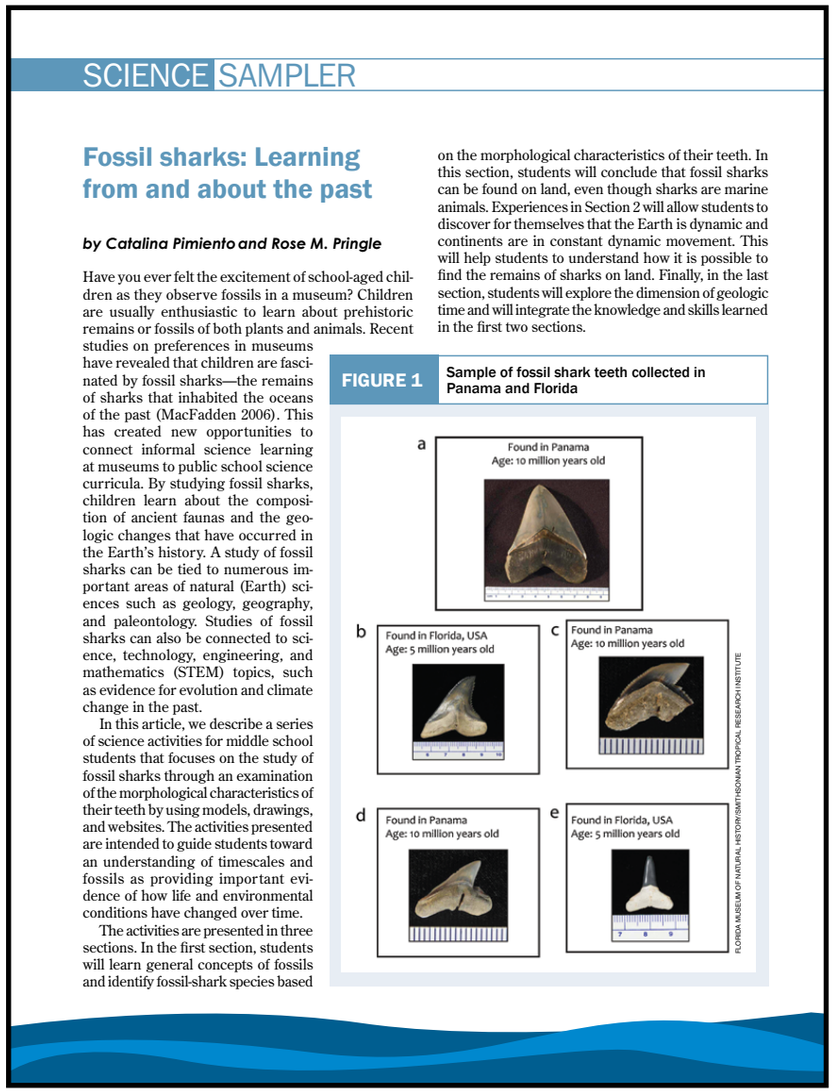
... the geohistorical record is a natural laboratory from which we can address the responses of species to environmental changes, helping us to understand which species will be most sensitive and what kinds of responses will be most common.

Training the next generation of scientist: Education and Outreach

website for kids

Pimiento 2010

classroom activities



SCIENCE SAMPLER

Fossil sharks: Learning from and about the past

by Catalina Pimiento and Rose M. Pringle

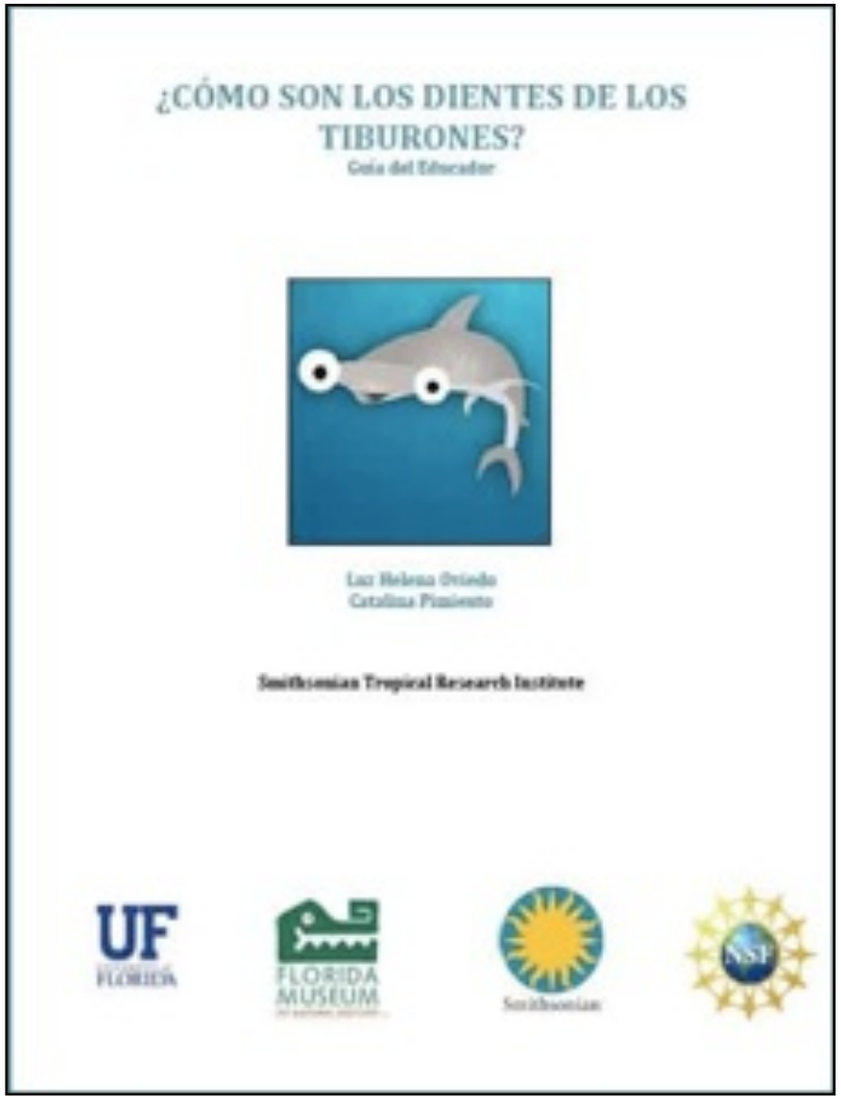
Have you ever felt the excitement of school-aged children as they observe fossils in a museum? Children are usually enthusiastic to learn about prehistoric remains or fossils of both plants and animals. Recent studies on preferences in museums have revealed that children are fascinated by fossil sharks—the remains of sharks that inhabited the oceans of the past (MacFadden 2006). This has created new opportunities to connect informal science learning at museums to public school science curricula. By studying fossil sharks, children learn about the composition of ancient faunas and the geologic changes that have occurred in the Earth's history. A study of fossil sharks can be tied to numerous important areas of natural (Earth) sciences such as geology, geography, and paleontology. Studies of fossil sharks can also be connected to science, technology, engineering, and mathematics (STEM) topics, such as evidence for evolution and climate change in the past.

In this article, we describe a series of science activities for middle school students that focuses on the study of fossil sharks through an examination of the morphological characteristics of their teeth by using models, drawings, and websites. The activities presented are intended to guide students toward an understanding of timescales and fossils as providing important evidence of how life and environmental conditions have changed over time.

The activities are presented in three sections. In the first section, students will learn general concepts of fossils and identify fossil-shark species based on the morphological characteristics of their teeth. In this section, students will conclude that fossil sharks can be found on land, even though sharks are marine animals. Experiences in Section 2 will allow students to discover for themselves that the Earth is dynamic and continents are in constant dynamic movement. This will help students to understand how it is possible to find the remains of sharks on land. Finally, in the last section, students will explore the dimension of geologic time and will integrate the knowledge and skills learned in the first two sections.

FIGURE 1 Sample of fossil shark teeth collected in Panama and Florida

Pimiento and Pringle 2011



¿CÓMO SON LOS DIENTES DE LOS TIBURONES?

Guía del Educador

Luz Helena Oviedo
Catalina Pimiento

Smithsonian Tropical Research Institute

Oviedo and Pimiento 2011

undergraduate course

- undergraduate course

undergraduate course

Blended course