Miocene coral reef ecosystems in South East Asia

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Dr. Lucas J. Lourens (UU)

NATURAL HISTORY MUSEUM

Universiteit Utrecht

THROUGHFLOW

MARIE CURIE ACTIONS

SEVENTH FRAMEWORK PROGRAMME

Contents

- Corals
- Coral Triangle
- Fossil corals in SE Asia
- Objectives
- Methods

CORALS

Phylum Cnidaria

- Class Hydrozoa
- Class Cubozoa
- Class Scyphozoa
- Class Anthozoa
  - Hexacorallia
    - Order Scleractinia
    - Order Antipatharia
    - Order Zoanthidea
    - Order Actiniaria
    - Order Ceriantharia
    - Order Corallimorpharia
  - Octoc/
    - Order Pennatulacea
    - Order Alcyonaria
    - Order Helioporacea

Reef base / Calacademy

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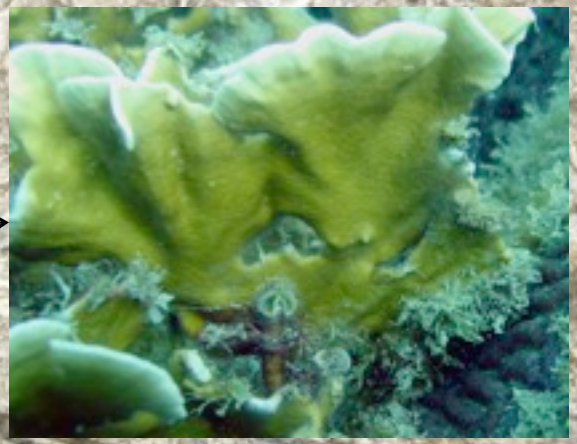

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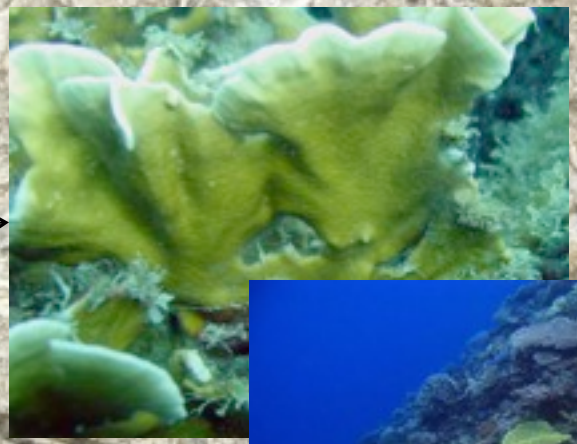

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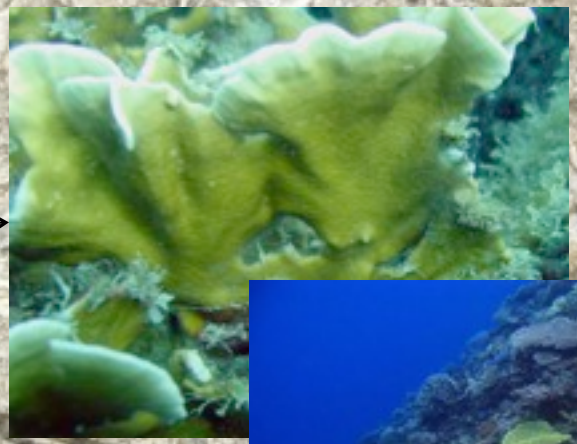

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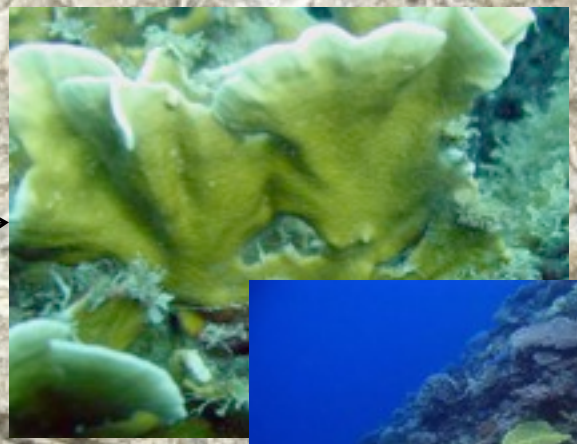


Reef base / Calacademy

Morphology of Scleractinian Coral

Veron, 2000

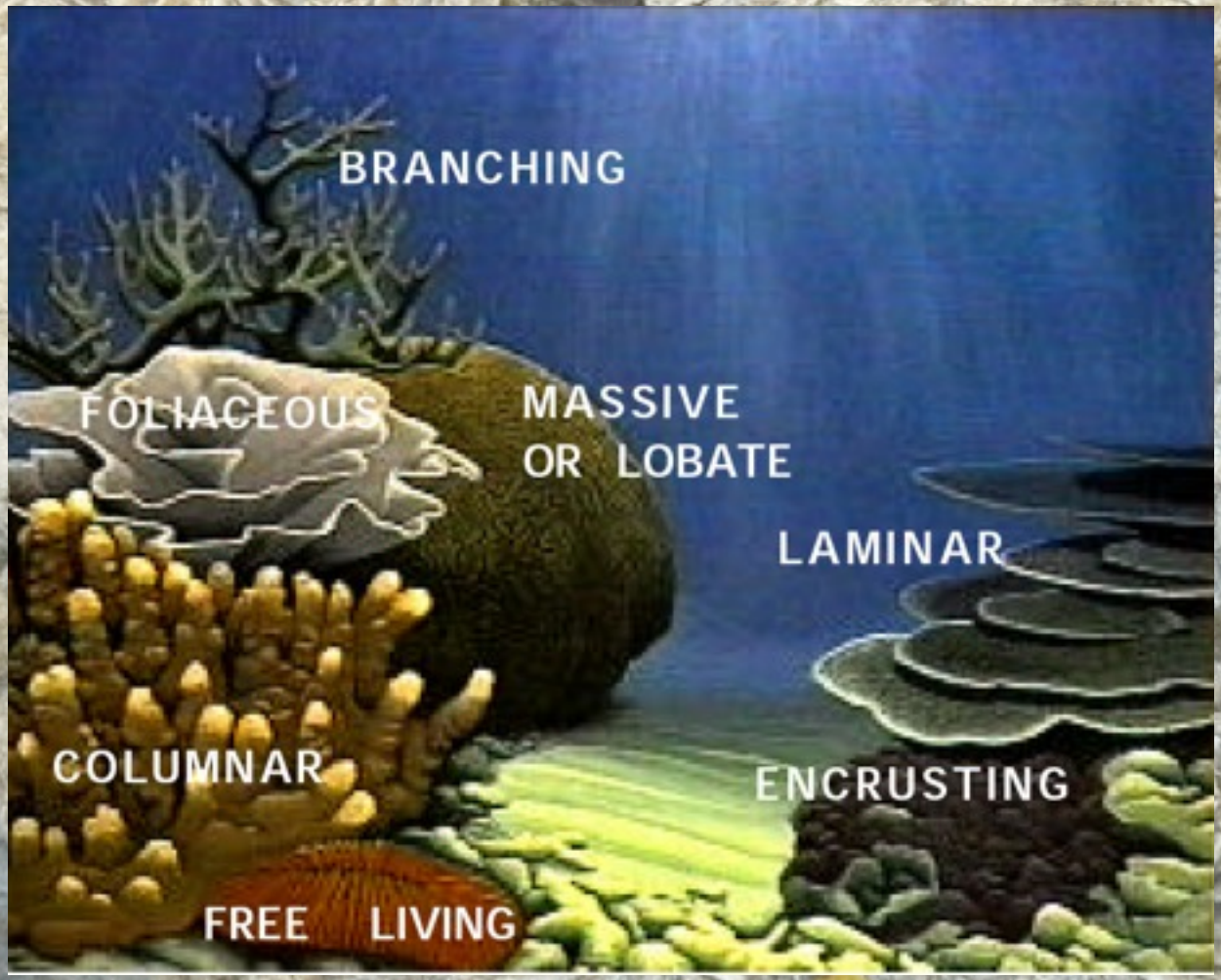
Morphology of Scleractinian Coral

Veron, 2000

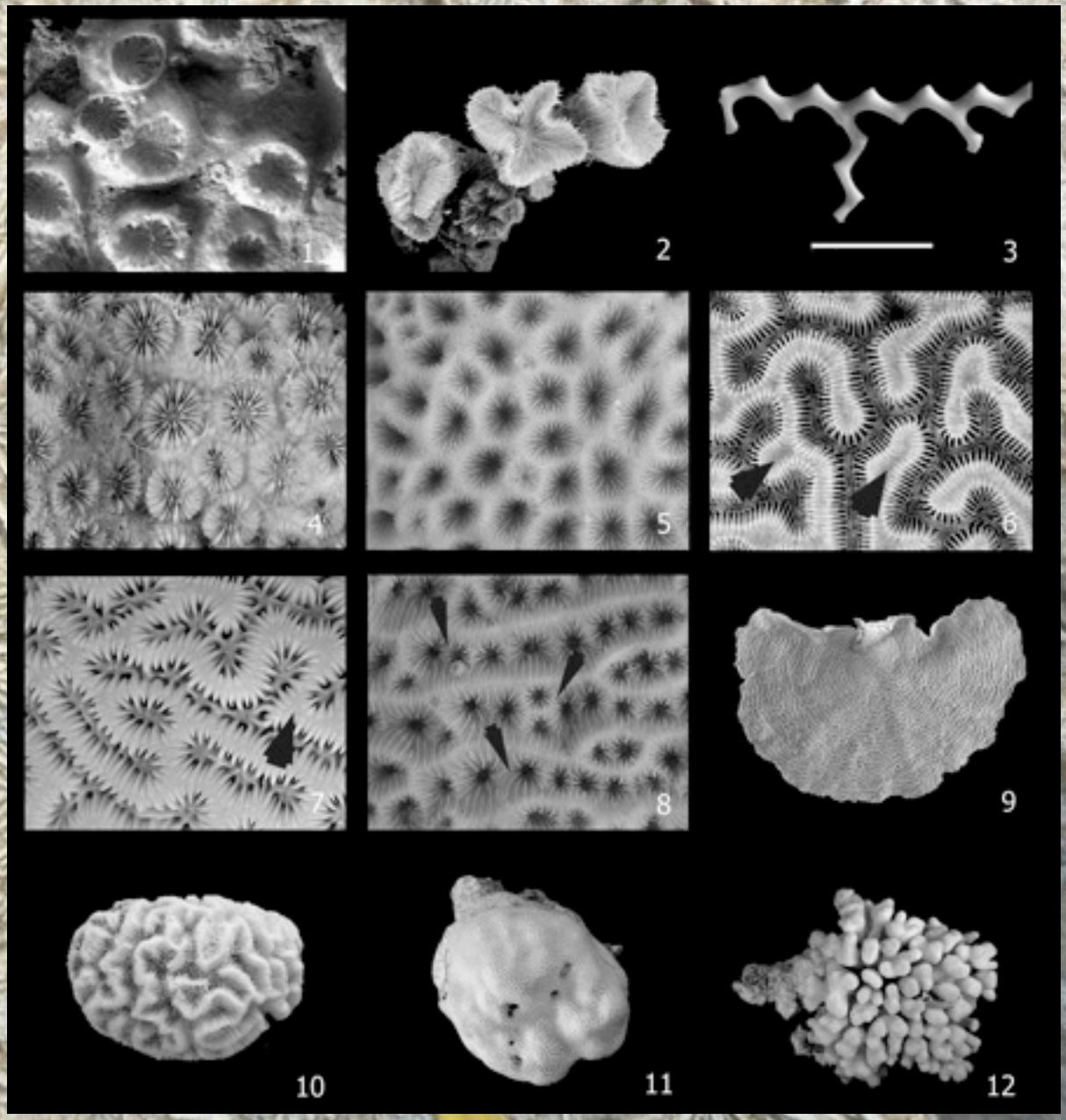
Morphology of Scleractinian Coral

Veron, 2000

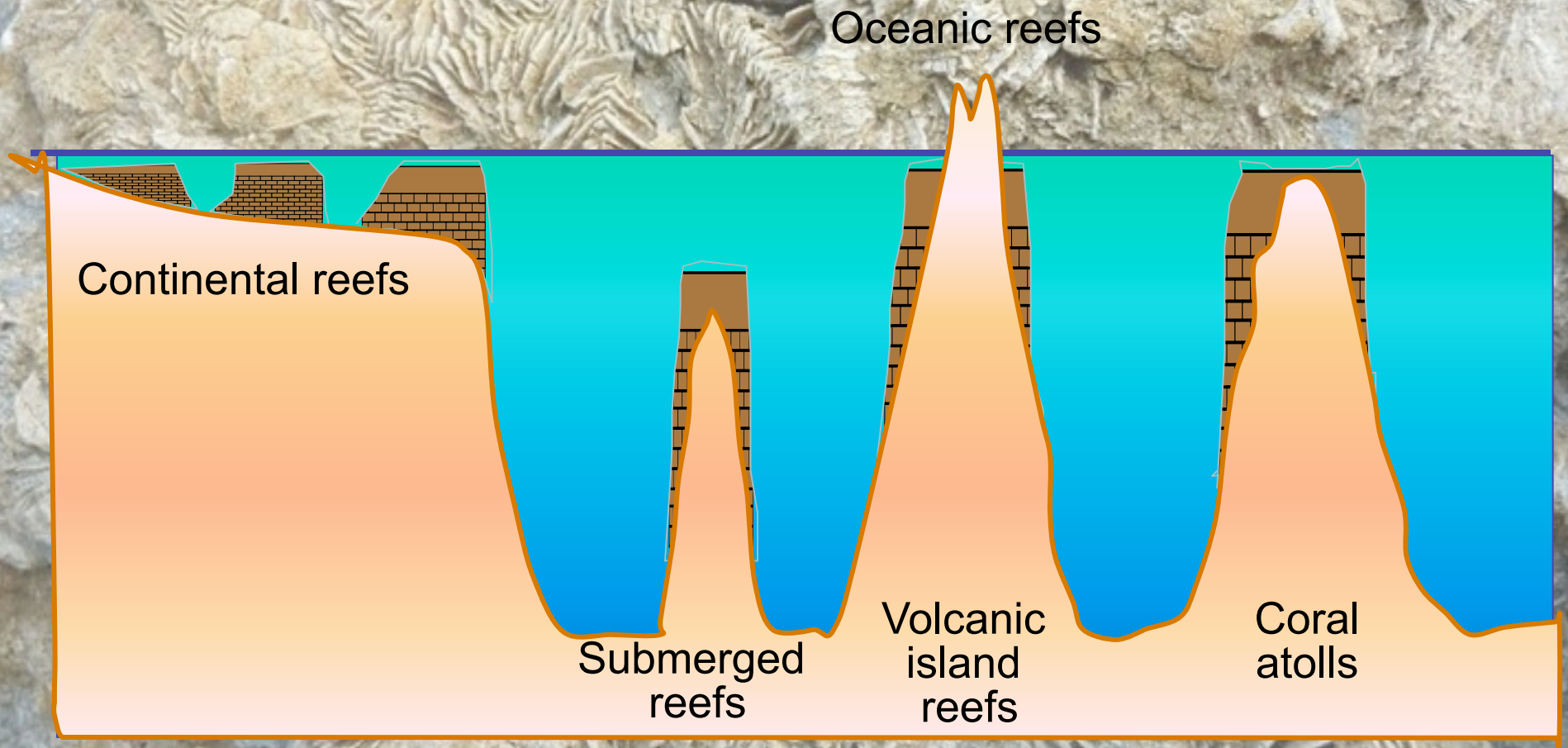
Colony growth forms



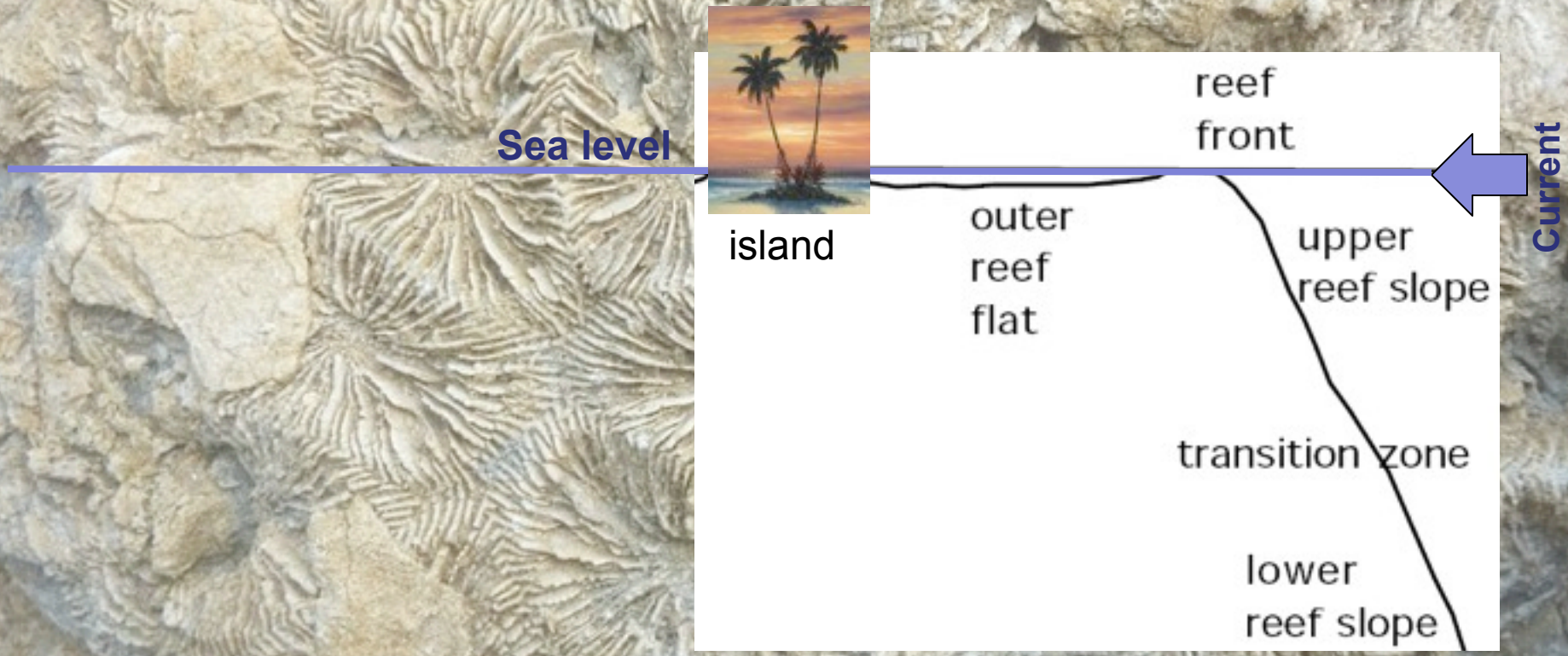
Colony forms



Types of reefs



Major geomorphological zones of a typical barrier reef



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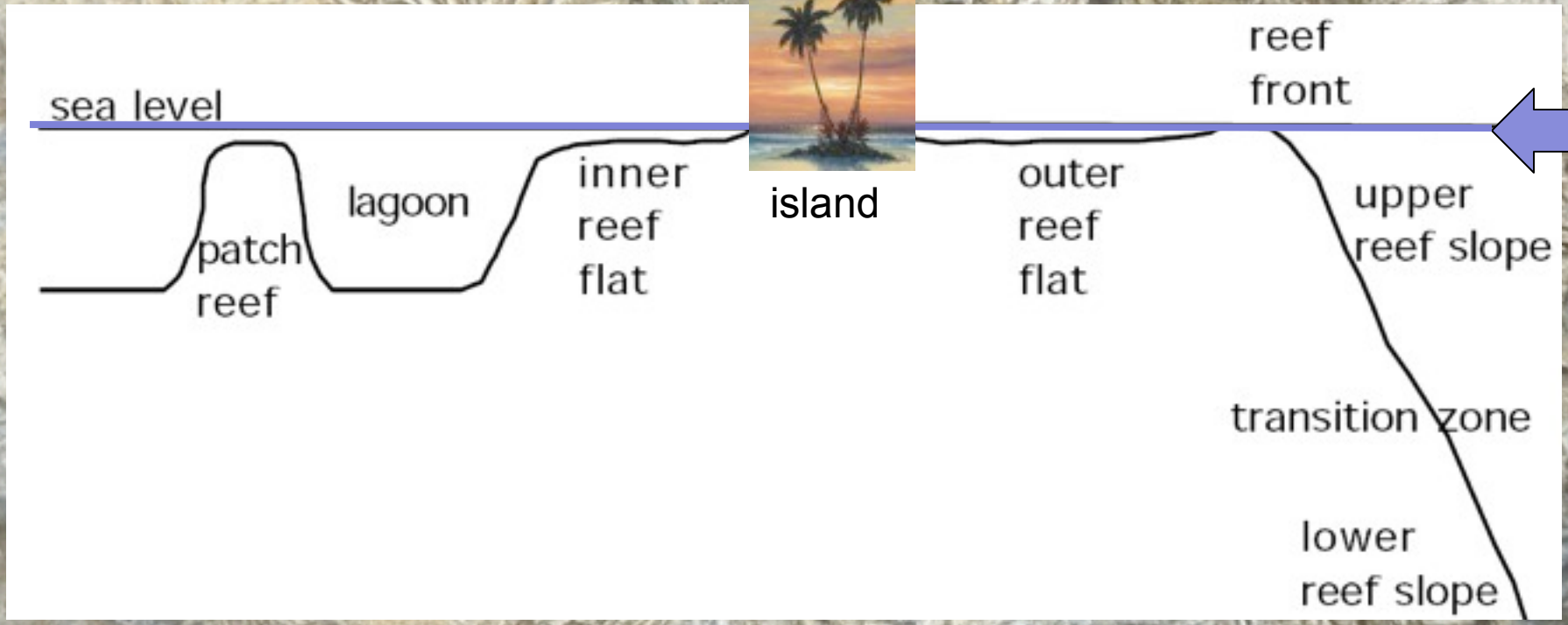
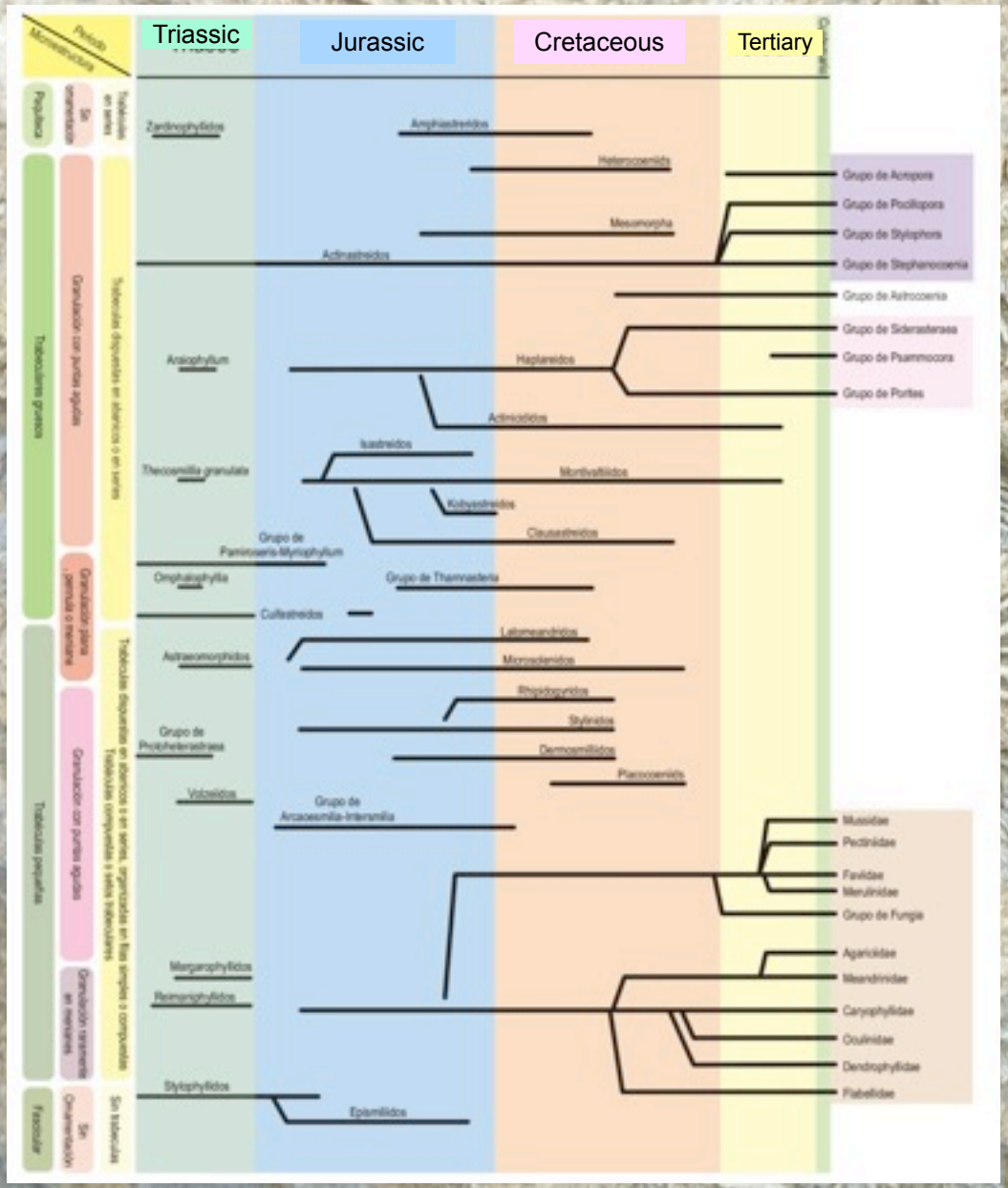


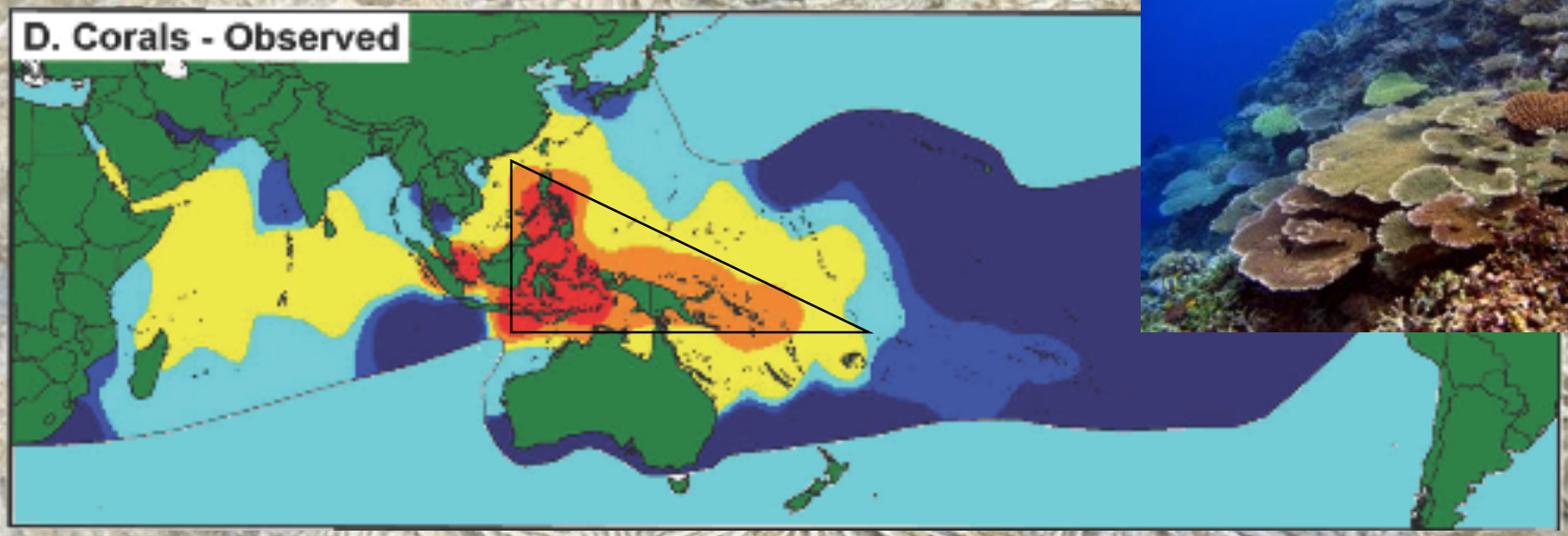
Evolution and diversity of corals in fossil record



Most of modern Families were originated during Tertiary

Stanley, 2003

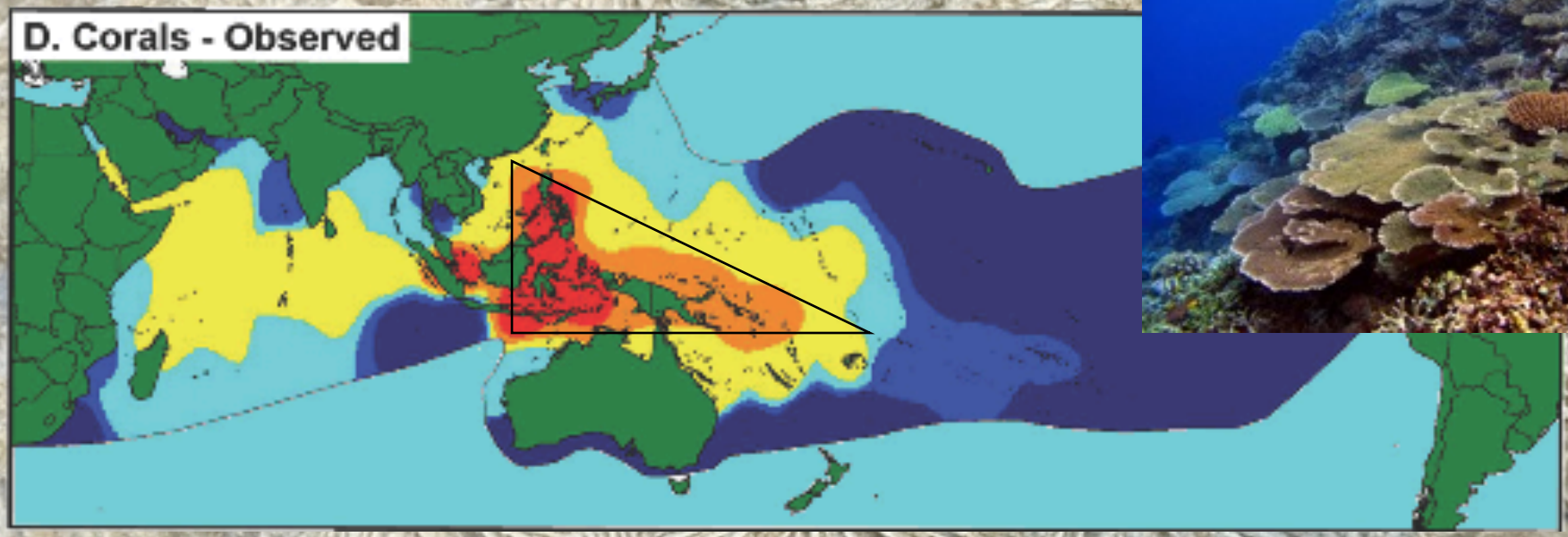
Coral Triangle: Centre of Maximum Diversity



Algae (Caulerpa)/Seagrasses: 29 spp/15 spp
Molluscs (snails): >thousands spp
Fish: 3000 spp

Bellwood et al., 2005

Coral Triangle: Centre of Maximum Diversity



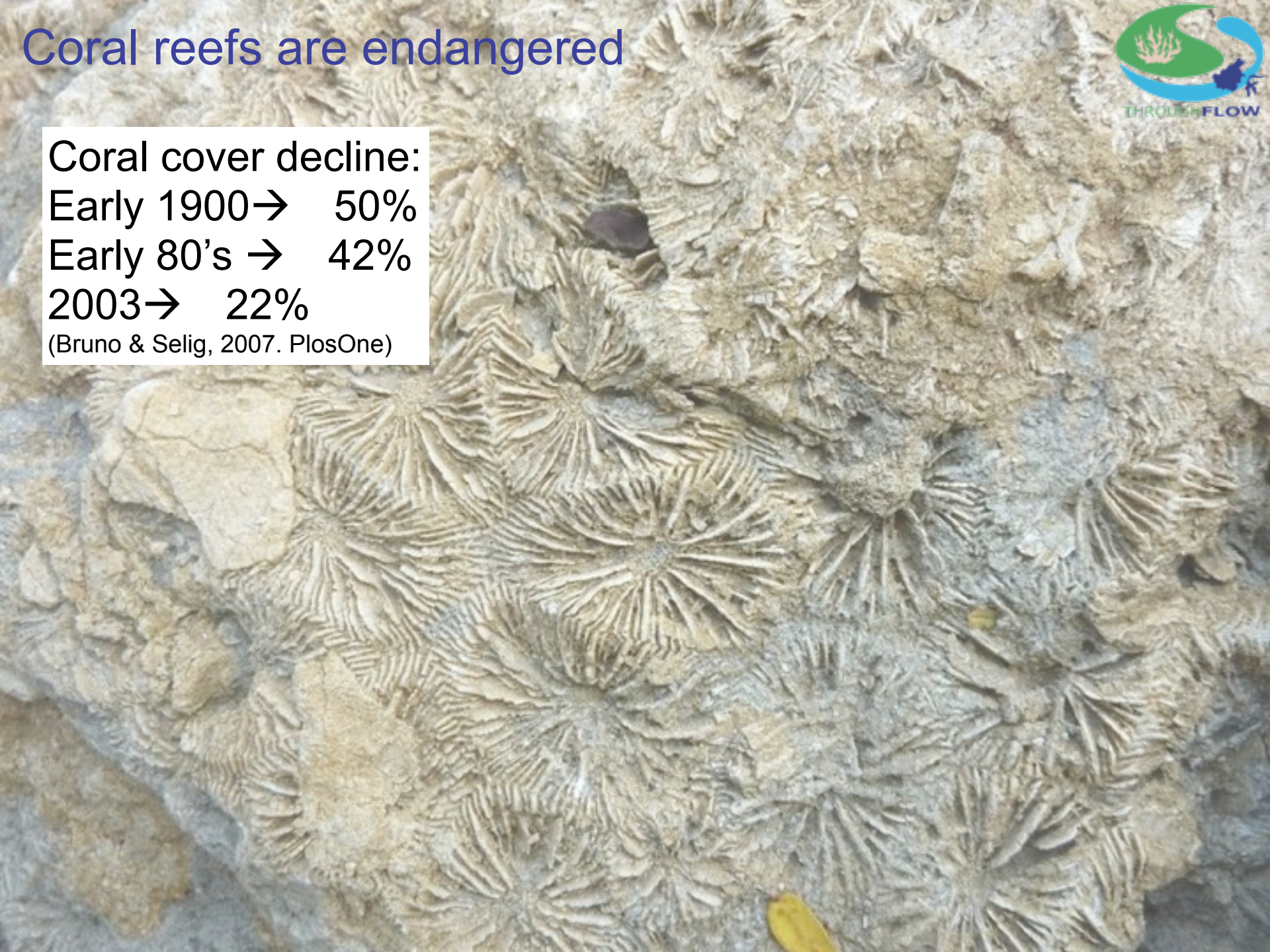
Algae (Caulerpa)/Seagrasses: 29 spp/15 spp
Molluscs (snails): >thousands spp
Fish: 3000 spp

Economic importance
>> 120 million people
>> $12 billion a year

Bellwood et al., 2005

Coral reefs are endangered

Coral cover decline:
Early 1900→ 50%
Early 80's → 42%
2003→ 22%
(Bruno & Selig, 2007. PlosOne)



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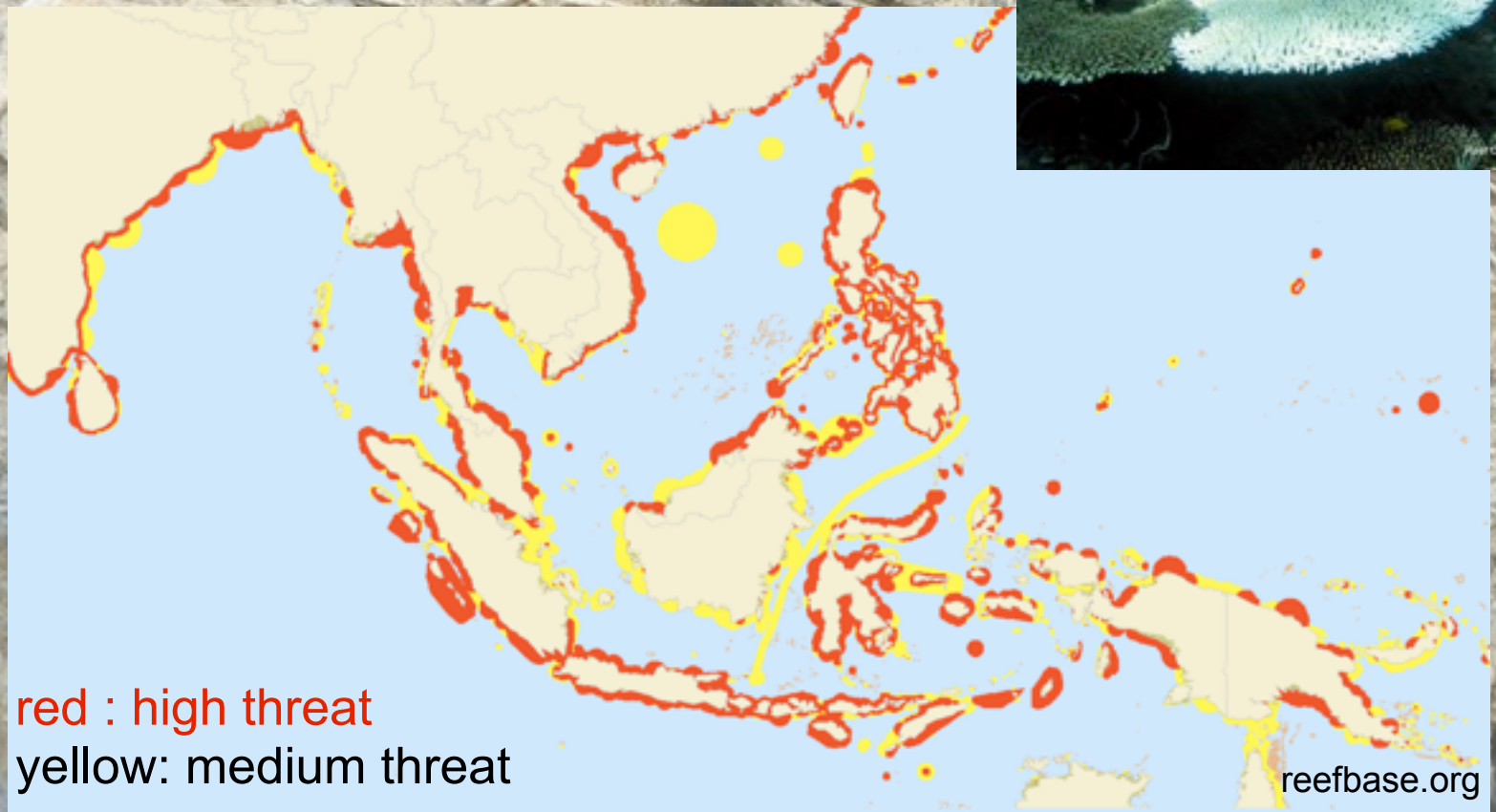


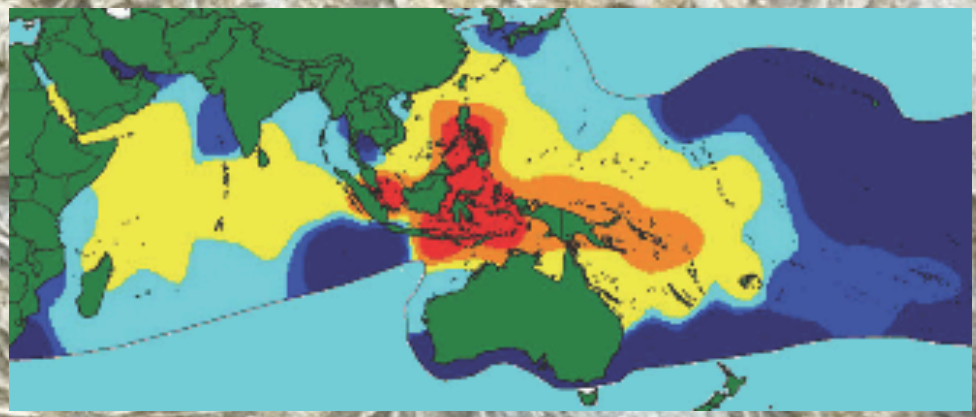
Coral triangle:
Origin of marine diversity?

Centre of speciation

Centre of overlap

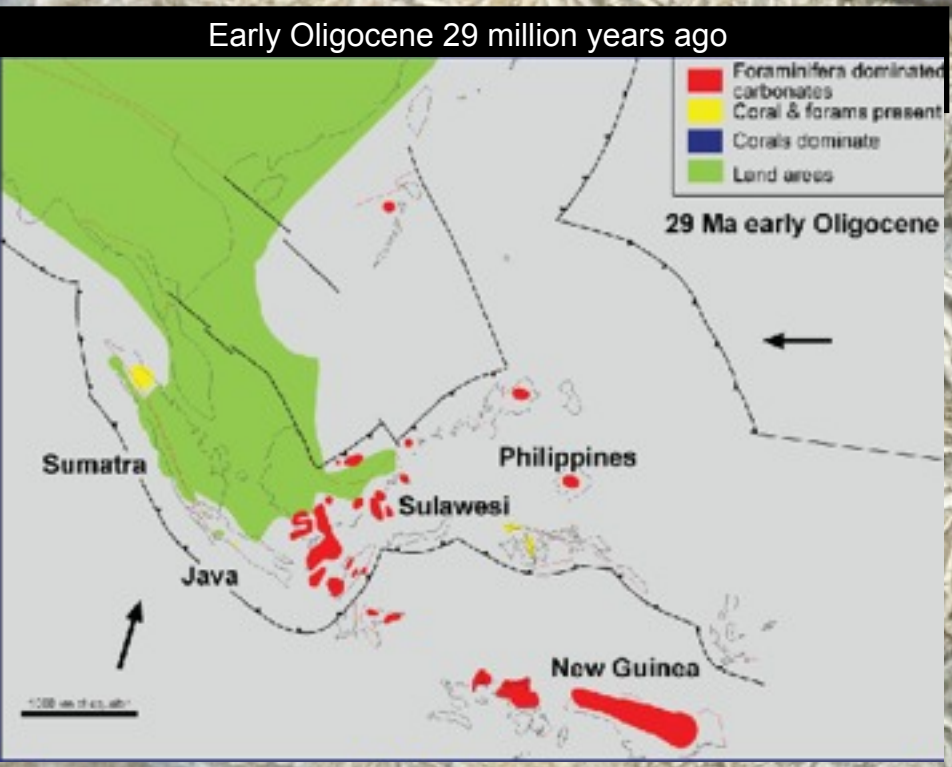
Centre of accumulation

Centre of survival



Hoeksema, 2007

Coral Reefs in SE Asia first appeared in Early Miocene



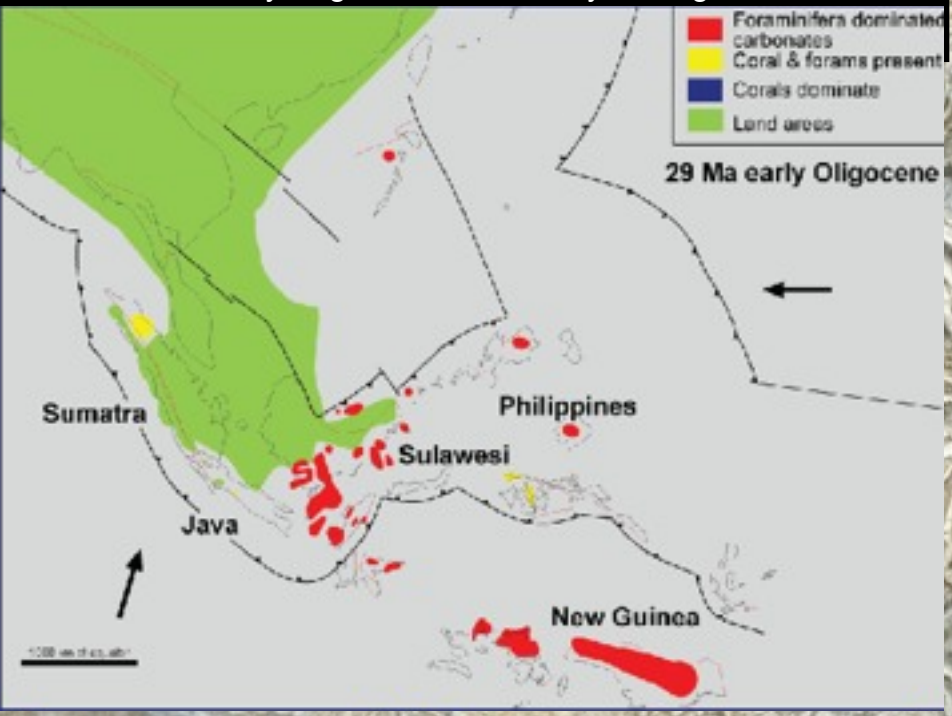
Forams

Corals

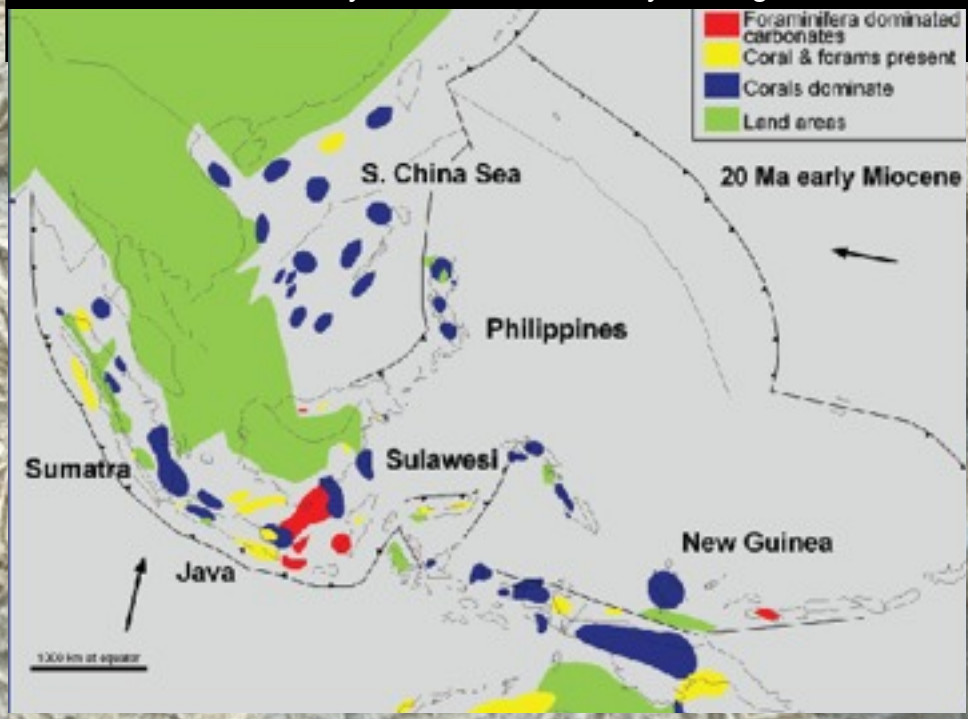
Wilson & Rosen, 1998

Coral Reefs in SE Asia first appeared in Early Miocene

Early Oligocene 29 million years ago



Early Miocene 20 million years ago



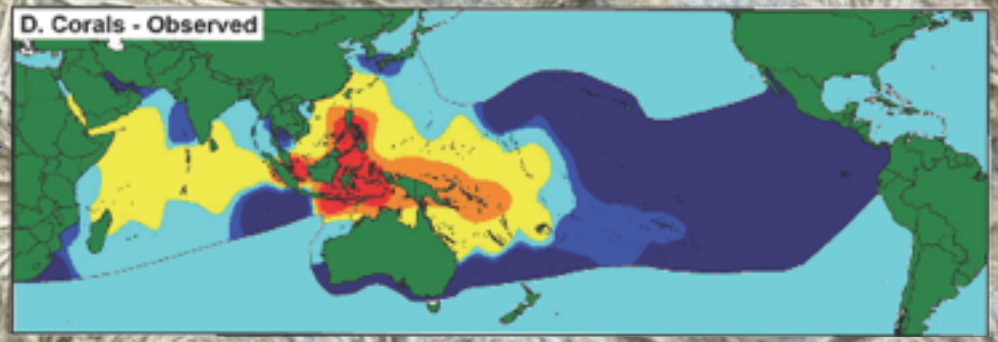
Forams

Corals

Wilson & Rosen, 1998

What is the relationship of the Throughflow with the present exceptional biodiversity?

?



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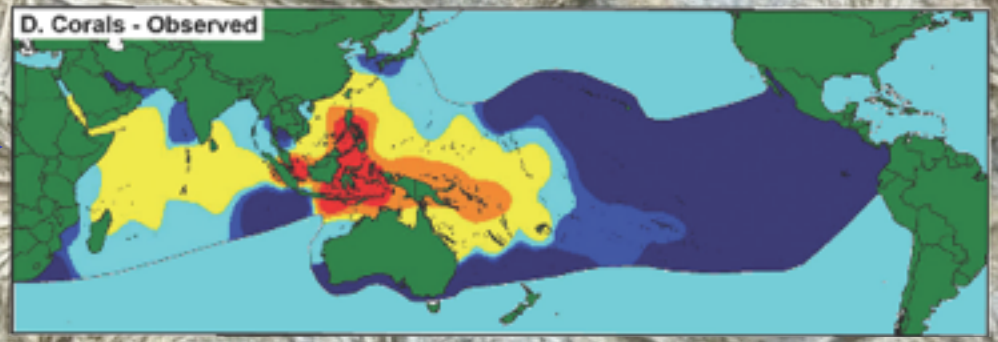


Fossil are direct evidence of historical changes

Fossil corals: How much do we know?

Martin, 1880 - 1888 (F.W. Junghuhn)

Felix, 1913-1925

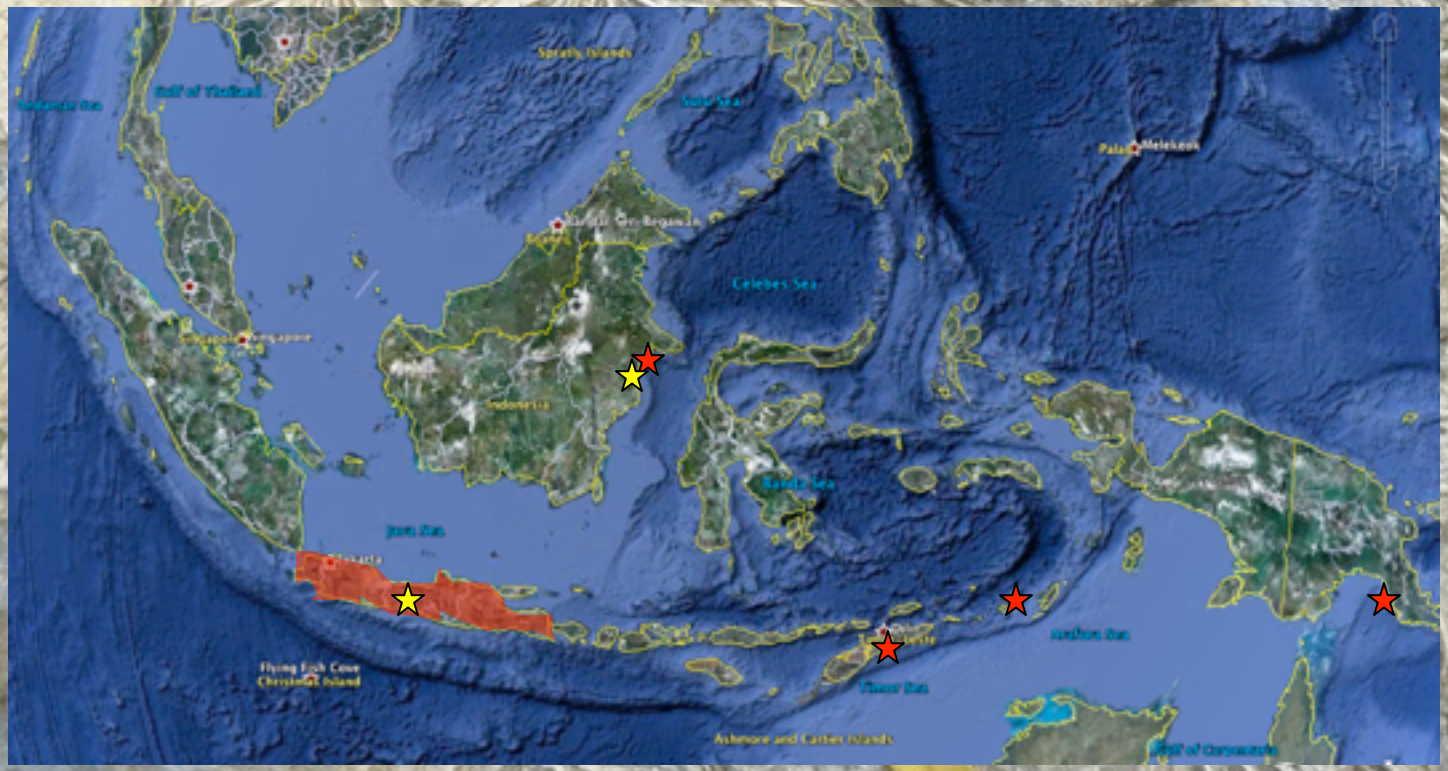
Gerth, 1931-1965

Umbgrove, 1924-1950

Veron & Kelly, 1988

Hoeksema, 1989 (Fungiidae)

This project Johnson & Renema, 2009-2010



Fossil corals: How much do we know?

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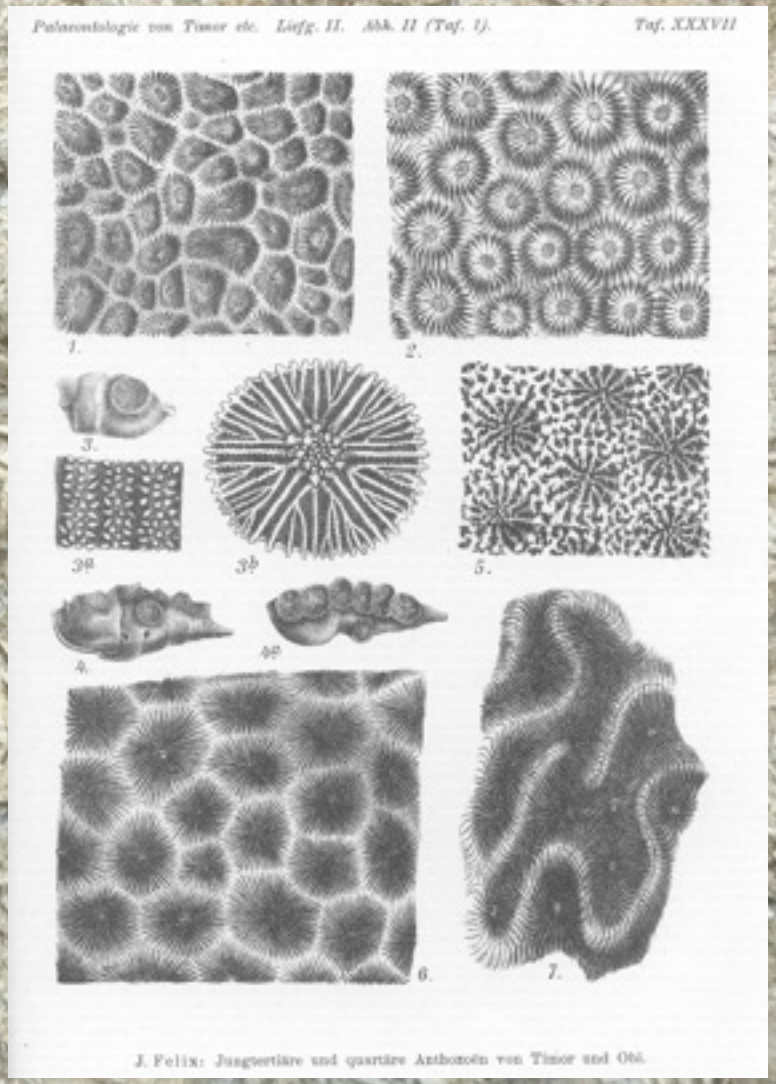


Fossil corals: How much do we know?

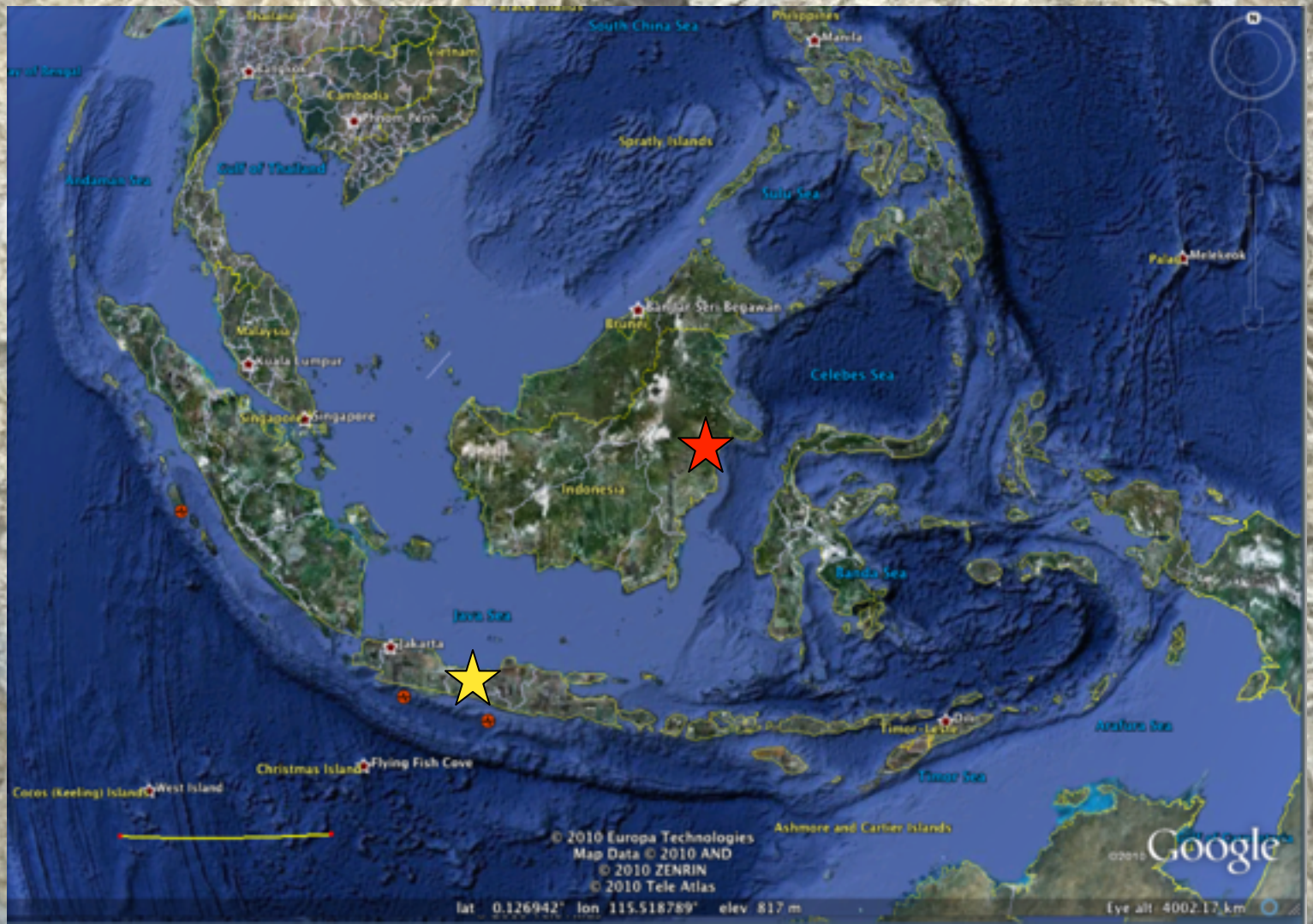
Collections ~ million specimens
916 references (Europe)

Collections ~ 10000 specimens
383 references (Entire IndoPacific)
Johnson et al. in prep
25 Families
76 genera
297 species → 173 extinct
124 extant

Fossil corals: How we will study them?

Field trips →15 Nov-20 Dec

June - July 2011



Objectives

1. To identify the biodiversity of Miocene coral assemblages in SE Asia (East Kalimantan). Recent vs. Extinct ?

2. To infer the palaeoecology of Miocene reef environments in SE Asia. Integration with other PhD students.

3. To study the taxonomy, systematics, and evolution of a “target” Scleractinian taxon, i.e. Agariciidae, *Pachyseris*.

Fossil corals: How we will study them?

Stratigraphy / Transects : reef structure

Fossil corals: How we will study them?

Stratigraphy / Transects : reef structure

Collections: taxonomic identification

Fossil corals: How we will study them?

Stratigraphy / Transects : reef structure

Collections: taxonomic identification

Electronic resources

CORALLOSPHERE

Home

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Taxonomy

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Tools

Welcome

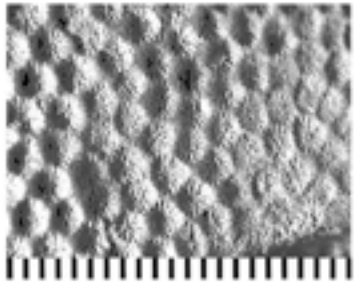
Search for a taxon: Try a name Go

"I sometimes think that general and popular Treatises are almost as important for the progress of science as original work." - Charles Darwin, in a letter to T. H. Huxley, January 1865

Corallosphere.org is a web application developed with the aim of exploring new approaches to compiling taxonomic information on extant and extinct scleractinian corals. Main areas covered in Corallosphere.org include text descriptions for diagnoses of valid genera, as well as tools for managing taxonomic synonymies, image databases, a bibliography, and an illustrated atlas of morphological terms. A flexible work-flow allows users of the system to be assigned roles with differing levels of access and functionality. Contributors may compile, edit, and review generic diagnoses directly from the internet, whereas all other users may post comments as part of an informal review process. The ultimate aim is to produce a system that will facilitate the rapid publication of the next version of the *Treatise of Invertebrate Paleontology* based on community-wide consensus, and help remove the taxonomic impediment that slows progress towards an increased understanding of the biology, ecology, and evolutionary history of the Scleractinia.

Please note that this site is a work in progress, please contact Ken Johnson at the Natural History Museum, London if you see any mistakes or would like to suggest improvements.

A syntype of of *Letepsammia formosissima* (Moseley, 1876).
info



Columactinastraea rennensis Alloiteau, 1952, holotype
info

Home | Acknowledgments

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Electronic resources

IPAEG

Indo-Pacific Ancient Ecosystems Group

Home

THROUGHFLOW

Cenozoic evolution of the Indonesian Throughflow and the origins of Indo-Pacific marine biodiversity: Mapping the biotic response to environmental change.

The mollusc *Architectonica songoensis* (Martin 1914) Kali Songo,Java, one of our fieldwork areas

The coral *Odontocyathus radiatus* Gerth, 1923 from East Kalimantan, our other fieldwork area

The research aim of THROUGHFLOW is to establish a greater understanding of key processes in the biotic response of reefs to long-term environmental changes resulting from closure of the Indonesian Throughflow during the Oligocene-Mic transition (~25 Million years ago). This will establish important baseline data on which researchers can model the impact predicted environmental change on present reef ecosystems.

Read more about us , our science, or our schedule of events.

THROUGHFLOW

Projects

- Throughflow
  - Events
  - Partners
  - Science

Resources

- Bibliographic Tool

User login

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Password: *

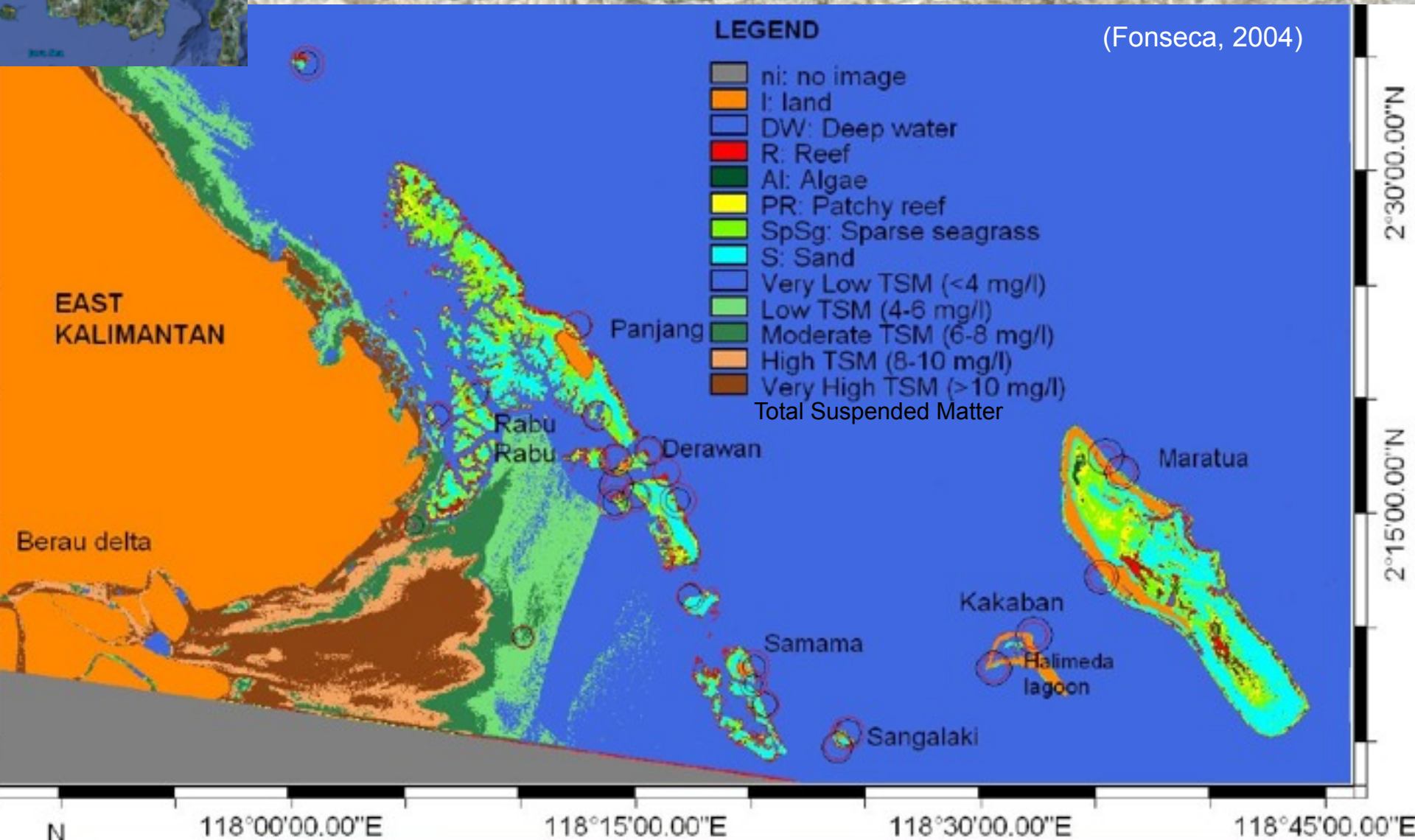
Log in

- Log in using OpenID
- Create new account
- Request new password

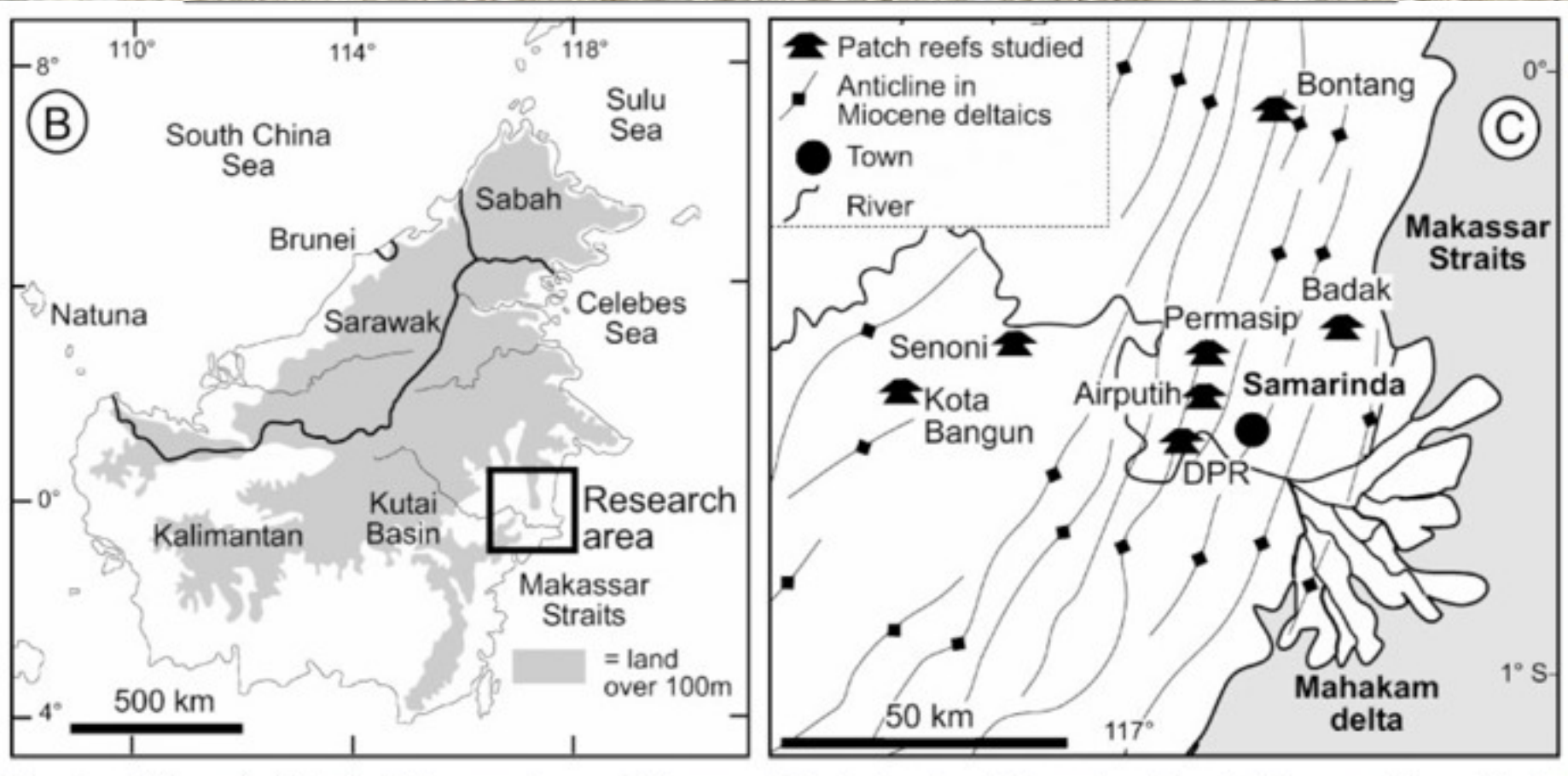
MARIE CURIE ACTIONS

SEVENTH FRAMEWORK PROGRAMME

Mapping of Berau Reef System

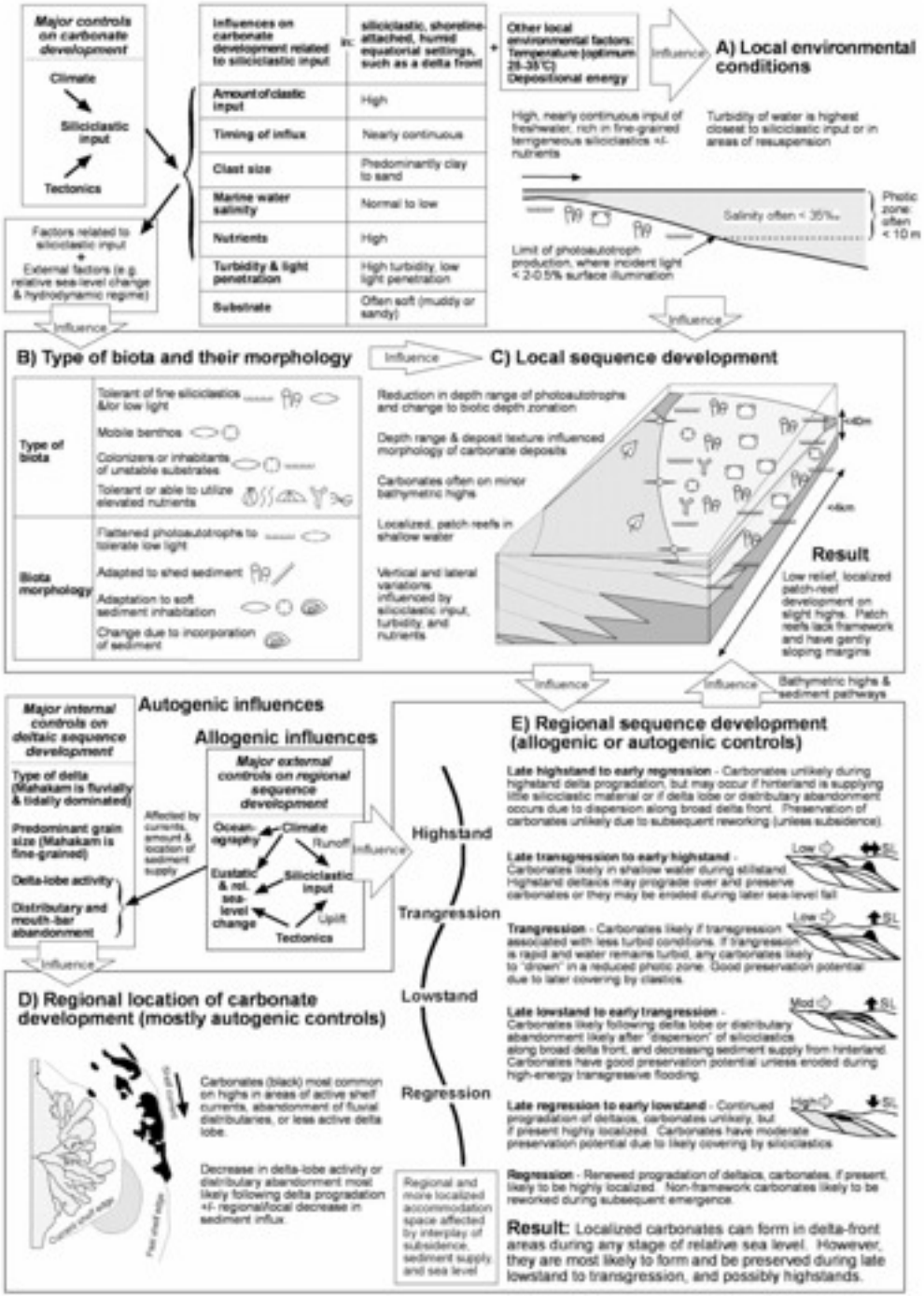


LET'S READ THIS PAPER



Development of equatorial delta-front patch reefs during the Neogene, Borneo

Wilson, 2005



Delta-front Patch Reef

•Carbonates occur in areas of high siliciclastic input.

•Turbid-water reefs may have moderate to high biodiversity, adaption to turbid-waters.
-mobility, heterotrophy,
-morphology to capture light.

• Patch-reef development on soft substrates / shallow waters.

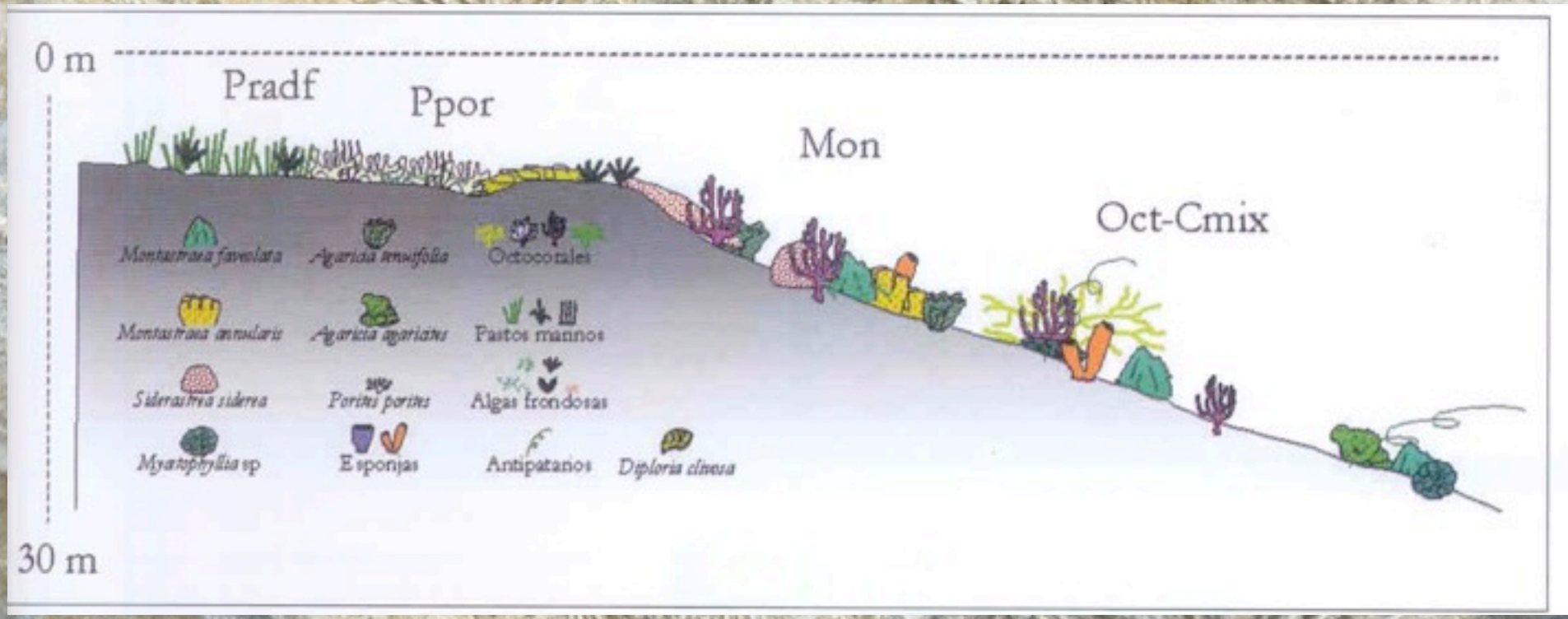
•Carbonate production and bioherm or patch-reef development may occur in turbid-water, delta-front areas as localized or more regionally extensive units during any phase of eustatic sea level.
Interplay of factors control carbonate development and preservation:
- Tectonics
- Eustasy
- Delta switching
- Currents
- Amount and size fraction of siliciclastic sediment

Wilson, 2005


Questions?

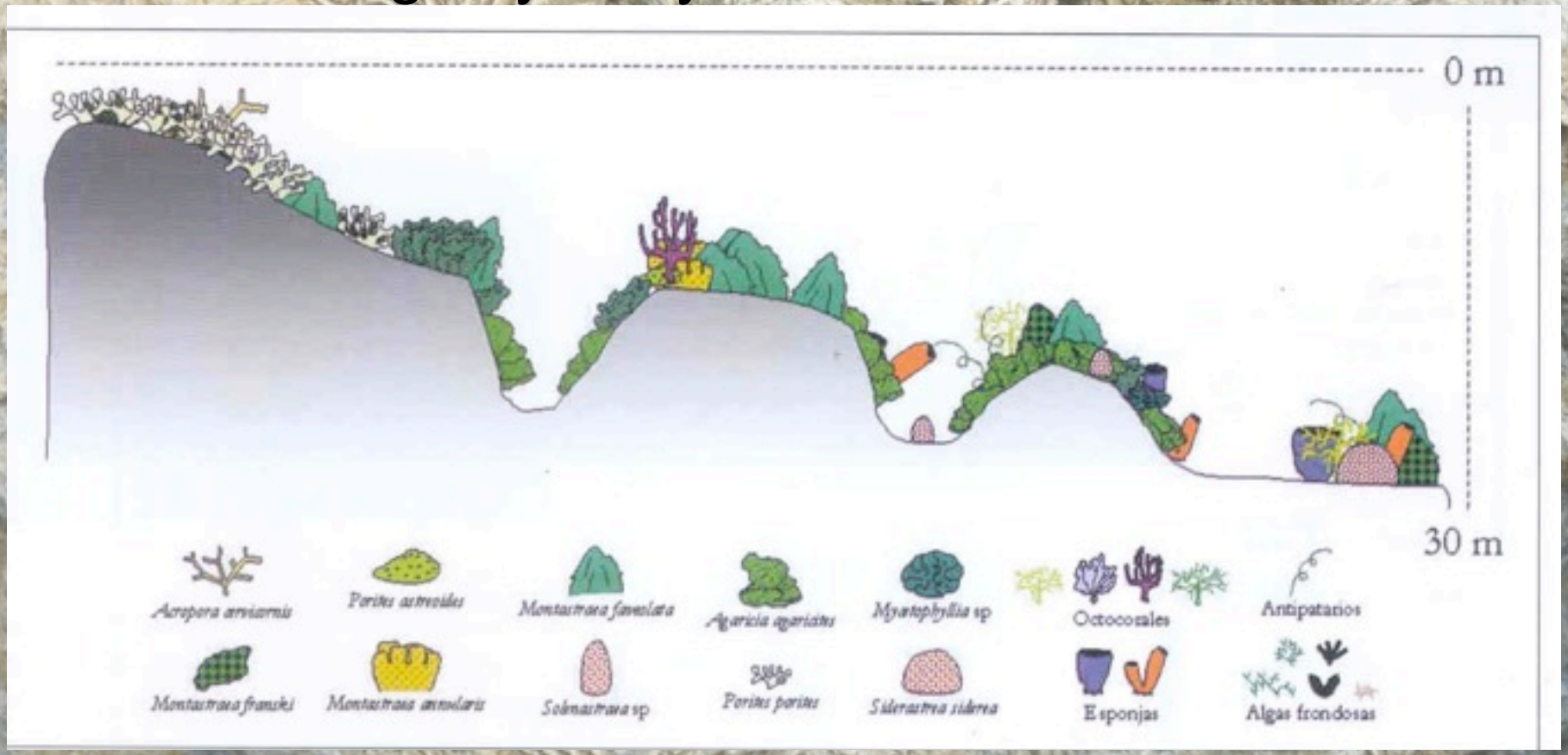
Zonation in shallow reefs

Leeward: Low hydrodynamic



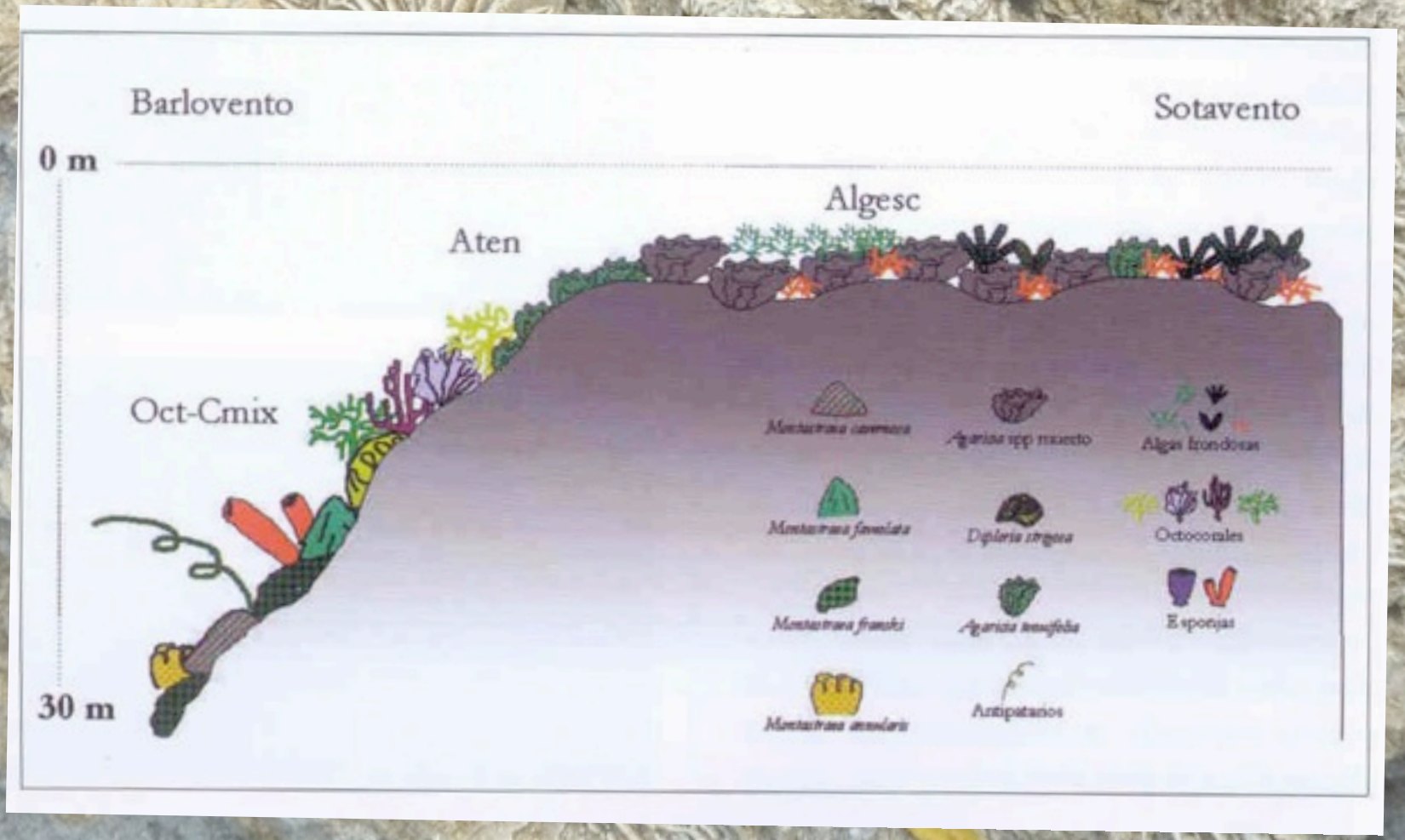
Zonation in shallow reefs

Windward: High hydrodynamic



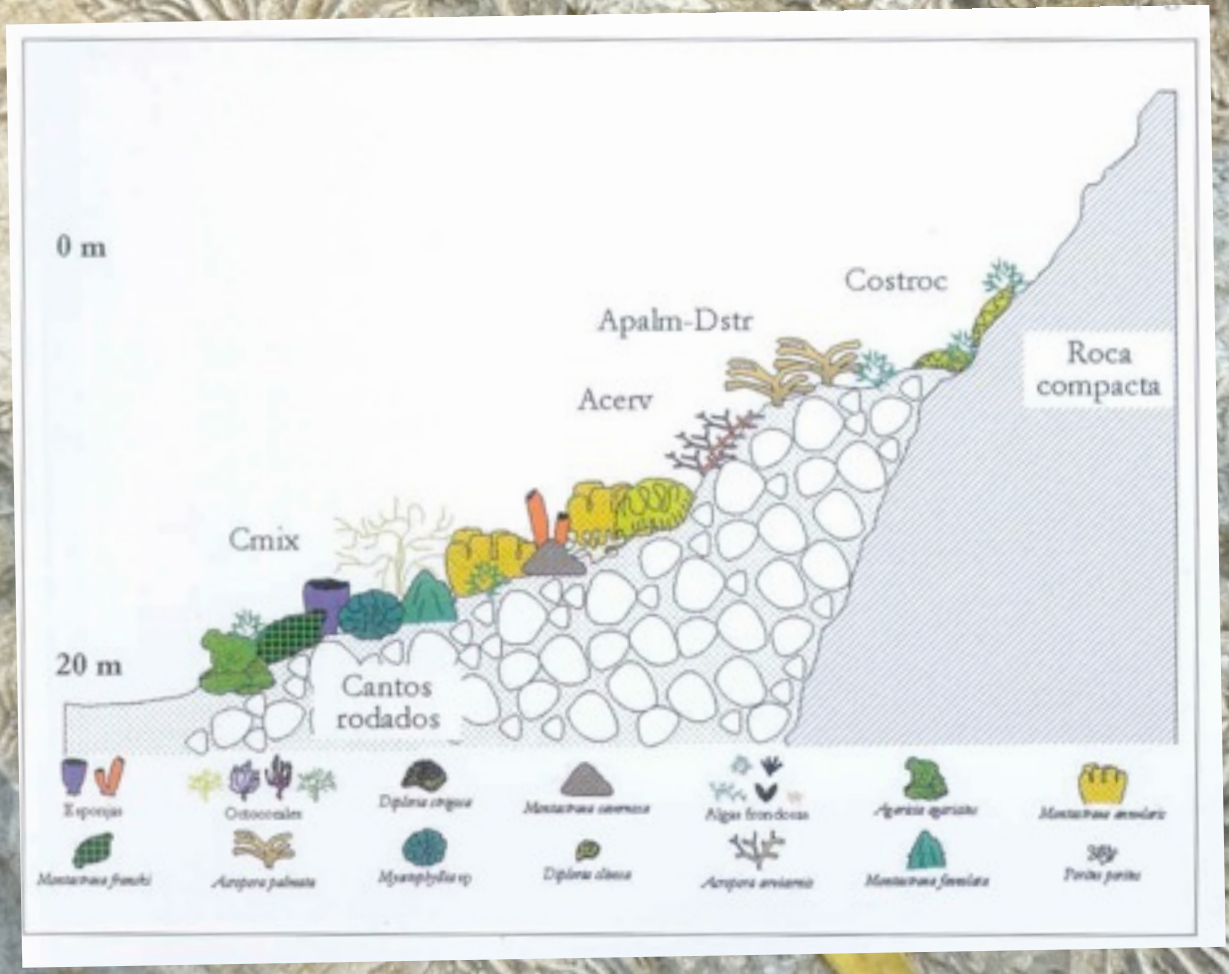
Zonation in a coral bank

Bajo coralino: Open waters offshore



Zonación en arrecifes someros

Fringing reefs: Associated to a rocky shore (Tayrona)



ZOOXANTHELLATE CORALS

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AZOOXANTHELATE CORALS

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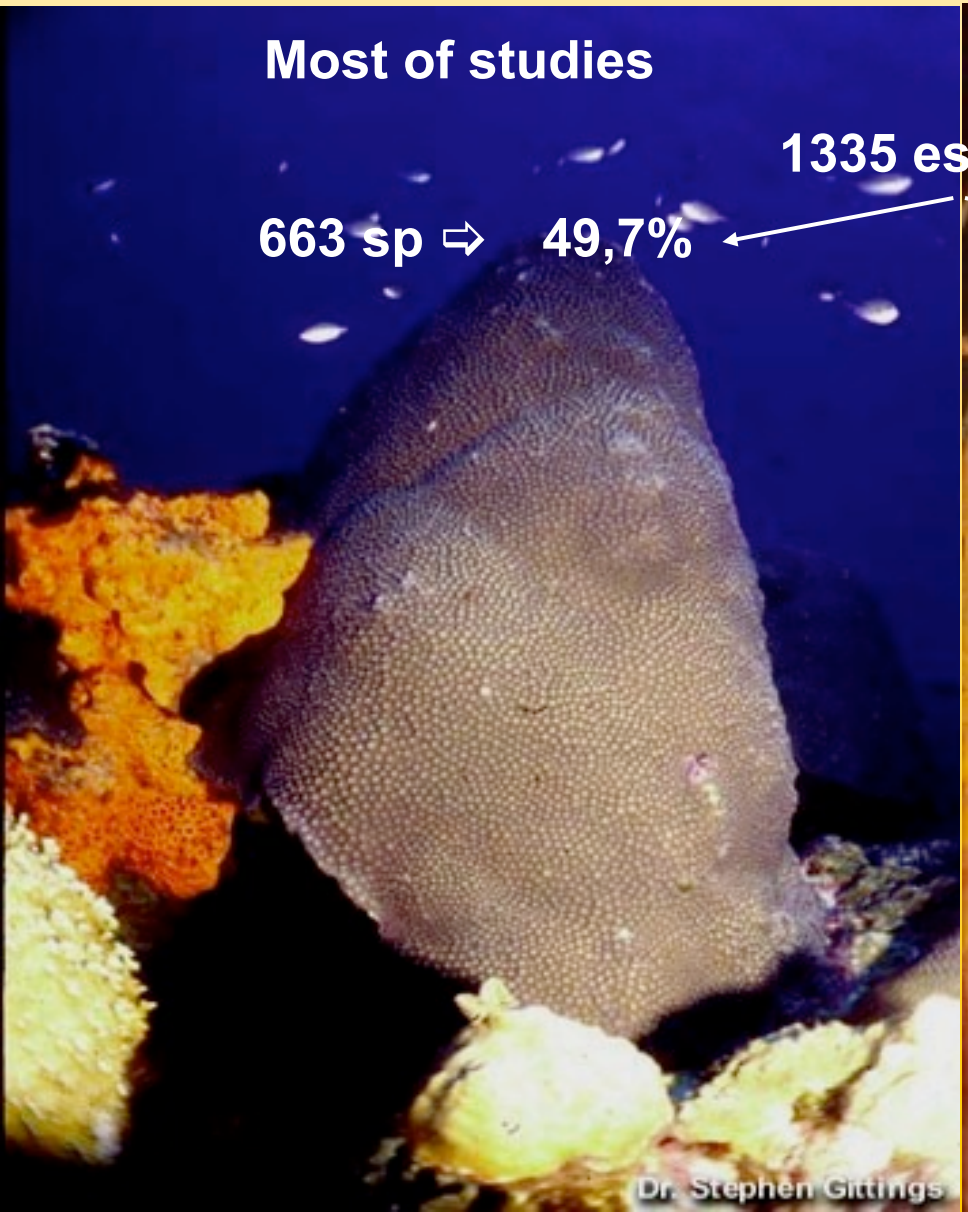
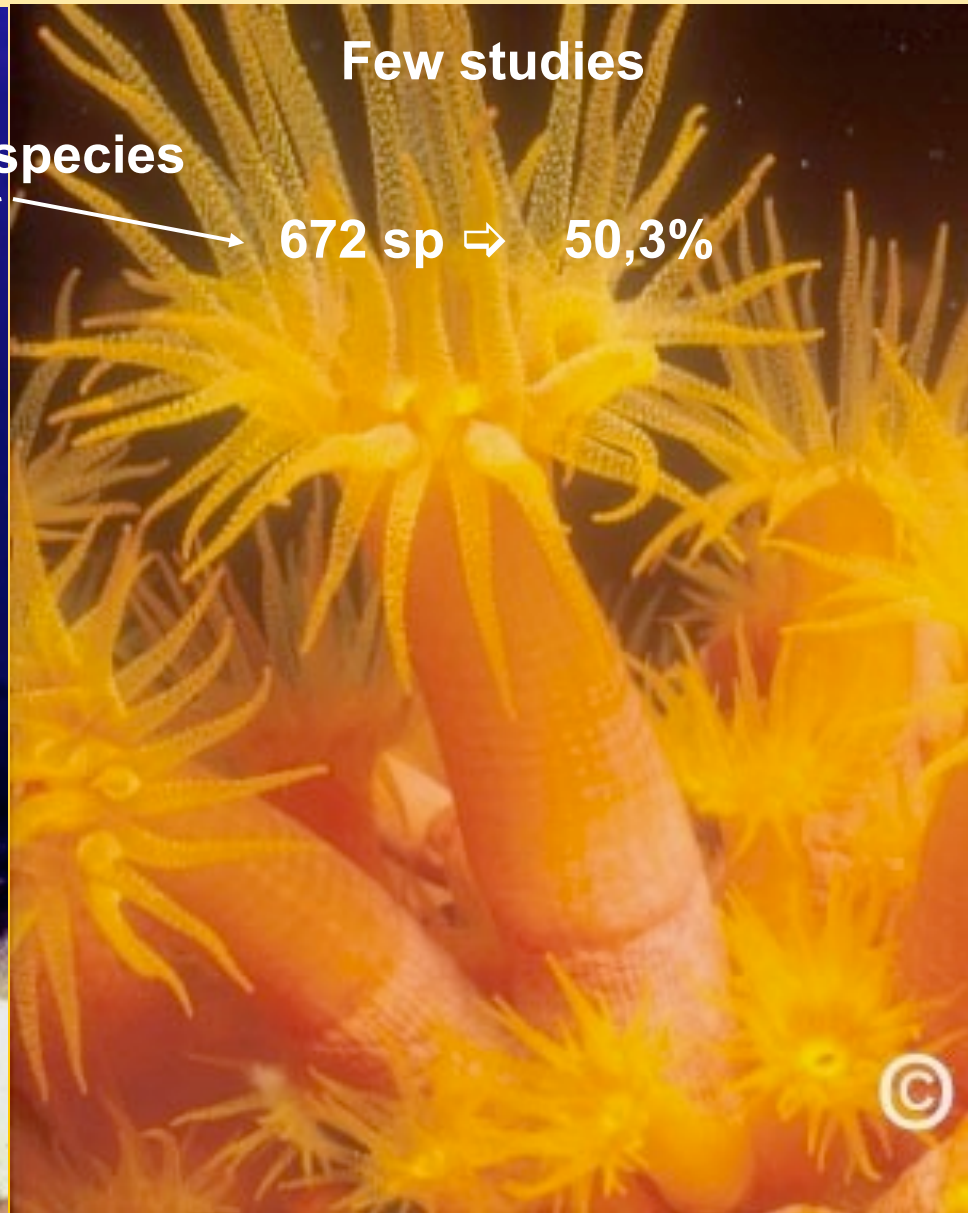




ZOOXANTHELLATE CORALS

AZOOXANTHELATE CORALS

Most of studies

1335 especies

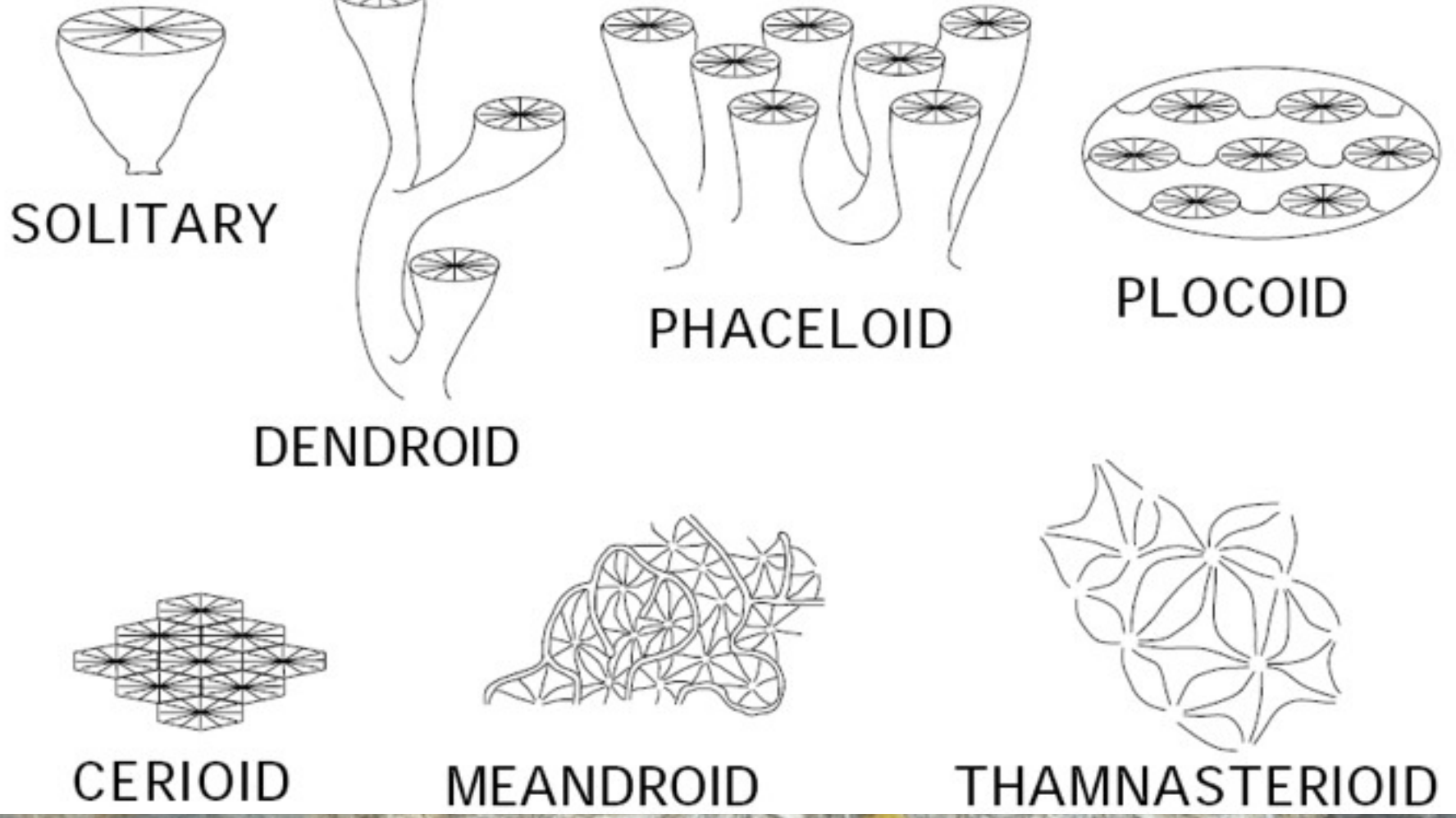
663 sp ⇨ 49,7%

Few studies

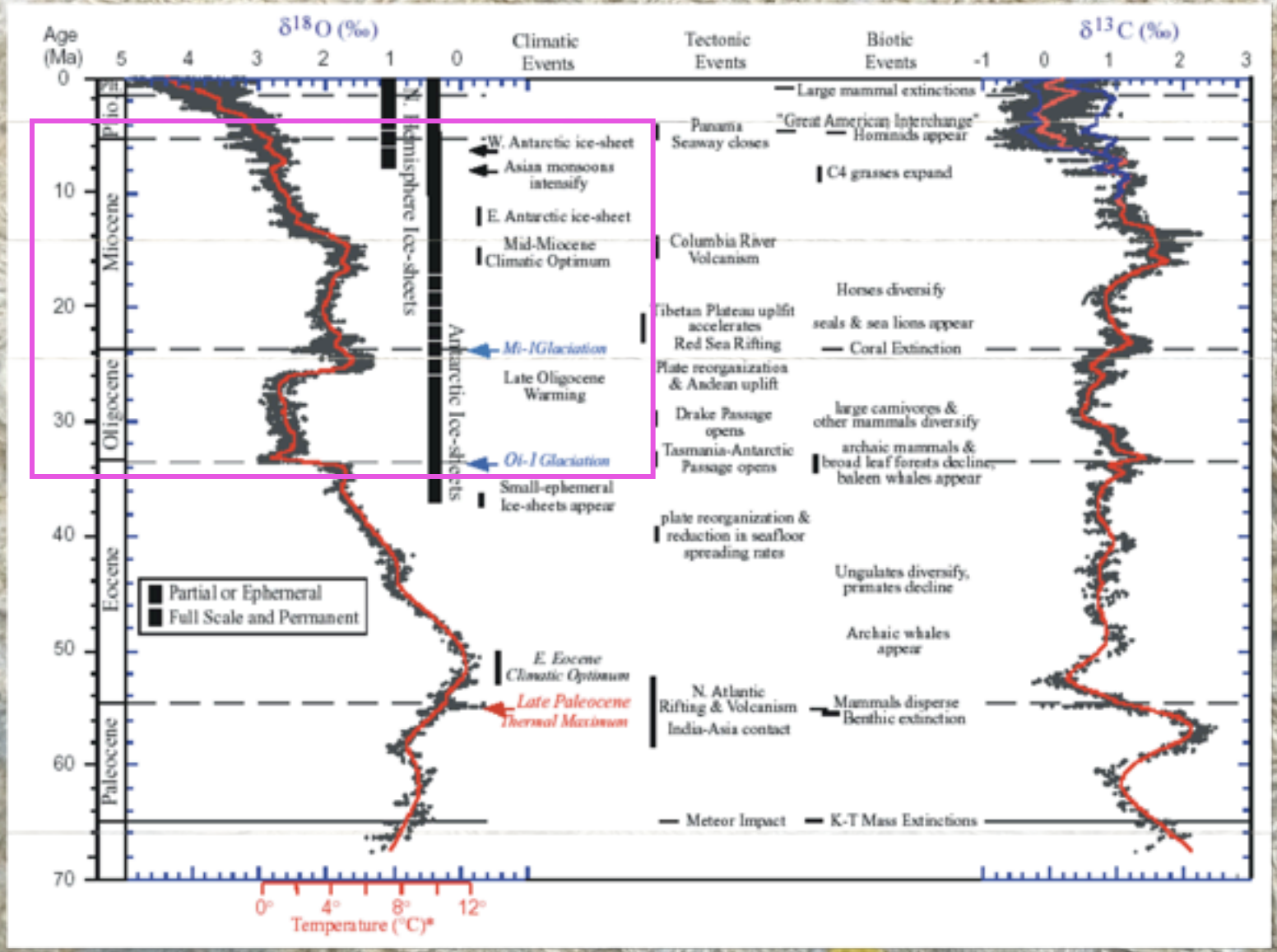
672 sp ⇨ 50,3%

Latitude	23ºN a 23ºS ± 10º	Equator to poles
Depth	0 - 25 m (-0.5 - 150m)	60 - 300 m (-0.5 - 6200 m)
Temperature	23 - 28ºC (11 - 40 ºC)	10 ºC (-1 - 35ºC)
Salinity	34 - 36	27 - 48
Euphotic zone	Hermatypic	Ahermatypic
Aphotic zone	Absent	Hermatypic - Ahermatypic

All environments
Hard and soft bottoms


SOLITARY
DENDROID
PHACELOID
PLOCOID
CERIOID
MEANDROID
THAMNASTERIOID

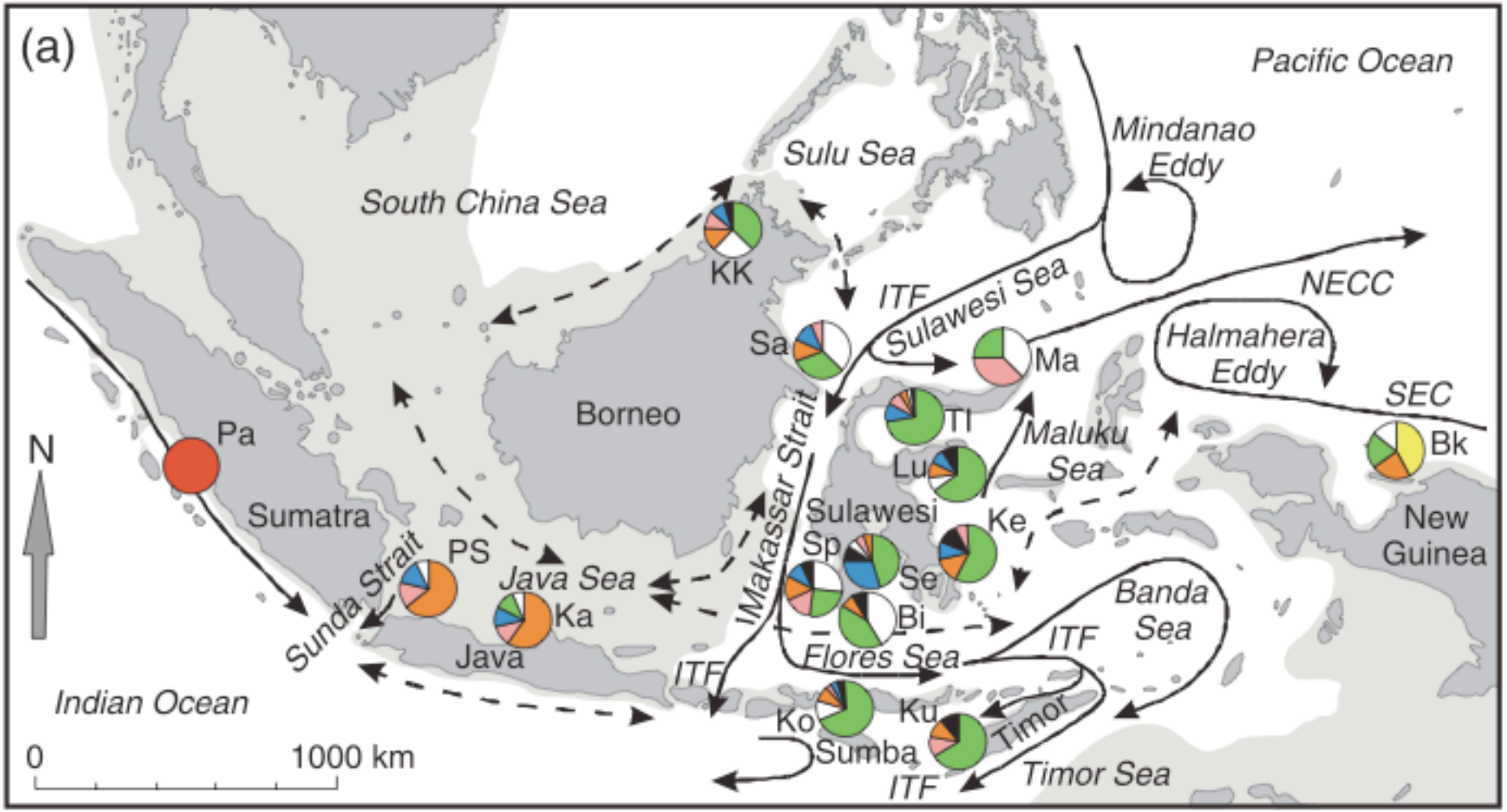
What can fossil corals tell us about the environment during this period?



Zachos et al., 2001. *Science*

Phylogeography

Indopacific Throughflow has a major effect on connectivity of extant diversity



Kochzius & Nuryanto, 2008

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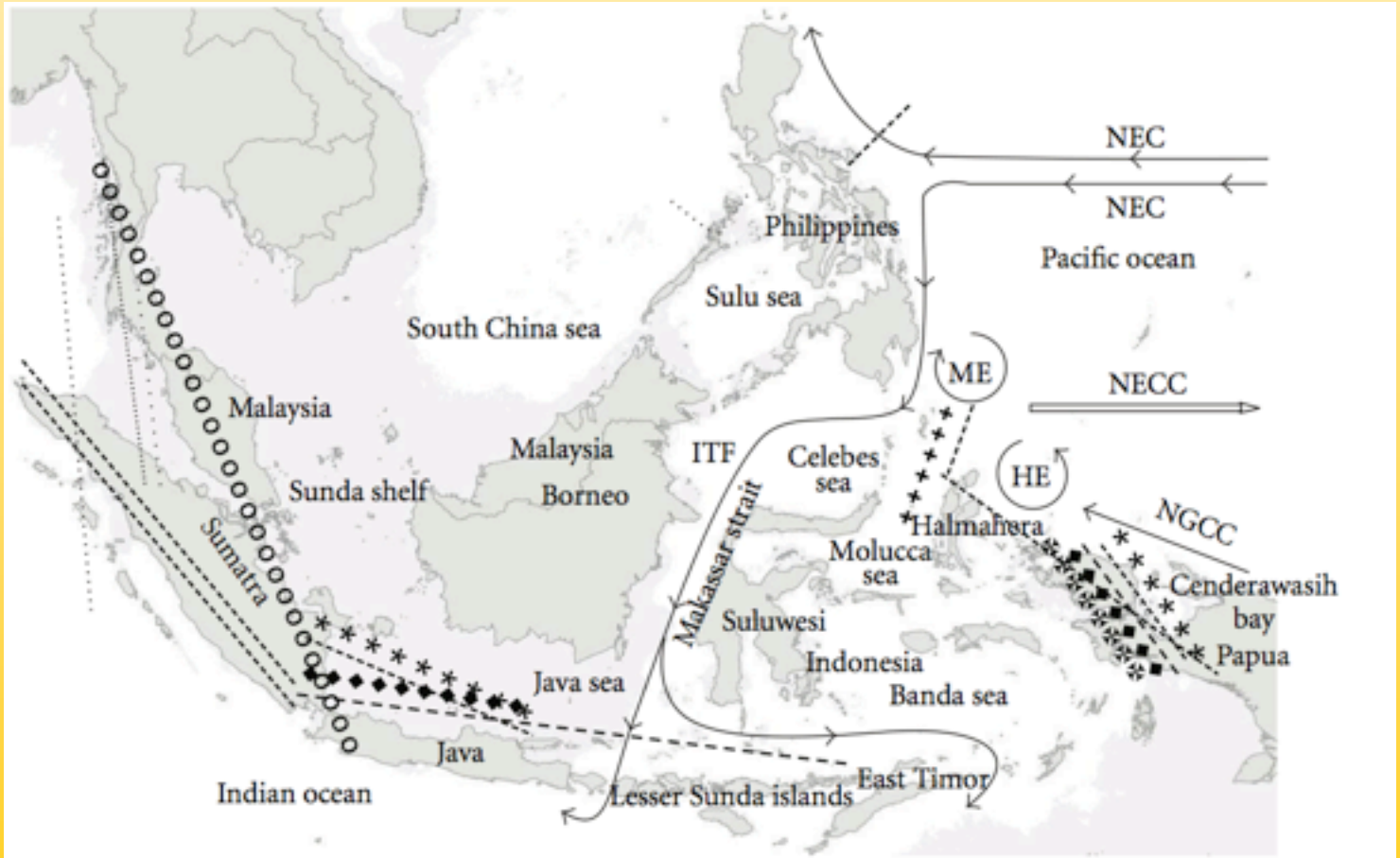


Carpenter et al., 2011

Coral Triangle: Centre of Marine Diversity

WWF, 2010

THROUGHFLOW

THROUGHFLOW

Why are the coral reefs in Southeast Asia the most diverse in the world?

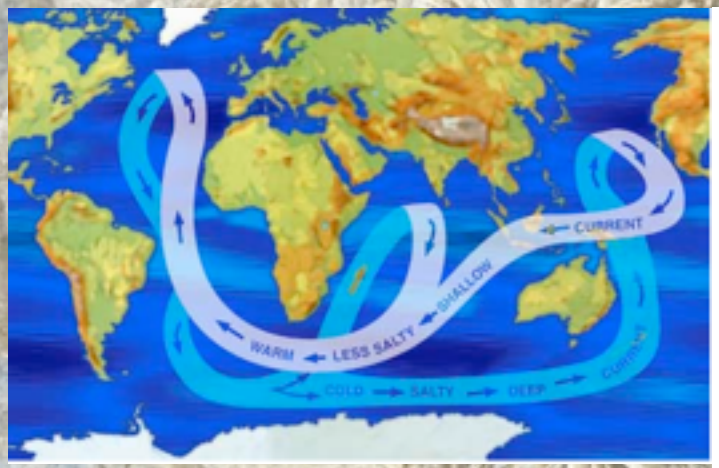
How have they responded to environmental changes in the past?

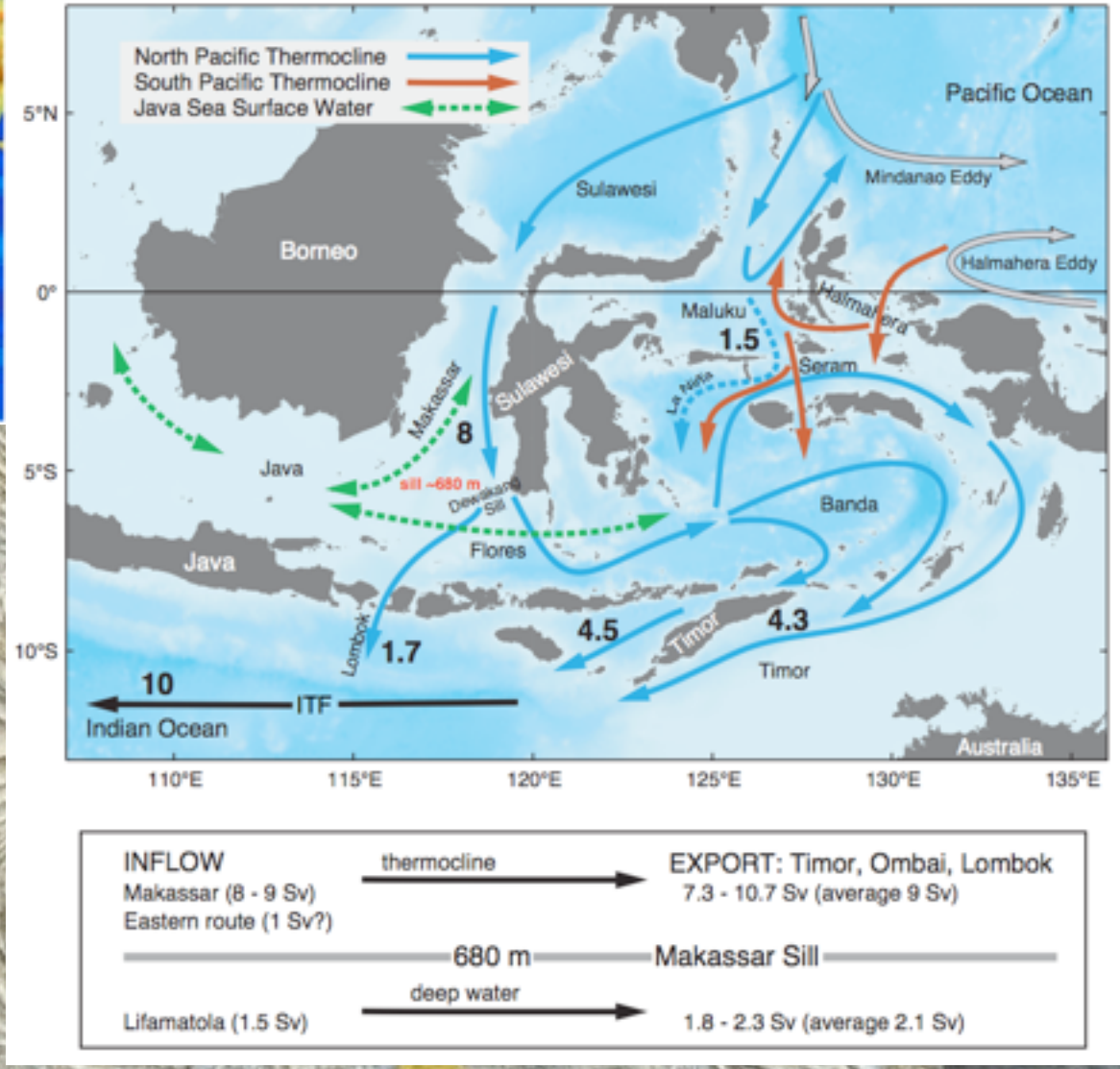
How are they likely to respond in the future?

Our expedition will start next week
November 15-December 20

Join us on-line at:
http://www.nhm.ac.uk/natureplus/blogs/borneo

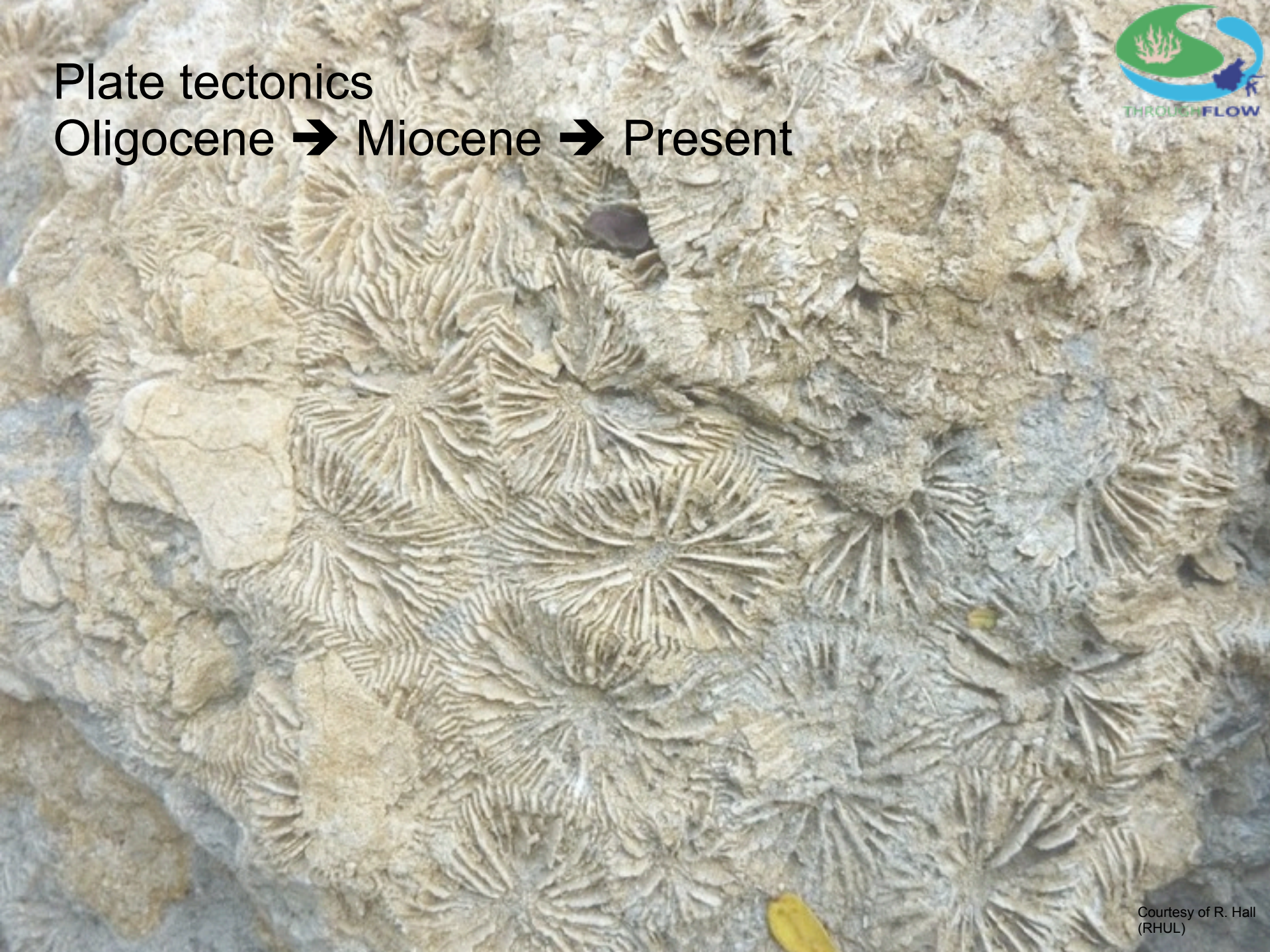
Indonesian Throughflow Current





Gordon, 2005. *Oceanography*

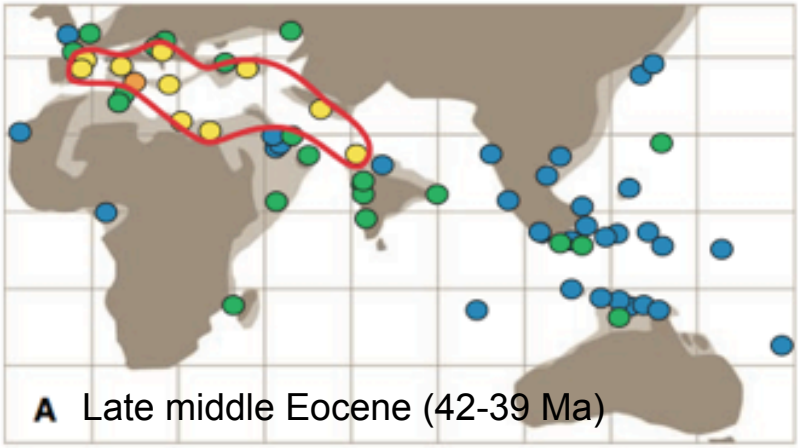
Plate tectonics
Oligocene ➔ Miocene ➔ Present

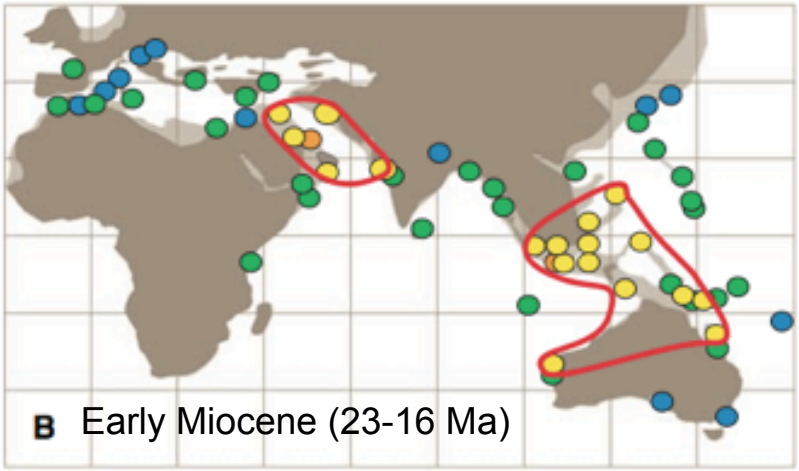


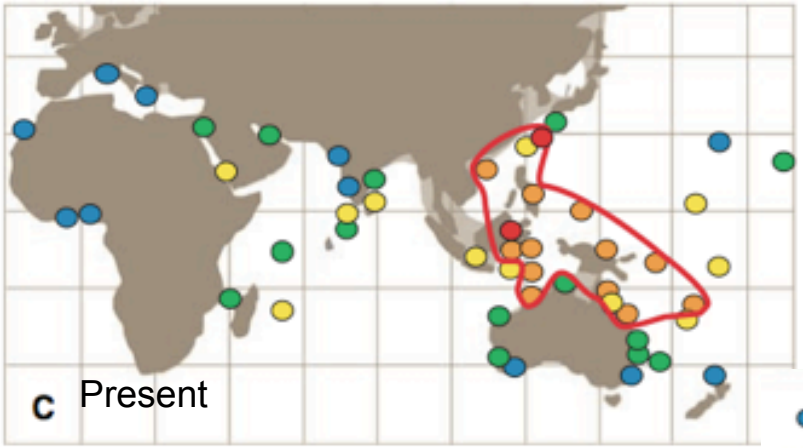
Courtesy of R. Hall (RHUL)

Plate tectonics + Eustatic Sea Levels
Oligocene ➔ Miocene ➔ Present

Courtesy of R. Hall (RHUL)







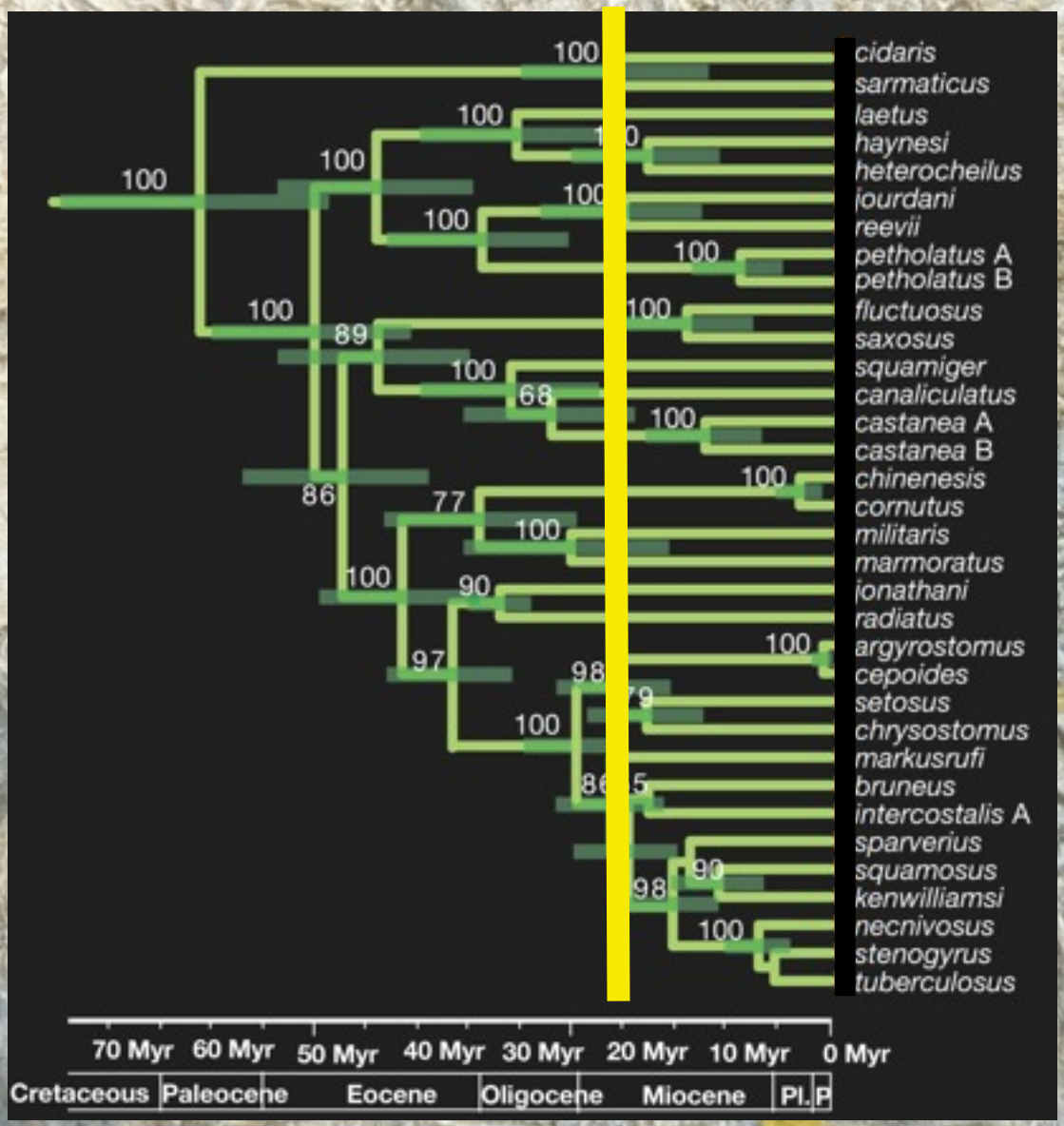
Hopping hotspots of marine biodiversity during the last 50 Ma

1-4 5-8 9-12 13-16 >16

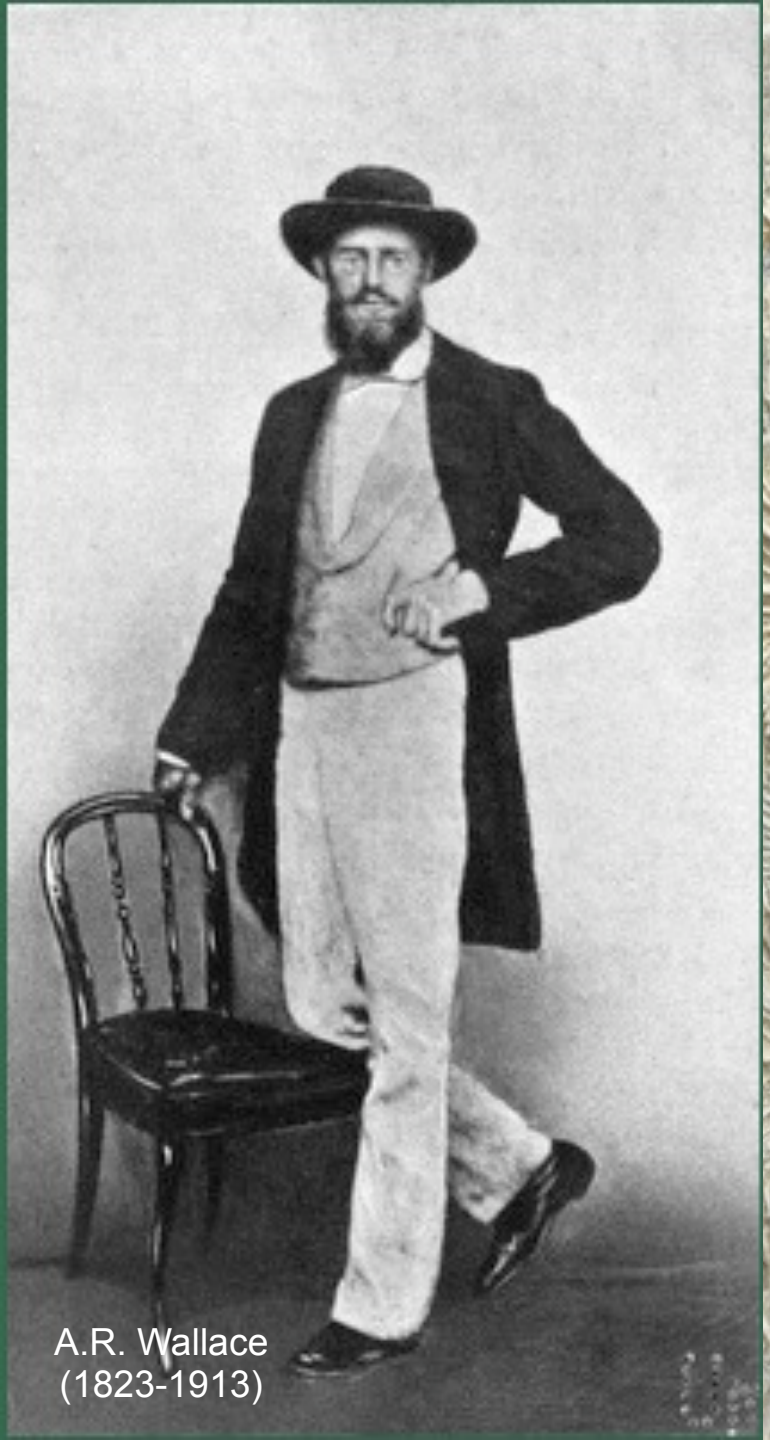
Renema et al., 2008

Phylogenies:

Modern day diversity first appeared about 20 million years ago



Williams 2007; Williams & Duda 2008



A.R. Wallace
(1823-1913)

Biologists have been working for over a century to understand the origins of the Southeast Asian diversity