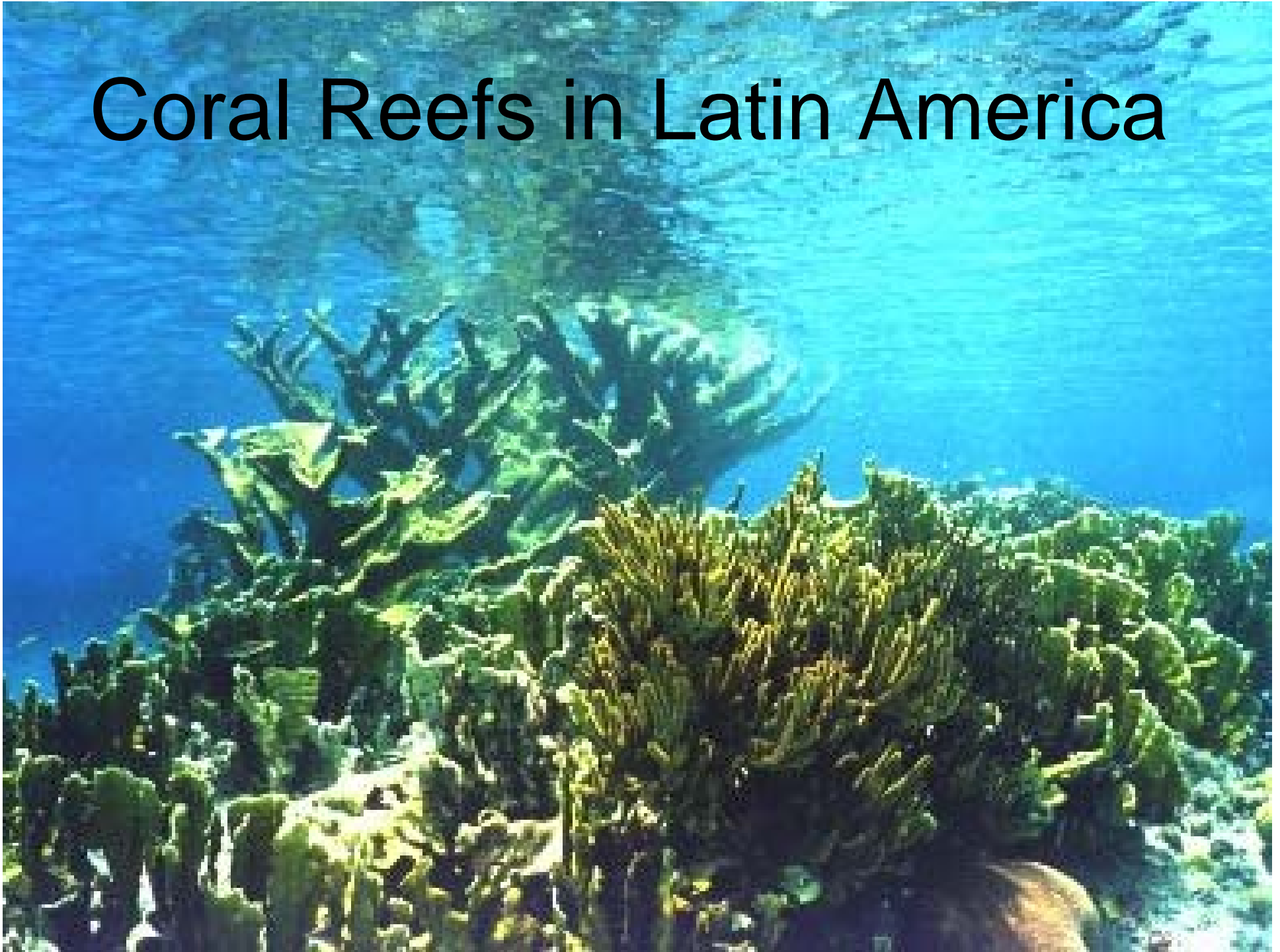


# Coral Reefs in Latin America



# Coral Reefs: Definitions

The primary criteria for classification as a reef are:

- 1) It is constructed of material of biological origin, mostly calcium carbonate.
- 2) It is a rigid structure due to interlocked and in-place framework elements.
- 3) It stands topographically above the surrounding seafloor and exerts some control on local oceanographic processes.

<http://cima.uprm.edu>

# Importance of Coral Reefs

- High Economic Value, \$ 1.6 billion to the economy of Florida. Up to half of the GDP of some countries is supported by coral reefs
- Storm Protection
- Biodiversity



# Conditions for modern reef development:

Modern reefs are highly dependent on the requirements of the main reef builders, *scleractinian corals* and *calcareous algae*, as follows:

## 1) Water must be warm, shallow, and of normal salinity:

- shallow water (<100m): within the local photic zone. Both calcareous algae, and the zooxanthellae which live symbiotically within scleractinian corals, depend on light for photosynthesis
- warm water (18 to 36°C; optimum 25 to 29°C) is required for the growth of hermatypic (reef-forming) scleractinian corals
- normal marine salinity (22- 40 parts per thousand).

## 2) Bottom must be firm and not too much mud in the water

- low terrigenous clastic (mud and sand) input: some reef-building organisms are killed by sand and mud.
- stable and firm seafloor is needed for reef builders to attach



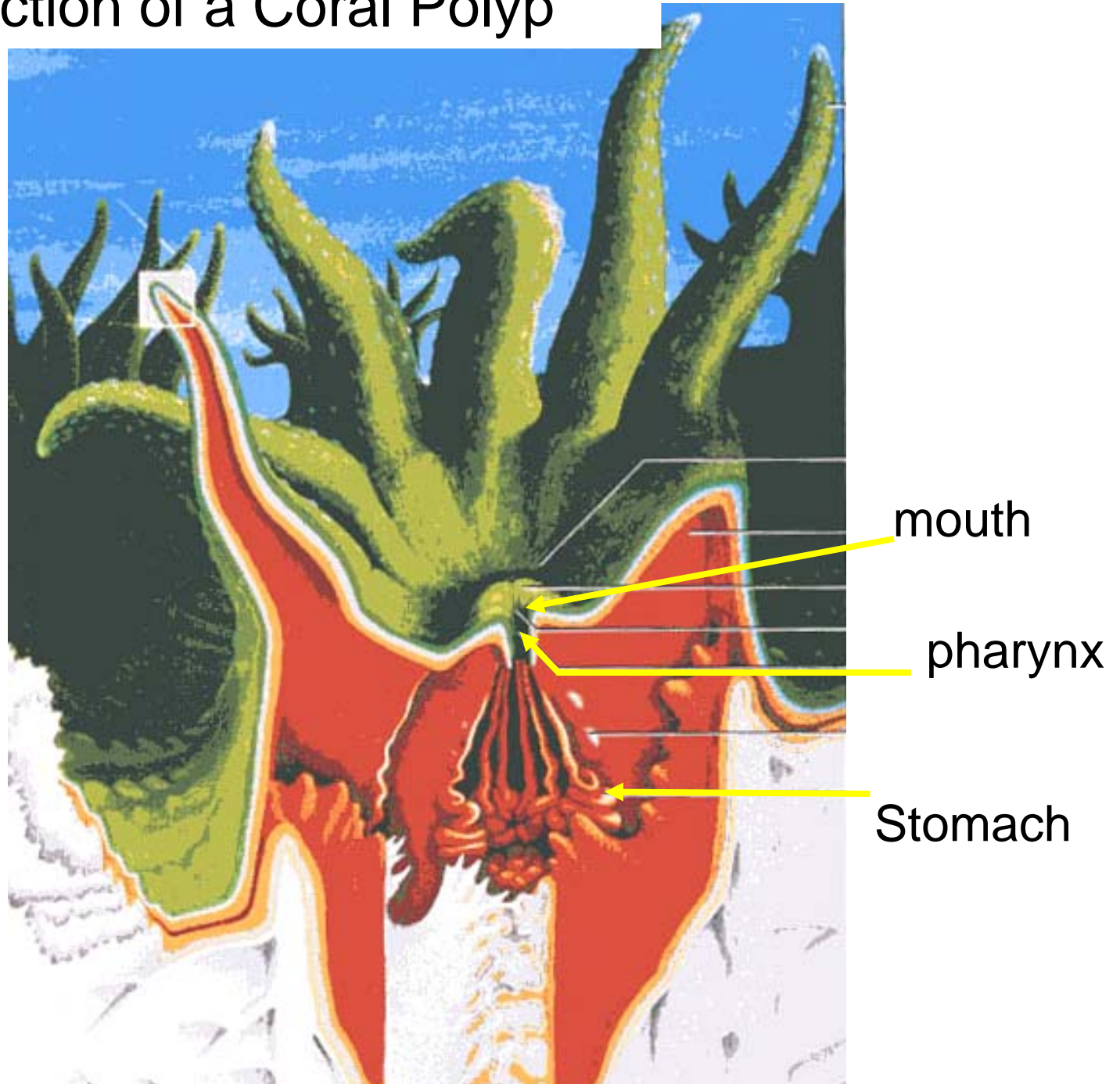


Corals are animals!  
The individual polyp is  
an invertebrate of the  
phylum *Cnidaria*.



# Cross Section of a Coral Polyp

The body is soft and tubular, with an oral opening surrounded by six (or multiples of six) tentacles. At night, these extend to trap plankton. The body wall consists of three layers, the innermost of which (gastrodermis) contains **zooxanthellae**





# Zooxanthellae

symbiotic photosynthetic single-celled algae

- Contained within the coral gastrodermal cells
- Use photosynthesis to create food for the coral host

## Symbiotic relationship between coral (animal) and zooxanthellae (plant)



**From zooxanthellae:  
Lipids, sugars, and O<sub>2</sub>**



**From coral:  
Nutrients,  
carbon dioxide  
& shelter**



Nitrogen and phosphorous derived from captured plankton are shared between symbiont (zooxanthellae) and host (coral).

# Scleractinian Corals

- Hard corals or stony corals
- Secrete calcium carbonate ( $\text{CaCO}_3$ )
- Most important group of organisms on a reef, because Scleractinian corals are reef building (= hermatypic).
- Contain zooxanthellae.





# Reef activity is concentrated in the Photic Zone

- The 'photic zone' is the uppermost part of the ocean, it reaches a maximum of 200 meters in the open sea, to which sunlight penetrates. This determines the depth to which photosynthesis can occur.
- Scleractinian corals cannot grow - and reefs cannot form - if zooxanthellae cannot survive.

# Precipitation of Calcium Carbonate by Corals (1)

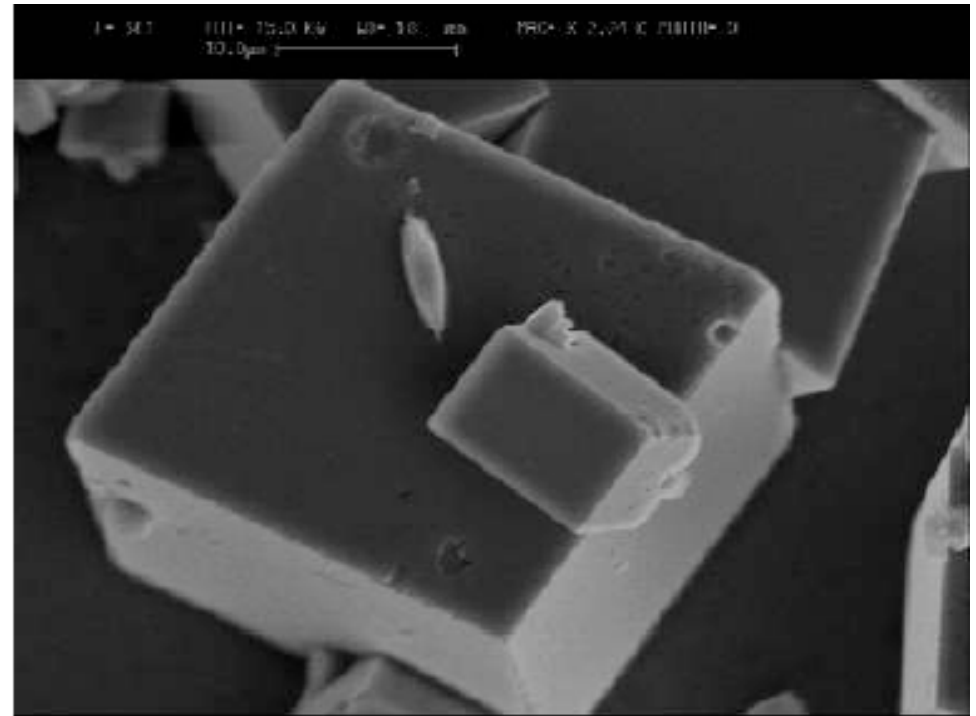
The ocean is saturated with the three major polymorphs of  $\text{CaCO}_3$  (aragonite, calcite and magnesian-calcite). Yet,  $\text{CaCO}_3$  rarely precipitates spontaneously in seawater. As a result, biologically mediated  $\text{CaCO}_3$  precipitation by corals is the most important contributor to building reefs. Coral polyps absorb calcium ions from seawater and move them to the site of calcification, where they are deposited as aragonite.

# Aragonite

Orthorhombic  $\text{CaCO}_3$



Crystal of twinned Aragonite  
from Spain

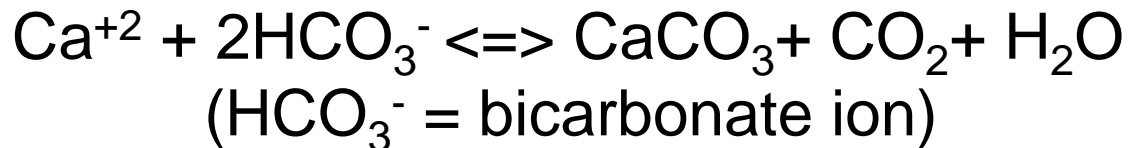


SEM image of Aragonite.

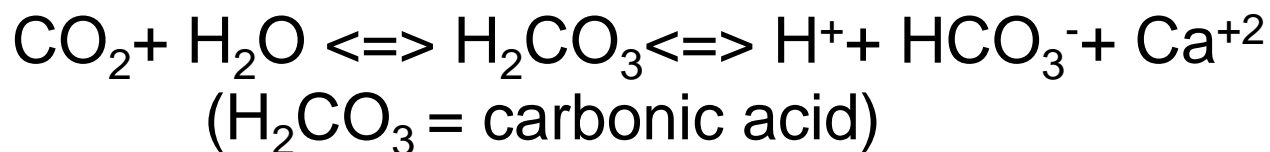


# Precipitation of Calcium Carbonate by Corals (2)

Calcium carbonate formation is described by the formula:



The production rate of aragonite is thus related to the abundance of  $\text{Ca}^{+2} + \text{HCO}_3^-$  in the water. The addition of  $\text{CO}_2$  to water yields bicarbonate through the following process:

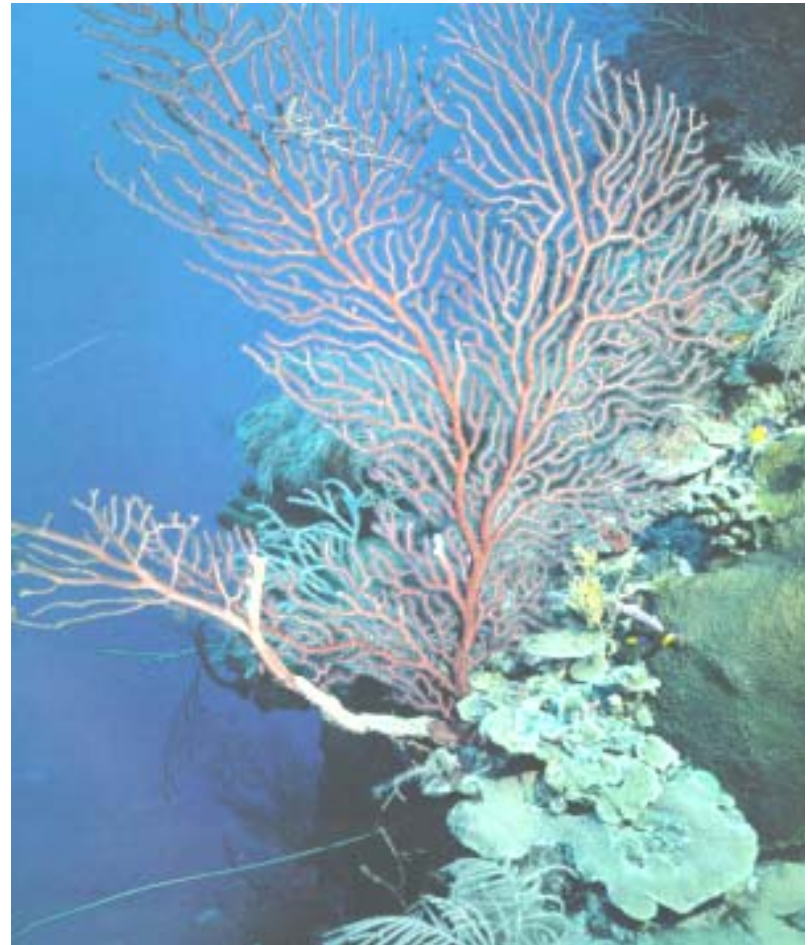


Free  $\text{H}^+$  lowers the pH ( i.e. makes the solution acidic).

Calcium carbonate dissolves in weak acid, so unless the excess  $\text{H}^+$  is removed, no aragonite can precipitate. Stony corals remove excess  $\text{H}^+$  from seawater and allows aragonite to precipitate.

# Alcyonarian Corals

- Soft corals
- Internal skeleton
- Large and feathery
- Not reef building
- Rely more on suspension feeding



# Calcareous Algae

As important as corals in reef and beach building.

Distribution is similar to that of coral.

Approximately 30 marine species

Early coloniser of tropical habitats, succeeded by sea-grasses

Accounts for a significant amount of  $\text{CaCO}_3$  deposits.

Produces up to 50% of all tropical beach sand

Highly productive



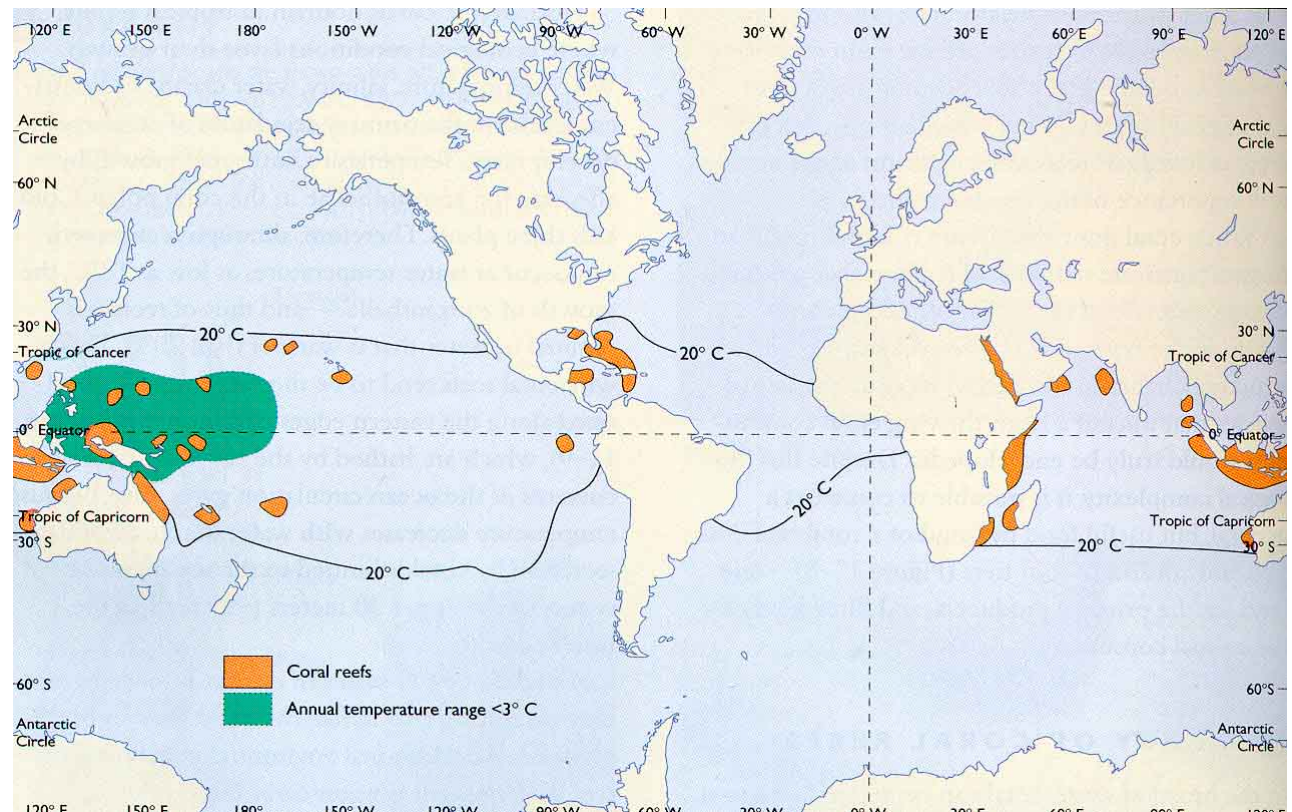
**Udotea**

**Halimeda**

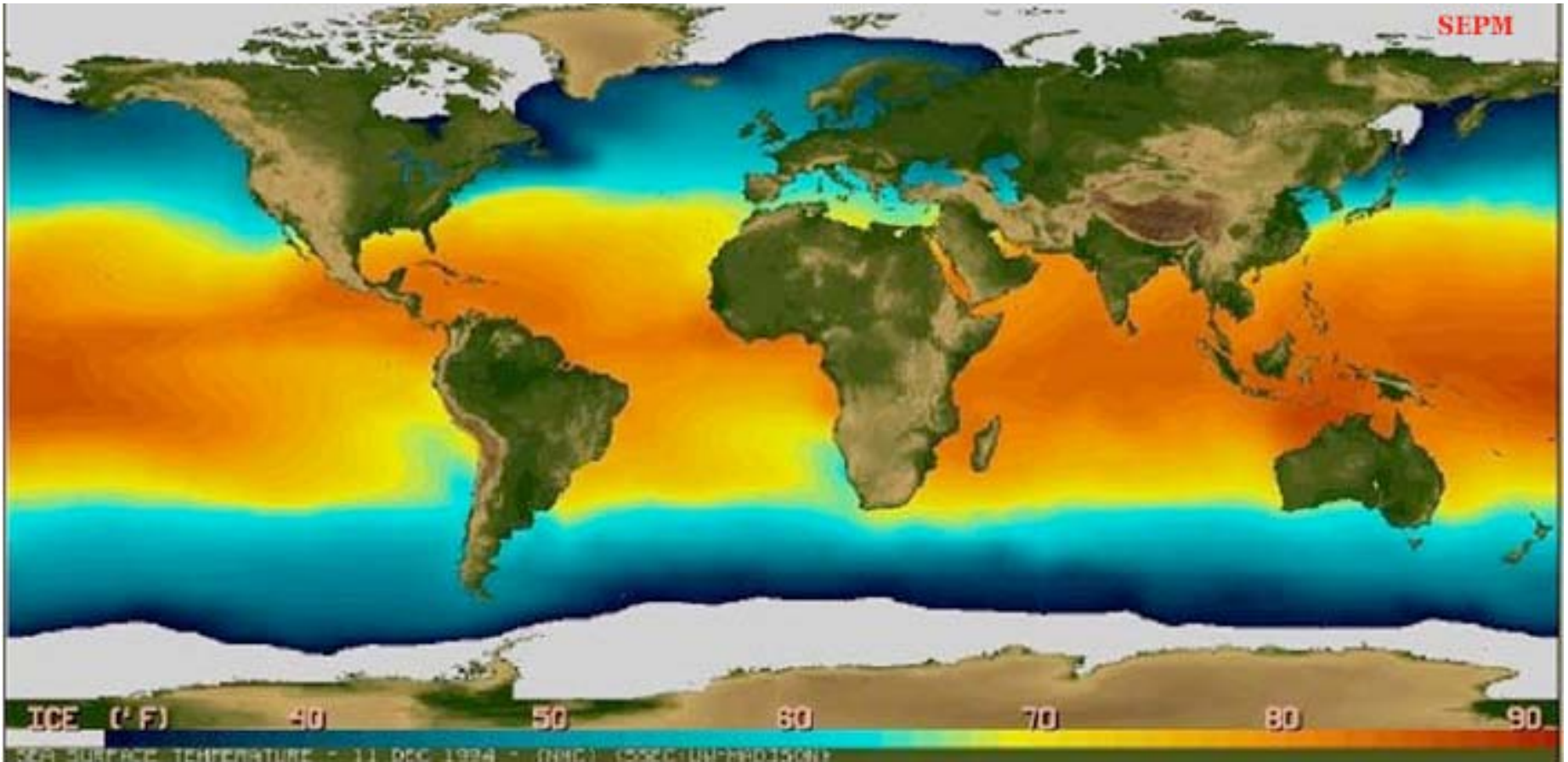


# Distribution of Reefs

- Defined by environmental requirements:
  - Light
  - Clear water (areas poor in nutrients)
  - Warm constant temperature water,  $> 20^{\circ}\text{C}$
  - Low turbidity (not off Amazon and Orinoco)
- Thus, limited to within  $30^{\circ}$  North and South of equator

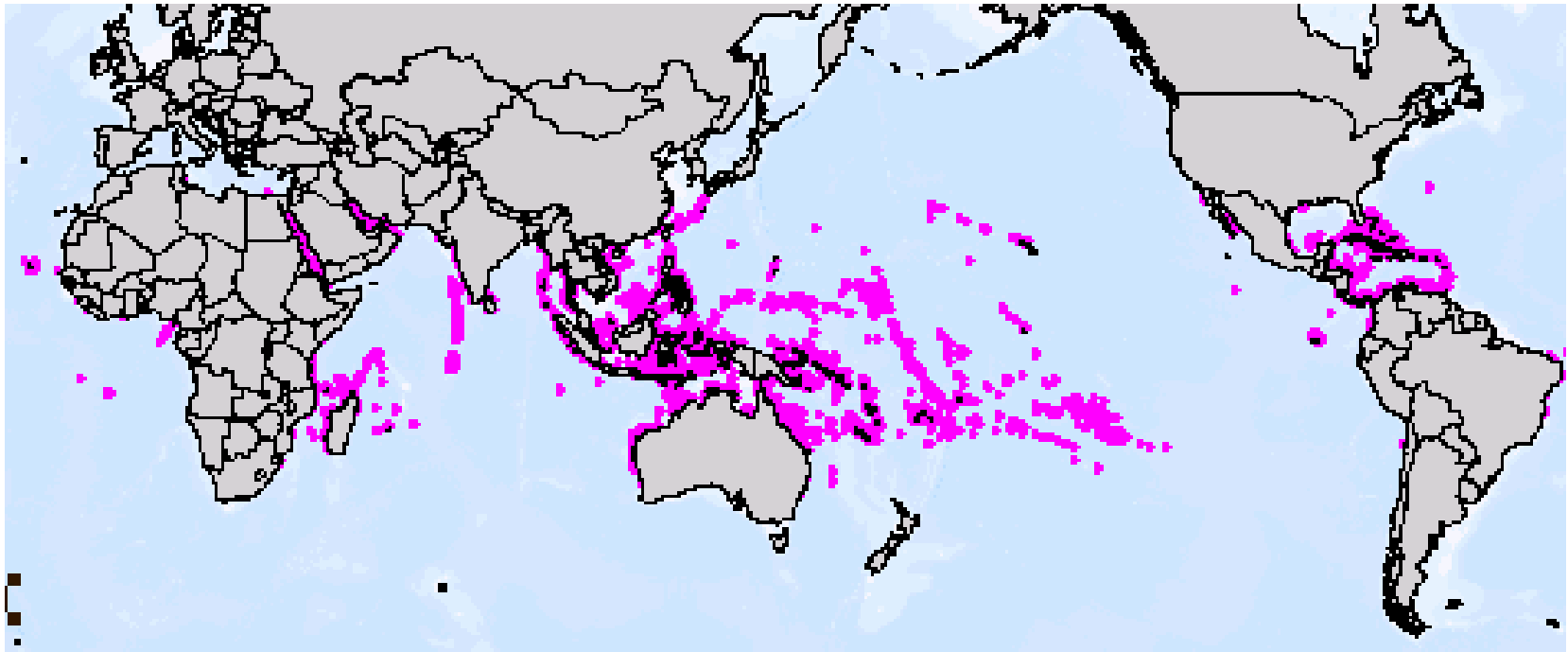


# Temperature Control



$$20^{\circ}\text{C} = 68^{\circ}\text{F}$$

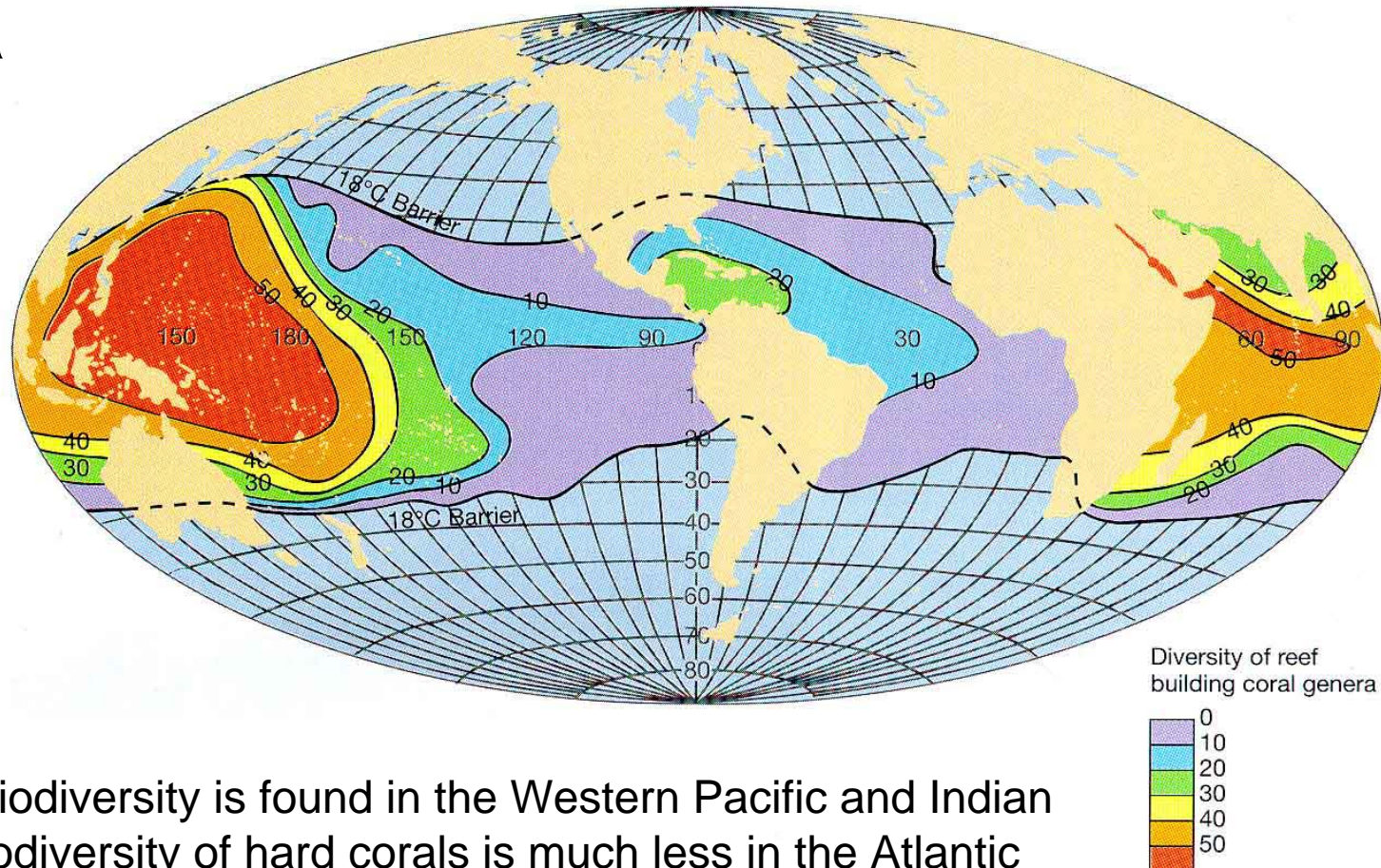
# Global distribution of Coral Reefs



Note that most of the reefs in Latin America are in the Caribbean and Greater Antilles, well north of the equator! Why?



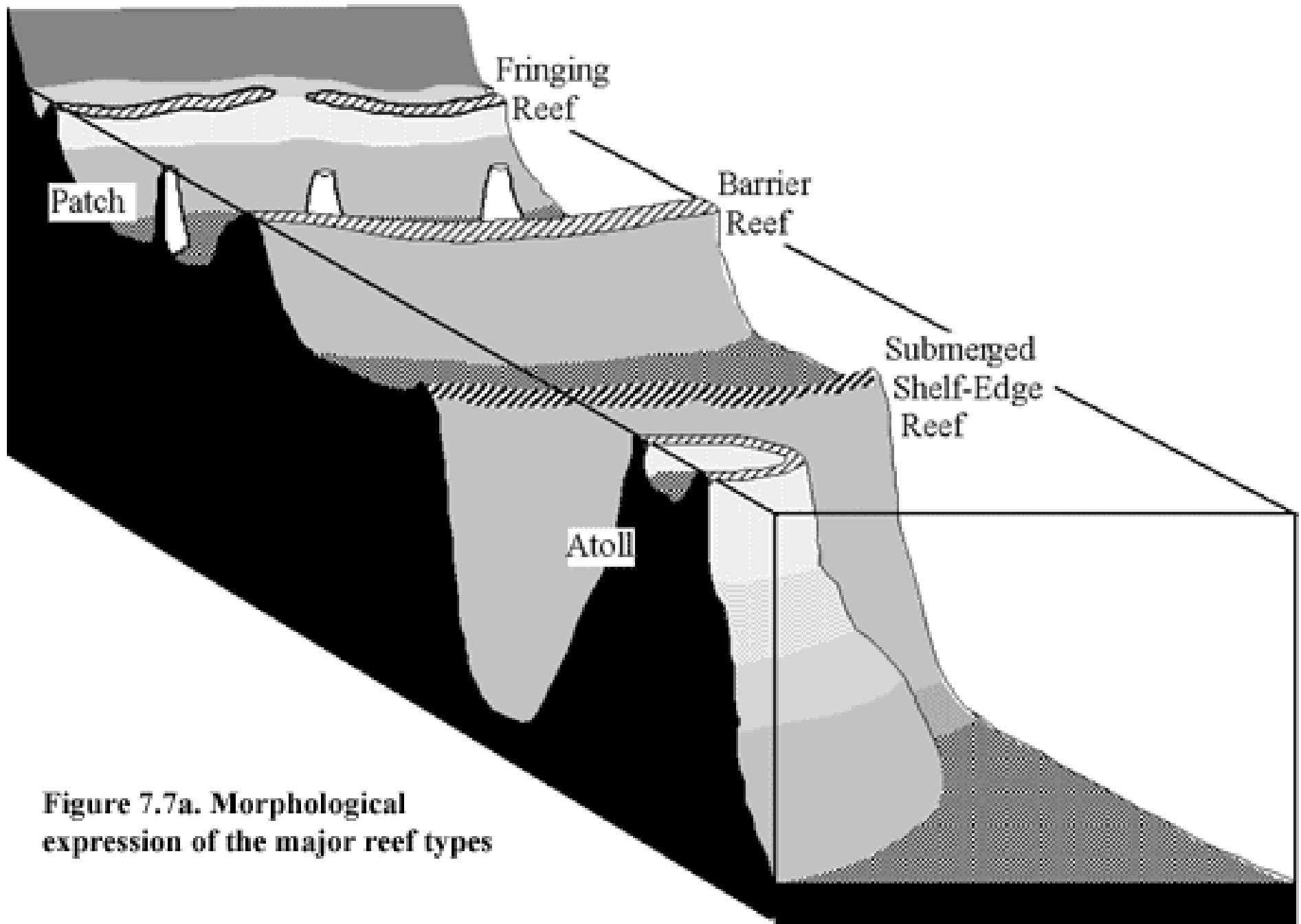
# Biodiversity of Scleractinian = number of genera



Maximum biodiversity is found in the Western Pacific and Indian oceans. Biodiversity of hard corals is much less in the Atlantic (and Caribbean) than in the Pacific

75% more genera and 85% more species in the Pacific compared to Caribbean.

Why is Biodiversity so low in Latin American reefs?



**Figure 7.7a. Morphological expression of the major reef types**



**Fringing Reef**

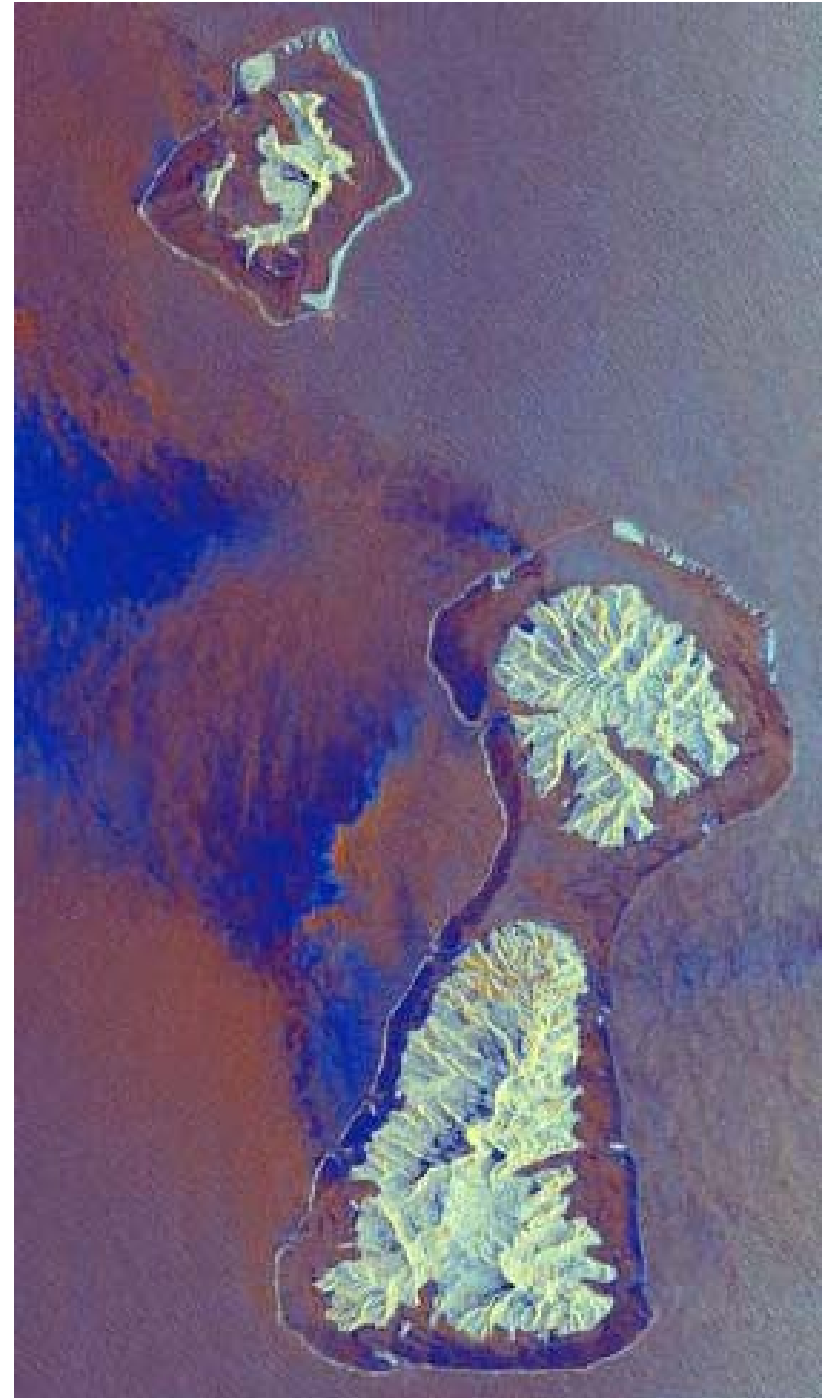


# Barrier Reef





# Radar image of Bora-bora barrier reef







## **Great Barrier Reef, Australia**

Most famous reef on Earth. GBR extends 2 000 kilometers and covers an area of 35 million hectares on the north-east continental shelf of Australia. BGR covers an area that is bigger than Italy.

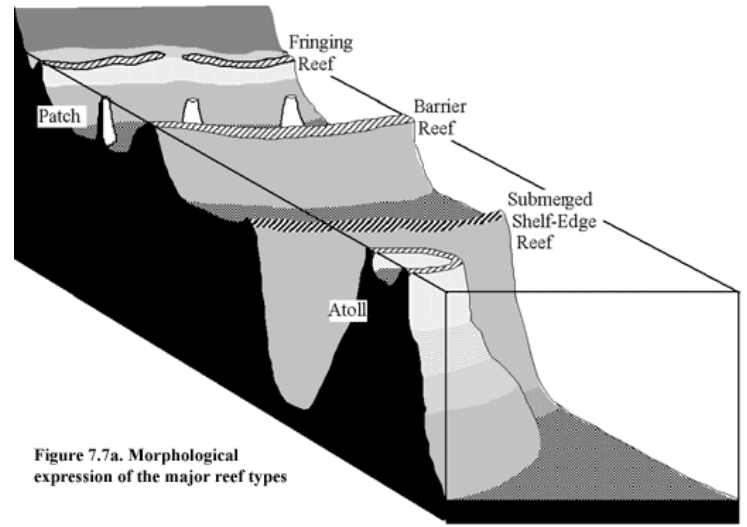
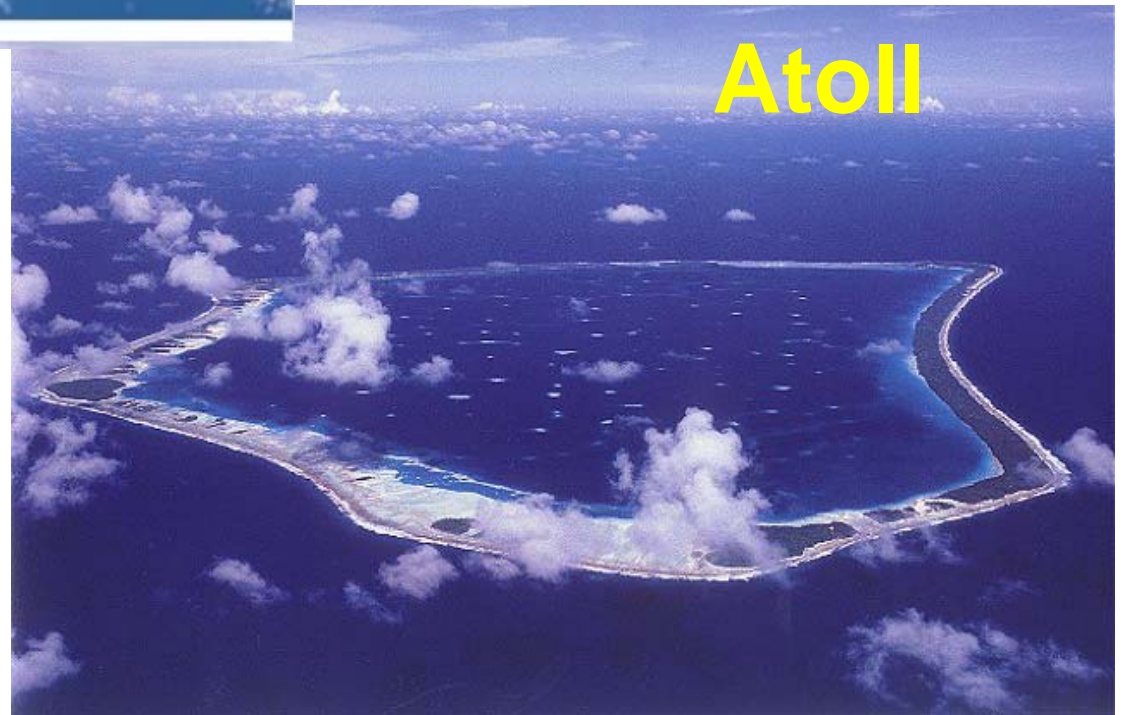


Figure 7.7a. Morphological expression of the major reef types

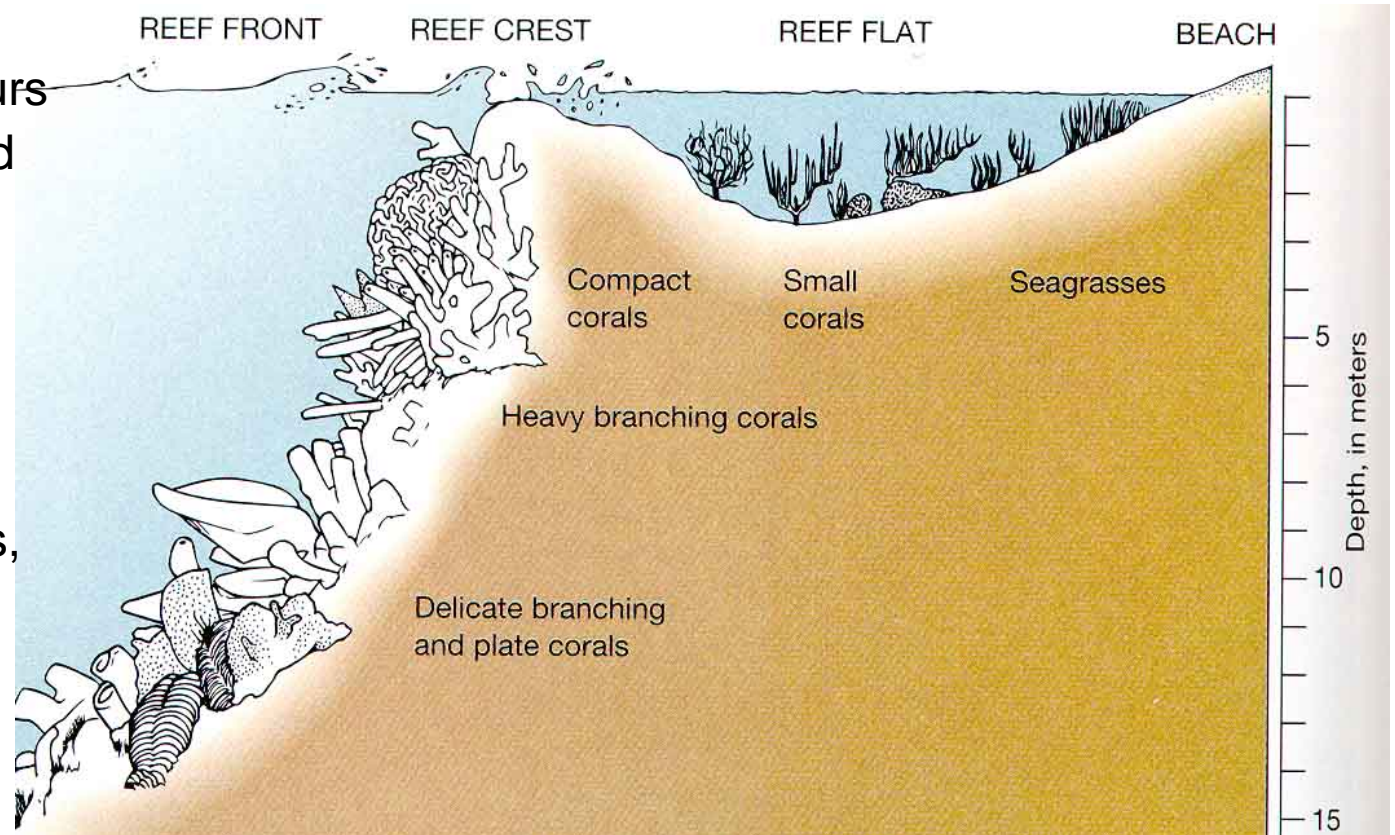
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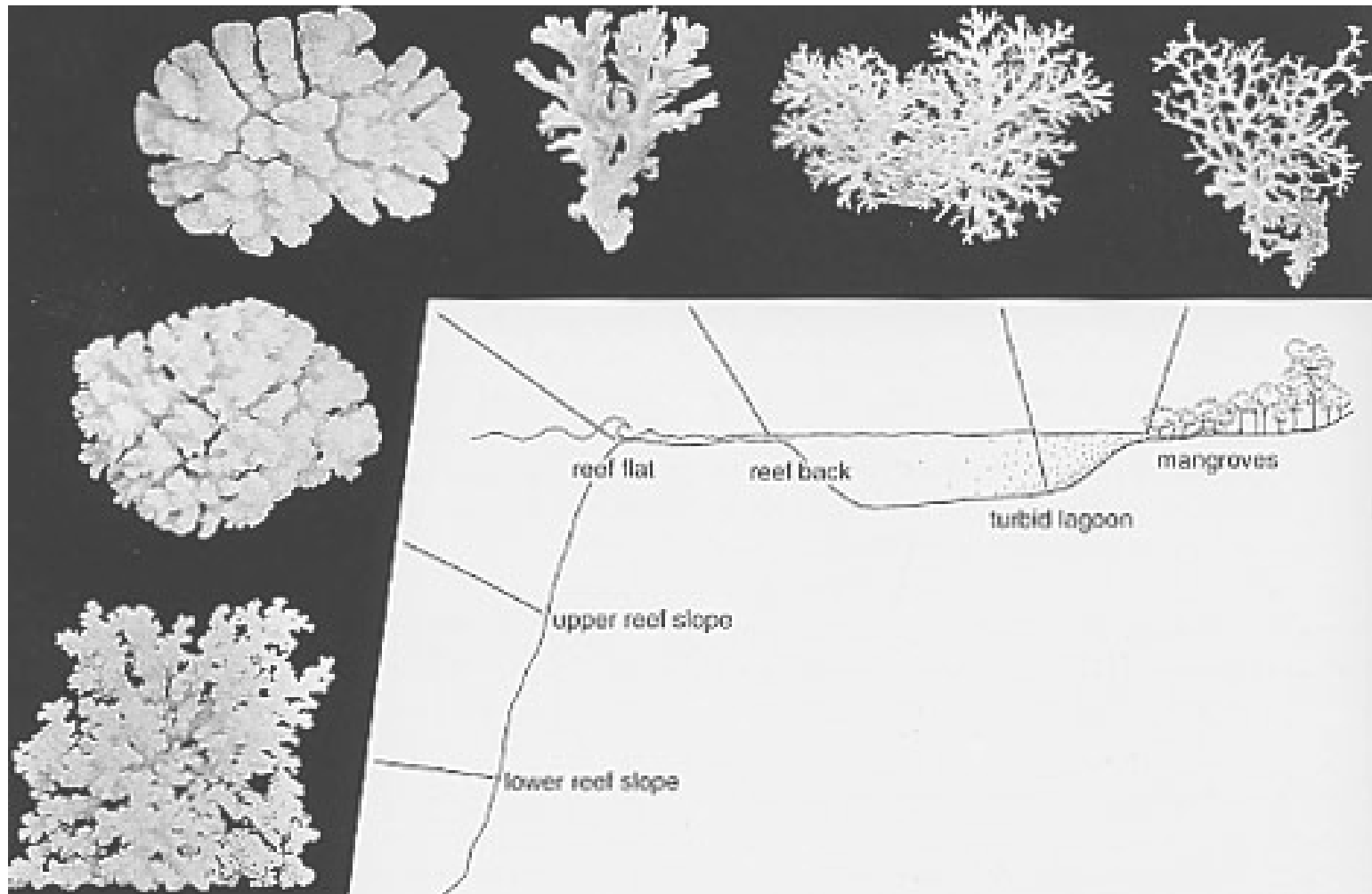
# Typical Reef Profile

- Seaward side: reef front and crest
  - Rise from depth to near the surface
  - Typically steep
  - Major surge area; waves determine species
  - Finger-like projections – spurs
- Back reef: beach and lagoon (reef flat)
  - Different assemblage of species than on seaward side
  - Coral rubble, sands, sea grass, patches of coral
  - Intertidal pools
- Position determines growth form



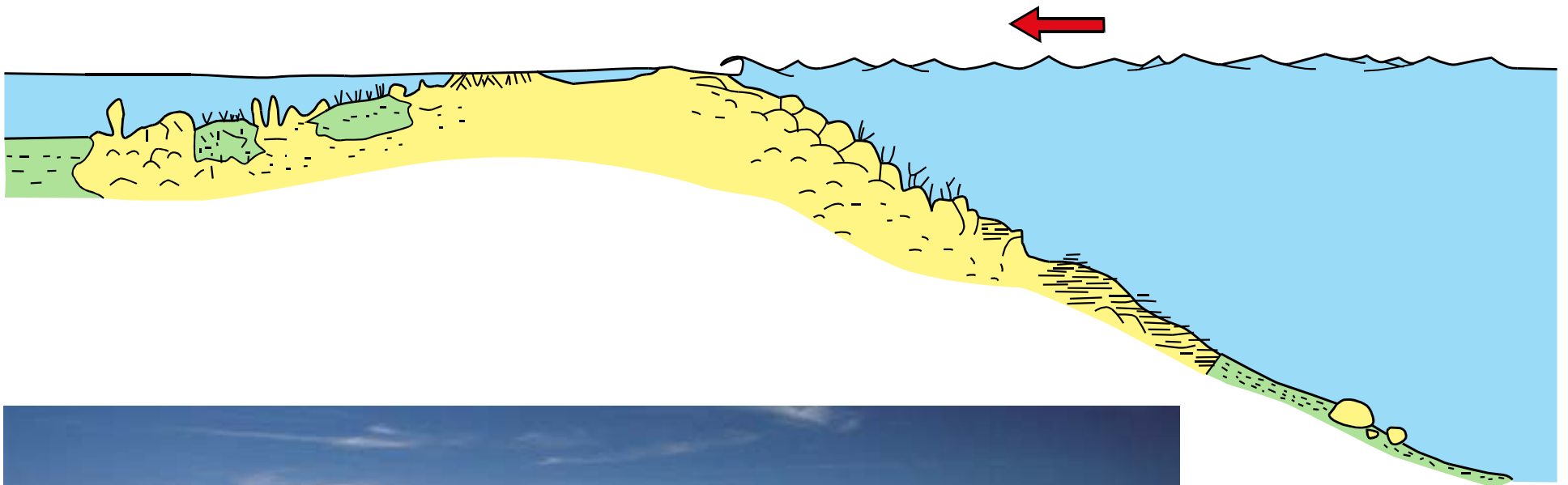


## Growth forms of the coral *Pocillopora damicornis*



# Coral forms

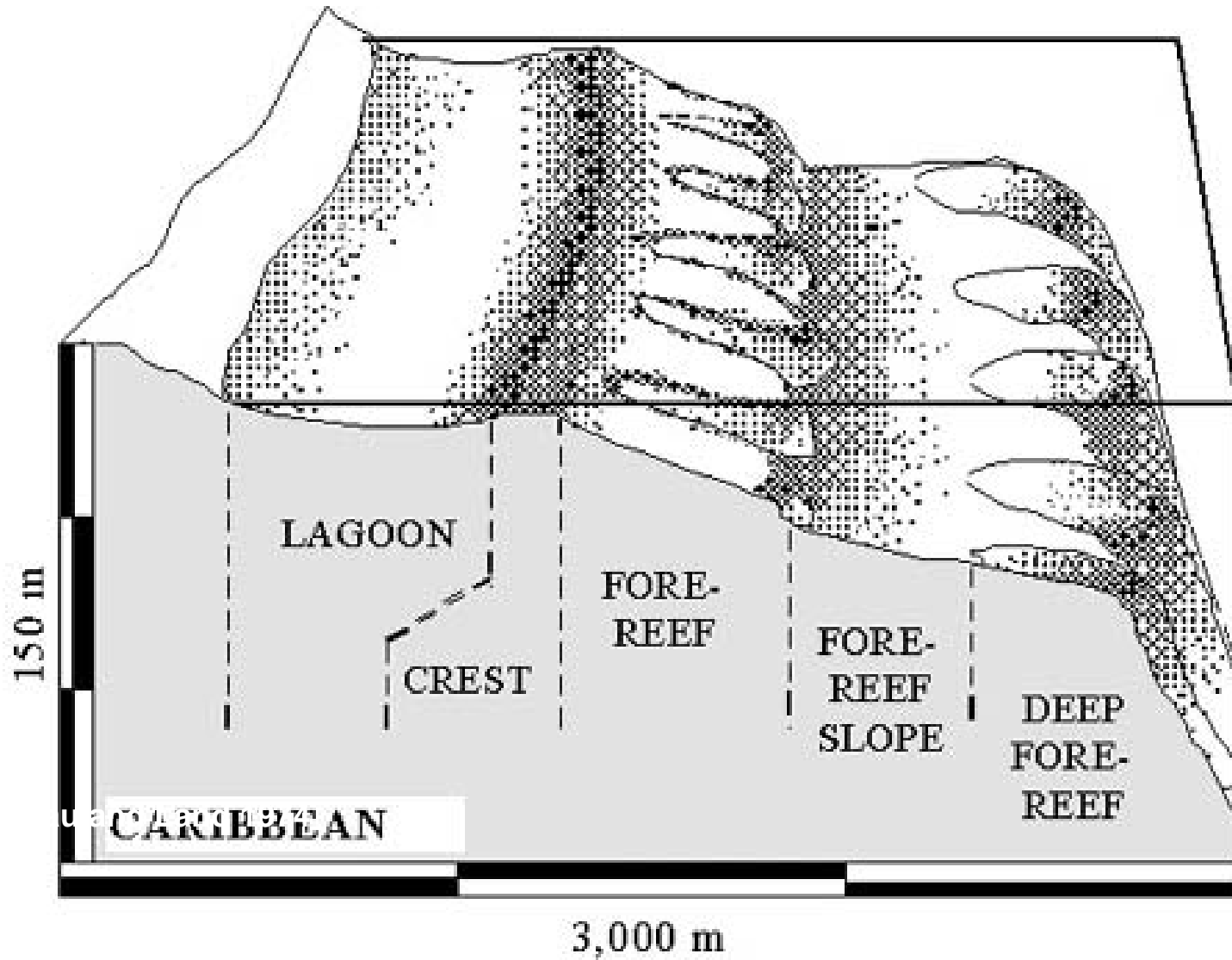


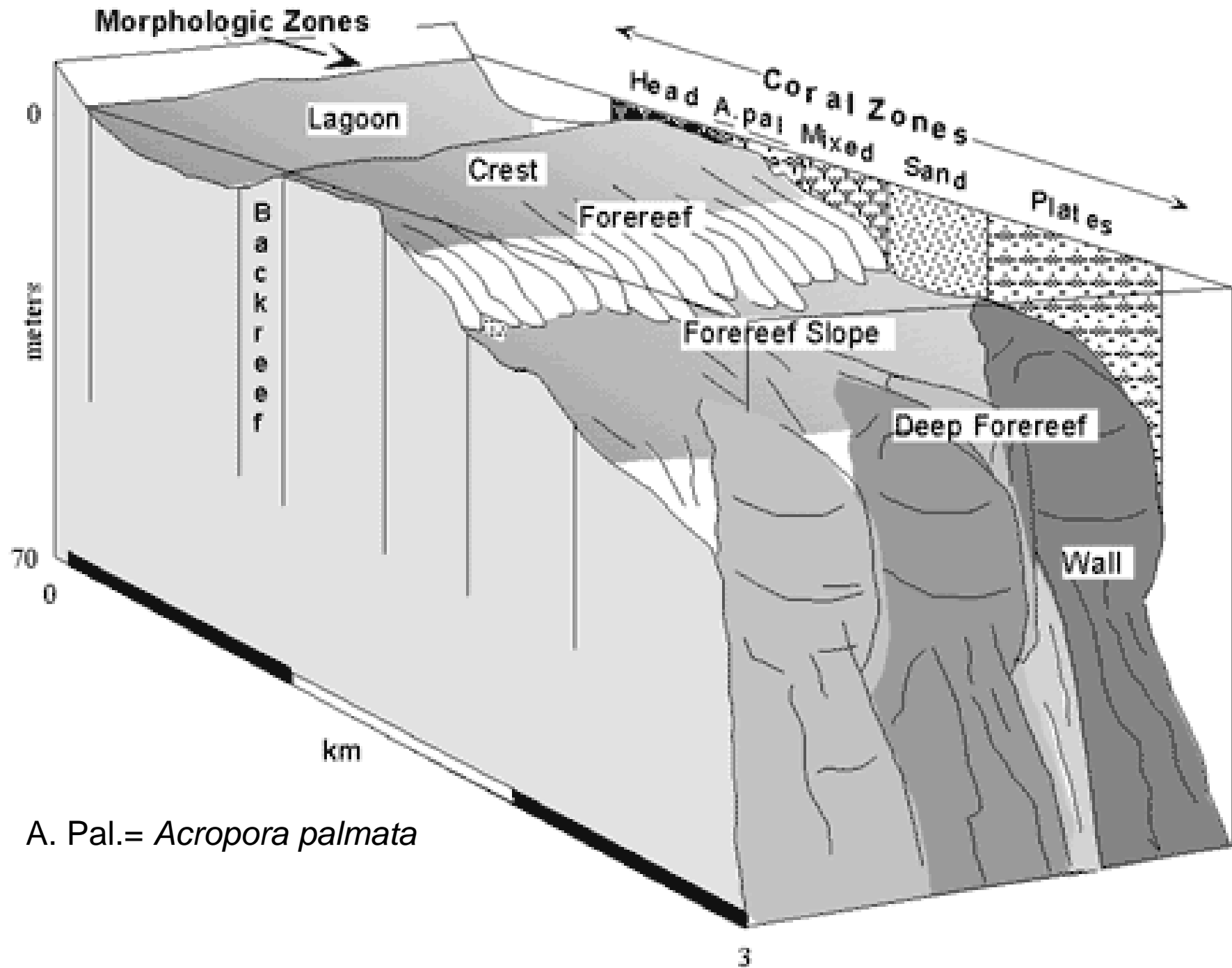


QAd2413c



# Typical reef profile





A. Pal.= *Acropora palmata*

Discovery Bay  
Jamaica

Reef flat

Reef crest

Reef front





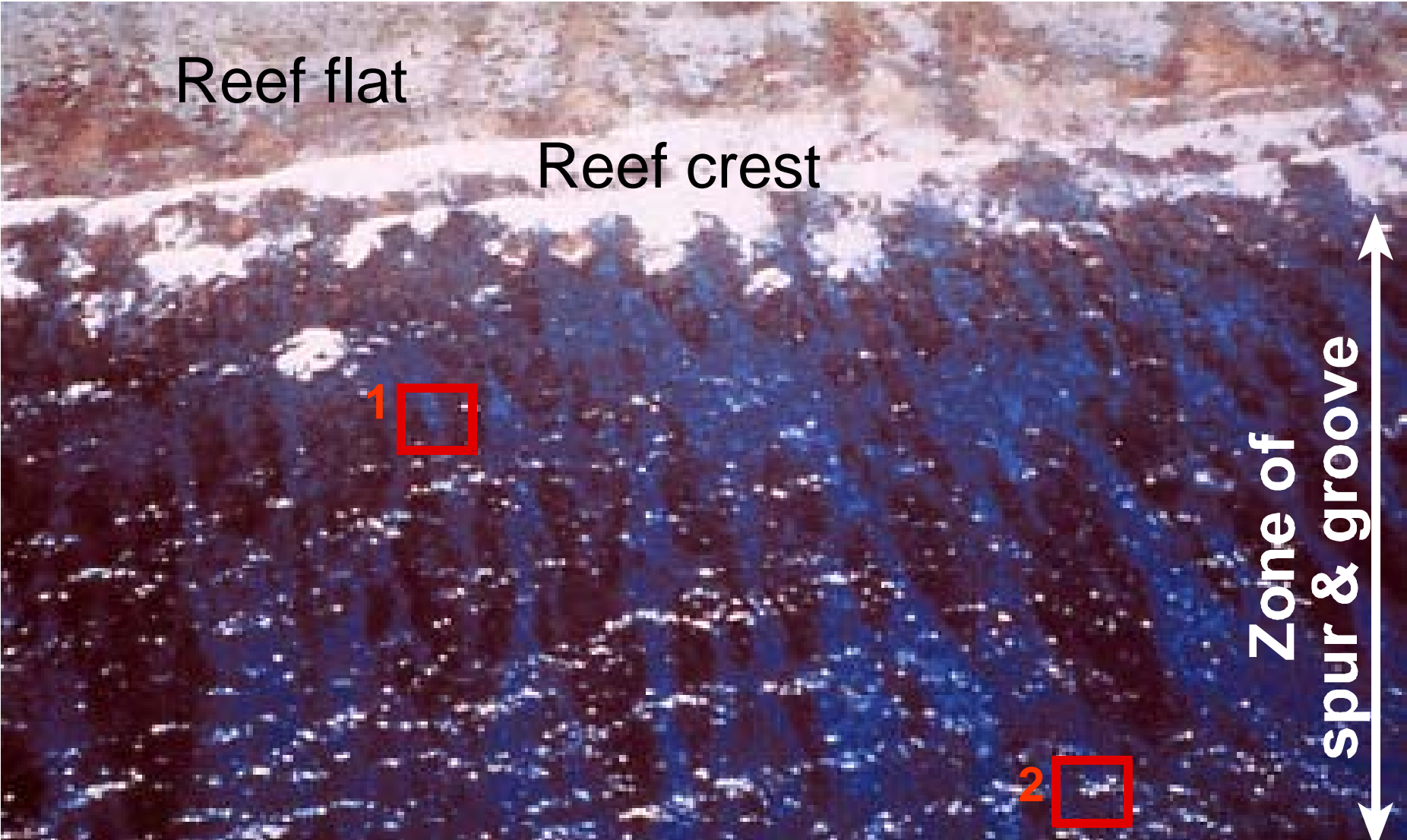
An aerial photograph of a coral reef system. The water transitions from deep blue in the distance to lighter turquoise and green near the reef. A small boat is visible in the center of the reef. The reef structure is visible as a darker, more textured area in the lower right. Labels 'Back reef', 'Reef crest', and 'Fore reef' are overlaid on the image. A red logo 'SEPM' is in the bottom right corner.

Back reef

Reef crest

Fore reef

SEPM



Reef flat

Reef crest

Zone of  
spur & groove

1

2



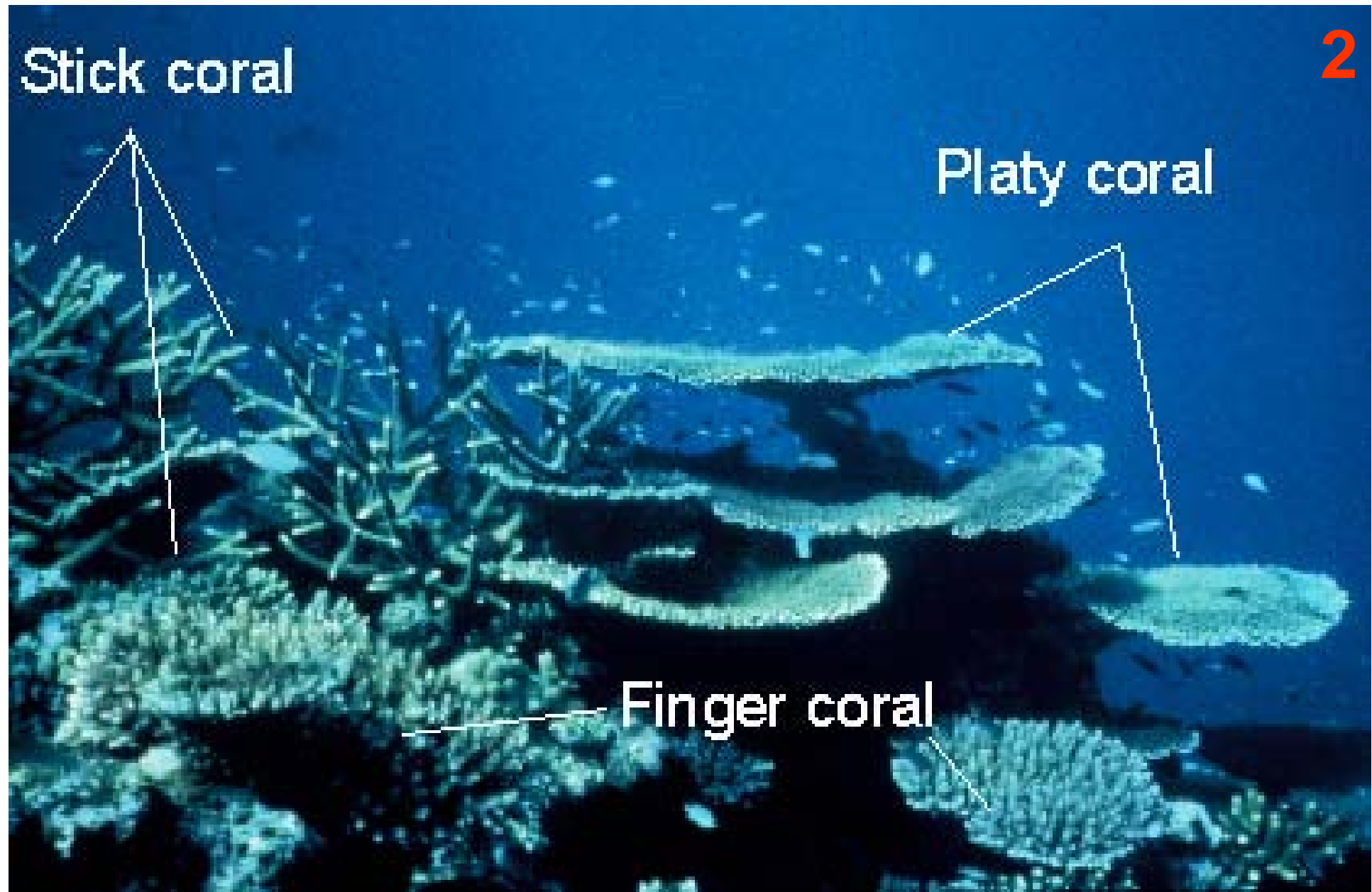
1



Stick coral

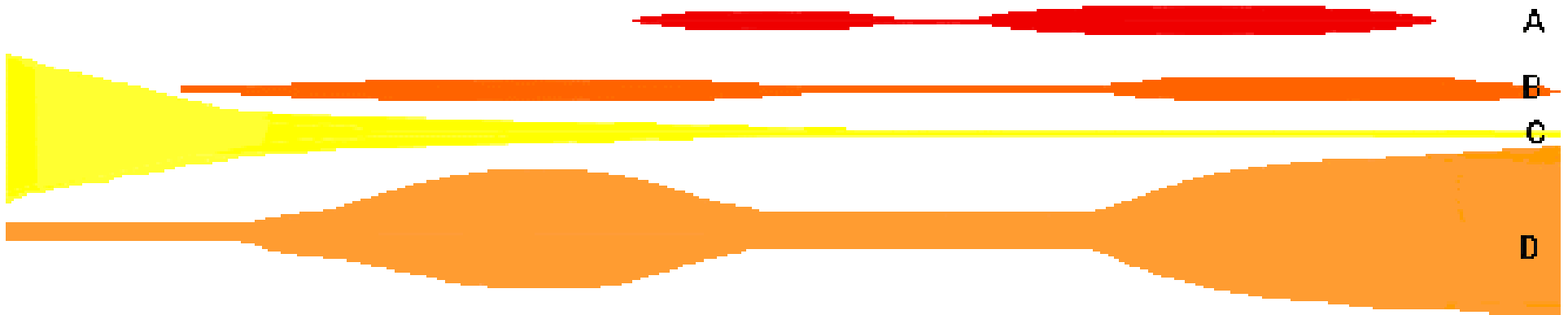
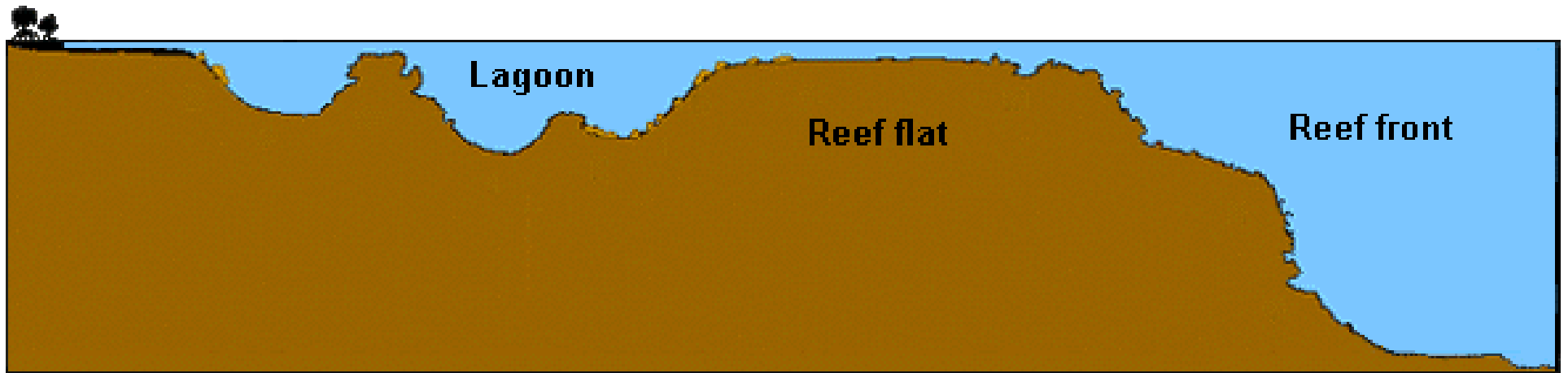
Platy coral

Finger coral



# Reef Front



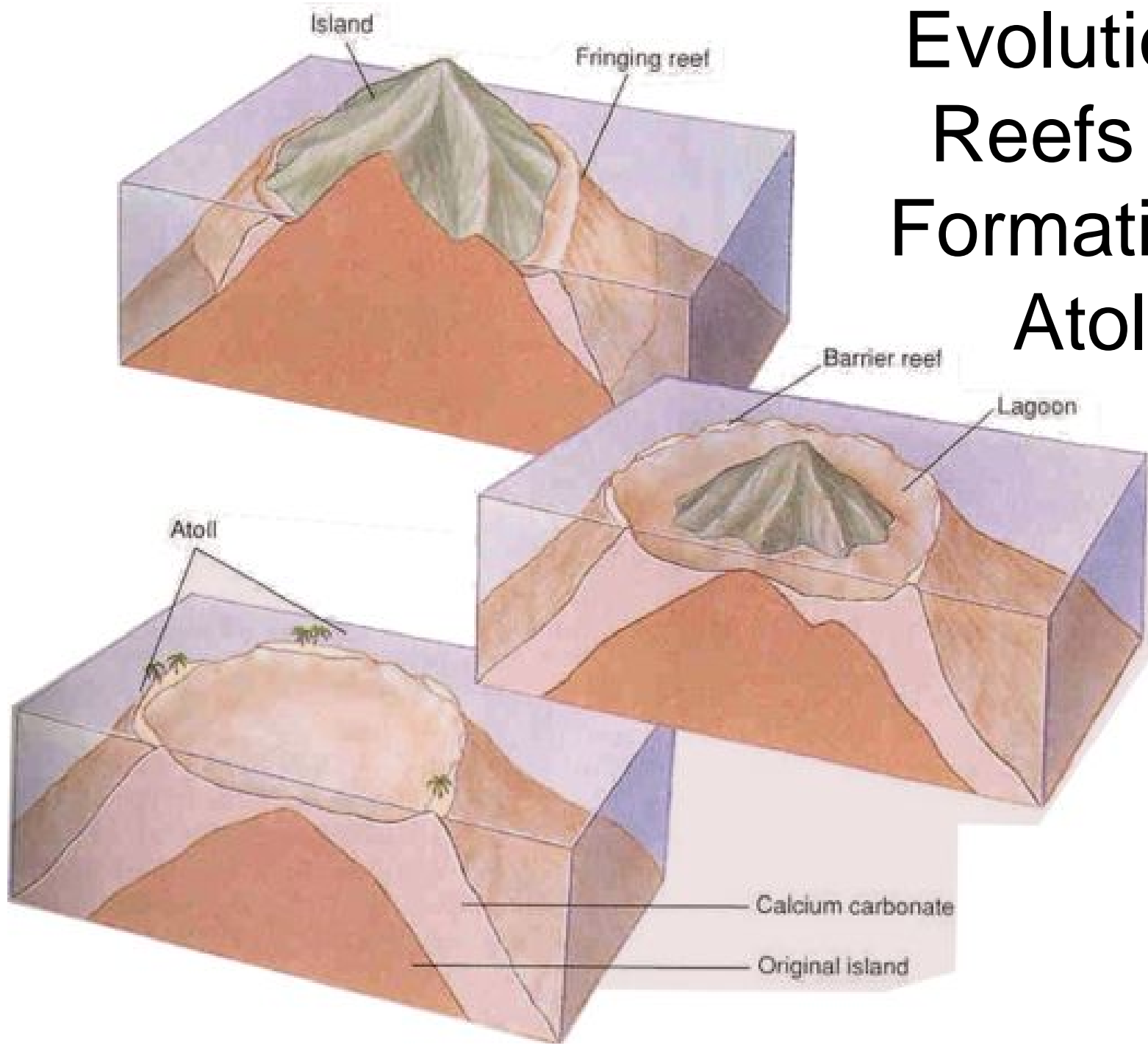


A = coarse sediments    B = fine sediments

C = daily temperature variation    D = number of different species

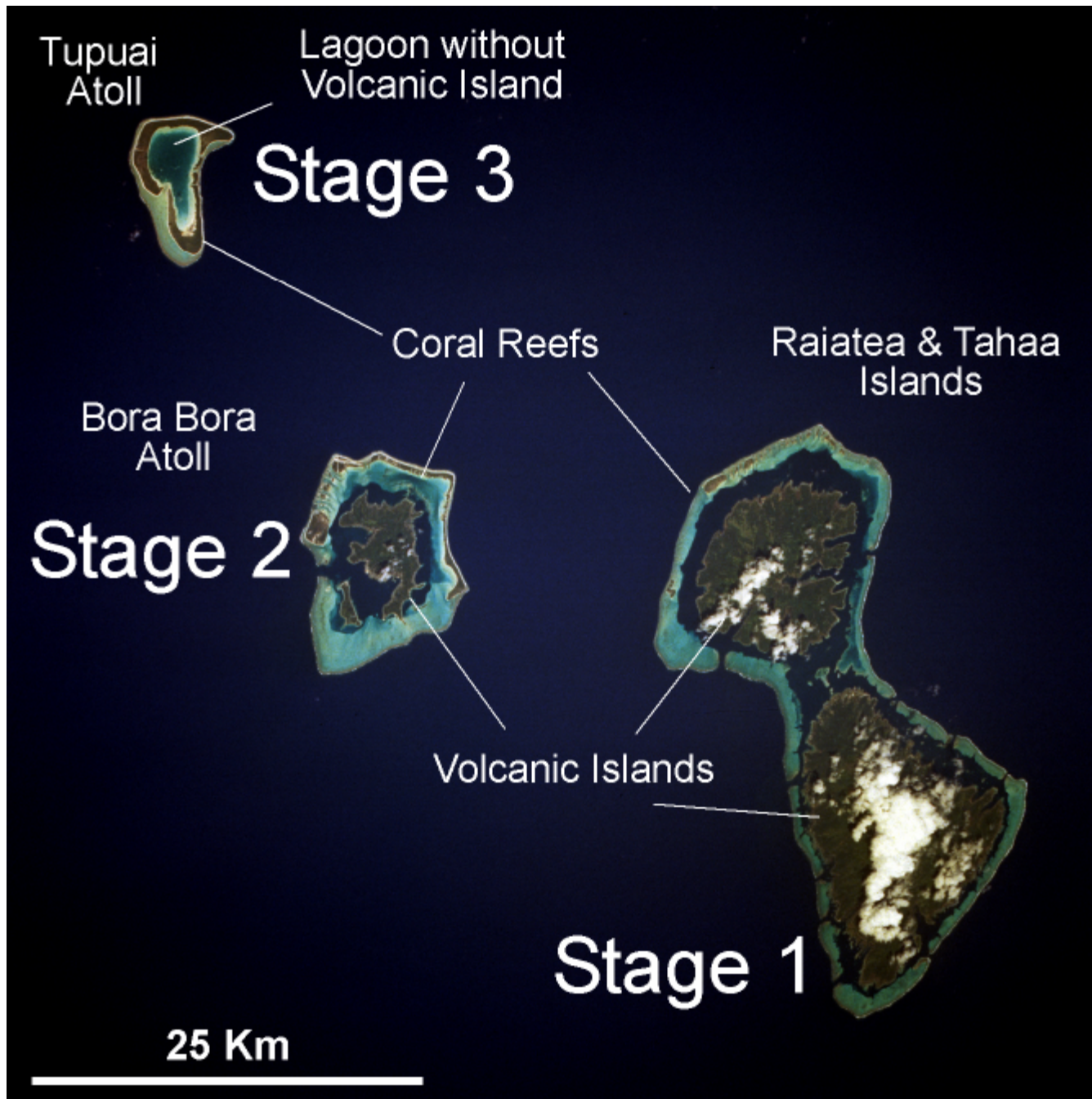
(according to H. Schumacher 1967)

# Evolution of Reefs and Formation of Atolls





# Darwin's sequence of Atoll formation



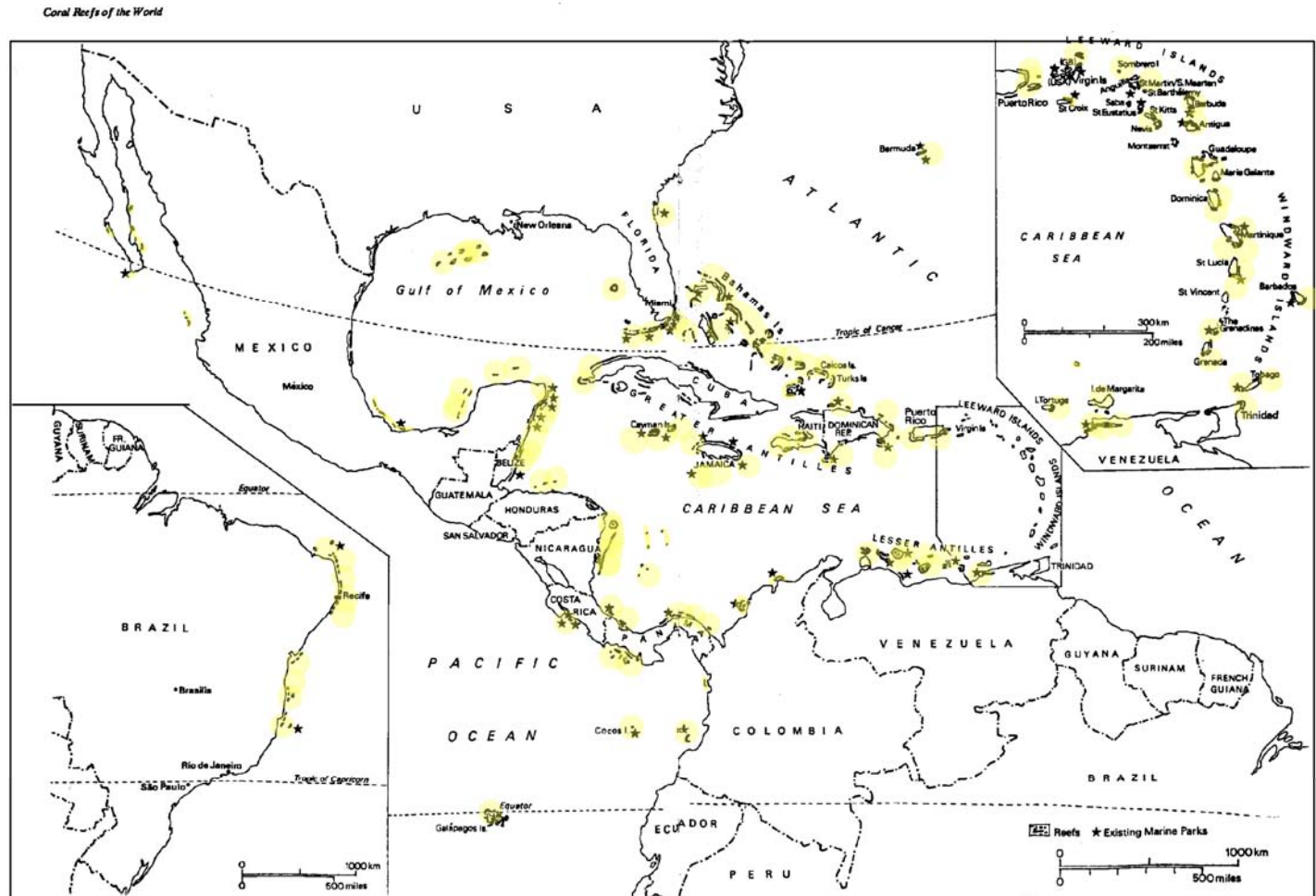
First: fringing reef

Second: barrier reef

Third: Atoll

# Caribbean Reefs

- About 14% of the area of the world's coral reefs are found here.
- Fringing and patch reefs are common around islands, on the side facing the prevailing winds (windward side).
- There is a long barrier reef system off Belize (approximately 220 kilometers) and the Andros barrier reef (approximately 176 kilometers) in the Bahamas.



# Belize



- Territorial disputes between the UK and Guatemala delayed the independence of Belize (formerly British Honduras) until 1981. Guatemala refused to recognize the new nation until 1992. Tourism has become the mainstay of the economy.
- **Area:**  
*total:* 22,966 sq km  
slightly smaller than Massachusetts
- **Climate:**  
tropical; very hot and humid; rainy season (May to November); dry season (February to May)
- **Elevation extremes:**  
*lowest point:* Caribbean Sea 0 m  
*highest point:* Victoria Peak 1,160 m
- **Geography - note:**  
only country in Central America without a coastline on the Pacific
- **Population:**  
272,945
- **GDP - per capita:**  
purchasing power parity - \$4,900 (2002 est.)
- **Languages:**  
English (official), Spanish, Mayan, Garifuna (Carib), Creole





# The Belize Barrier Reef and the three offshore atolls [STS060-85-W, 1994].

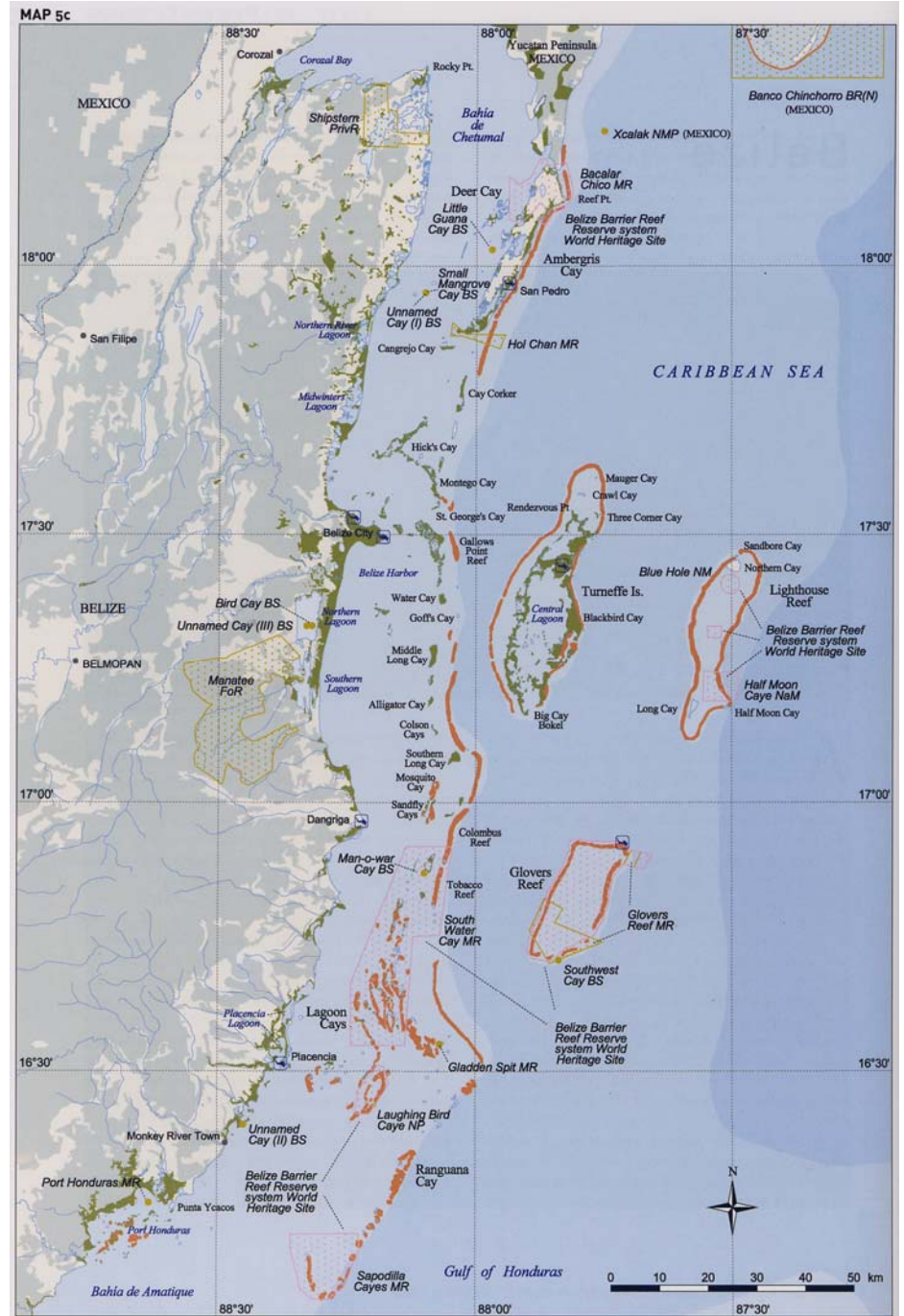
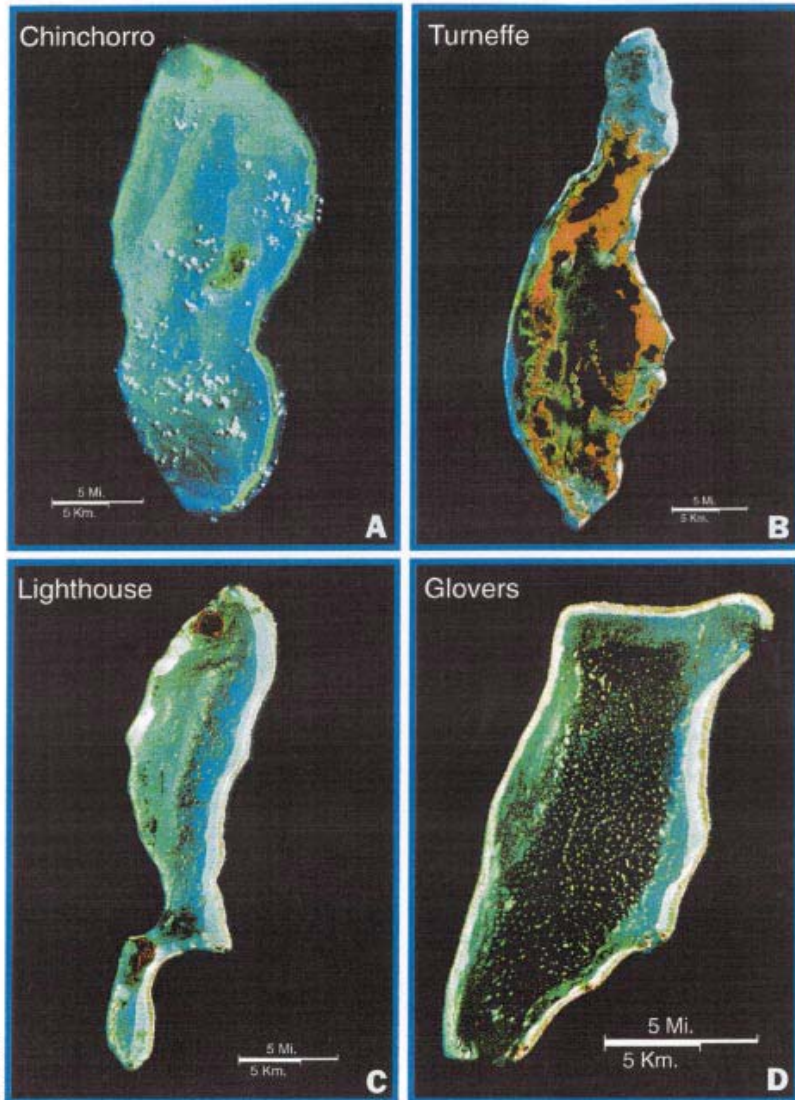


45 km N



# Belize

- Bank or bank-barrier reefs are common. Atolls are also found.



# Reefs of Greater & Lesser Antilles

- Reef development is often greater on the smaller, low islands with low rainfall and little sedimentary runoff such as Barbuda, Antigua, St. Croix, Grande Terre and the Southern Grenadines.
- The Greater Antilles (Cuba, Hispaniola and Puerto Rico) generally have larger reefs than the Lesser Antilles (Putney 1982).

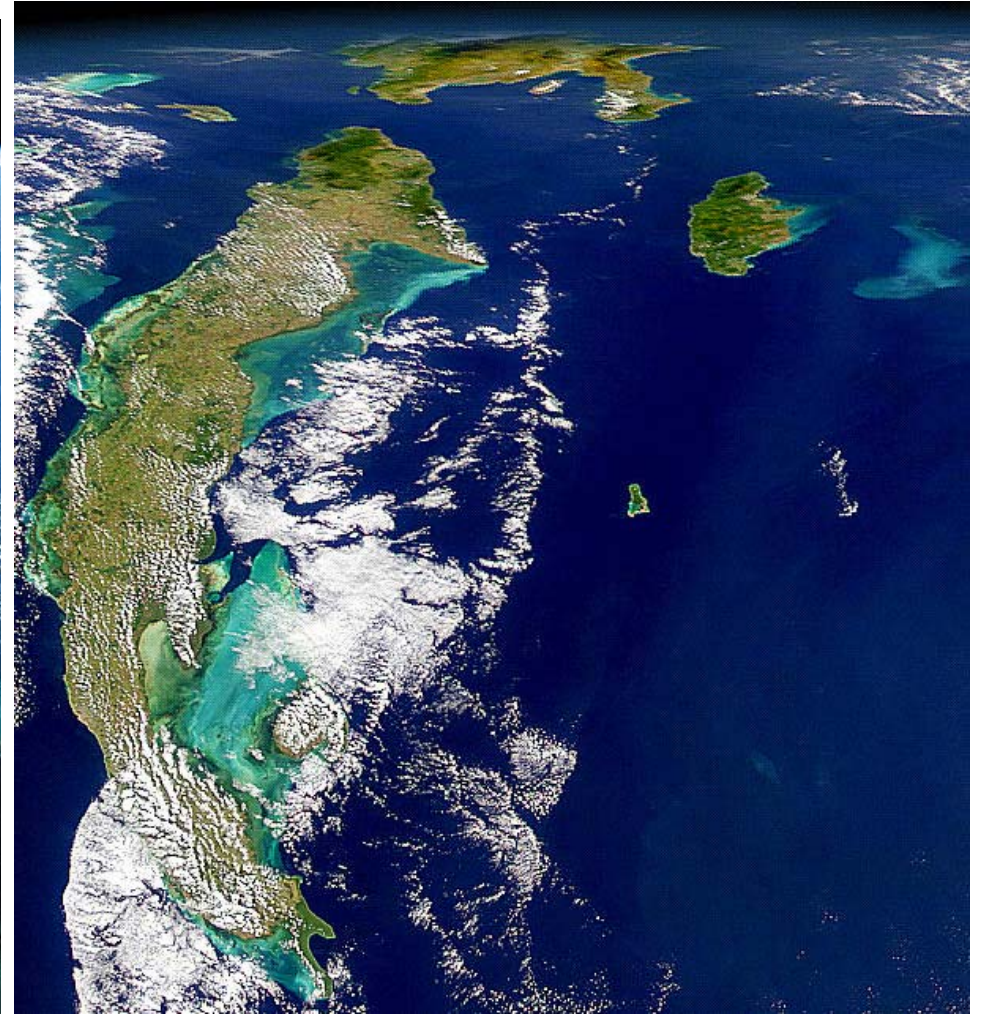




# Reefs of Florida and the Greater Antilles



Florida and Bahamas



Cuba



# Reefs in the Western Atlantic Brazil

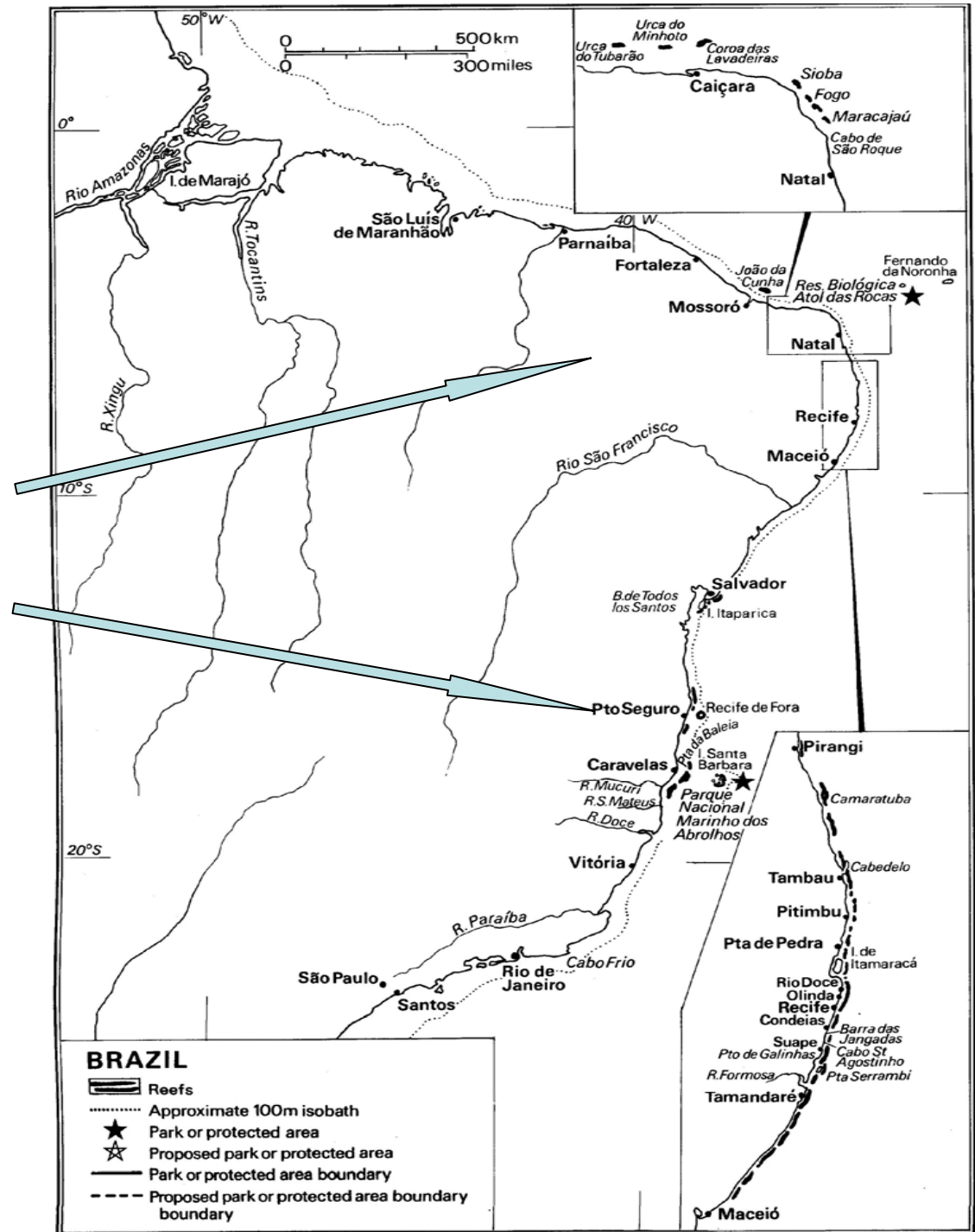
- The distribution of coral reefs in the South Atlantic is limited to tropical areas along the coastline and offshore islands of Brazil.
- According to UNEP/IUCN (1988) the Brazilian coral fauna has long been considered of interest on account of its high proportion of endemic species.
- Some 3,000 kilometers of coast have reefs. Ten of the 18 hermatypic coral species known from Brazil are endemic.





# Brazil Reefs

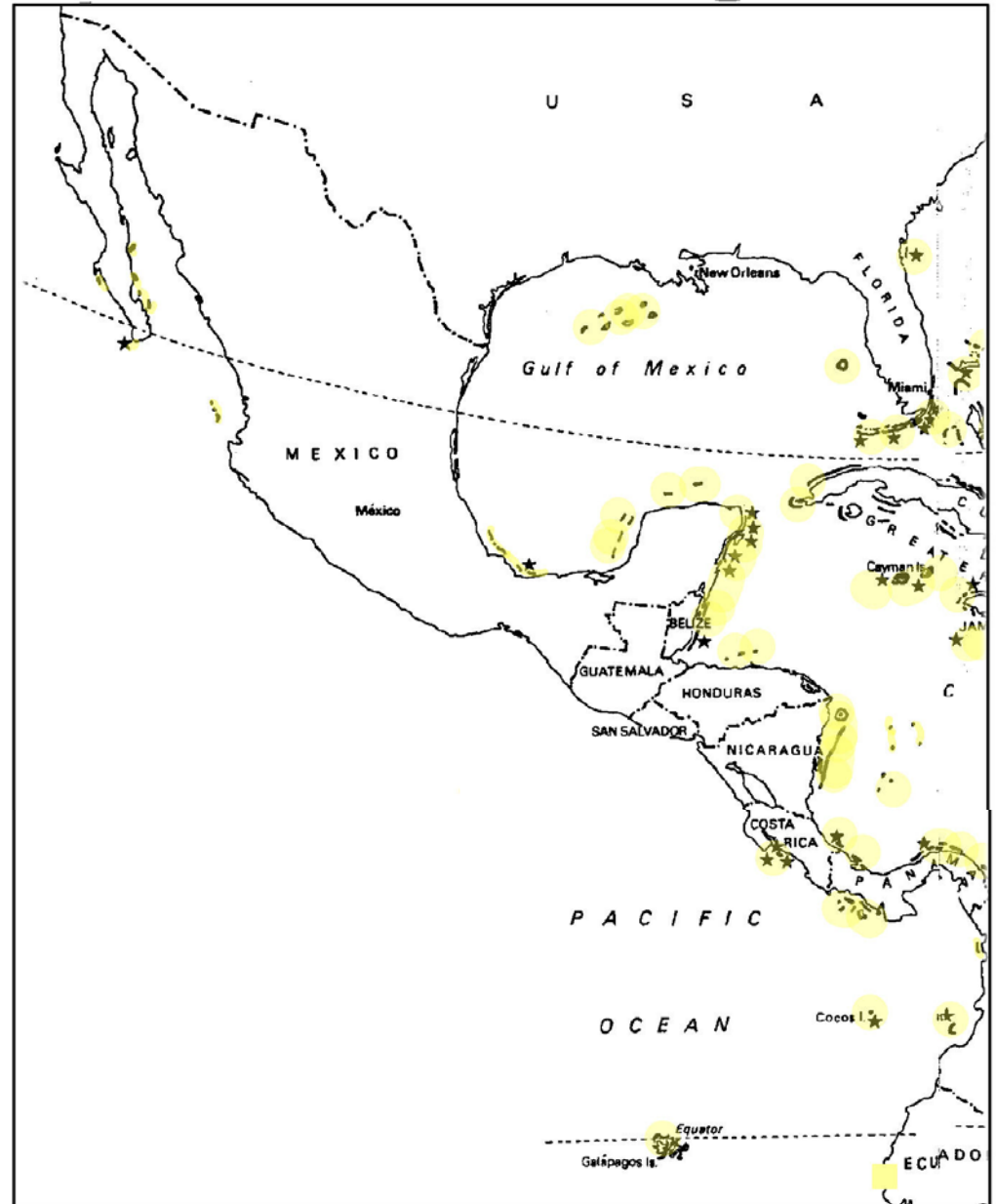
- Two main coral reef localities are found on the Brazilian coast.
  - Grupo Recifal do Cabo São Roque, from Cabo de São Roque to Natal in Rio Grande do Norte State, including the Fernando de Noronha archipelago and the Rocas atoll
  - Coral reefs along the south coast of Bahia State (the Abrolhosa Archipelago), the richest and most developed coral reef formation in the region.
- Coral reefs also occur between Natal and the São Francisco river mouth and on the latitude of Salvador Bahia (both usually associated with calcareous reefs).
- The northeast coast formations are rocky calcareous outcroppings forming reefs and hence differ from the coral reef formations such as those of the Abrolhos archipelago.



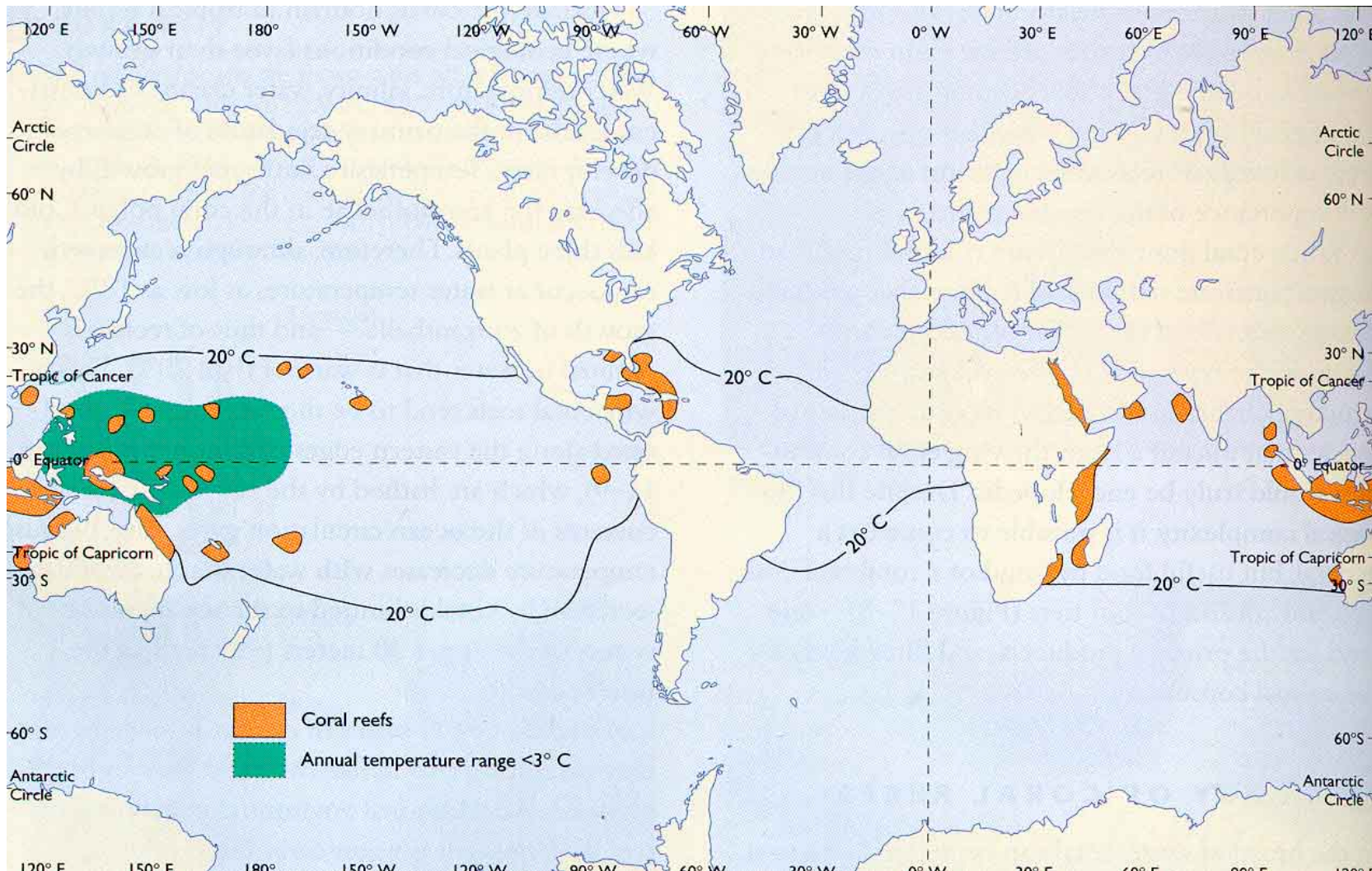
# The Pacific Reefs

- Coral reefs of the Eastern Pacific are not nearly so extensive or diverse as those along the Atlantic coast of Central America and in the Caribbean.
- Coral formations have been described off the coasts of El Salvador, Costa Rica, Ecuador, Panama, Colombia, and many of the offshore islands (Glynn and Wellington 1983). The northern limit of distribution of coral reefs for the Eastern Pacific lies in the Gulf of California, with the southern limit at Machalilla in Ecuador and the Galápagos Islands (both at around  $1^{\circ} 30'S$ ).
- In Central America, the upwelling of colder water inhibits reef development (UNEP/IUCN 1988).

*Coral Reefs of the World*



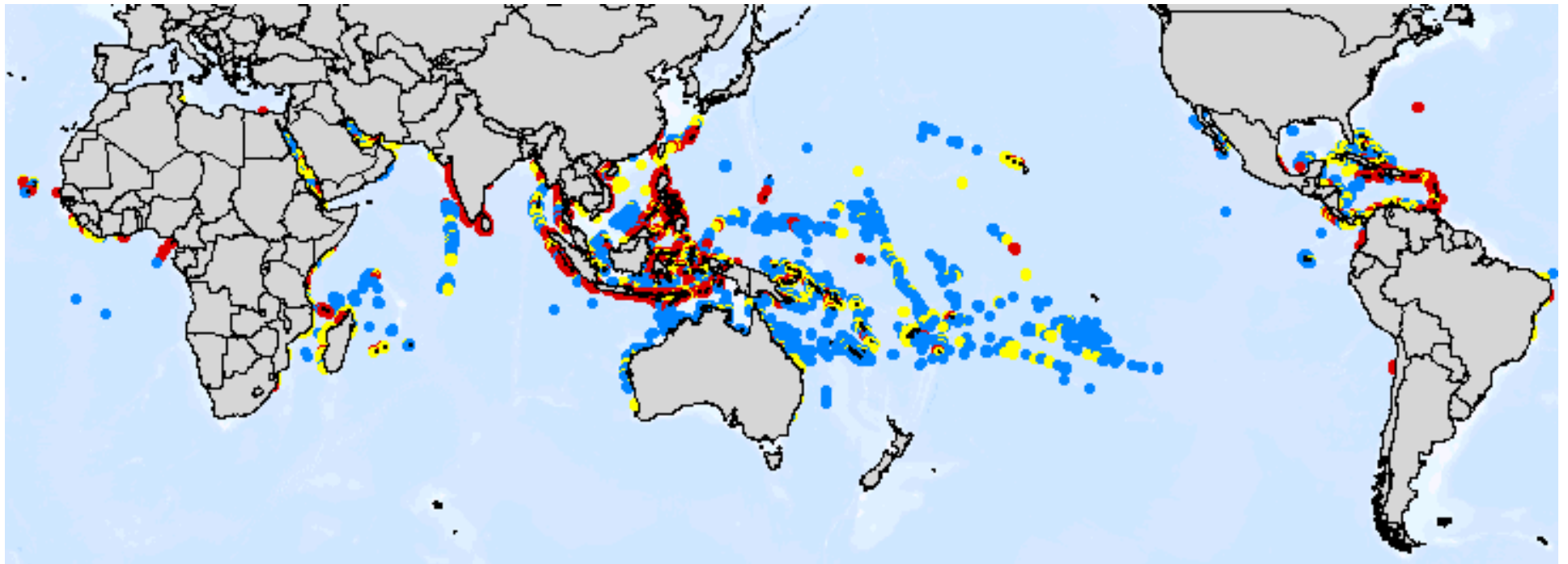
# Why so few reefs around South America?



Reefs are concentrated around the equator, but not in South America. Why?



# ***Coral Reefs at Risk***



■ Low    ■ Medium    ■ High

# Natural Threats

- Hurricanes & Typhoons
- Natural Predators
- Disease
- Sea-level rise and fall

**Black band disease**

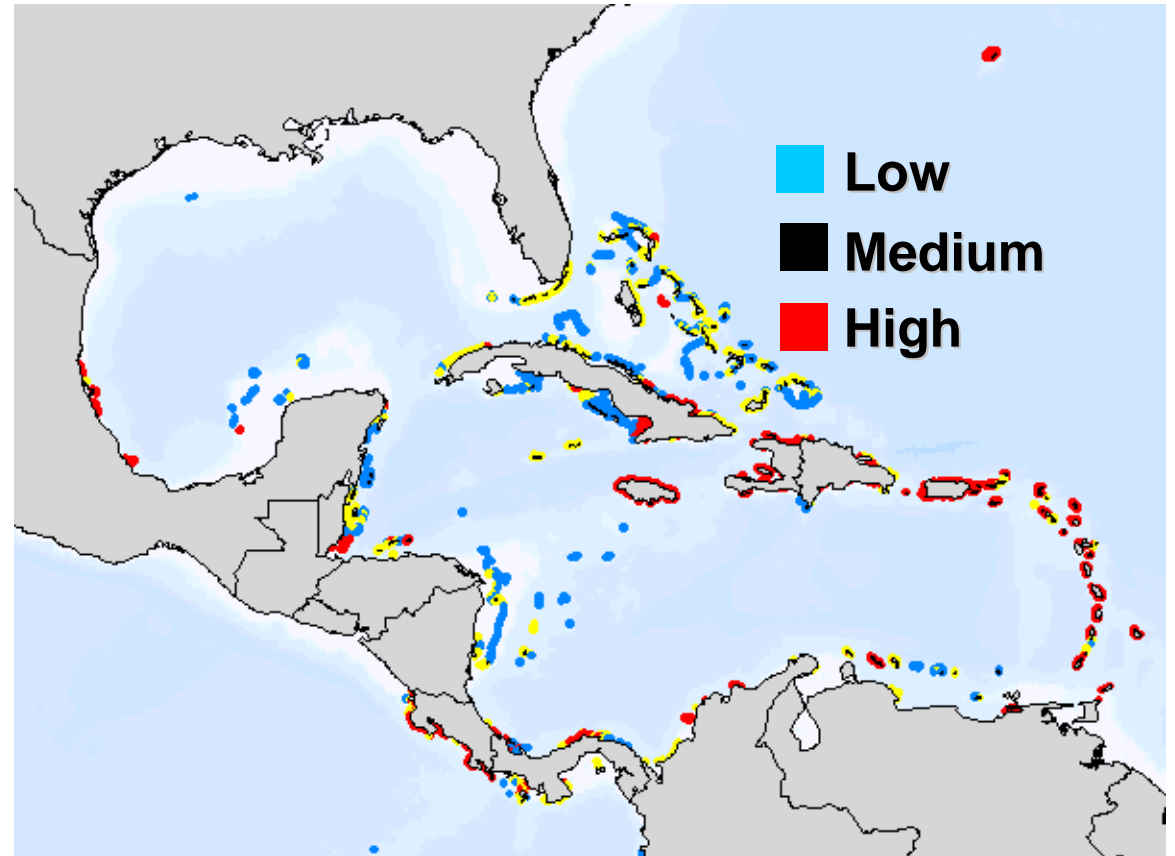


# Threats From Humans

- Over-fishing and poor fishing practices
- Sedimentation from development and mining
- Water pollution (runoff from above, poor waste removal, Oil spills)
- Careless eco-tourism, divers, boat anchor damage
- Global climate change (global warming, UV radiation)

# Almost two-thirds of Caribbean reefs are threatened

- Reefs in the Caribbean are under severe threat.
- Problems include coastal erosion from dredging and construction, pollution from sewage and fertilizers, removal of large quantities of fish (including use of toxic and hazardous materials to flush out fish), and resulting changes in fish populations, as well as damage from boat anchors and recreational misuse (Wilson 1987).
- Bermuda's reefs are severely affected by coral diseases, particularly Black Band disease.





# Some Excellent websites for Coral reefs

<http://cima.uprm.edu/~morelock/corgeol.htm>

NASA just released a coral reef library - see

[http://www.nasa.gov/vision/earth/lookingatearth/coralreef\\_image.html](http://www.nasa.gov/vision/earth/lookingatearth/coralreef_image.html)

And

[http://pao.gsfc.nasa.gov/gsfcc/earth/cr/creef\\_im.html](http://pao.gsfc.nasa.gov/gsfcc/earth/cr/creef_im.html)

<http://www.reefbase.org/>

Reefbase includes a GIS system so you can examine things interactively

<http://earth.jsc.nasa.gov/newsletter/CoralReefs/>

Astronaut photography of coral reefs