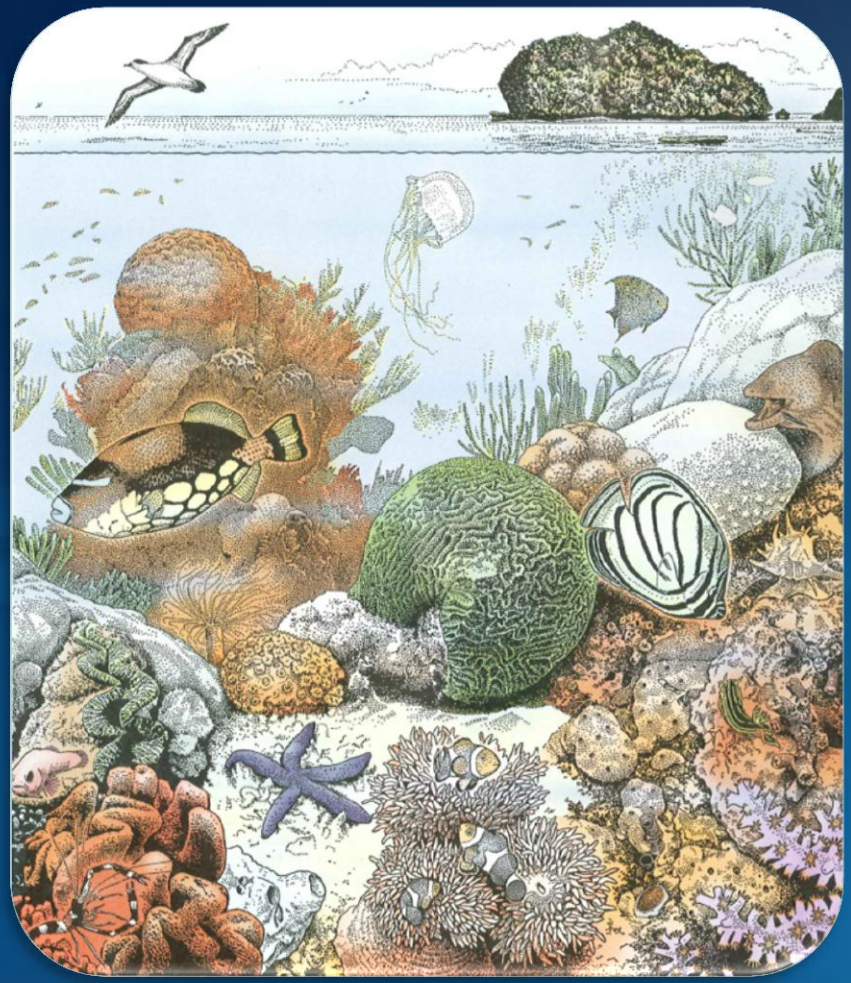
Coral Reef Ecology

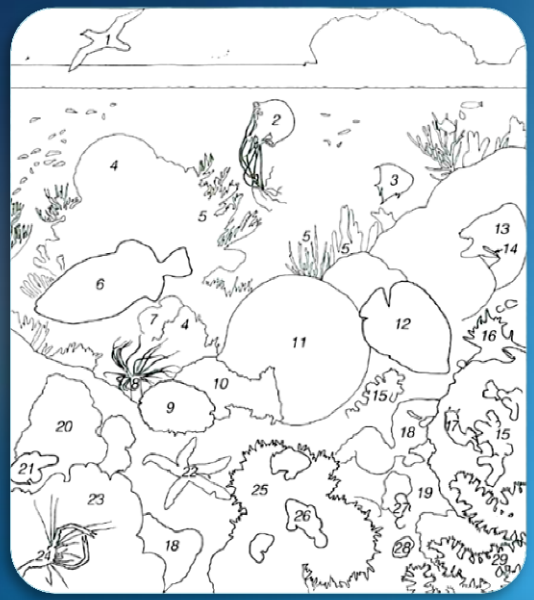
Introduction to Oceanography
(OCS 1005-4)

October 27, 2009

Introduction to Coral Reefs

Coral Reef Ecosystems





Key for coral reef habitat

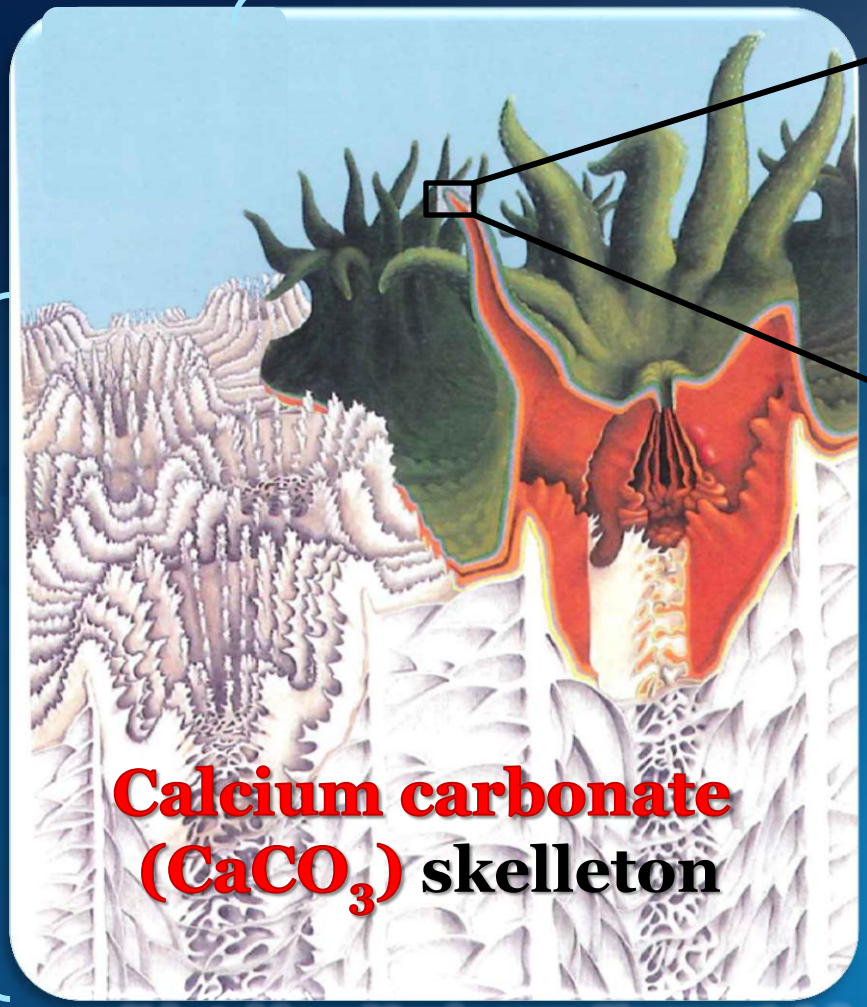
1 black-capped petrel
2 sea nettle
3 angelfish
4 lobed corals
5 sea whips and soft corals
6 triggerfish
7 sea fans
8 tube anemone
9 orange stone coral
10 bryozoans
11 brain coral
12 butterfly fish
13 moray eel
14 cleaner fish
15 tube corals
16 muricid snail
17 nudibranch
18 sponges
19 colonial tunicate
20 giant clam
21 purple pseudochromid fish
22 cobalt sea star
23 soft corals
24 barber pole shrimp
25 sea anemones
26 clown fish
27 worm tubes
28 cowrie
29 sea fan

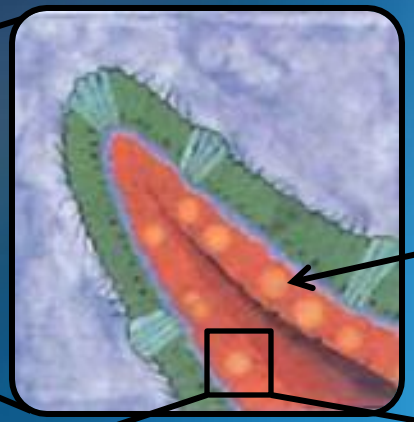
(Garrison 2007; Fig. 16.2 (a-b); p. 460-461)

"Coral Reefs"

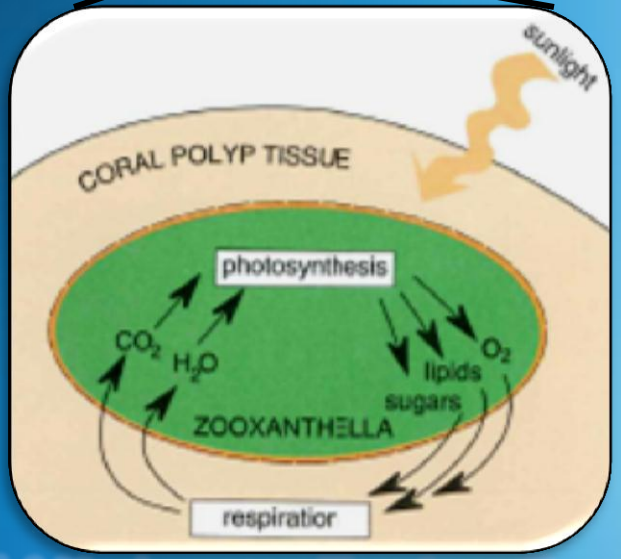
Biologic Context

Geologic Context





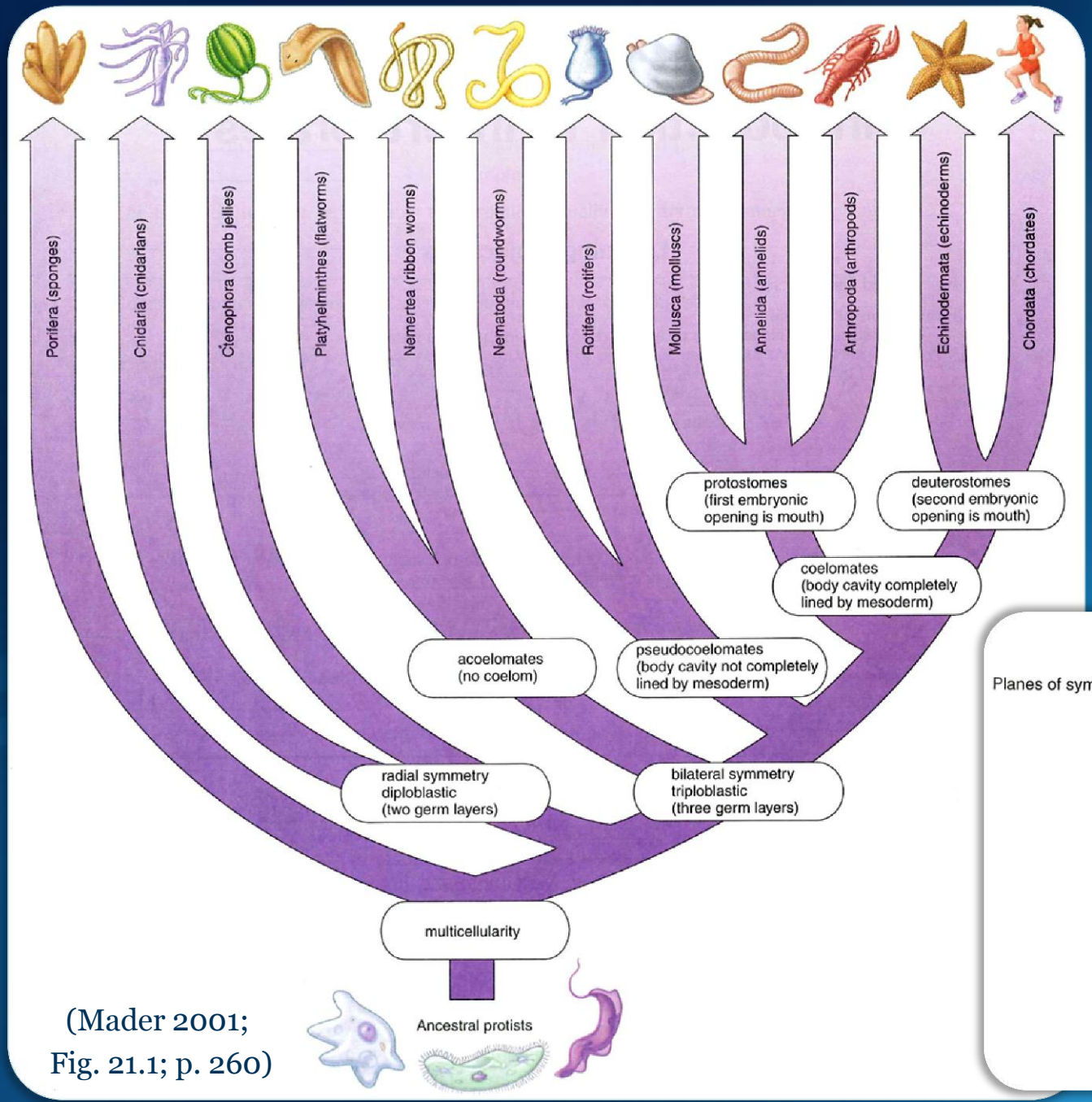
Zooxanthellae (algae)



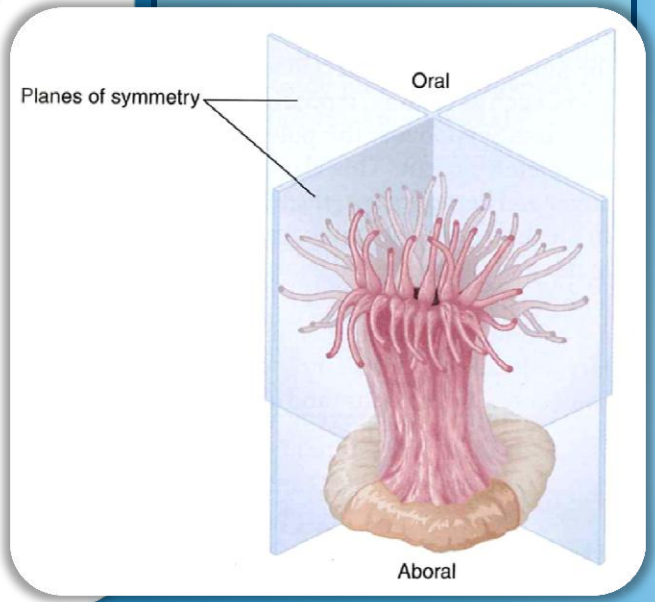
(Adapted from: Murphy 2002, Fig. 2, p. 46; & Sumich & Morrissey 2004; Fig. 9.6; p.258)

Basic Coral Biology

- Kingdom **Animalia**
  - Phylum **Cnidaria**



(Mader 2001; Fig. 21.1; p. 260)



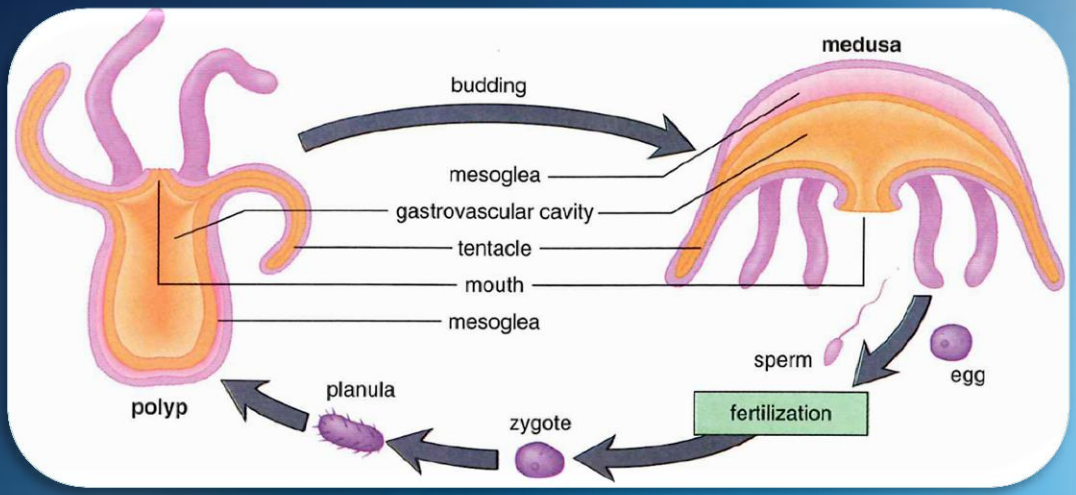
Biological Context of Reefs

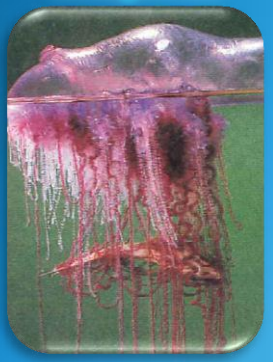
Cnidarian Life Cycles

- **Life Cycle is 1 to 2 Phases**
  - **Many only have 1 phase** (Polyp or Medusa)
  - **When both are present…**
    Phase 1= Polyp (asexual phase)
    Phase 2= Medusa (sexual phase)

- Class **Anthozoa**:
  - **Sea Anemones: solitary polyps**
  - **Corals: colonial polyps** (usually)
- Class **Hydrozoa**:
  - **Jellyfish** with **colonial polyps** & **free-swimming medusae** phases
  - ex. *Obelia* & Portuguese man-of-war
- Class **Scyphozoa**:
  - **True Jellyfish:** small **polyp** (phase 1) & large, pronounced **medusa** (pase 2)

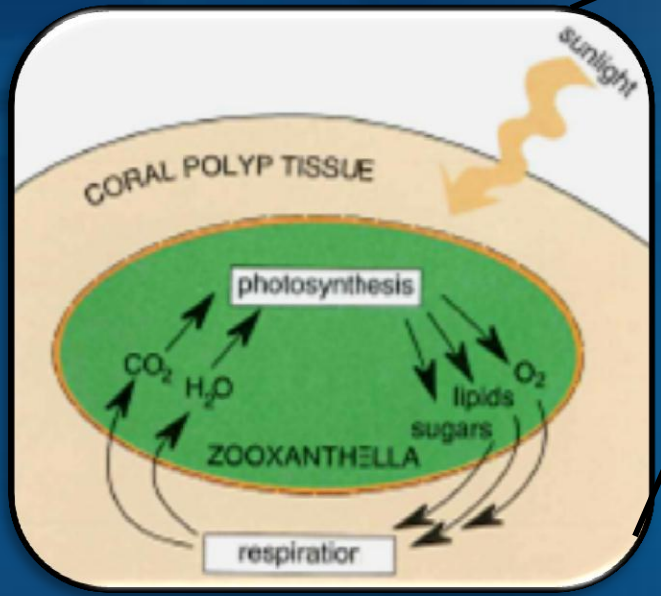
(Mader 2001; Fig. 21.4; p. 266)

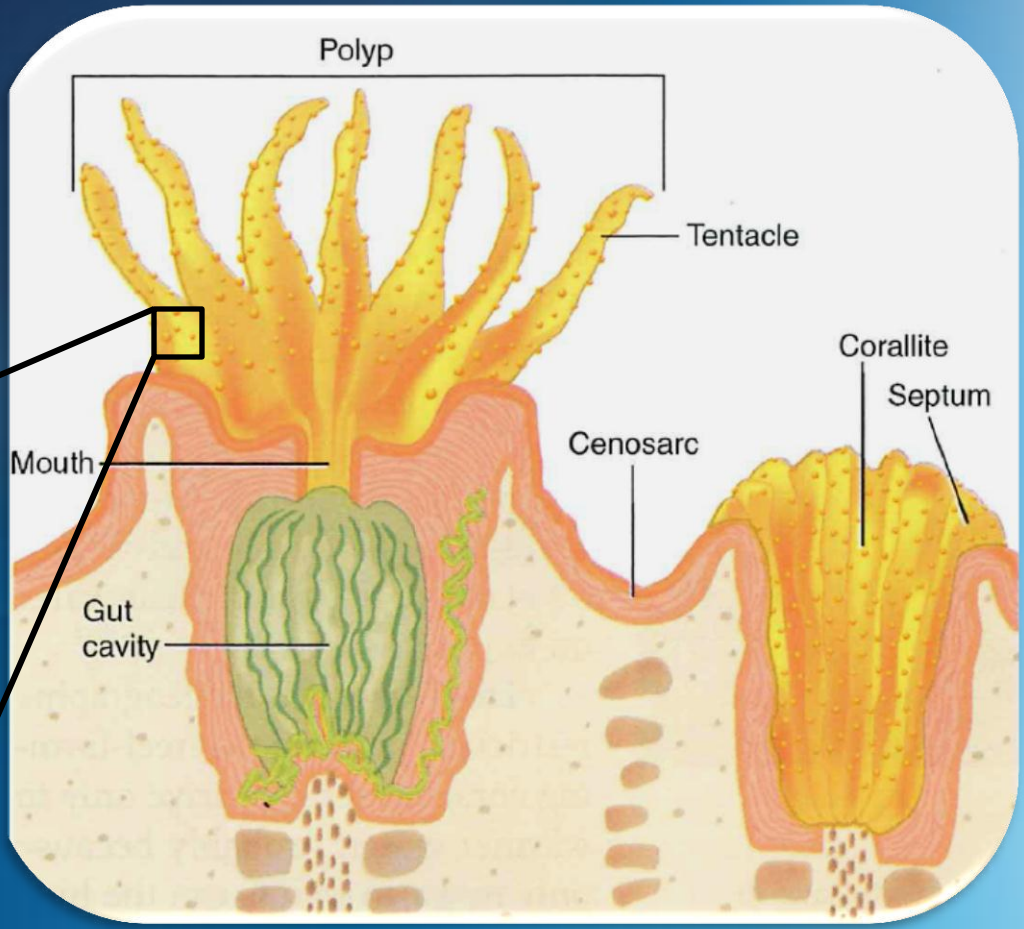


Anthozoa		Hydrozoa	Scyphozoa
Sea Anemones	**Corals**	**Jellyfish**	**True Jellyfish**
			
solitary polyp	colonial polyps (usually)	colonial polyp s with free-swimming medusa phases	small polyp with large, pronounced medusa phases

Biological Context of Reefs

Basic Coral Biology

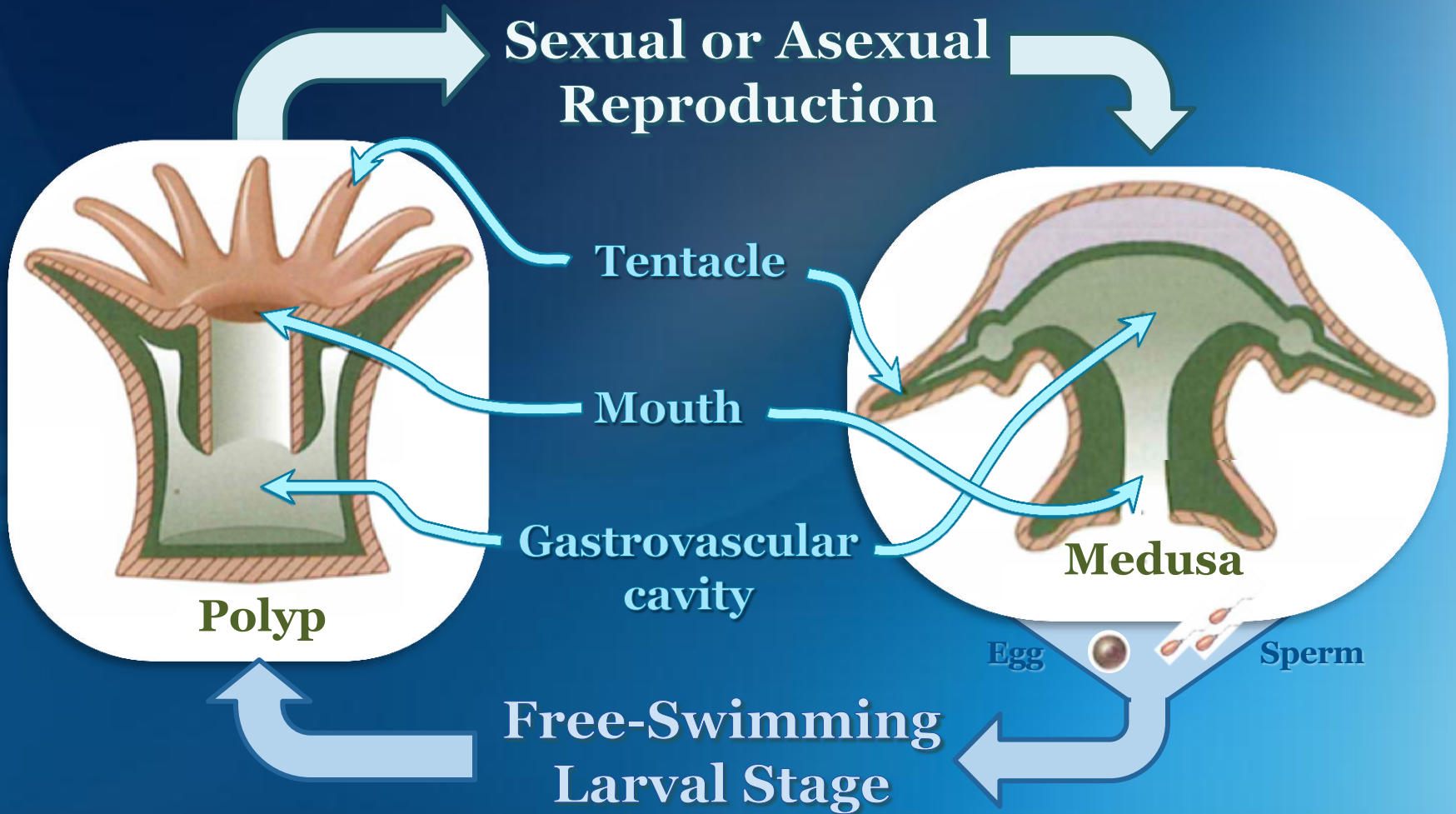




(Sumich & Morrissey 2004; Top Left: Fig. 5.12, p.136; Right:Fig. 9.2, p. 255)

Biological Context of Reefs

The **Biology**, **Reproduction**, & overall **Life Cycle** of Corals

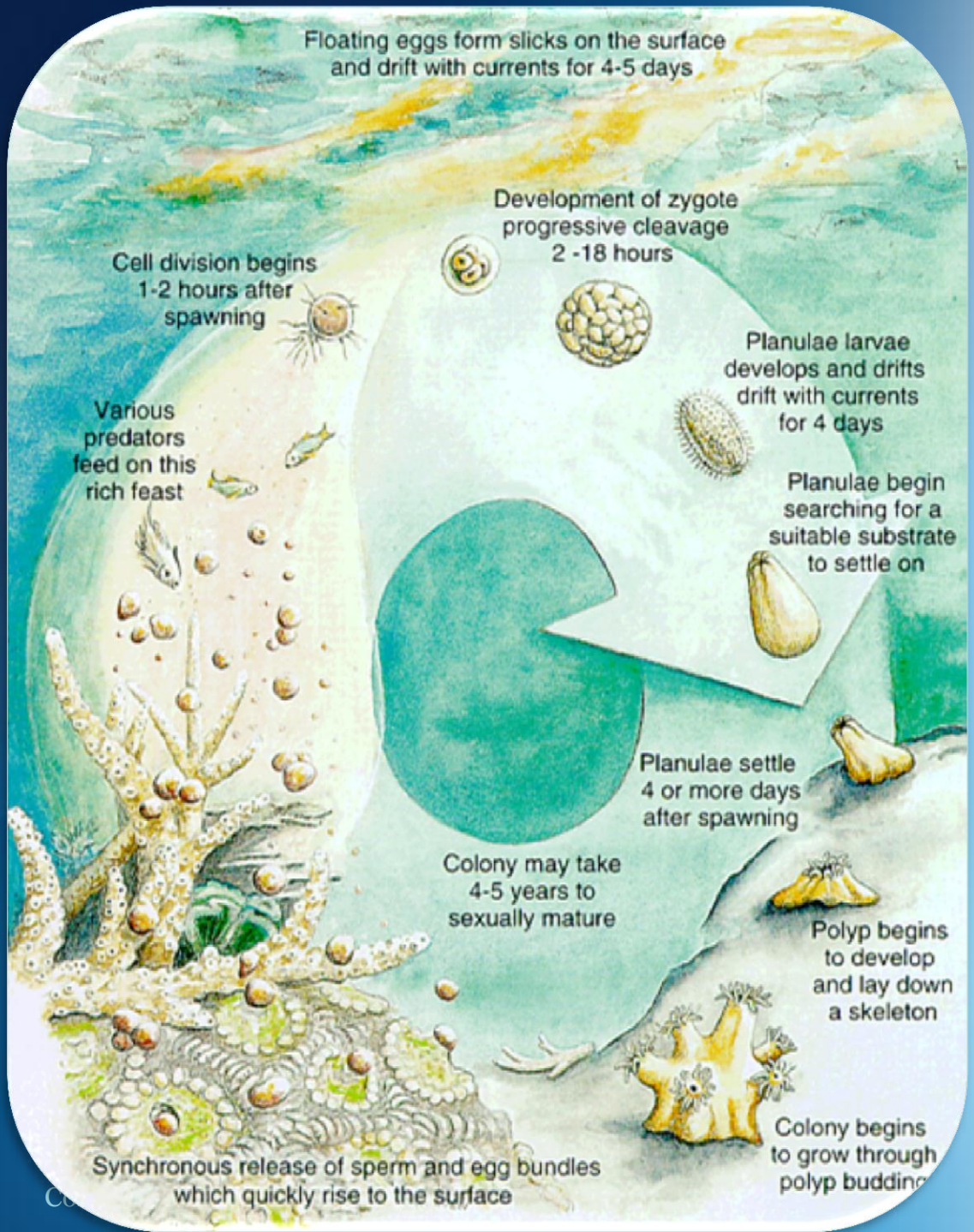


(Adapted from: Sumich & Morrissey 2004; Fig. 5.10; p. 134)

Biological Context of Reefs

Coral Growth & Reproduction

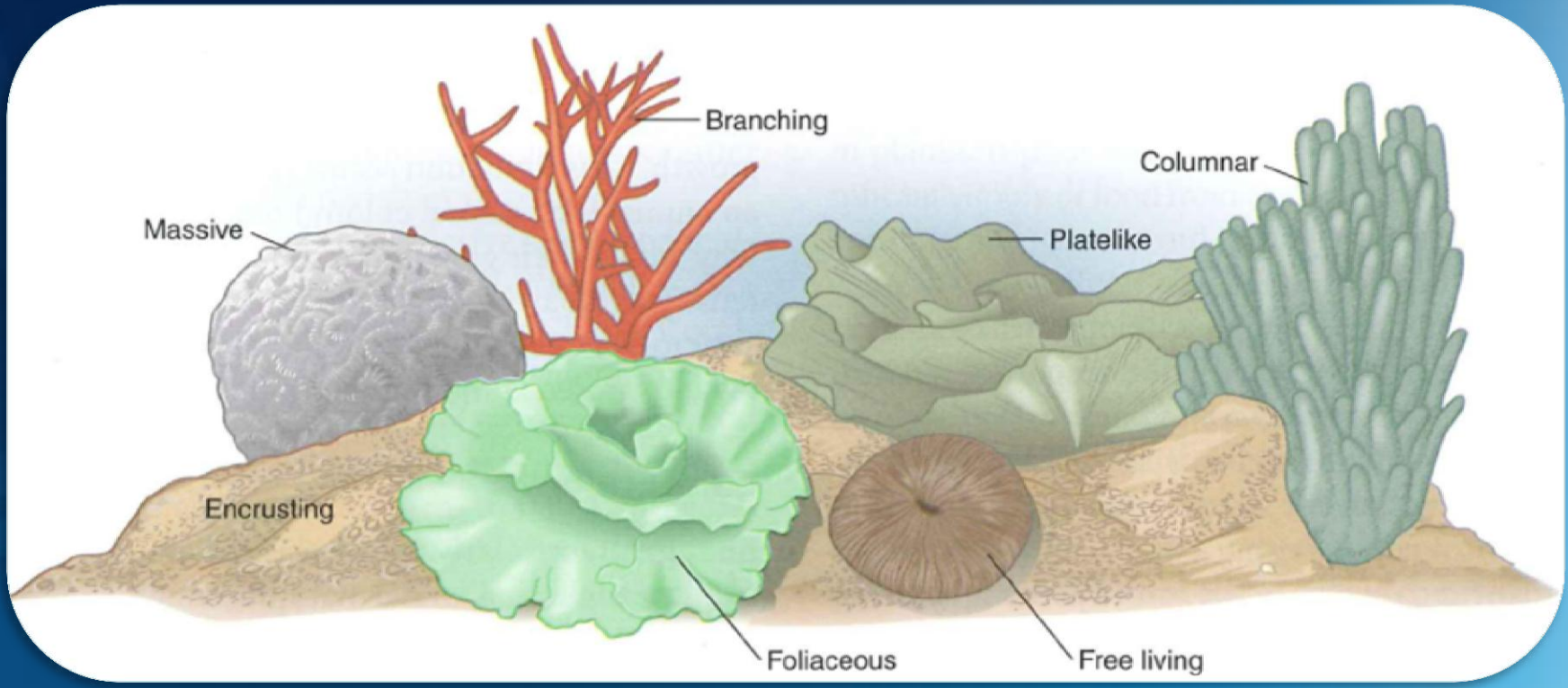
- This figure depicts Coral Reproduction by a _____ Spawner
- Corals need a hard substrate to attach to
- Grow in direction of current/wave action



(http://www.aims.gov.au/pages/reflib/bigbank/pages/bb-09e.html)

Biological Context of Reefs

Coral Morphologies

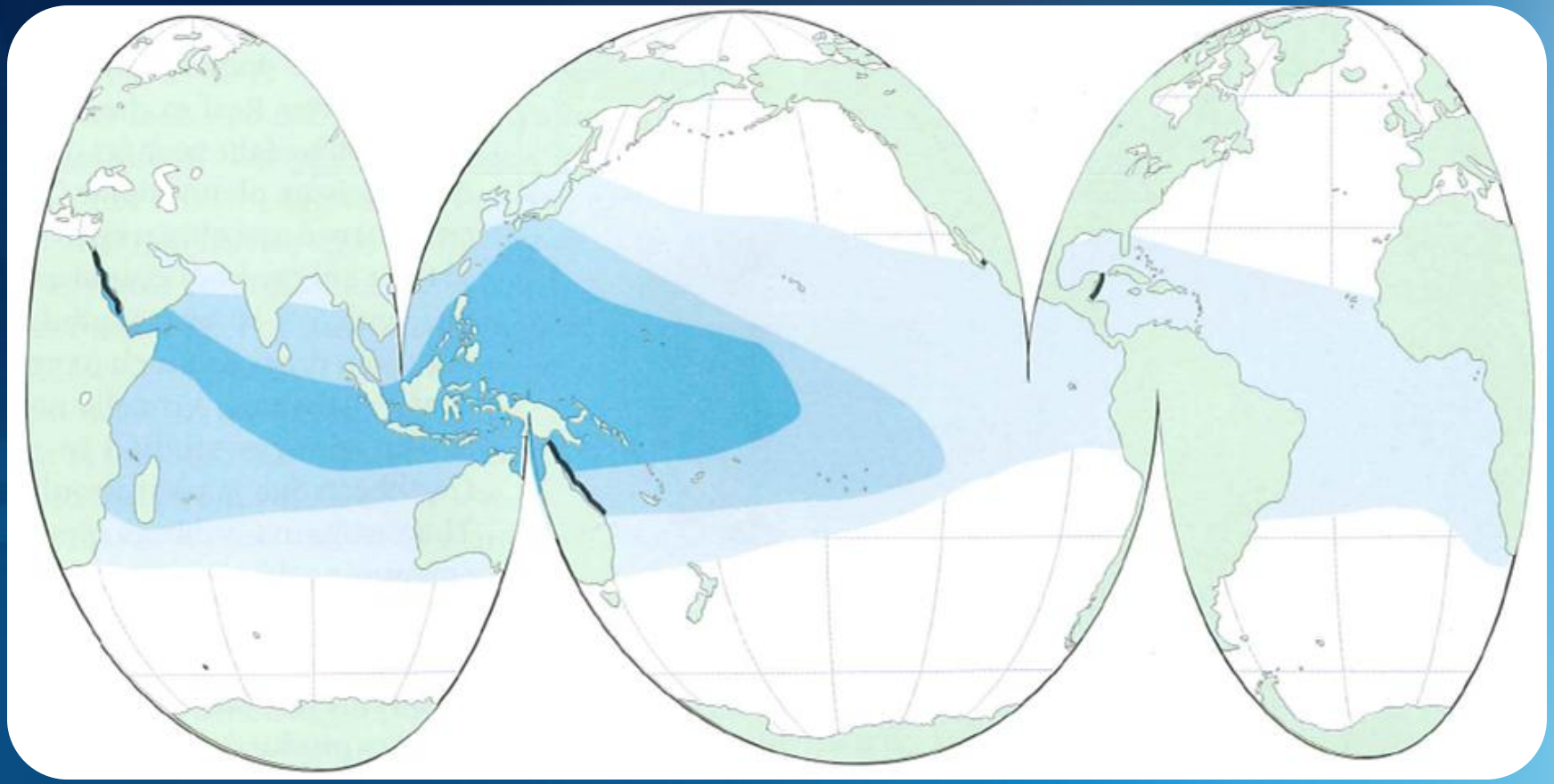


- Massive
- Branching
- Free-living
- Columnar
- Encrusting
- Foliaceous
- Platelike

(Sumich & Morrissey 2004; Fig. 9.3; p. 255)

Biological Context of Reefs

Geographic Distribution & Diversity of Corals



> 40 Genera **20 – 40 Genera** **< 20 Genera**

(Sumich & Morrissey 2004; Fig. 9.5; p. 257)

Geological Context of Reefs

Charles Darwin & Coral Reefs

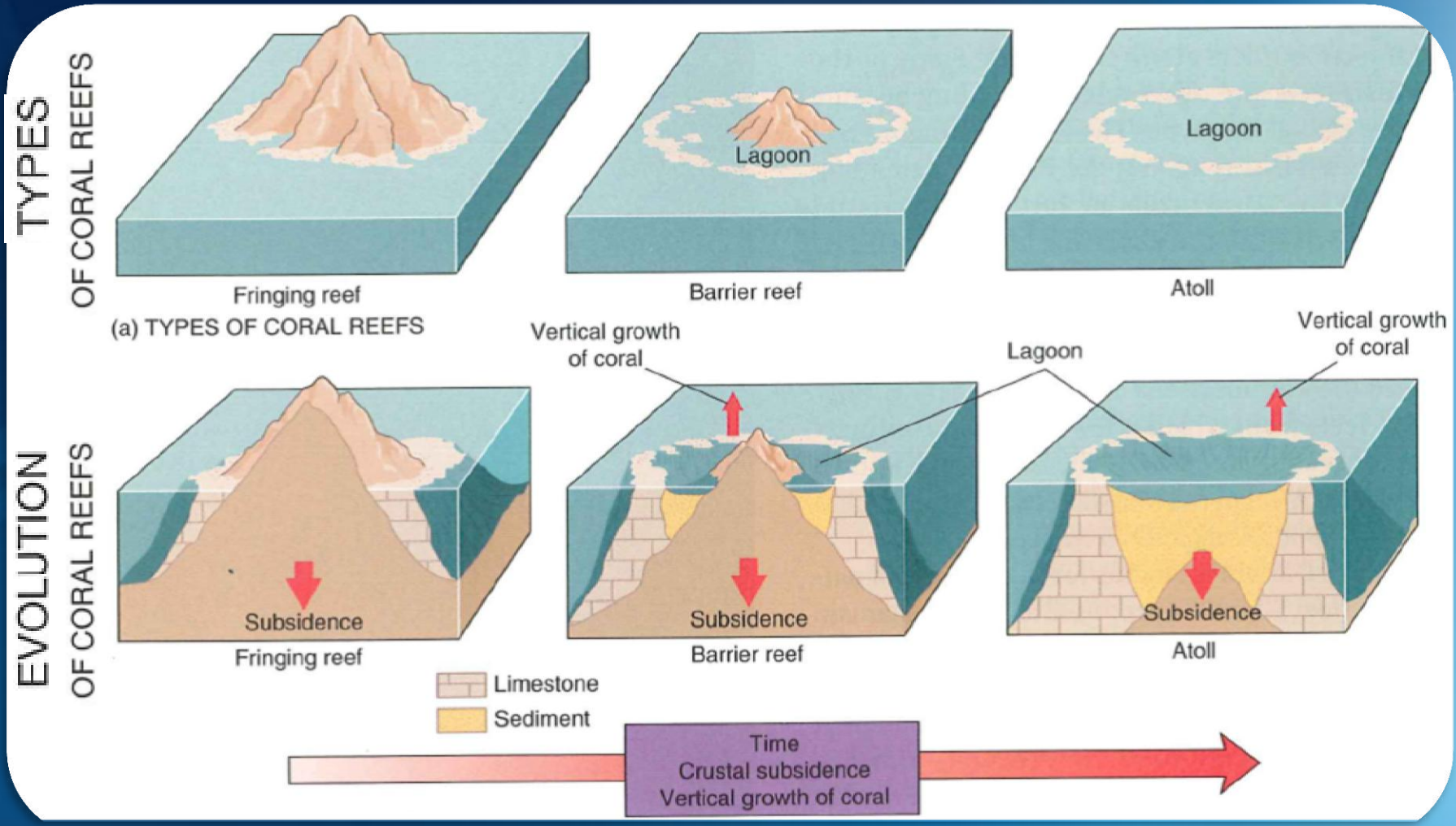
Thery of Subsidence of Atolls and Coral Reefs

On leaving the Cocos Islands on the 12th April 1836, Charles Darwin wrote, *"I am glad we had visited these islands, such formations surely rank amongst the wonderful objects of this world. We feel surprise when travellers tell us of the vast dimensions of the Pyramids and other ruins, but how utterly insignificant are the greatest of these when compared to these mountains of stone accumulated by the agency of various minute and tender animals! This is a wonder which does not at first strike the eye of the body, but after reflection, the eye of reason."*

http://earthguide.ucsd.edu/team/yasuda/oceanography/tectonics/atolldarwin.jpg

Geological Context of Reefs

Types & Evolution of Coral Reefs

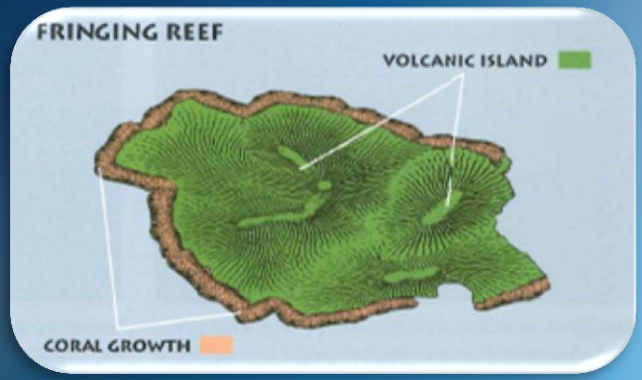


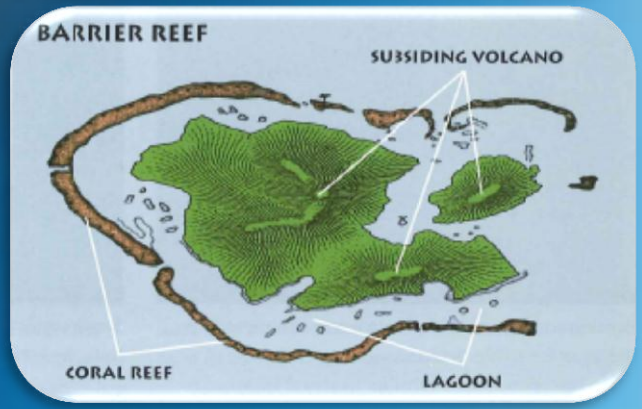
(Sumich & Morrissey 2004; Fig. 9.8; p. 260)

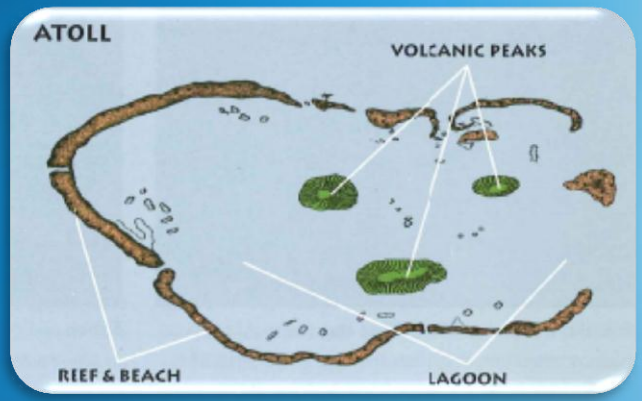
Geological Context of Reefs

Types & Evolution of Coral Reefs

- **Fringing Reefs**
  - Cling to land
  - Areas with low rainfall & clear water
- **Barrier Reef**
  - Separated from land by a _____
  - Great Barrier Reef is the largest structure made by living organism (135,000 mi²)
- **Atolls**
  - Ring-shaped island of coral reefs surrounding a lagoon
  - **Formation**: Volcano → Fringing reef → Barrier reef → Atoll
  - > 1000 feet of coral fragments beneath present reefs





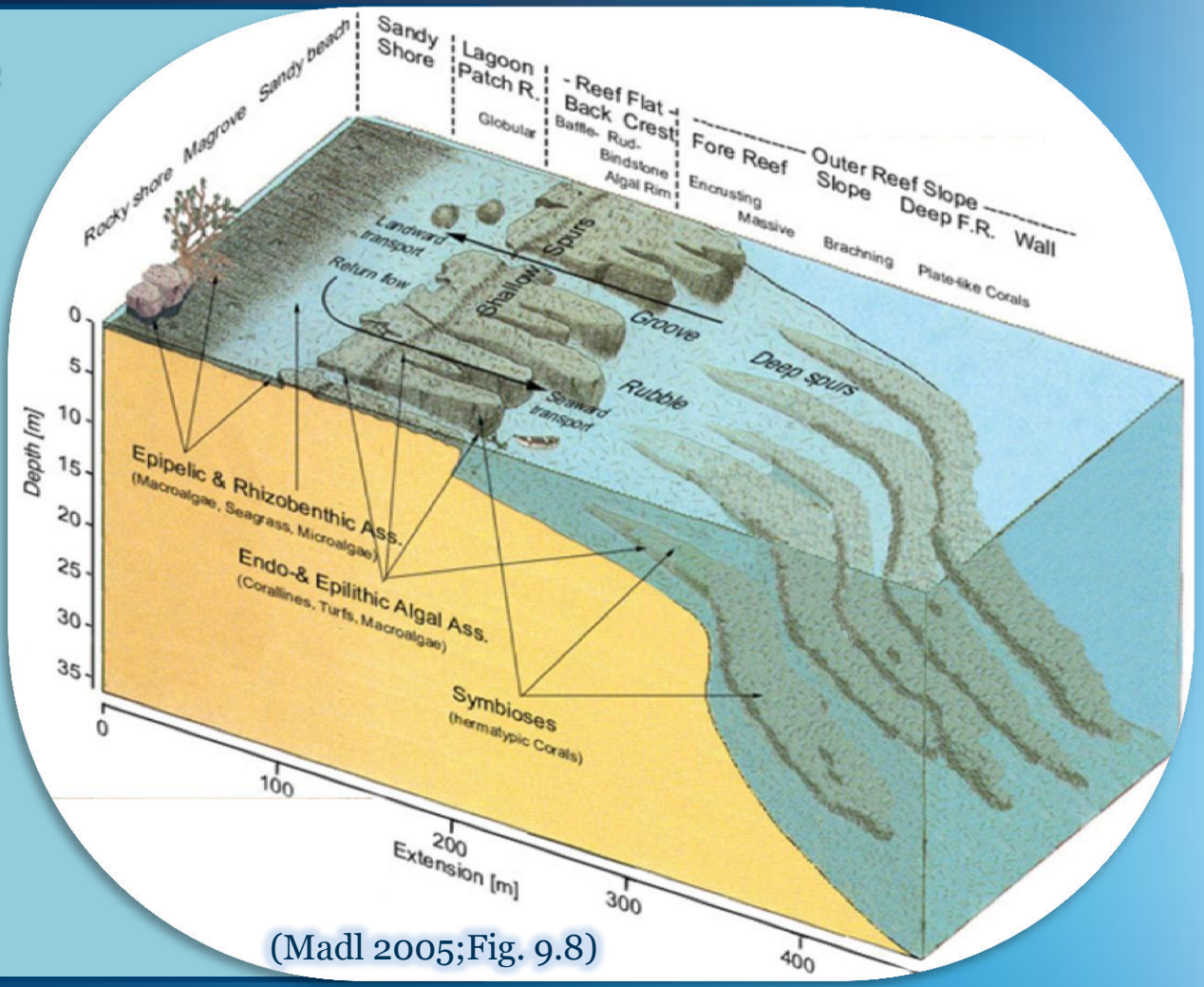


(Figures: Tackett & Tackett 2002; p. 31)

Geological Context of Reefs

Types & Evolution of Coral Reefs

- **Spur & Groove Formations**
  - Adaptation to _____ & _____
  - Mechanism for Sediment _____ during storms



(Madl 2005;Fig. 9.8)

Importance of Coral Reefs

- Protection from Wave Erosion
- Mitigate Hurricane Damage
- Base of the food chain, providing habitat & protection
- Economic reasons – Food/Tourism
- Enhances Quantity & Quality of Life
- Beauty

Current Status of Corals

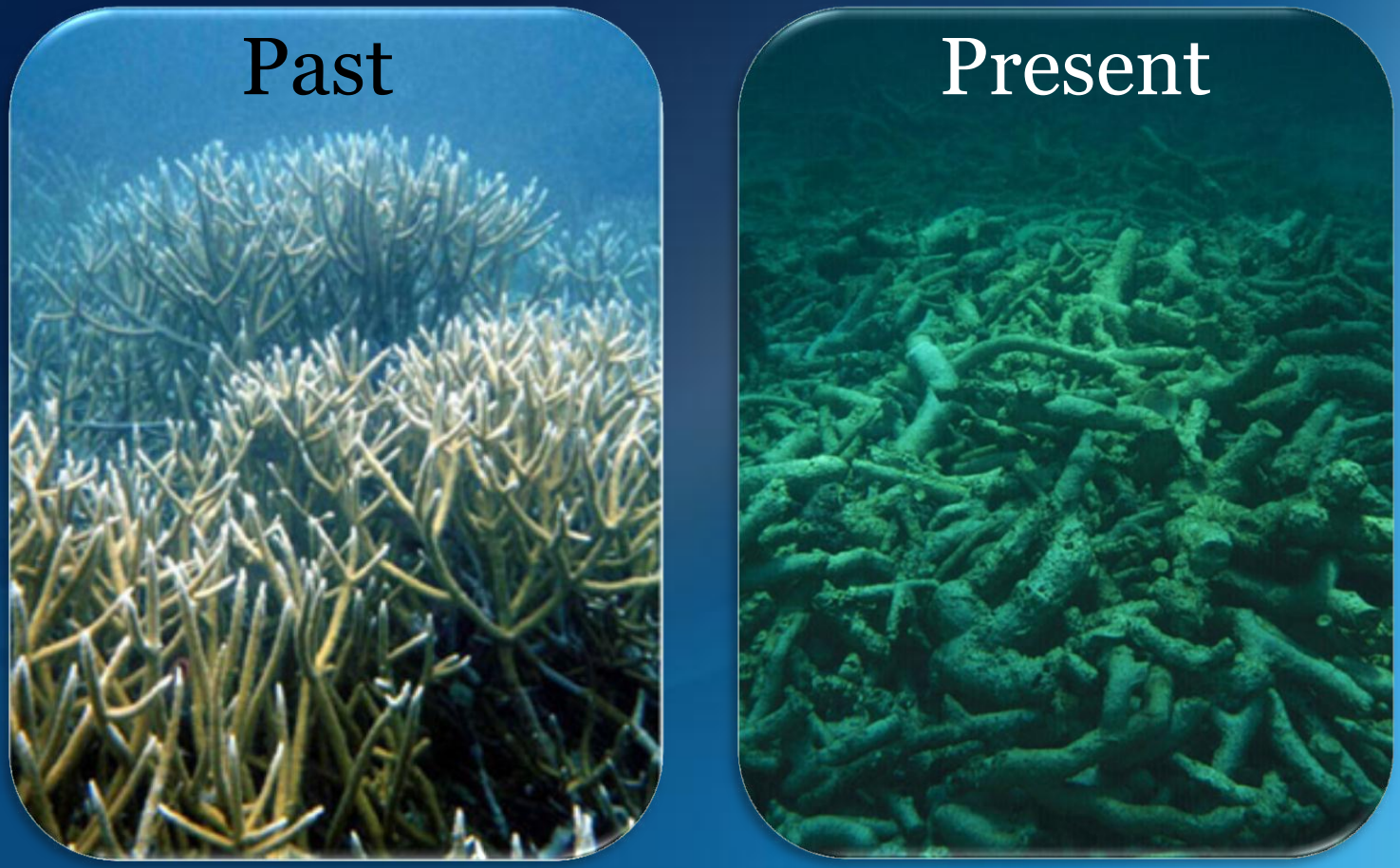
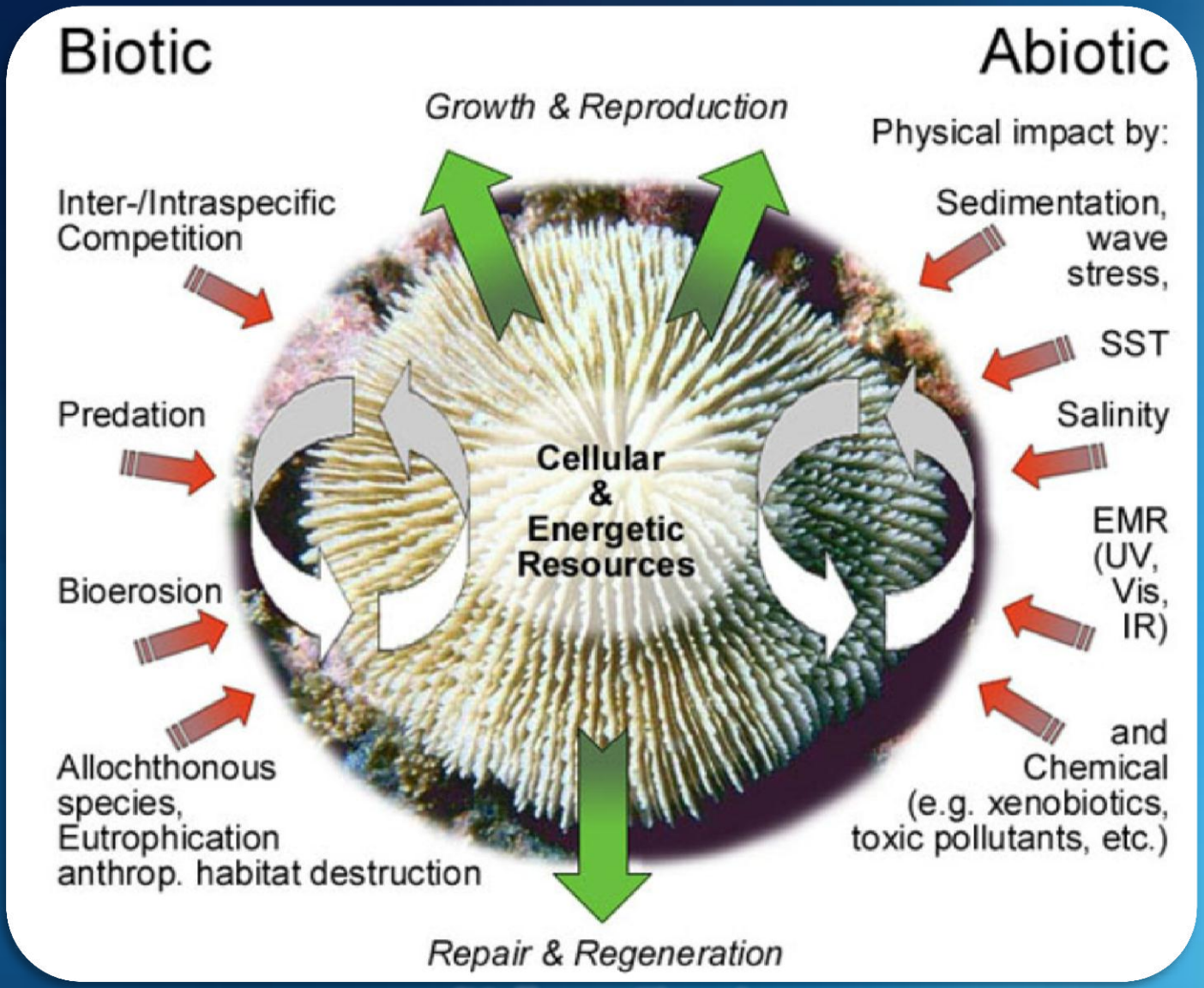


Fig.3.15a: Images from a Caribbean coral reef. Major storm events change a reef from a more or less intact community to one dominated by dead coral, algae and bioeroders.

(Madl 2005; Fig. 3.15a)

Coral Stressors

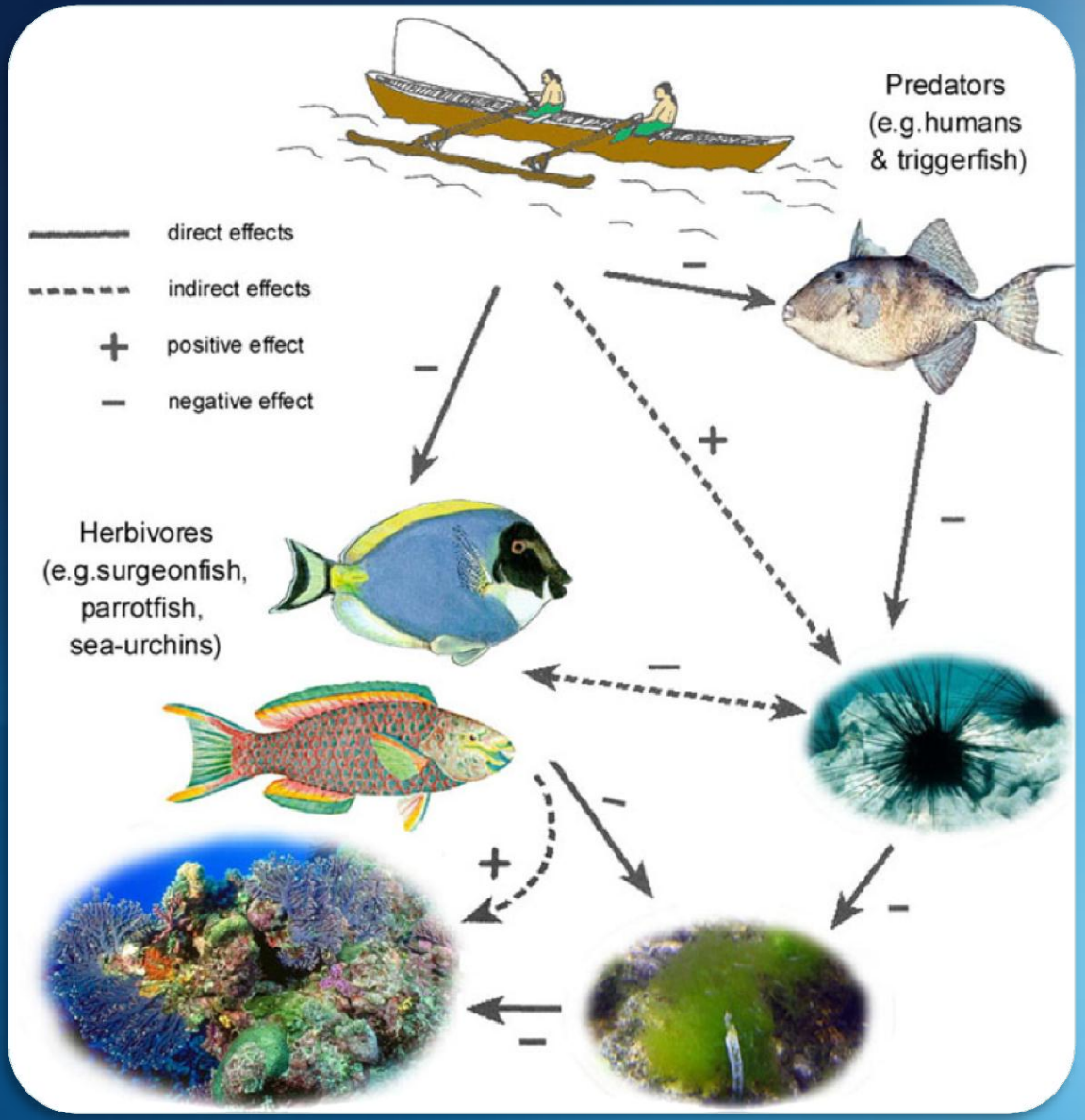


(Madl 2005; Fig. 4.1)

Coral Stressors

Over-fishing

"Herbivorous feeding pressure: Since herbivorous fish and sea urchins consume algae any fishing pressure exerted on these species by humans does interfere with the sensitive balance of feeding pressure and algal blooms"



(Madl 2005; Fig. 3.7)

Coral Stressors

Dynamite or Blast fishing

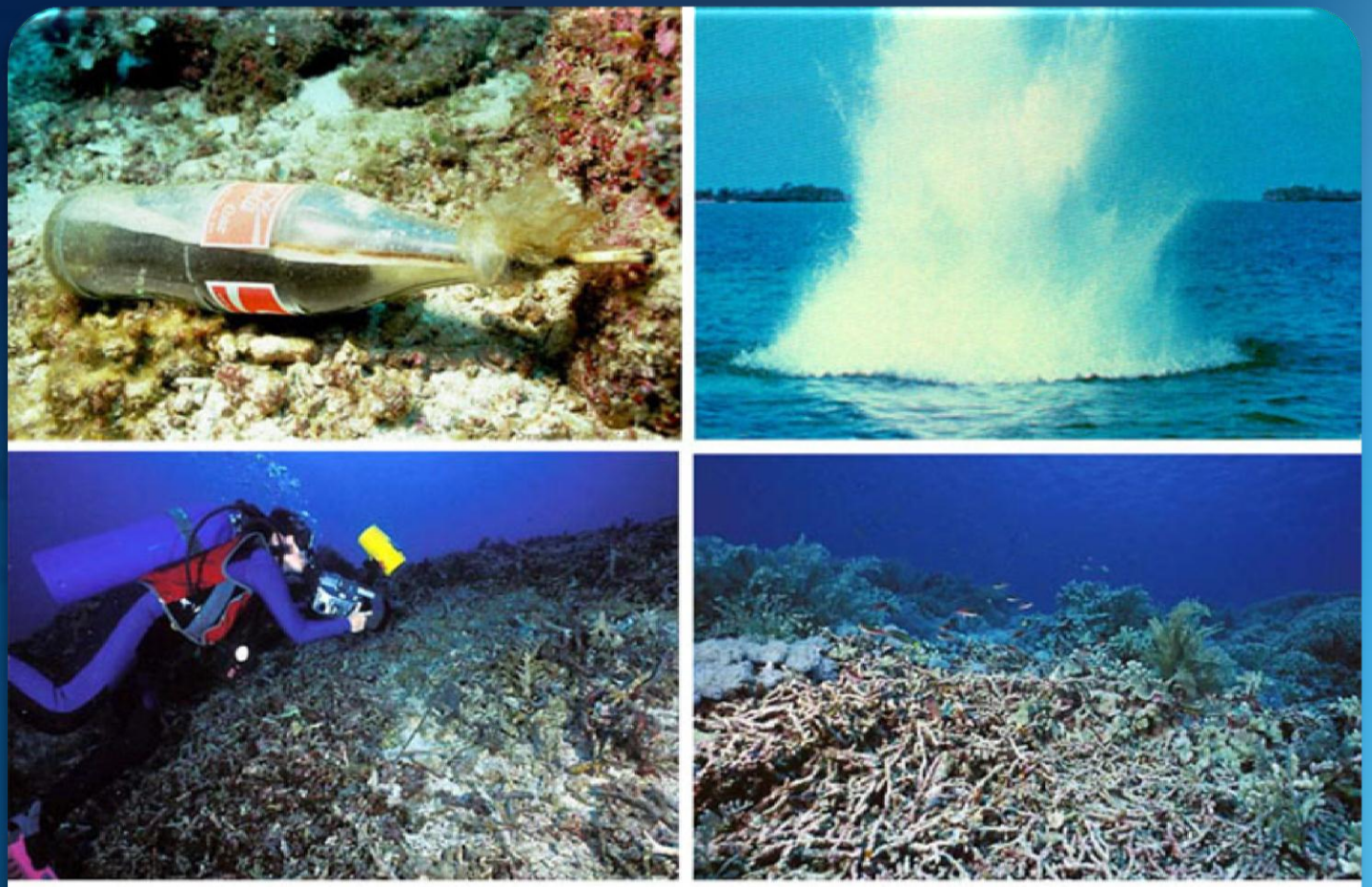


Fig.3.8a: Dynamite or blast fishing is a practice in which fishermen use explosives to kill and harvest fish. Although it is illegal, it is practiced in forty countries worldwide and is a major threat to coral reefs . The explosion, which indiscriminately kills all fish within the blast radius also destroys living coral. An explosive the size of a coke bottle will shatter to pieces all stony corals within a three meter radius. Repetitive blasting in an area reduces coral to rubble, which cannot support marine life.

(Madl 2005; Fig. 3.8a)

Coral Stressors

Cyanide-fishing

Fig 3.8b: Although the practice has been outlawed in most countries, and despite many importers of of reef fish refuse to acept cyanide-tainted fish, widespread use of cyanide continues to devastate huge areas.

(Madl 2005; Fig. 3.8b)

Coral Stressors

Hydrocarbon Pollution from Oil Spills

Fig.3.10a: Crude oil polluting reefs in the Caribbean (left), oil washing on the coast of the northern Gulf of Aqaba / Eilat following an oil spill (right).

(Madl 2005; Fig. 3.10a)

Coral Stressors

Sedimentation

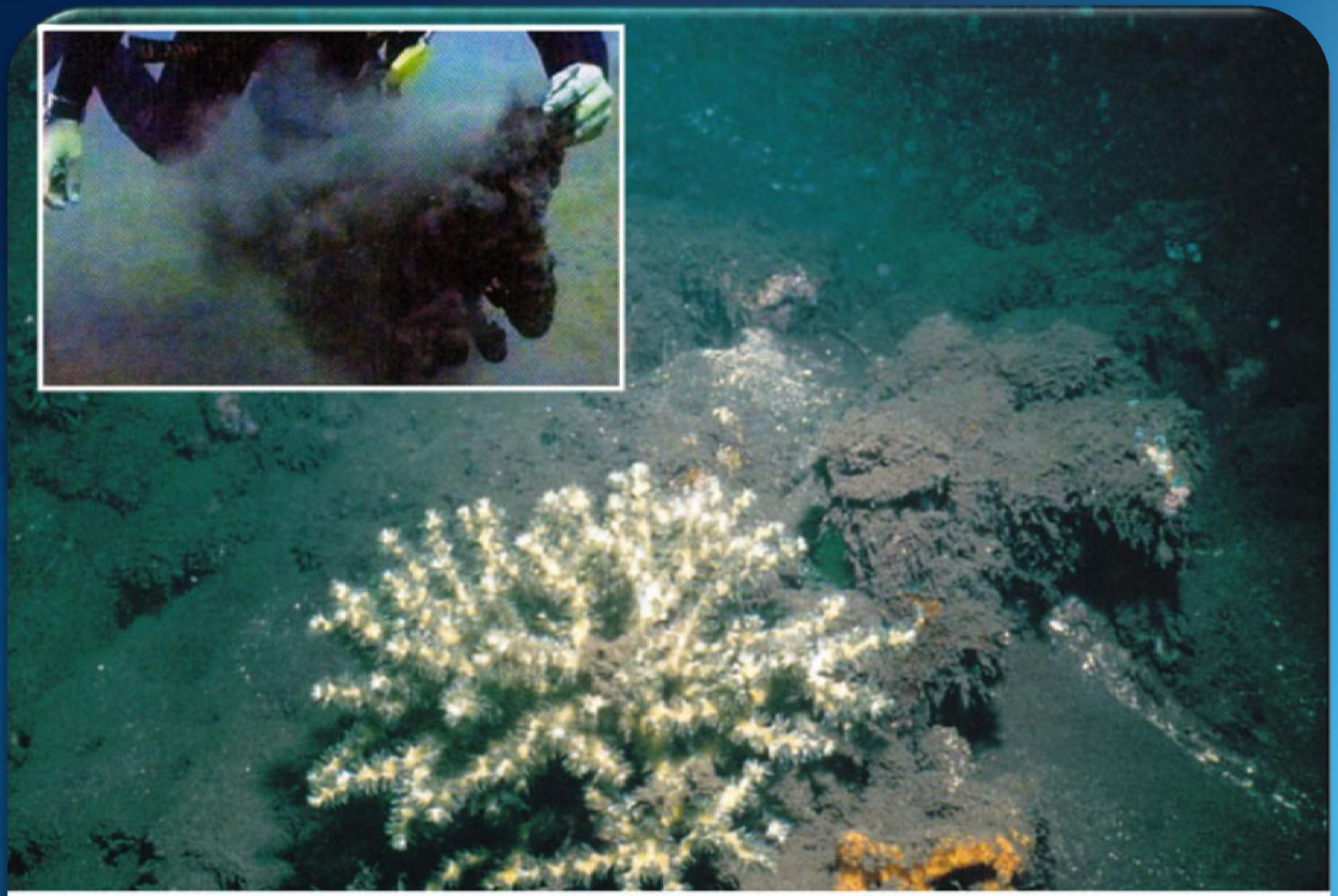
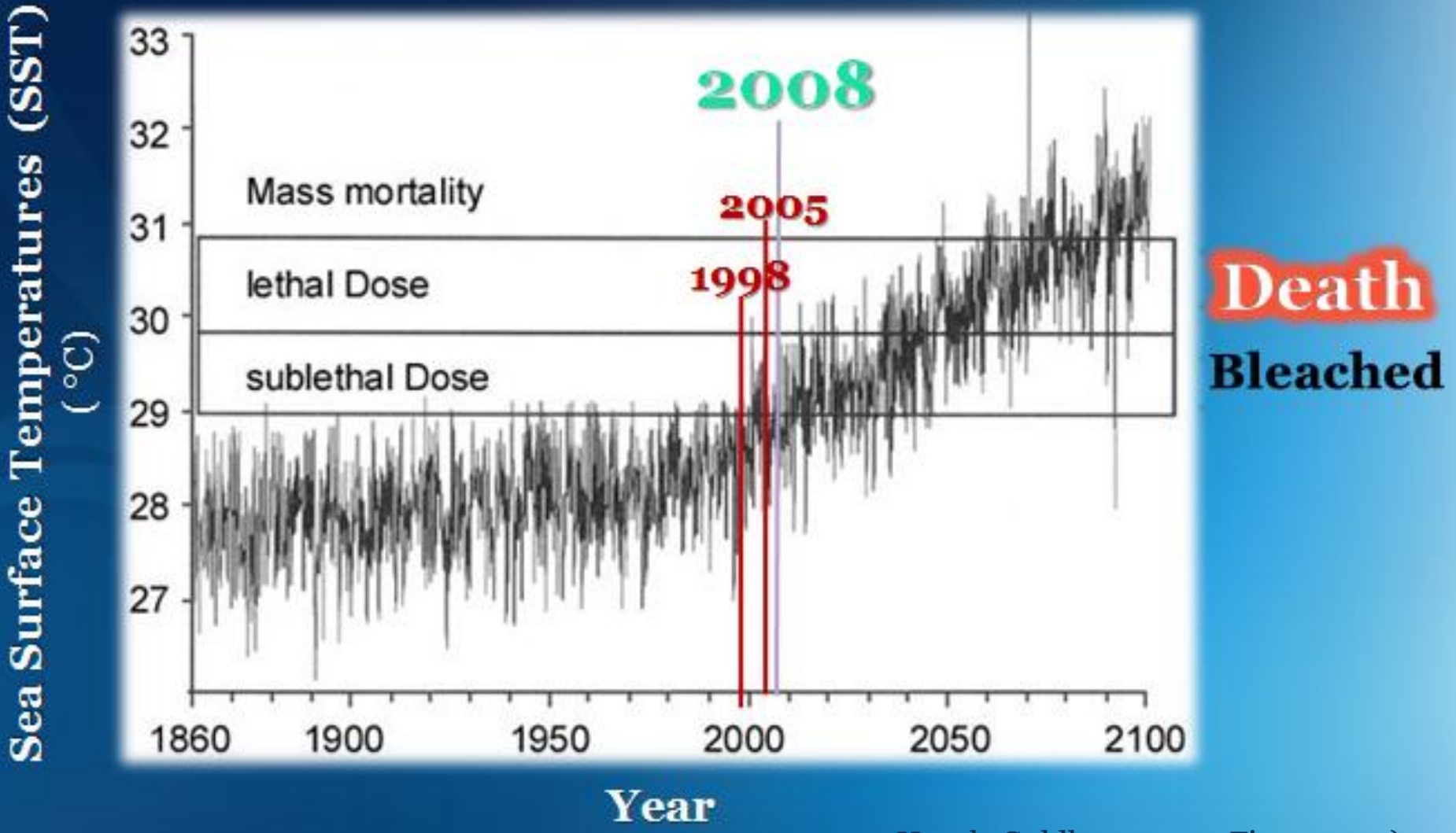


Fig.3.4b: Nutrient pollution and sedimentation from coastal development blocks sunlight, thereby reducingthe coral's viability. Bryant et al. 1998, Loya 2004

(Madl 2005; Fig. 3.4b)

Coral Stressors: Temperature

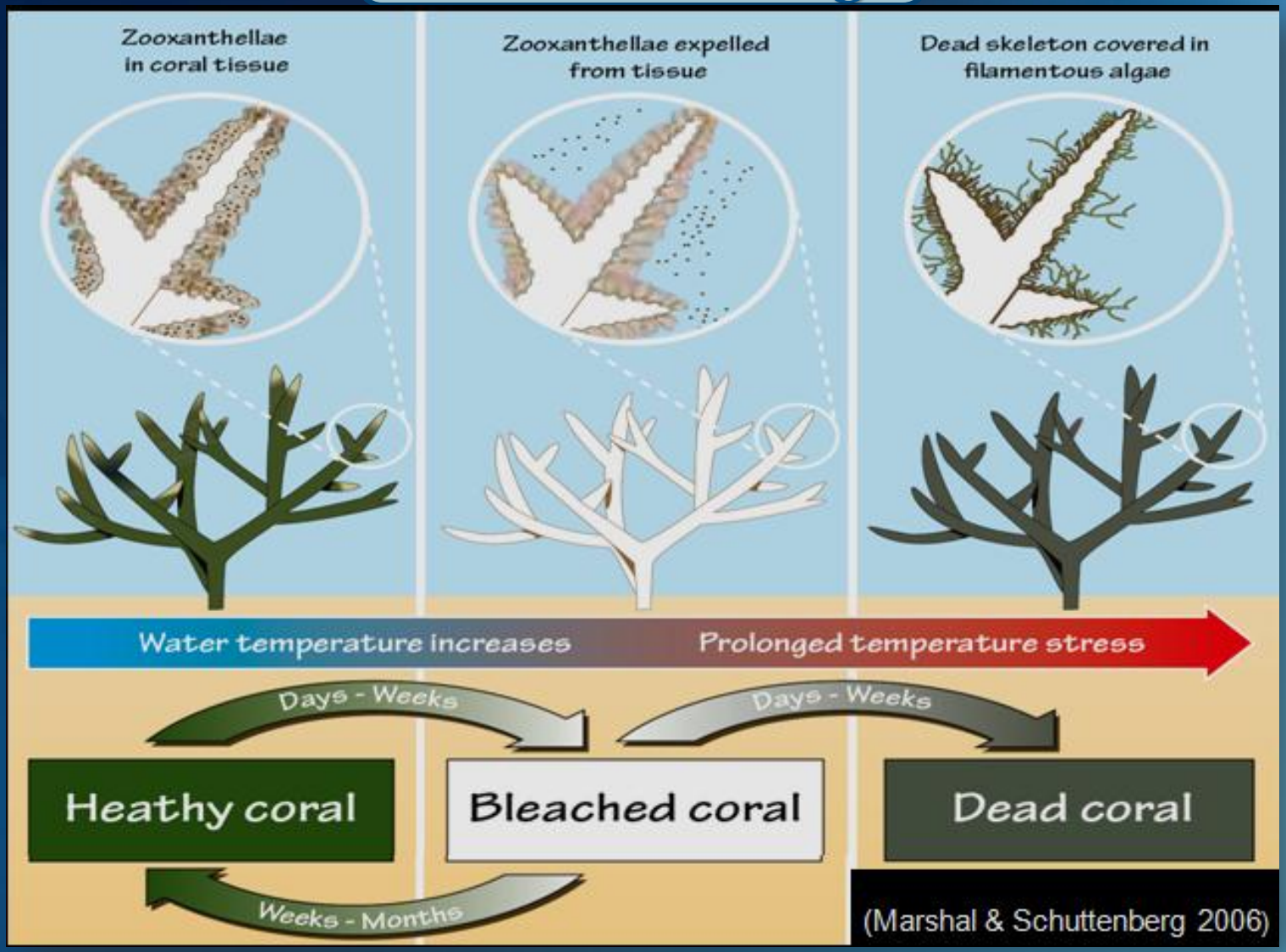
Coral Bleaching



(Hoegh-Guldberg 2004; Fig. 2; p. 14)

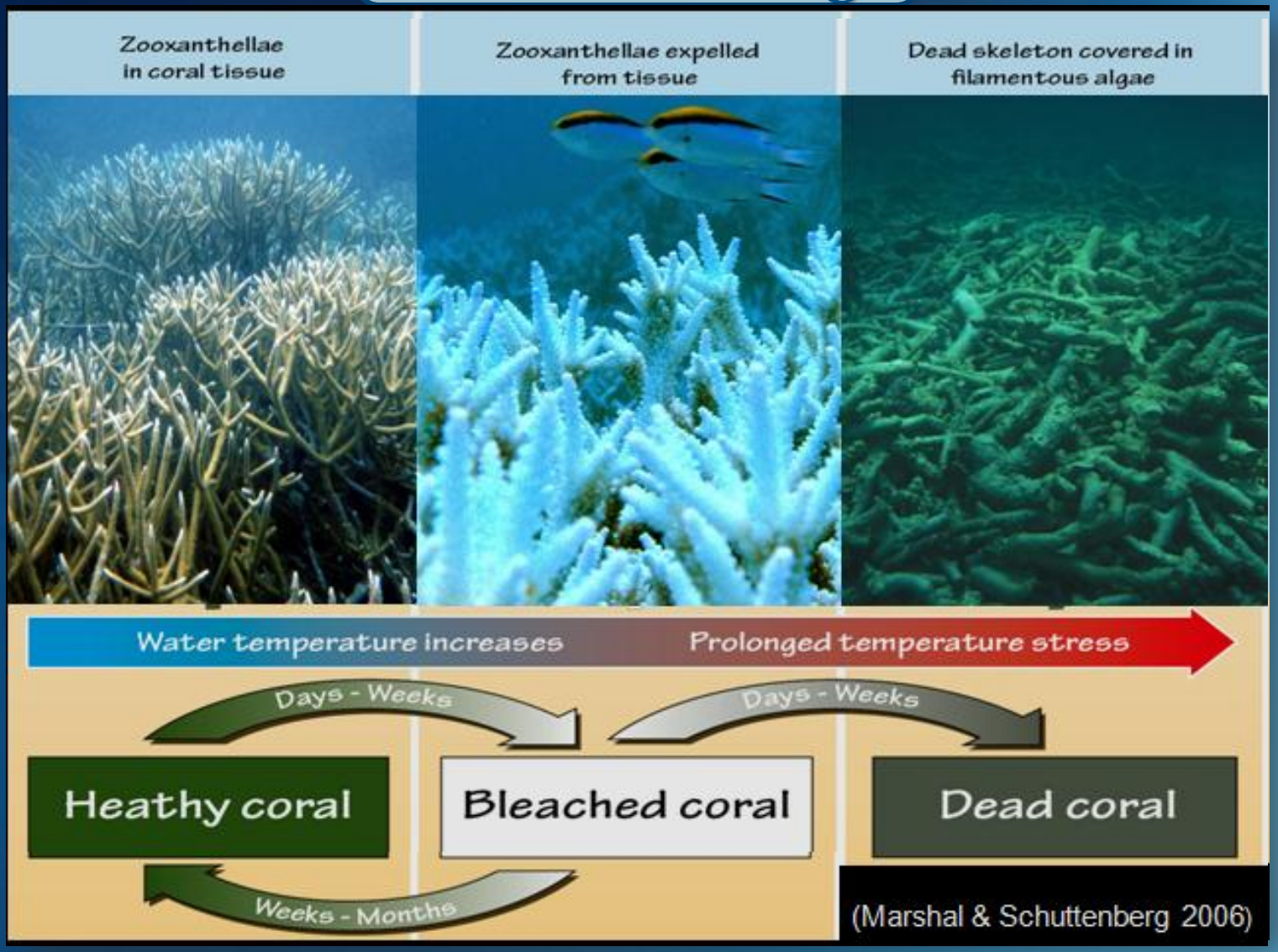
Coral Stressors: Temperature

Coral Bleaching



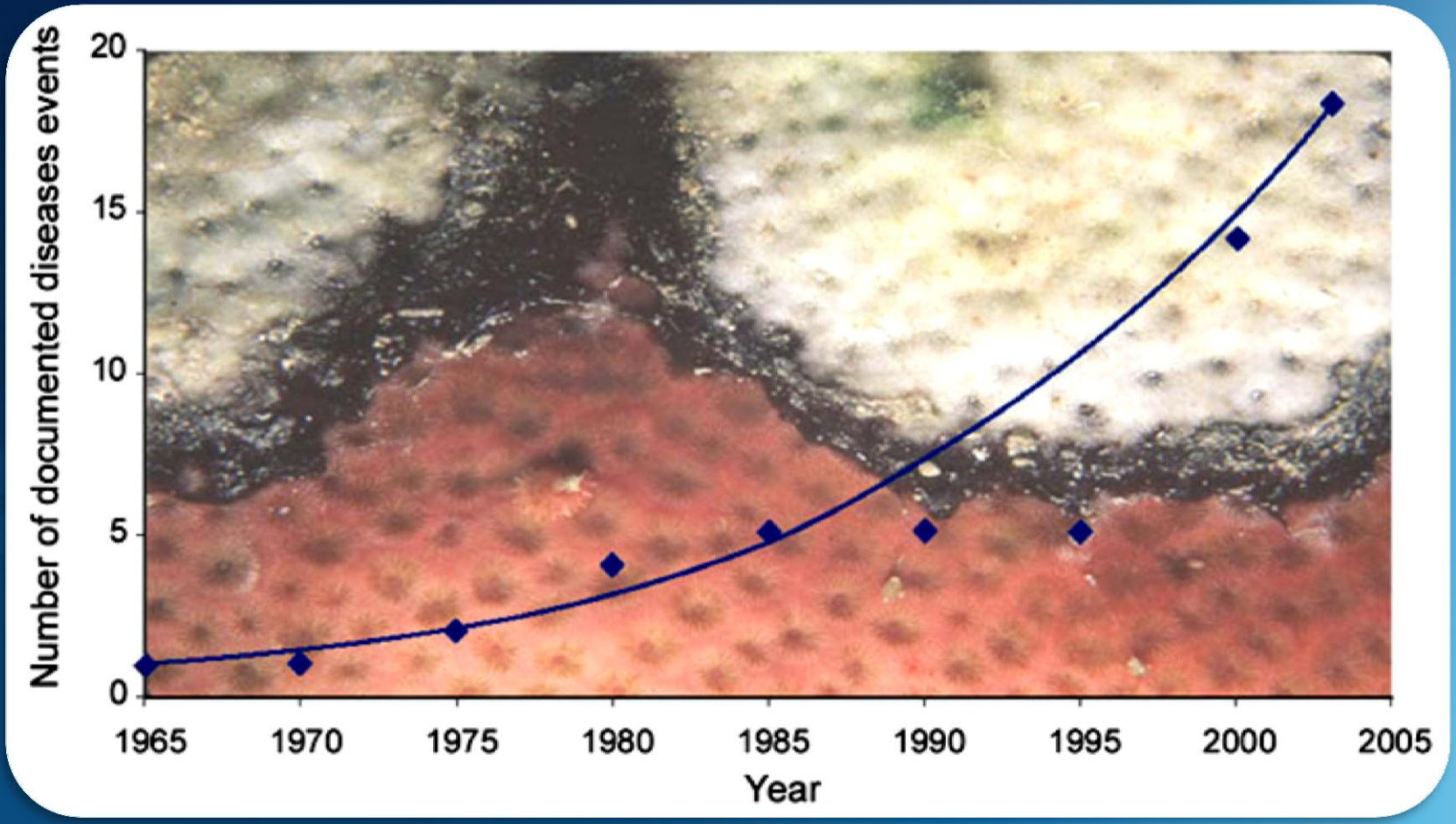
Coral Stressors: Temperature

Coral Bleaching



Coral Diseases

Coral Diseases

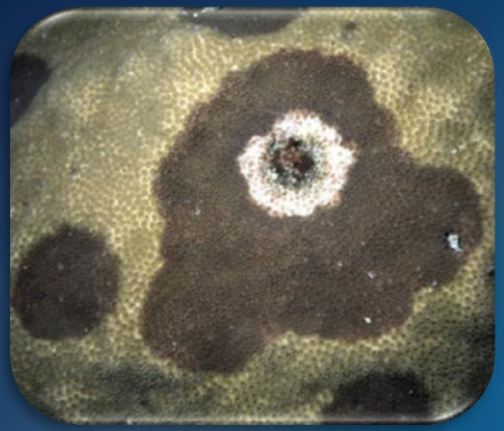


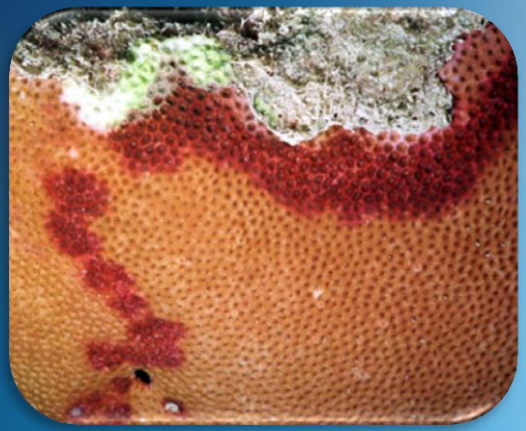
Exponential increase in the number of described coral diseases since the first since the first report of disease in 1965.

(Madl 2005; Fig. 4.5)

Coral Diseases

Coralline Lethal Disease (CLD)





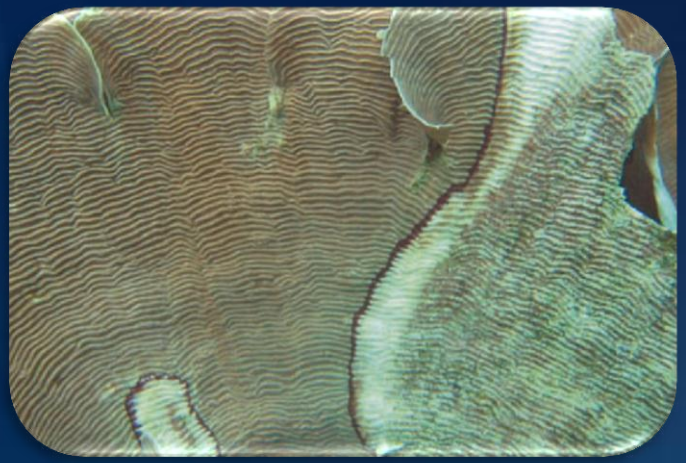
Dark Spots Disease/Syndrome (DSD/S)

Coralline Lethal Orange Disease (CLOD)

Pink Line Disease/Syndrome (PLD/S)

(Madl 2005; CLD: Fig. 4.7; CLOD Fig. 5.8; DSD/S: Fig. 4.9; PLD/S: Fig. 4.10)

Coral Diseases



Red Band Syndrome (RBS)

White Plague Disease (WPL)

Yellow Blotch Disease (YBL)

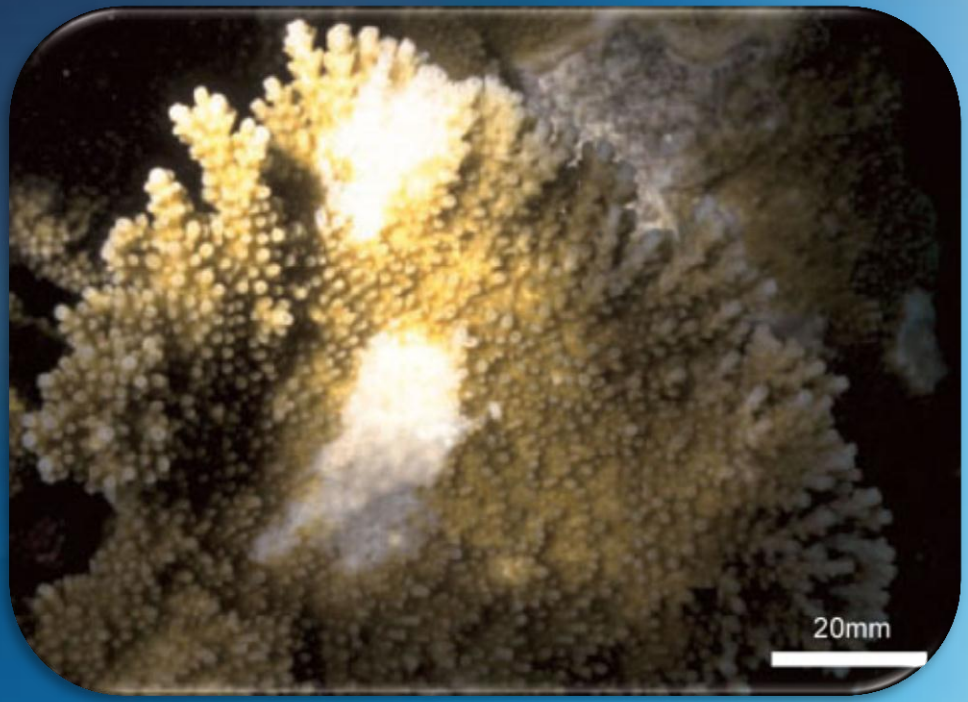
Rapid Wasting Disease (RWD)

(Madl 2005; RBS: Fig. 4.11; WPL: Fig. 4.20-4.21; YBD: Fig. 4.23)

Coral Diseases

White Band Disease
(WBD)

White Pox Disease
(WPX)

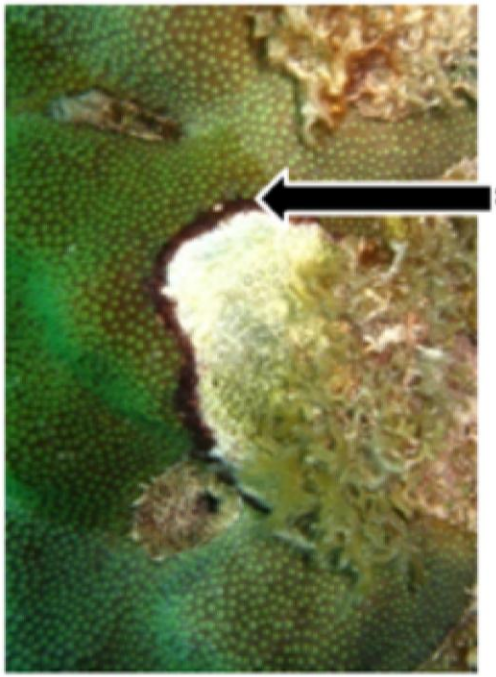


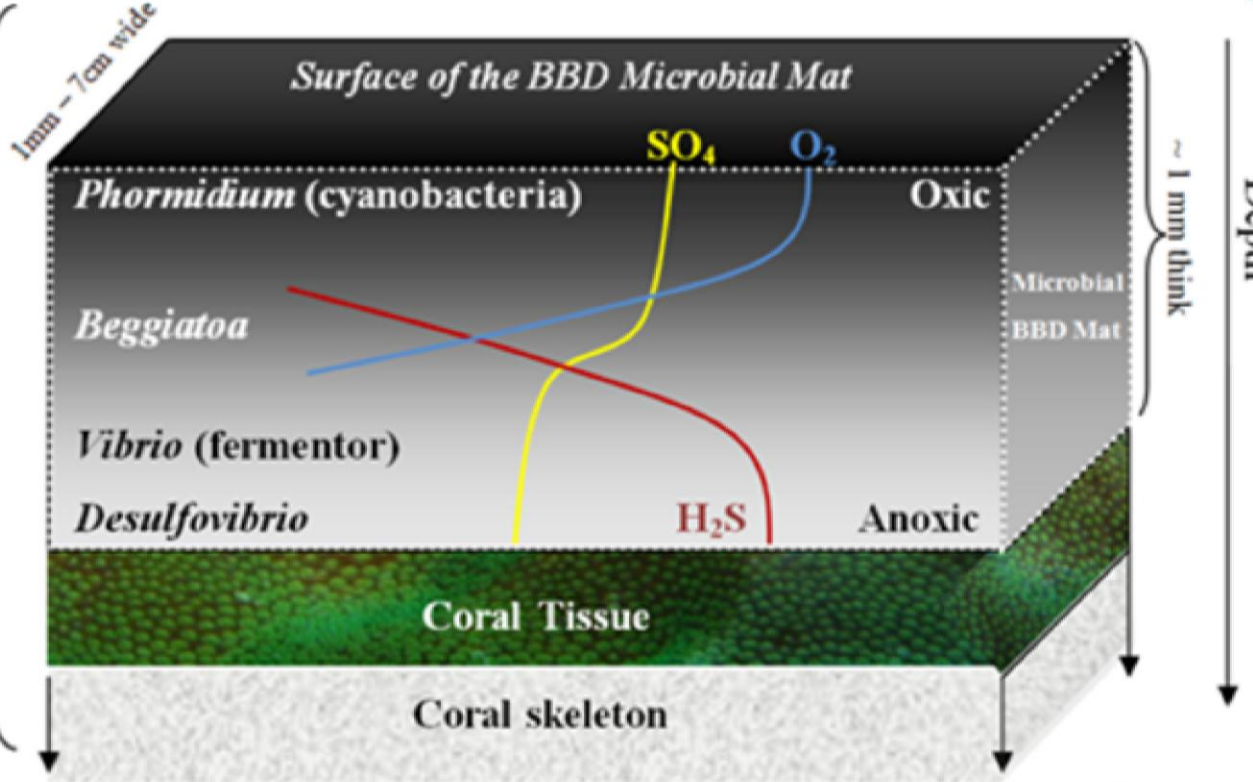
in the Caribbean WBD & WPD only affect the coral genus *Acropora*

(Madl 2005; WBD: Fig. 4.19; WPX: Fig. 4.22)

Coral Diseases

Black Band Disease (BBD)





Stylistic cross-section of the dominant microbes of the microbial consortium making up the BBD mat. *Note: this diagram is not done to scale.*

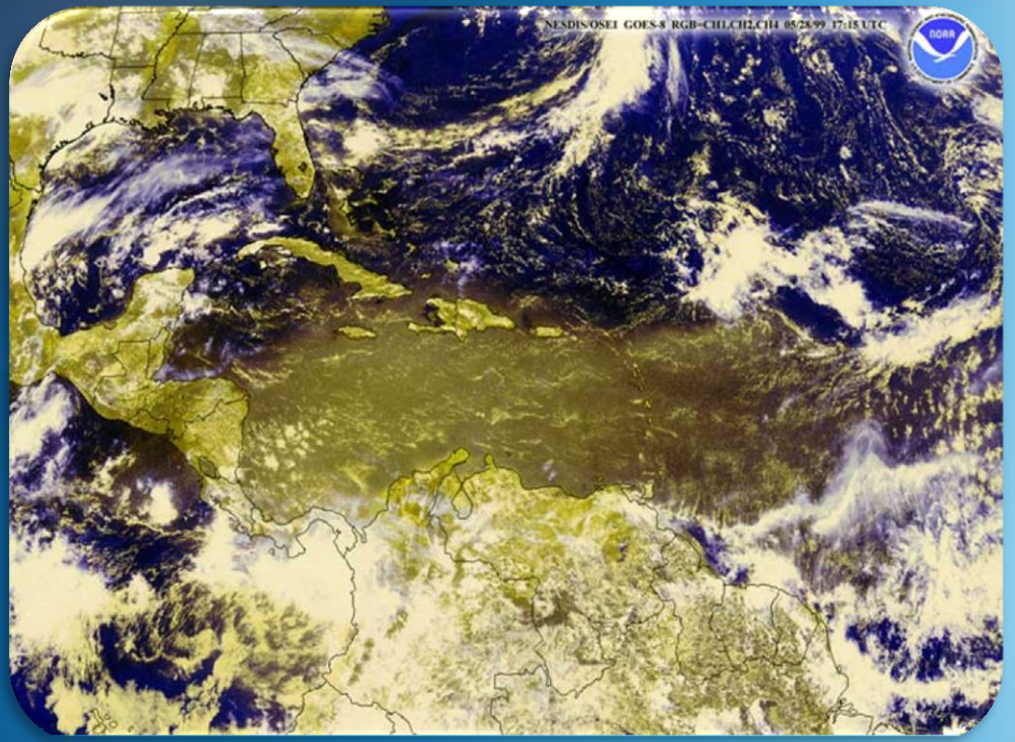
(Lentz 2006, unpublished.)

Coral Diseases

Aspergillosis (ASP)

- Caused by the terrestrial _____, *Aspergillus sydowii*
- Causes irregularly shaped white crumbly patches on *Gorgonian* sea fans
- Visually identified by the **purple** line inbetween the diseased & healthy coral
- The fungus is carried from Africa to the Caribbean by the trade winds

(Madl 2005; Fig. 5.7a



(http://coastal.er.usgs.gov/african_dust/index.html)

What can be done?

- Marine Reserves- preserve breeding stocks!
- No Anchoring
- Reduce stressors – pollution, sediment, cruise ships!
- Ban humans after bleaching events
- Seed reefs with fast growing *Acropora* spp.
- Re-introduce Diadema urchins
- Clean algae off dead corals to increase
- Create Artificial hard substrate for coral recruitment

Positive Note

Flower Garden Banks National Marine Sanctuary

- 110 miles from coast
- 66 ft-150 ft deep
- No anchoring
- No discharges
- Fishing by hook/line
- No take zone

- Reefs Healthy and
- provide breeding stock
- for Caribbean reefs
- Bathed in Loop Current
- Warm Eddy water

http://www.csmonitor.com/2007/0314/csmimg/p13b.gif

Window in the Waves: The Flower Garden Banks

10 minute Documentary Video

Quiz # 14

- **Question:**

  What is the **name of the chemical compound** that corals secrete to form their "skelleton," making up the geologic framework or structure of reefs?

- **Answer:** _____

References

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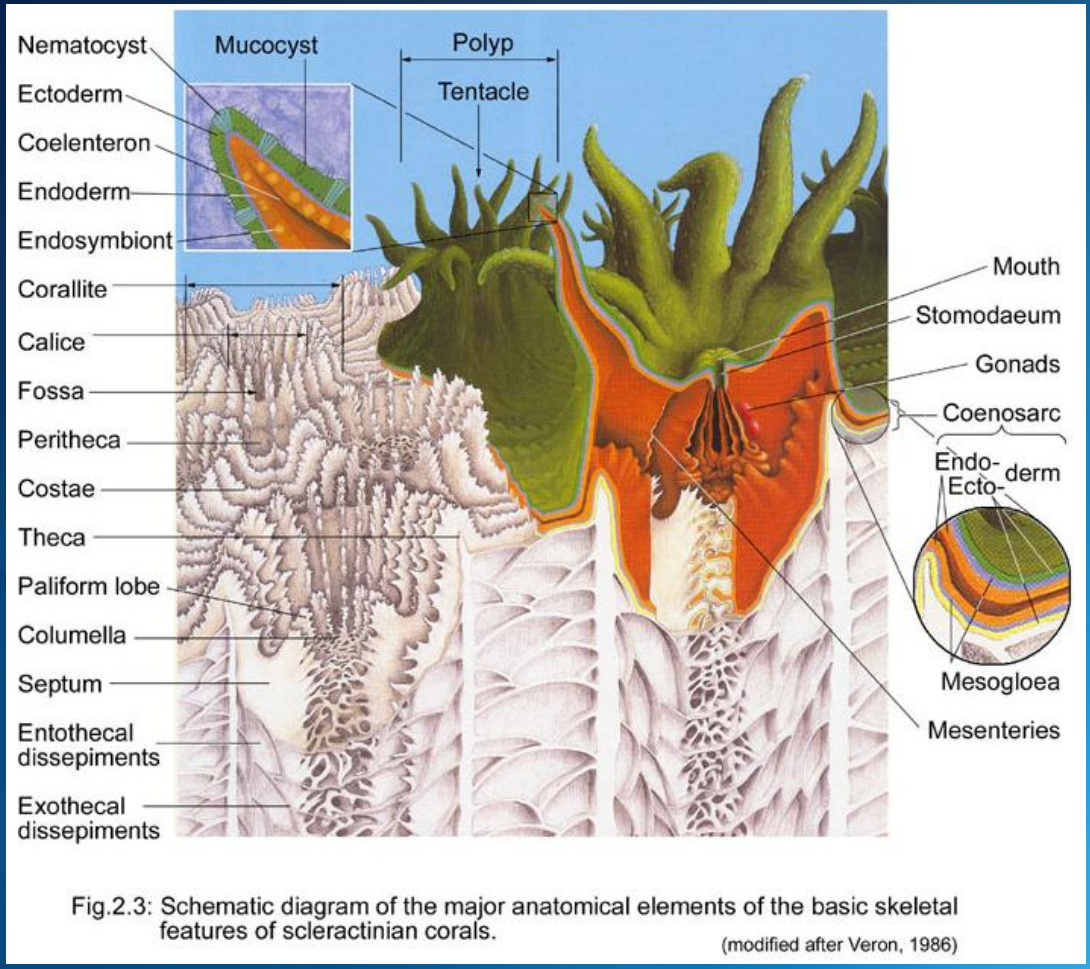
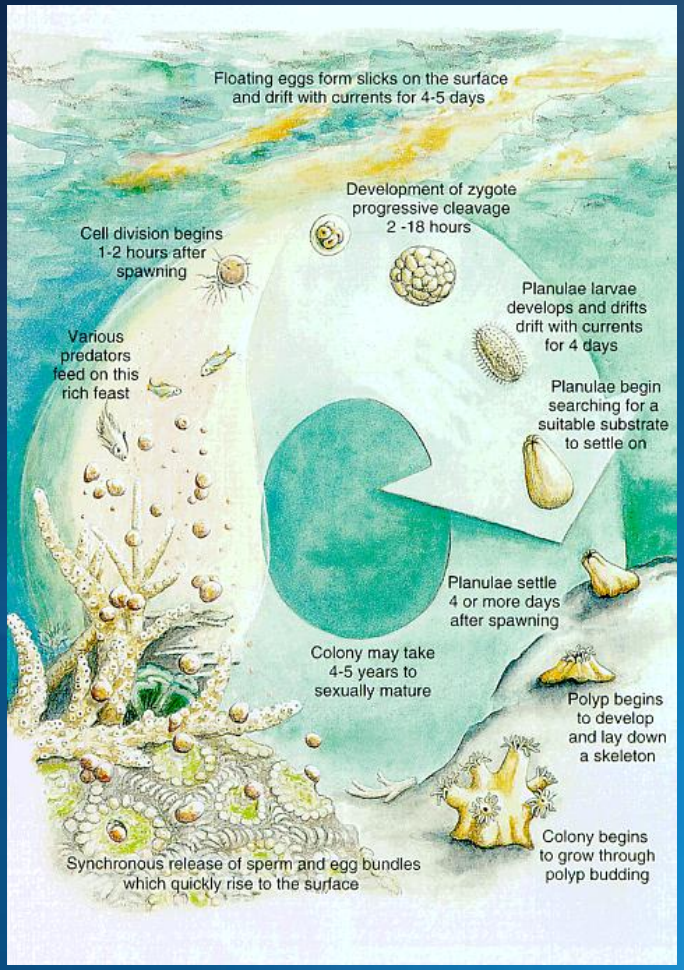
Yasuda M (2009) Introduction to Oceanography: OCEA 112(3767)-Fall 2009, Lecture Note Summary; Lecture resources – Oceanography; 2. Plate techonics; E. Notes and diagrams; 11. Darwin's problem – seafloor sinking. Available online at: http://earthguide.ucsd.edu/team/yasuda/oceanography/tectonics/atolldarwin.jpg

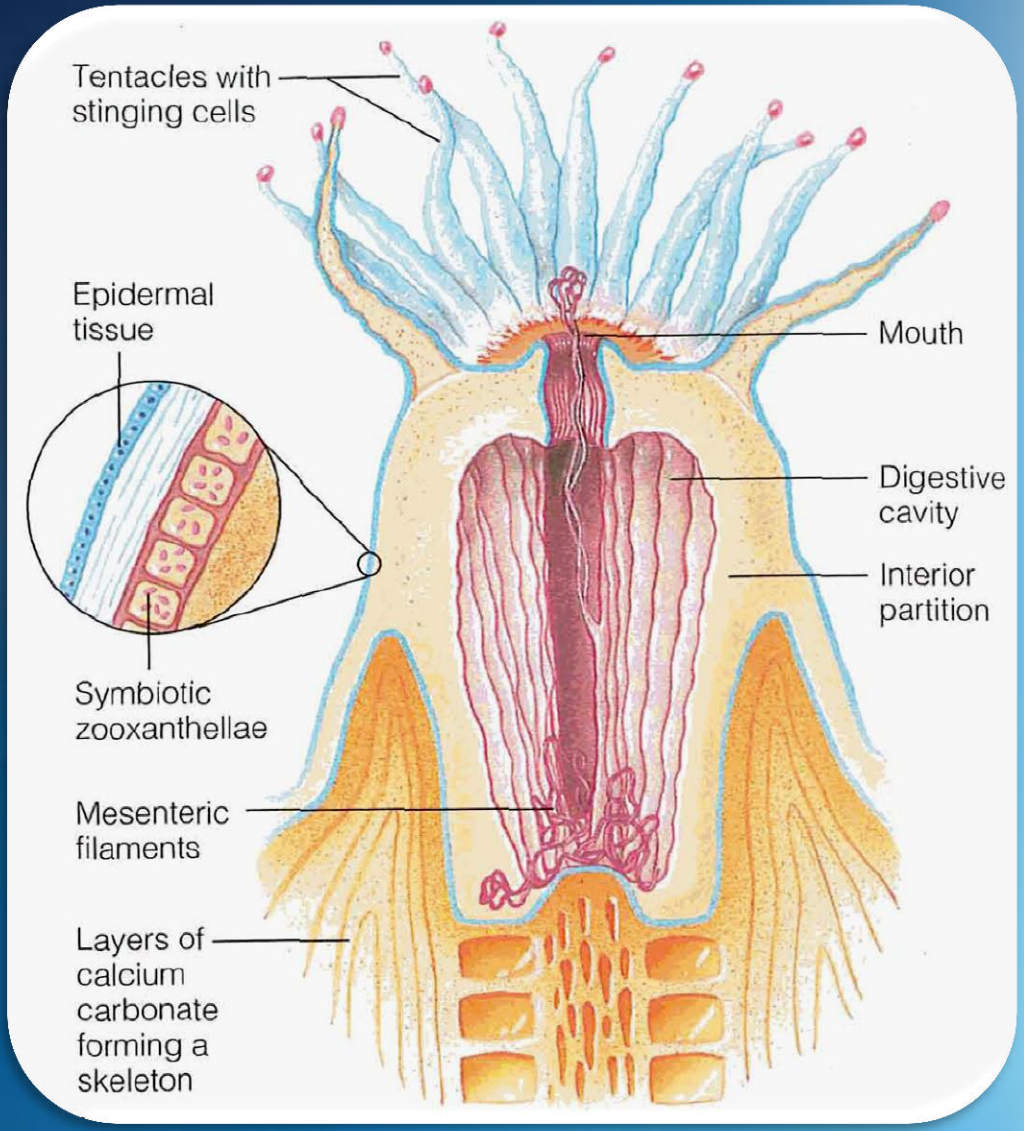


(Madl 2005; Fig. 2.3)


Floating eggs form slicks on the surface and drift with currents for 4-5 days
Development of zygote progressive cleavage 2 -18 hours
Cell division begins 1-2 hours after spawning
Planulae larvae develops and drifts drift with currents for 4 days
Various predators feed on this rich feast
Planulae begin searching for a suitable substrate to settle on
Planulae settle 4 or more days after spawning
Colony may take 4-5 years to sexually mature
Polyp begins to develop and lay down a skeleton
Colony begins to grow through polyp budding
Synchronous release of sperm and egg bundles which quickly rise to the surface

Biological Context of Reefs

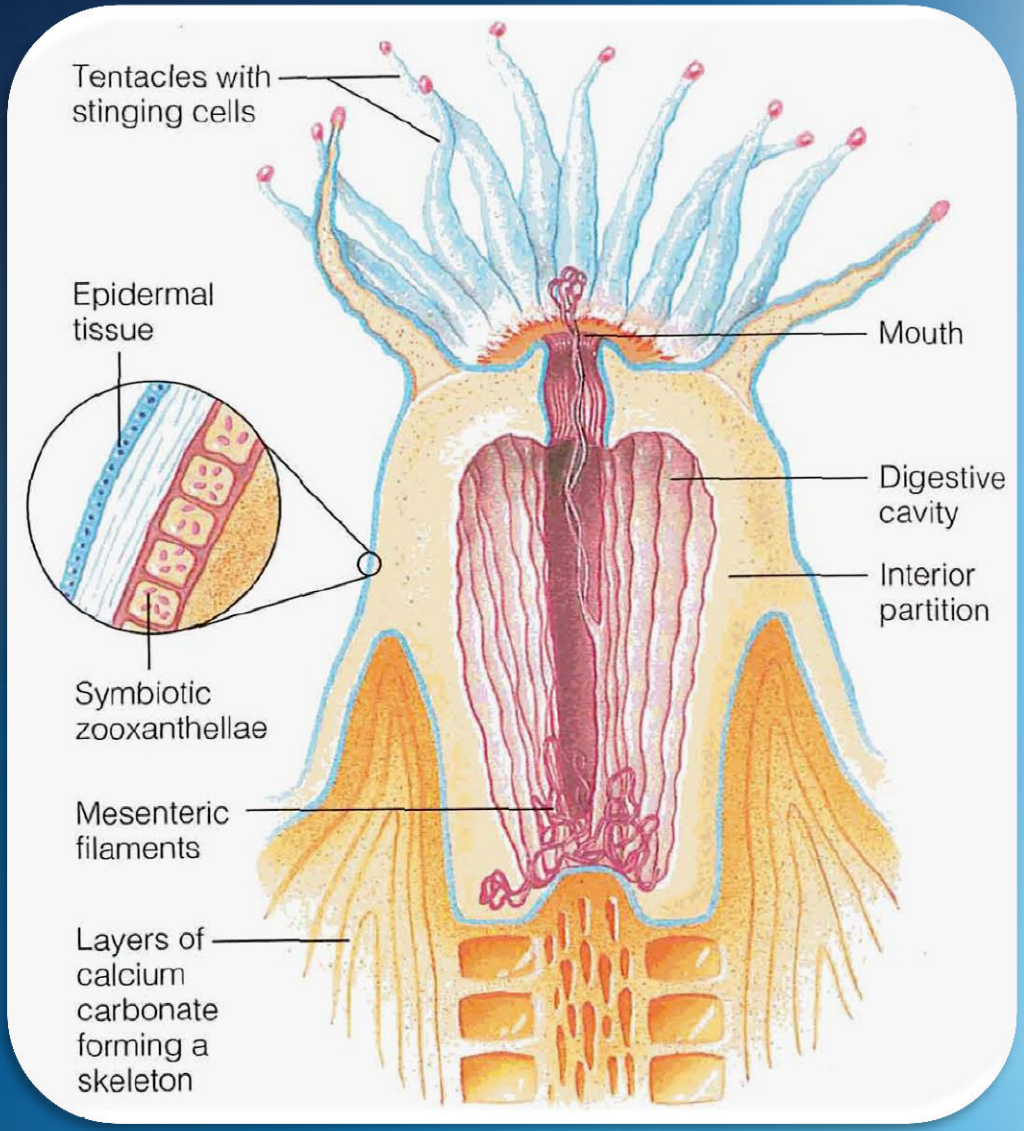
Basic Coral Biology



(Taken from Garrison 2007; Fig. 15.6; p. 412)

Biological Context of Reefs

Basic Coral Biology



(Taken from Garrison 2007; Fig. 15.6; p. 412)

Coral Stressors

Temperature

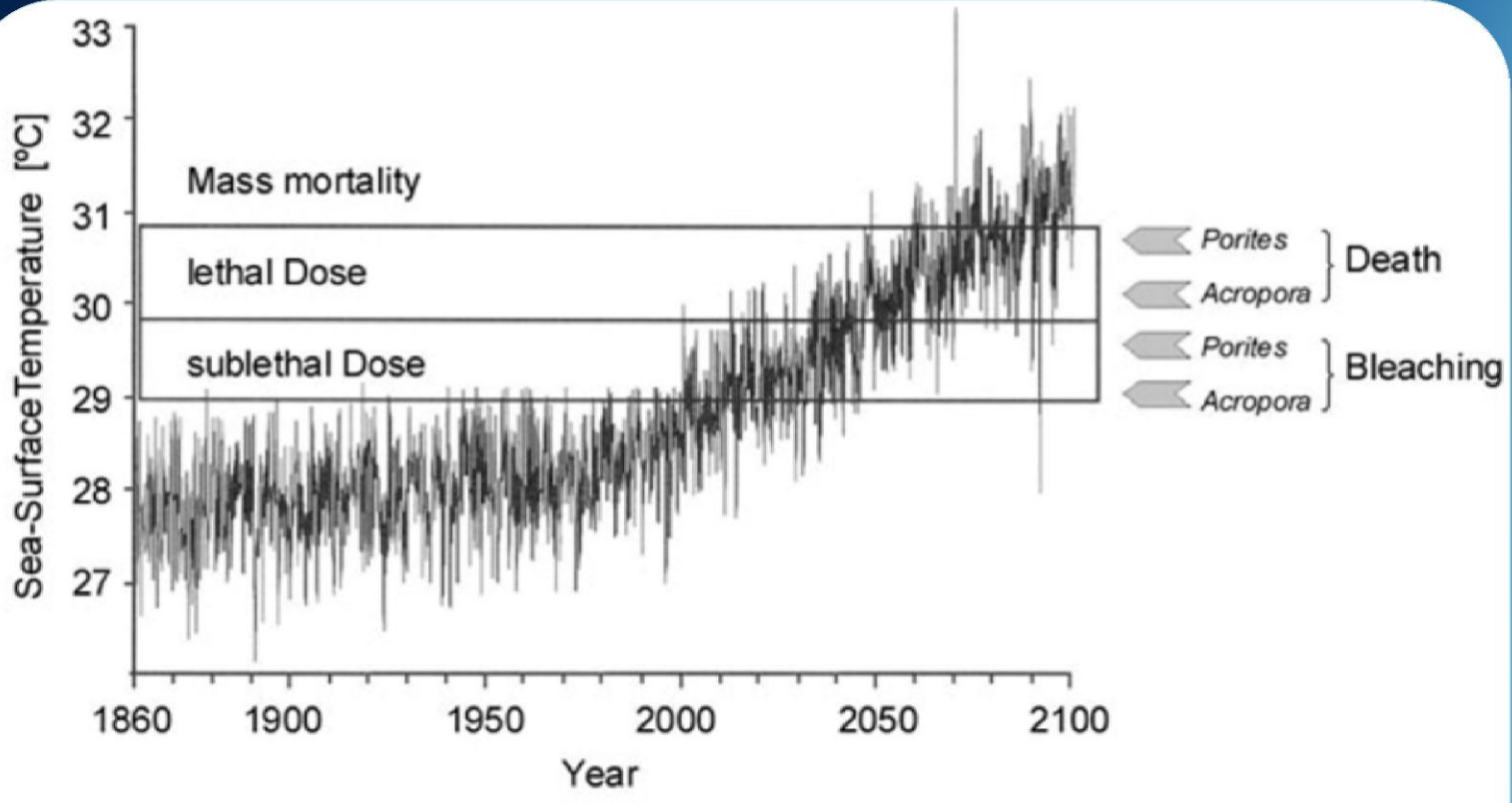


Fig.3.12b: Computed predictions of differences in bleaching and mortality tolerances among species plotted against a gradual increase in sea-surface temperature (ECHAM4/OPC3 based on the atmospheric-ocean coupled ICE-Model of the Max Planck Institute). The bandwidth in tolerance for both sub- and lethal thresholds are species dependent with Acroppora-species being more susceptible than species of Porites. The predictions cover a temporal window of 240 years (1860-2100) and include the effects of ENSO (El-Niño, Southern Oscillation) to match with the IPCC 1992 scenario.

Hoegh-Guldberg, 2004

(Madl 2005; Fig. 3.12b)