Unique Ecosystems of the Oceans

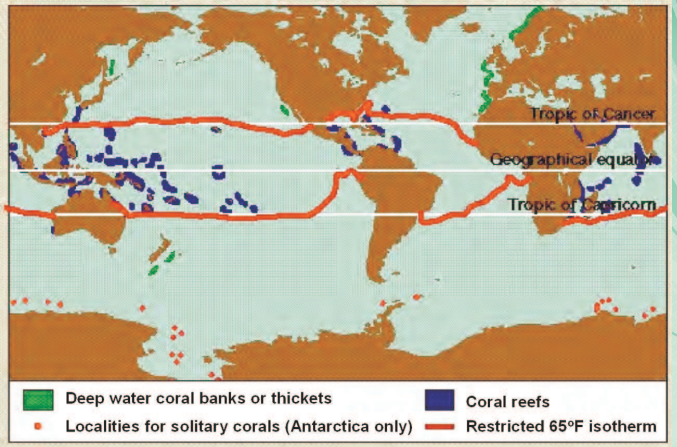
The "Uniquosystems" of Coral Reefs and Hydrothermal Vents

Coral reefs

- Coral reefs develop in **warm** (>18°C or 65°F), **clear waters** of normal to slightly elevated salinity (~35-38 ‰).
- Water clarity due to little terrigenous sediment input (mud) from river runoff, and **scarce dissolved nutrients** to support phytoplankton biomass.

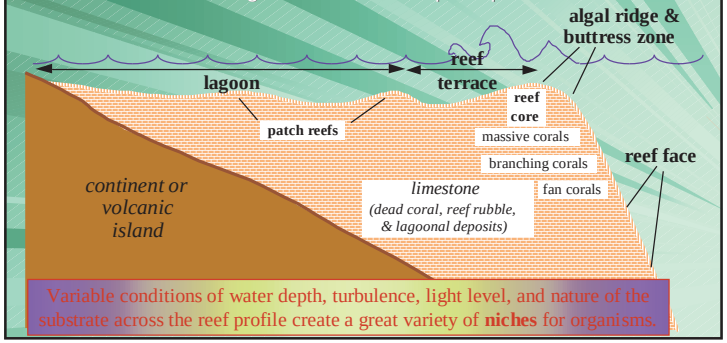
Most coral reef organisms are **stenohaline** & **stenothermal**

Global Distribution of Coral Reefs

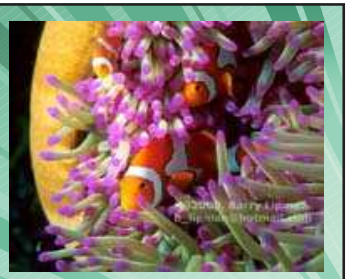


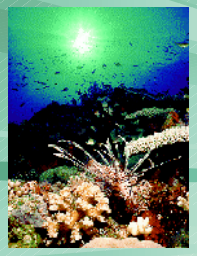
Coral reef structure

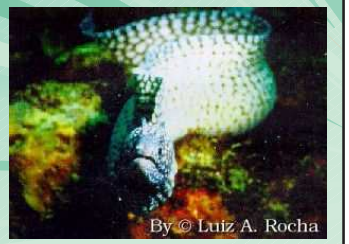
- **Corals reefs** = rigid structures of calcium carbonate ($CaCO_3$) built by colonial corals and calcareous algae.
- These wave resistant structures **support biologically diverse communities** of organisms in the tropical photic zone.



Variable conditions of water depth, turbulence, light level, and nature of the substrate across the reef profile create a great variety of **niches** for organisms.







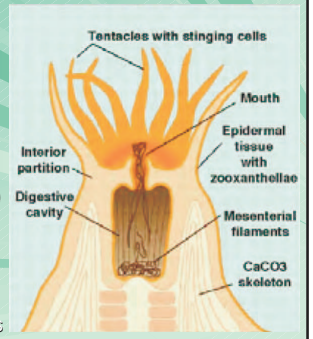
Rainforests of the sea

- coral reefs, like tropical rainforests, are among most **biologically diverse ecosystems** on the planet, and like the rainforests, coral reefs are **highly productive**, despite limited availability of nutrients
- both ecosystems are **highly efficient at recycling nutrients** and capitalizing on **symbiotic relationships** at all levels of the intricate food webs
- ***symbiosis*** = *intimate co-existence of two different organisms, or the dependence of one organism on another*
- symbioses are common in reef ecosystems

  for example:
  - clown fish & anemone, cleaner fish & moray eel, remora fish & shark
  - microscopic algae (dinoflagellate protists called *zooxanthellae*) live in the tissues of coral polyps

Coral polyps & zooxanthellae

- living part of reef just a thin veneer on the surface
- a mutualistic, or symbiotic, relationship
  - polyps – the coral *animals*
    - corallite – $CaCO_3$ exoskeleton formed by the polyp
    - feed (respire) at night
    - give off CO_2 and nutrients (waste)
    - provide protection and nutrients for zooxanthellae
  - zooxanthellae – microscopic dinoflagellates (algae, or *plants*)
    - photosynthesize during the day
    - produce O_2 and use up wastes
    - represent up to 75% of total tissue weight of polyp
    - provide food and oxygen for polyps

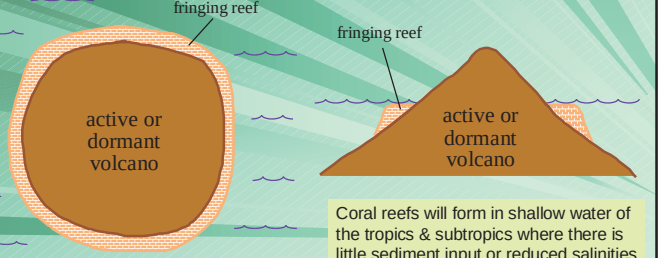


Another symbiotic relationship

Stage 1 – fringing reef

Map View

Profile

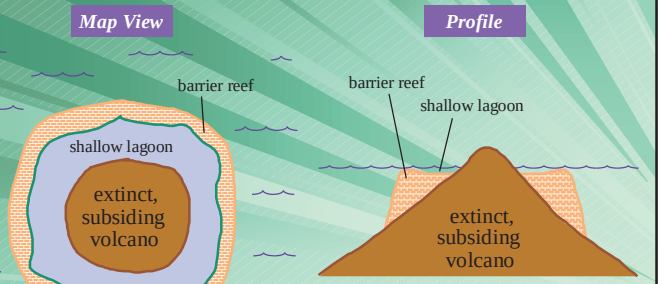


Coral reefs will form in shallow water of the tropics & subtropics where there is little sediment input or reduced salinities from river runoff.

Stage 2 – barrier reef

Map View

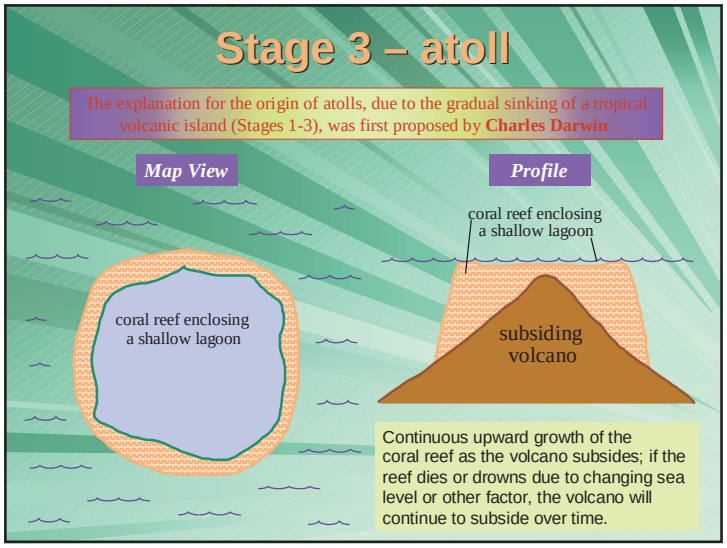
Profile



hard, resistant coral reef framework grows nearly to sea level and drops off abruptly to the adjacent seafloor

Stage 3 – atoll

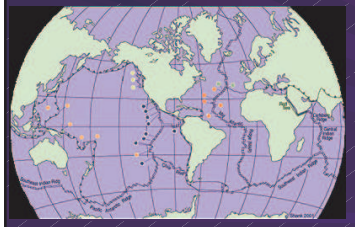
The explanation for the origin of atolls, due to the gradual sinking of a tropical volcanic island (Stages 1-3), was first proposed by **Charles Darwin**.



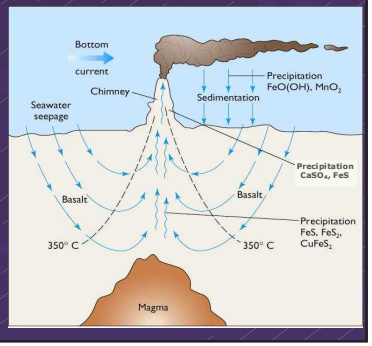
Continuous upward growth of the coral reef as the volcano subsides; if the reef dies or drowns due to changing sea level or other factor, the volcano will continue to subside over time.

Hydrothermal vent systems

- volcanic vent communities discovered along sea-floor spreading ridges
- beginning in late 1970's
- recently found in the Arctic
- studied, sampled with ***Alvin***
- seawater **heated by magma** rises and leaches metal from the basalts
- sulfide and sulfate minerals precipitate to form chimneys called **black smokers** on the sea floor



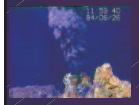
Map showing the global distribution of major hydrothermal vent sites. Colored circles show vents with similar animal communities.
http://www.divediscover.whoi.edu/hottopics/biogeo.html

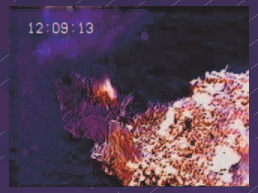


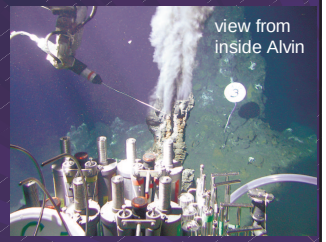
Hydrothermal vent communities

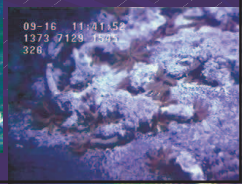
- base of the food webs in biological vent communities consists of **chemosynthesizing bacteria**
  - obtain energy to manufacture food (CH_2O) by oxidizing hydrogen sulfide (H_2S) gas:
  - $CO_2 + O_2 + 4(H_2S) \rightarrow CH_2O + 4S + 3(H_2O)$
    compare to photosynthesis:
  - $CO_2 + H_2O + (\text{inorganic nutrients} + \text{solar radiation}) \rightarrow CH_2O + O_2$
- chemosynthethic bacteria support diverse set of macrofauna that thrive around hydrothermal vents
  - large clams
  - tube worms
  - spider crabs
  - shrimp
  - fish

Hydrothermal vents in action



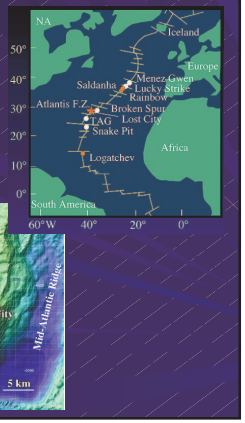






The Lost City – A new type of vent field

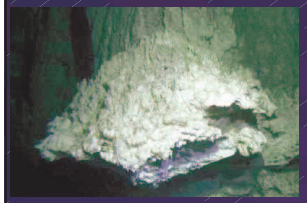
- on 4 Dec 2000, scientists onboard the *R/V Atlantis* discovered a new hydrothermal vent field in the Atlantic
  - located at 30°N, 15 km west of the Mid-Atlantic Ridge
  - on an undersea mountain called the "Atlantis massif"
    - formed by faulting and uplift between Mid-Atlantic Ridge and Atlantis Fracture Zone
    - taller than Mt. Rainier
    - consists of old (1.5 Ma), mantle-like rocks at top
- wonderful example of serendipity in science
- may hold clues to earliest life on Earth



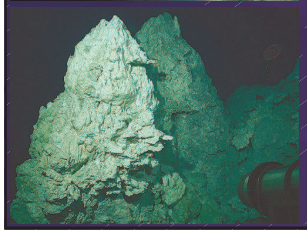
The Lost City – A new type of vent field

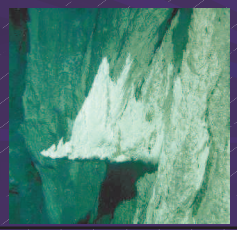
- The Lost City is ***unique***, vastly different from any other vent field previously discovered on Earth
  - chimneys made entirely of $CaCO_3$ (vs. metal sulfides)
  - chimneys taller, can reach max. ~180 ft (vs. ~80 ft.)
  - sits atop mantle-like rocks (vs. volcanic rocks)
    - peridotites, mostly olivine (vs. basalt)
    - reacts with seawater to form serpentine – **"serpentinization"**
  - heat generated during serpentinization drives hydrothermal water circulation (vs. heating from magma driving it)
    - water venting out is ~ 40-75°C or ~105-170°F (vs. ~ 350°C or ~700°F)
    - tends to *seep* out gently at vent sites (vs. *spewing* out rapidly)
  - surrounding water is basic, pH = ~9-10 (vs. acidic, pH = ~2-5)
    - allows precipitation of $CaCO_3$ (vs. metal sulfides)
    - supports microbial community but very few macrofauna (vs. abundant macrofauna)
- There may be others though!
  - three similar mountains within a 60-mile radius of Lost City
  - other possible sites along slow-spreading sections of ridges in the mid-Atlantic, Indian Ocean, and Arctic

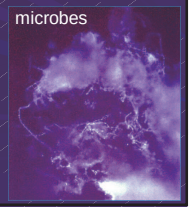
The Lost City – A new type of vent field



thin section of Lost City $CaCO_3$







The Yeti Crab – A new type of vent critter

- discovered March 2005 by scientists using *Alvin*
  - in South Pacific, along Pacific-Antarctic Ridge
  - found near hydrothermal vents
- dubbed *Kiwa hirsuta* (meaning hairy guardian of the sea)
  - a decapod
  - ~15 cm (~6 in) long
  - unique – new genus
  - not well-understood
    - purpose of setae (hair)?
    - apparently blind
    - houses filamentous bacteria in its pincers – why?
  - ***please*** *don't ever eat one*!