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Week Thirteen Oceanography Notes
December 3rd to December 7th

Class December 3rd
Coastal Ecosystems and Coral Reefs

- Coastal Ecosystems
  - Abundance of life
  - Ecosystem services
  - Proximity to humans
  - 16/23 megacities are coastal: big human footprint, cities rely on coastal ecosystems. We need them: they stop storm surges, decrease erosion
- Lots of primary production
  - Shallow, well-mixed
  - Species diversity
  - Respiration
    - Remineralizing, refuel and release of nutrients
- Dynamic Spatial Gradient
  - Rapid changes over space
  - Salinity
  - Temperature
  - Light
  - Nutrients
  - Diverse Sediment
  - Water Levels/ Tides
  - Really productive, high biodiversity
- Different Types of Coastal Ecosystem
  - Sub-tidal, Underwater (for the most part)
    - Coral reefs
    - Seagrass meadows
    - Kelp forests
  - Intertidal Habitats
    - Mangroves (tropical)
    - Salt Marshes (temperate)
    - Estuaries
- What is a Coral? (It's an animal)
  - Cnidarian (same phylum as a jellyfish)
  - Colonial organisms: Many Individual polyps (very small) make up an enormous colony
  - Produce $CaCO_3$, making stony, hard part of coral reef underneath them
- Reefs
  - Warm water (between 30 degrees N and 30 degrees S → band around the center of the globe)
  - Fully saline, near 33ppt

    - Shallow
    - Hard substrate
    - Very limited exposure to air
    - clean, clear water with low sediment supply
- Sediment supply increase harmful to coral (think of how much dirt would be mixed up if you cut down a mangrove)
- Coral Anatomy
    - Stomach and mouth surrounded by tentacles (which can be used for defence, stinging cells called a nematocyst -- not all sting humans)
    - Nematocyst
        - In tentacles (outer tissue)
        - Potentially used to capture prey
        - Capture organic particles in mucus
    - Food goes in (and out) of mouth
    - Feed mostly at night
- Symbiotic algae called Zooxanthellae give corals their color
- Mutualistic relationship with phytoplankton
    - Algae live inside the tissue and photosynthesizes giving a source of food to corals
    - Also helps process waste
    - Coral gives algae a home and safety and more nutrients, algae give coral food
    - Tropical systems have lower nutrient availability so this is big for algae
    - VERY efficient, tight recyclers, 90% of organic matter is given back to the coral. You don't find this level of efficiency very often.
- Massive Reef structures all made of $CaCO_3$
    - Corals can grow up and up and make layers of calcium carbonate underneath
    - BUT They are slow growers: 2mm-10cm a year. They can't grow back very quickly.
- Corals can have a super long life in untouched or undisturbed (ugh humans)
- Both asexual and sexual reproduction
    - Sexual provides further genetic diversity and adaptation
    - Sexually reproduce every 7-10 years
    - Broadcast spawning or Brooding
    - Asexual: boosts size of colony, can be achieved through fragmentation
- Most coral are hermaphroditic (about 75%), meaning they produce both male and female gametes
- Spawn once a year, based on cues (full moon and sunset, pheromones)
- Synchronized spawning: larva and planula will float around for awhile, suspended in the water column
- About 80% of coral in the Caribbean has been destroyed in the last thirty years (save the planet)
- Brooding
    - Internal fertilization

    - ¼ of species (less common)
    - Coral release larvae (not eggs or sperm)
    - Extended season
- Types of Coral
    - Branching
    - Tabletop
    - Pillar
    - Folaise
    - Encrusting
    - Massive
    - Mushroom
    - Elkhorn
- Off the East Coast of the US, there is Deep Sea Coral that lacks zooxanthellae
- Organisms on Coral Reefs (hint: there are a lot of them and you should do everything in your power to save coral)
    - Mobile invertebrates
        - Crustaceans
        - Echinoderms
        - Polychaetes
        - Mullusks
    - Sessile invertebrates
        - Corals themselves
        - Sponges
    - Cone Snails
    - Algae
    - FISH
- Coral Reefs have the highest biodiversity of any ecosystem.
- **25% of ocean species rely on coral. Please read that again.**
- Coral Bleaching
    - If a coral experiences water temperatures that are too hot they will expel their zooxanthellae and will be sick and far, far less productive for a time before they eventually die.

Class December 5th, 2018

Mangroves and Salt Marshes

- Coastal Wetlands
    - Mangroves (equatorial)
    - Salt marshes (temperate)
    - Some arctic and subpolar salt marshes
- Intertidal zone
- Mangroves are **forests**
    - Can only exist in salt water
    - Specially adapted

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- Salt marshes are grasslands
    - Halophytes: love salt
- Red Mangroves
    - “Prop” root system
    - Roots contain a waxy substance that keeps salt out
    - ~25m in height
    - Barriers: prevent erosion, slow the impact from waves
    - Trap sediment
    - Can handle fully saline conditions
- Black Mangroves
    - Roots have pneumatophores or snorkels that reach up above the water for fresh oxygen
    - No prop roots, live in waterlogged conditions
    - Trap oxygen for oxygen-starved roots
    - 20-25m high
    - Isolated groups
- White mangroves
    - Shortest
    - About 5m high
    - Closest inland
    - No prop roots
    - Doesn’t like complete inundation
    - Releases salt through glands onto leaves, leaves will be coated in salt crystals
- Many creatures rely on mangroves
- Complex food webs (complicated graphic in lecture slides)
- Mangrove leaves: food? yes, plus they have toxins in them, adaptation to predation
- Importance of flooding and ebbing tides in coastal or mangrove ecosystems
- Mangroves are great habitats, but they are also important because they are
    - Nurseries
    - Filter water
    - Protect from storms
    - CARBON SINKS
- SERIOUS carbon sink, most productive forest on earth as far as carbon fixation goes
- Watched a video about the Great Marsh (Massachusetts), subject to erosion, hotspots, human effects of mosquito control which the marsh can’t recover from
- Dynamic Salt Marshes
    - Maintain ability to keep pace with Sea Level rise
    - Grow, trap sediment, decompose
    - Naturally balance themselves
    - Ebb and flow of tides
- Sea level rise
    - Risen over the last 18k years by 100m
    - Humans impact this greatly, especially in the last 2 decades (boooo!)

    - Sea level refers to the relation of the ocean to a stationary surface reference point
    - There is **Eustatic Sea Level,** which is climate-driven
    - And then there is **Isostatic Sea Level,** which is local
    - Since the 1990s, sea level has been rising about 3.5mm per year
    - Sea level trends vary around the globe
        - Since Louisiana is sinking, sea level rise is much stronger there
    - TWO dominant reasons for sea level rise
        - Thermal Expansion ( greater than 50% attributed to this) -- the warming of the ocean has caused the molecules within it to grow further apart and as they expand, so does the ocean
        - Melting of Glaciers and Ice Caps→ this one you're changing the volume of the ocean, adding more water
- Salt marshes are constantly balancing erosion and decomposition and sediment deposition and primary production, which allows them to keep pace with sea level rise.

Class December 7, 2018
Bigfoot: Nitrogen, the Ocean, and You

Nitrogen

- Nitrogen is essential for life. Without Nitrogen, there is nothing.
- You need it for diet, muscles, DNA, Amino Acids
- Humans are 3% Nitrogen by weight, about the weight of your neck.
- Humans get nitrogen from food: corn, burgers, cupcakes, falfel, etc., then they excrete it and it goes into the ocean. This has a huge impact, or a **Nitrogen Conundrum.**
- There are two types of nitrogen.
    - Biologically Usable, Reactive Nitrogen (Nr). This is Ammonia ($NH_4^+$), Nitrate($NO_3^-$), and Nitrite ($NO_2^-$)
    - Biologically Unusable, Unreactive Nitrogen, or $N_2$, Dinitrogen gas.
- Most organisms cannot use $N_2$.
- Some CAN take $N_2$ and turn it into $NH_4^+$, this is peanuts, peas, and trichodesmium. They fix Nitrogen.
- Malthusian Catastrophe
    - Malthus- hypothesizes that the carrying capacity of the Earth was going to be exceeded and thus we would not have enough people to feed.
    - For awhile, humans were very concerned that there was not going to be enough food to feed the growing global population
- Nitrogen is major limiting factor: Think back to Liebig and his law of the minimum
- Finding Sources of Nitrogen
    - Birds and their Guano
- Peru upwelling
    - Supporting phytoplankton, bringing nitrogen up from the bottom
    - "Buffet of the Ocean"

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- Upwelling (nutrient rich) → phytoplankton → Life → Zooplankton → Fish → Birds
- Birds: Coastal
    - Bird Guano (poop) appears in mountains full of nitrogen
    - Prime circumstances: good, protected habitat and perfect weather conditions makes bird guano pile up.
    - Humans mined it and very quickly depleted it (surprise)
- Deep water circulation is linked to physical processes here on Earth
- Humans need nitrogen to fertilize, all this nitrogen is coming from the ocean
- Guano: super valuable resource
- Humans take 600k tons of guano in 30 years
- The Wheat Problem
    - Haber-Bosch Process
        - Chemistry and Industrialization
        - Turning N2 into Ammonium
        - Learning to fix Nitrogen, one of the greatest invention a human has ever achieved
        - Made the Earth able to grow from 1.6billion people to 7 billion
        - About fifty percent of the global population is alive today because we can fix nitrogen
- However, once Nitrogen is in the environment, you can't really take it out. It cascades through the environment and the Haber Bosch Process has increased the Nitrogen Cycle by 1300%
- Too much Nitrogen causes a lot of problems
- Also, Nitrogen in farm fertilizer is not that efficient of a process. In the end, about 14% of Nitrogen is consumed, the rest goes into the ocean.
- Negative Consequences of too much N in Marine waters
    - Algal blooms and excess nutrients
    - Hypoxia
    - Aphotic conditions
    - Eutrophication
    - Oxygen suck
    - Dead zones
    - Algal mats
    - Fish kills
    - Loss of biodiversity
- Seagrasses and Oxygen
    - Human impact: putting DINr into the ocean
    - Grows more phytoplankton
    - Organic matter falls to the bottom and makes hypoxia or anoxia
- How do we feed a growing population without harming the ocean?
    - Eat vegetarian
    - Reduce your fossil fuel use
    - You can calculate your Nitrogen Footprint at www.n-print.org