Marine Ecosystems

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High Productivity Marine Environments

- **Coastal ecosystems are highly productive ecosystems for several reasons:**
  - 1. Benefit from nutrient-rich runoff from land.
  - 2. Being shallow, the benthic organisms in these ecosystems live in the upper photic zone, instead of the bottom as in the open sea.
  - 3. Salt-tolerant plants can grow in the well-lit shallows, providing shelter.
  - 4. These plants act as the foundation for several different types of ecosystems that cannot exist in the open ocean.
- A combination of nutrients, ample light, and shelter make coastal ecosystems diverse and rich.
- Human activities have wide-ranging potential effects on coastal ecosystems.
  - Because people live near water, this means that *many* of our activities potentially affect coastal ecosystems. **We can't always anticipate consequences to the ecosystems**. Two examples are agricultural fertilizer and pollutants.
- **Eutrophication** is an overabundance of nutrients that causes an ecological imbalance. It is a stimulus to some species and a detriment to others. Red tides are caused by eutrophication.

Estuaries video

- **Factors that limit productivity are**:
  - Organisms in the ecosystem must tolerate wide salinity ranges.
  - Variations in salinity tend to reduce the variety of species to only euryhaline.
  - Osmotic stress caused by tides mixing with fresh water is fatal to many organisms.
  - The tendency of decomposition to deplete the oxygen level.
- Estuaries serve as nurseries for **more than 75%** of the commercial fish species.
- **Estuaries contribute to the productivity of adjacent marine ecosystems**:
  - 1. By providing surviving juvenile species with shelter for them to mature. By increasing the number of individuals that survive the hazardous larval and juvenile stages.
  - 2. By providing nutrients to adjacent ecosystems while trapping sediment and other materials in runoff from rain and storms. By reducing eutrophication and other runoff damage were the runoff to reach the open sea.

NOAA/National Estuarince Research Reserve Collection

Where river meets sea

NOAA/National Estuarine Research Reserve Collection

Where river meets sea

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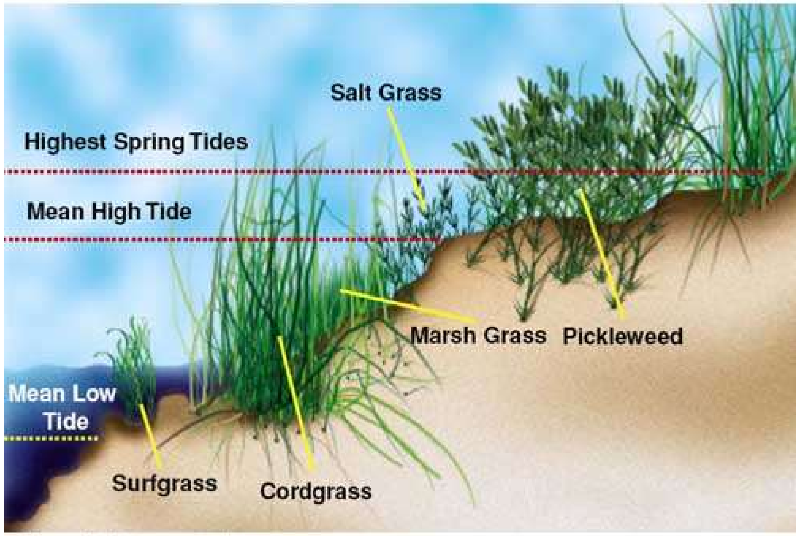
Salt Marshes

- Salt marshes exist in estuaries and along the coasts.
- The **upper marsh** includes the areas only **rarely flooded by the tides**.
- The **lower marsh** includes areas **flooded by salt water and a regular part of the tidal cycle**. Organisms living here must tolerate significantly more osmotic stress than species with niches in the upper marsh.
- **Halophytes** are plants that have adaptations that allow them to survive in salt water.
- **Lower marsh halophytes** deal with constant osmotic stress and have adaptations to deal with it. **Adaptations include**:
  - Pores in the leaves through which it breathes.
  - Concentrates salts in its roots.
  - Salt glands on leaves and stem.
- **Upper marsh halophytes** have much reduced osmotic stress. **Adaptations include**:
  - Sacrificial leaves.



Salt marsh plant community

Mangrove Swamps

- **Red mangroves** grow above the waterline on stilt-like roots allowing oxygen to get to the roots.
- **Black mangroves** have roots that grow in the sediment below the waterline. They aerate their roots with snorkel-like tubes that carry air from above to the roots.
- **White mangroves** lack special root adaptations. They are very saltwater tolerant, but thrive high on the tideline.
- **All species of mangroves share two important characteristics** that make them the basis of mangrove ecosystems.
  - First, strong, tangled roots that provide habitats for juvenile fish and invertebrates. This provides a nursery for nearby marine ecosystems, particularly coral reefs.
  - Second, due to size they hold the soil well, protecting the habitat and coast from erosion from storm surges, waves, and weather.

OAR/NURP/NOAA

Red mangroves

NOAA Restoration Center

Black mangroves

NOAA National Estuarine Research Reserve Collection

White mangroves

Seagrasses video

- **Seagrasses differ from other halophytes in several ways**:
  - They are the only plants, living entirely underwater except during rare, very low tides.
  - They have no means of extracting fresh water from seawater.
  - They extract oxygen from the seawater and have internal air canals.
  - They do not need to have a freshwater source because they have an internal salinity the same as seawater.
  - They reproduce by releasing pollen into the water, much like land-based plants release pollen into the wind.

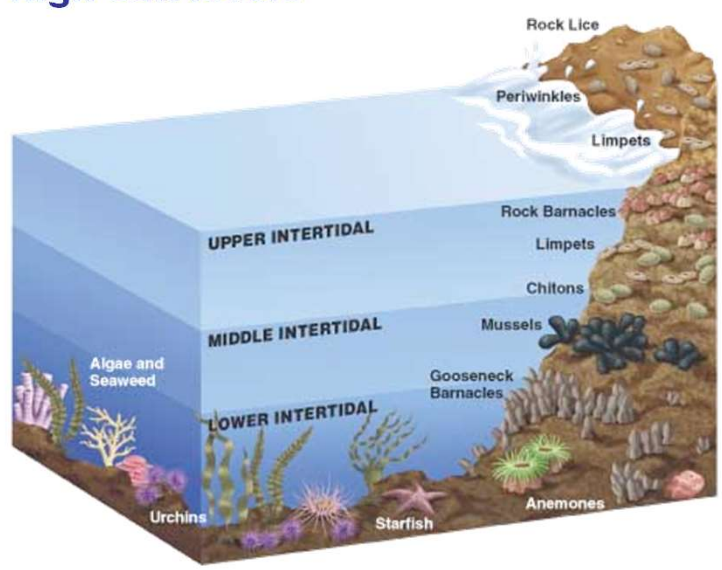
Heather Dine/Florida Keys National Marine Sanctuary/NOAA

Seagrasses

- **They differ from other halophyte-based ecosystems because**:
  - They do not need to have a freshwater source and they can exist in deep water.
  - They are edible and provide food for ecosystem inhabitants like microbes, invertebrates, fish, turtles, manatees, and dugongs.

Intertidal Zones

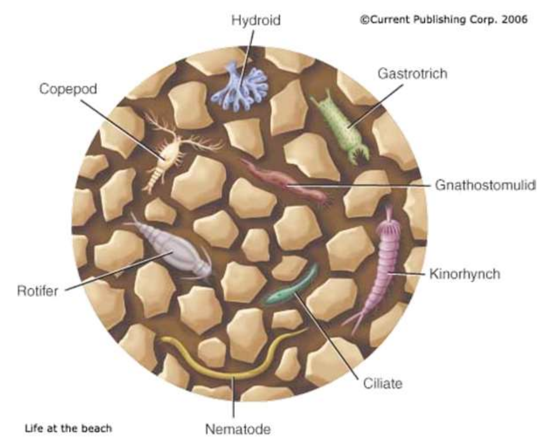
- Ecosystems in the intertidal zones exist in areas that may be above the waterline at times. Other portions reach depths of 10 meters (32.8 feet).
- The **supralittoral zone** is the area only submerged during the highest tides.
  - The greatest challenges facing organisms that live in this zone are **drying out**, **thermal stress**, **and water motion**.
  - With the constant spray of seawater evaporating, **high salt levels** can also be a problem.
- The **littoral zone** is the area between high and low tide.
  - The organisms here must also deal with **drying out, thermal stress**, **and water motion**.
  - With ample water nutrients, and sunlight, this is a highly productive region. One challenge to life here, therefore is **massive competition**.



Rocky shore community

Beaches

- **Beaches** are rich and productive ecosystems; they have important roles that affect other marine ecosystems.
  - The first way beaches affect the ecosystem is **the sand protects the coastline by reducing sedimentation caused by coastal erosion**.
    - Complex organisms, (worms, mollusks, and fish) live in the submerged beach sand. Algae and nonanimal organisms live among the sand grains.
  - The second way beaches affect other marine ecosystems is the **interaction between water motion and the meiofauna**.
    - The *meiofauna* – benthic organisms – live in the spaces between sand grains.
    - The physical and organic process in the beach ecosystem break down organic and inorganic materials making the beach a giant filter that processes compounds from runoff to the sea or washed up from the sea.



Kelp and Seaweed Ecosystems

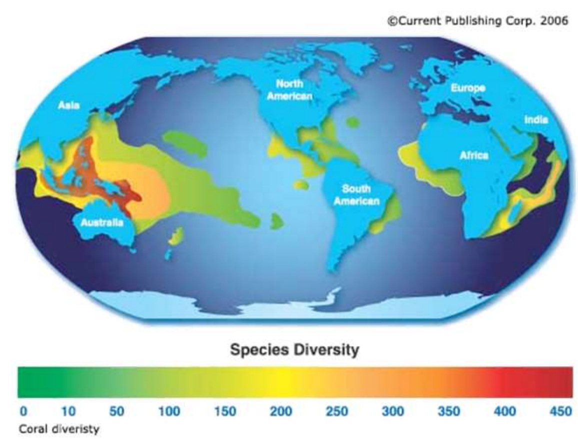
- **Kelp** provides a clear example of why it is important to study ecology, not simply individual organisms. Until protected, in some areas the sea otter was hunted nearly to extinction. Amazingly, in these areas the kelp began to die off rapidly.
  - Few organisms eat kelp. The sea urchin is one that does. They especially like the rubbery holdfast that anchor the kelp.
  - The sea urchin is one of the sea otter's primary foods and the sea otter eats a substantial number of sea urchins.
  - **Killing the sea otters disrupted the kelp forest's ecological balance by removing the sea urchin's chief predator**.
  - This allowed the sea urchin population to rise relatively unchecked. More urchins meant more grazing on kelp holdfasts.
  - In the end, the sea urchins ate the kelp faster than it could grow.

Commander John Bortniak, NOAA Corps.

Upsetting the balance

Coral Reefs

- **Coral reefs** are the **most taxonomically diverse of all ecosystems** on Earth. While diverse, they are also fragile.
- The conditions coral requires for life are narrow and specific:
  - Clear water; dinoflagellates coexisting in the polyps need light for photosynthesis.
  - Water that's in moderate motion as **this prevents sediments from accumulating on polyps**.
  - Water that is relatively free of nutrients. Lack of nutrients actually protect coral from other organisms. With too many nutrients, algae grows displacing coral and plankton grows reducing water clarity and the amount of sunlight. When a body of water is choked by plant life it is called **eutrophication**.
- **Threats to coral reefs include**:
  - Eutrophication levels have been rising over the last several decades.
  - Thermal stress also threatens coral reef ecosystems.
  - Coastal dredging and construction cause sediment to accumulate on the polyps faster than water motion can remove it.
  - Coral diseases are more common.



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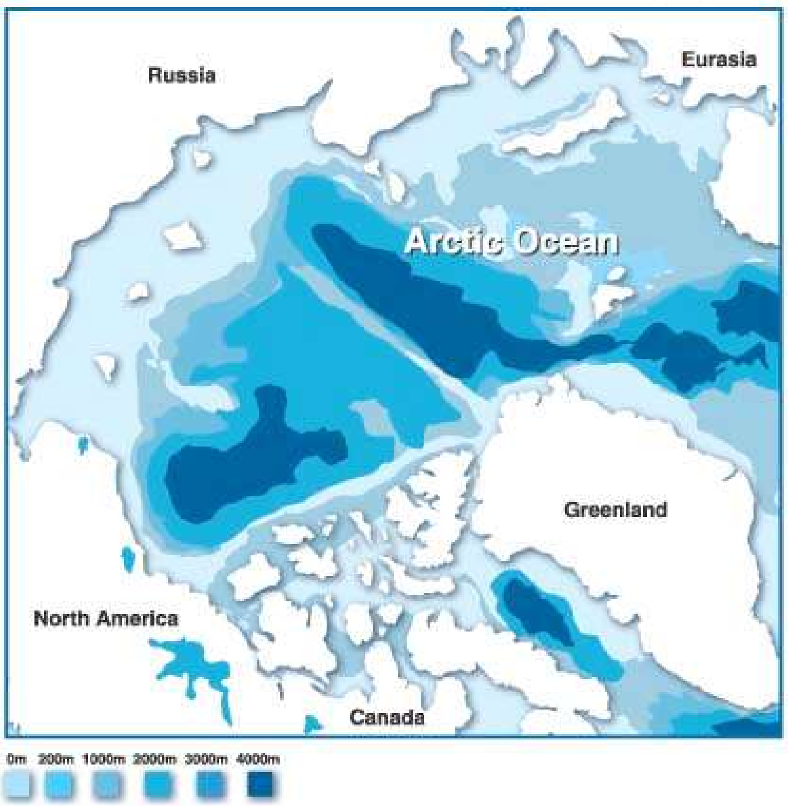
The Arctic



The Arctic Ocean

- For the following reasons life is relatively scarce under the ice cap.
  - Marine ecosystems in the **Arctic** face the challenges of **reduced sunlight under the ice and water that's barely above freezing**.
  - Much of this sea is a **permanently frozen ice cap on top** of the Earth.
- **At the edge of the cap**, life intensifies during the warmer months. As the sun melts ice in the **spring**, water flows off the ice, sinking into deep water. Warm currents from the south interact with the cold water and that churns up nutrients from the shelf bottom.
- **Extremely high productivity occurs along an arc in the North Pacific and across the North Atlantic from April to August**. Massive fisheries, marine mammals and other organisms take advantage of the nutrients.

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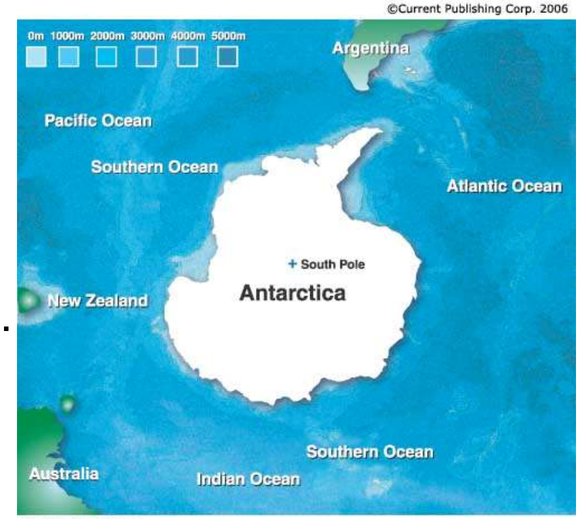
The Antarctic



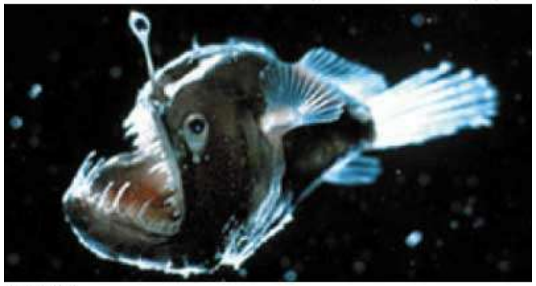
The Southern Ocean

- **Antarctica** is a continent, not a frozen sea, and it has it's own continental shelf.
  - Antarctic winters have widespread freezing and the continent almost doubles in size as the ice sheet expands.
  - When summer comes, **the melting of this sheet sets off an explosion of bioproductivity**.
  - Cold melt water sinks. This downwelling results in an upwelling from the deep ocean.
- **The nutrient-rich water reaches the surface at the Antarctic Divergence, located at 65° to 70° south latitude. This area extends northward to an area called the Antarctic Convergence located at about 50° to 60° south latitude**.
- This is the largest nutrient-rich area on Earth.
  - There are massive phytoplankton blooms from November through the southern summer. The copepod and krill populations are larger than any other species population found in any other ecosystem. The krill swarms have been estimated as exceeding 100 million tons!

The Abyssal Zone

- The abyssal zone covers about 30% of the Earth's surface.
- **Without sunlight, there's no photosynthesis**; consequently, there's no primary productivity in most of the deep ocean.
- **Marine snow** makes the deep ocean rich in nutrients.
  - Marine snow is the constant fall of sediment, dead organisms, fecal pellets, and other nutrients from the productive shallow water above.
- Without primary productivity the **abyssal zone** lacks dense life concentrations. However, there is a vast species diversity.
  - Without photosynthesis there are not many multicellular organisms. Those that do survive are primarily echinoderms, such as **sea cucumbers**, **sea lilies**, **and brittle stars**.
  - Submersibles have seen **rattails, deep-sea dogfishes**, **catsharks**, **crustaceans**, **mollusks and many species of deep-ocean fish**.
  - **The diversity is found in the meiofauna**. Representatives from almost all the animal phyla can be found living in the deep-ocean mud or sediment.

E. Widder/Courtesy Harbor Branch Oceanographic



Anglerfish

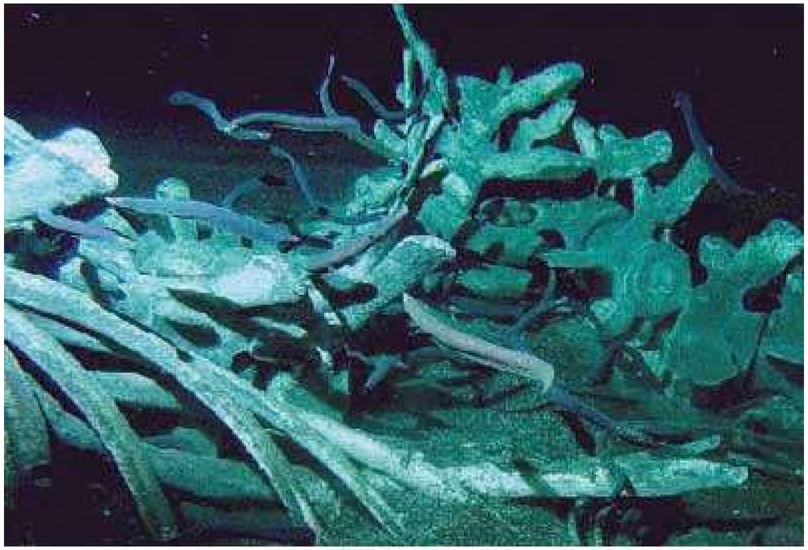
E. Widder/Courtesy of Harbor Branch Oceanographic

Viperfish

Whale Falls

- **A whale fall** is exactly what the name says – a place where a dead whale comes to rest on the deep-ocean floor.
  - Stages of whale fall ecosystems are:
    - 1. During the first stage the scavengers arrive. They consume the whale's soft tissues in a few months. Hagfish, grenadiers, deep-sea spider crabs and sleeper sharks are associated with this stage.
    - 2. Stage two lasts about a year. Worms, small crustaceans, and other small organisms feed on the remaining soft tissue and the tissue dispersed around the whale as detritus.
    - 3. The final stage involves the decay of the skeleton. This can last several years or even decades. The bones provide a steady supply of sulfide as they're broken down. Chemosynthetic bacteria live on this sulfide and in turn create a food source. These bacteria appear to be the same as those associated with hydrothermal vents.

NOAA Oceanexplorer

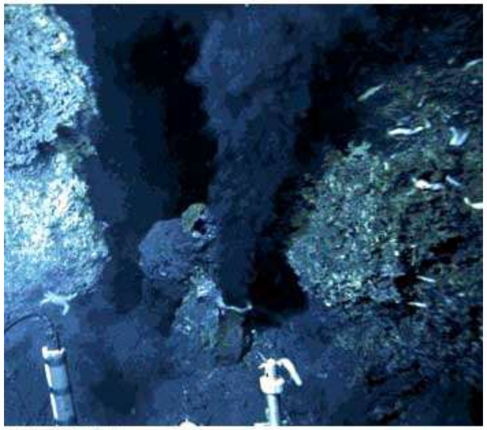


Whale fall in Santa Cruz basin (approx. 18 months)

Hydrothermal Vents and Cold Seeps

- **Hydrothermal vents** are sources of primary productivity. Chemosynthesizing bacteria consume sulfides dissolved in the heated water emerging from the vents. These bacteria act as the base of a trophic pyramid for a diverse community living in these deep-ocean ecosystems.
- **Cold seeps** are areas where hydrocarbons and sulfide-rich fluid seep from the underlying rock in the ocean floor. Heated by geothermal energy from inside the Earth. They are called "cold" seeps because they're cool compared to hydrothermal vents.

Courtesy of U.S. Geological Survey

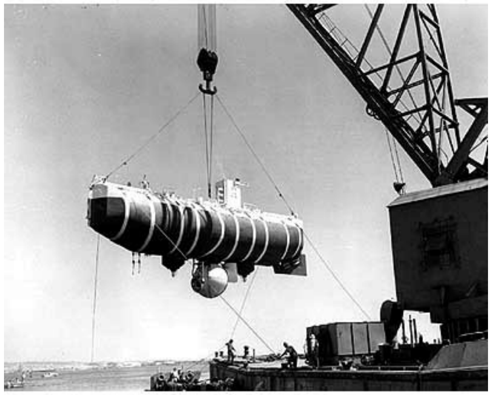


Life in the dark

The Hadal Depths – Ocean Trenches

- Scientists know little about the **hadal zone** ecosystems primarily because of **the limits of technology**. Depth and pressure make it expensive and difficult.
- Depths range from 5,000 to 6,000 meters (16,404 to 19,685 feet). Some spots are as deep as 11,000 meters (36,089 feet). Few submersibles exist that can go to these depths.

Courtesy of Space and Naval Warfare Systems Center in San Diego



Another small step for man

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