UNIT 1
SUSTAINING ECOSYSTEMS

Chapter 4

Sustaining Aquatic Ecosystems

Science 1206

Earth: The Blue Planet

- Water covers more than two thirds of our planet
- 97% of the water is saltwater
  - Which we cannot drink
- Oceans control weather systems and provide a constant supply of water through evaporation
- Freshwater is stored as snow and ice
  - Only 0.0005% is available to sustain human population

Aquatic Ecosystems: Introduction

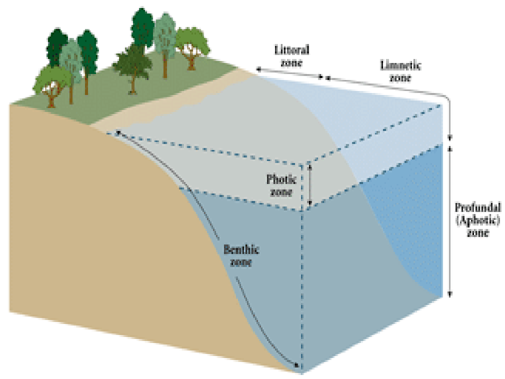
- Aquatic ecosystems are generally less productive than terrestrial ecosystems
  - They can support only a fraction of the organisms that can be found on land
  - Soil - 50kg biomass
  - Ocean – 5kg biomass
- Abiotic conditions are very different from those found on land

Abiotic Factors in Lakes

- There is considerable variation among aquatic ecosystems
- Swamps, lakes, ponds, marshes, rivers, and marine ecosystems all have distinct abiotic factors that require specific adaptations for those organisms that live there
- While on the surface all water may appear the same, below there are many differences
- Can you think of any abiotic factors that change in the water?
- Light levels, O_2 levels, temperature, available nutrients

Lake Structure

- Littoral Zone
  - Area extending out from the lakeshore to where rooted plants can no longer be found
  - Lilies and bulrushes
- Limnetic Zone
  - Area of the lake where there is enough light for photosynthesis to occur
  - Mostly occupied by plankton
- Profundal Zone
  - Area beneath the limnetic zone where there is insufficient light for photosynthesis
  - Main source of nutrients is detritus (decaying plant and animal remains)



See figure 1 on page 126 in textbook

Plankton

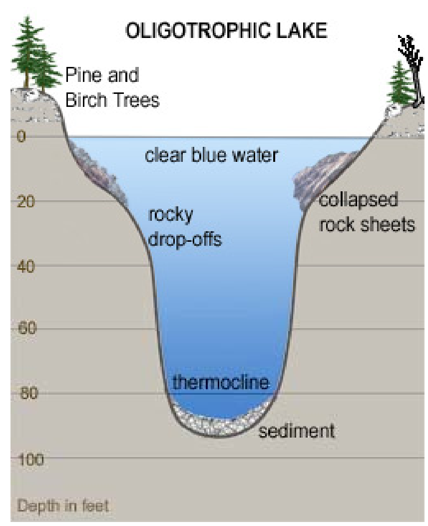
- Autotrophic and heterotrophic micro organisms
  - Autotrophic are phytoplankton – algae and tiny plants
  - Heterotrophic are zooplankton – tiny insects
    - May feed on zooplankton
- Both provide nutrients to higher-level consumers

Importance of Decay

- As plants and animals die, their remains sink to the bottom of the water
- Bacteria and bottom-dwelling organisms break down their remains (detritus) returning nutrients to the soil for plants to grow
- Bacteria use up the oxygen, thus reducing O_2 levels in the water
- Absence of sunlight and plants in the profundal zone to replenish oxygen, may lead to low oxygen levels
  - Very few organisms can tolerate low nutrient and oxygen levels

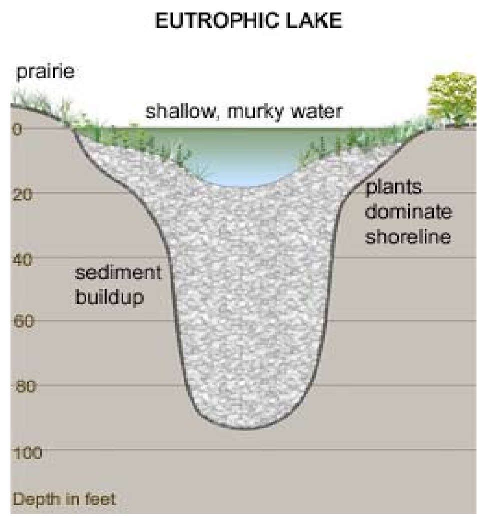
Two Kinds of Lakes - Oligotrophic

- Features
  - Tend to be deep and cold
  - Low nutrient levels (limiting the size of producers)
  - Water tends to very clear because there are so few organisms
- Oligotrophic lakes gradually become eutrophic over time
  - Eutrophication
  - May be sped up by humans by adding excess nutrients to the system



Two Kinds of Lakes - Eutrophic

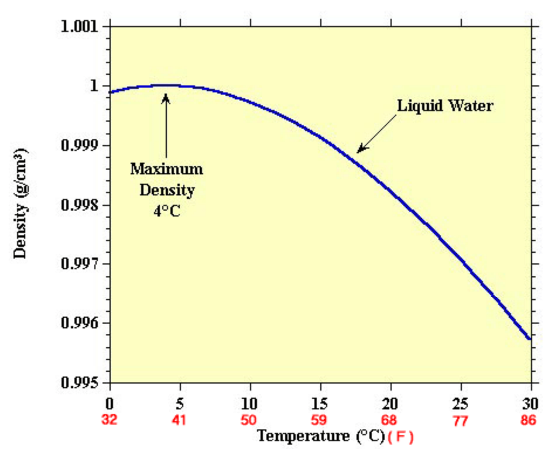
- Features
  - Tend to be shallow and warmer
  - Excellent supply of nutrients
  - Often the water is murky (cloudy) because favourable abiotic factors lead to high numbers of organisms



- Fig. 2 pg. 127 shows the progressions from an oligotrophic to eutrophic lake

Seasonal Variations in Lakes

- Like many substances, as water cools, it becomes more dense
  - Going from gas (low density) to liquid (higher density)
- However, a strange thing happes as it cools below 4°C, it becomes less dense
- This is why ice floats, forming a layer on top of cold water and the lowest layer in a lake or the ocean tends to be 4°C



Lakes in Winter

- Often covered in ice and snow, preventing atmospheric oxygen from dissolving with the water
- The water is layered according to density
  1. Ice
  2. Water at 0ºC – 3.9ºC
  3. Water at approx. 4ºC
- These layers are the same regardless of how cold the air is, though the ice layer will thicken
- If the ice is thin enough, and not covered in snow, light can penetrate enough to allow some photosynthesis to occur
  - Without which, O_2 levels may drop, which may lead to massive die-offs each winter because larger organisms cannot tolerate the low O_2 levels

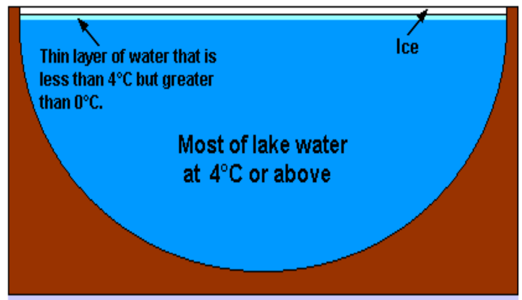


Figure 6 During the winter, ice prevents lake water mixing. Stratification can occur during this time of winter stagnation.

Lakes in Spring

- Spring brings storms and melting ice
- Oxygen can now pass into the water from the air
- Wind creates waves that increase surface area and the rate of O_2 dissolution
- As the water warms to 4ºC it sinks below the less dense water carrying the O_2 with it
- This mixing is called **spring turnover**

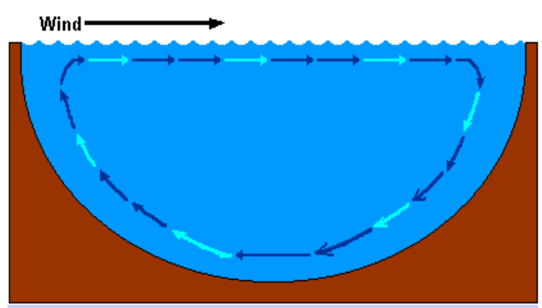
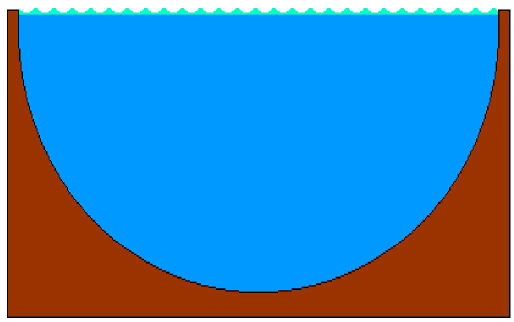


Figure 1 Complete mixing of water can occur when all water within the lake is generally the same temperature. Wind helps to drive this process.

Lakes in Late Spring

- As surface water warms above 4ºC it will no longer sink because it is less dense than the cooler water below
- The thermocline decreases for the summer
- Layers in the lake are:
  - **Epilimnion** – top layer of water that warms in the summer and remains water beneath ice in winter
  - **Hypolimnion** – the bottom which remains at low temperature in summer and about 4ºC in winter
  - **Thermocline** – The narrow region between the hypolimnion and epilimnion where the temperature drops from warm to very cool



Lakes in Summer

- The epilimnion and hypolimnion do not mix during the summer
  - This reduces oxygen movement to the hypolimnion, so organisms must use O_2 reserves from spring turnover
- In the epilimnion it is warm, as the temperature increases the amount of dissolved oxygen decreases
  - During a hot spell, organisms, like trout, in a shallow lake may die

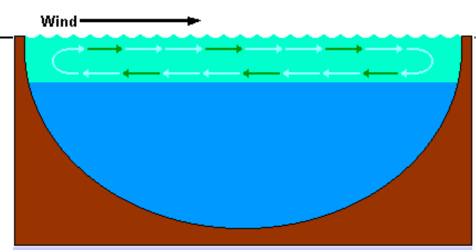
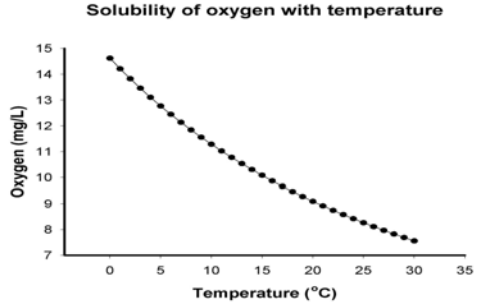


Figure 3 During summer density differences act as a barrier to complete mixing of the lake. This deprives the lake bottom of oxygen.



Lakes in Fall

- As temperature drops, surface water begins to cool
- As water cools to 4°C it sinks down through the lake
- **Fall turnover** renews O_2 levels to the hypolimnion, breaking up the summer thermal layers

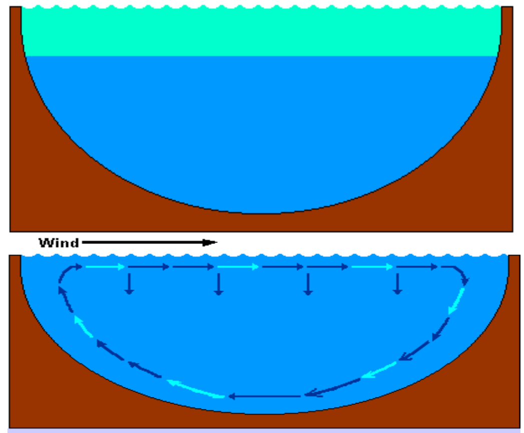


Figure 5 Complete mixing of water can occur when all water within the lake is generally the same temperature. In addition, the atmosphere cools the water at the lake's surface. This dense water sinks to the bottom and further contributes to lake mixing.

Individual Lake Variations

- All lakes have their own unique conditions that determine the species that are able to live in them
  - Ex. Trout are unable to tolerate low O_2 levels, so they would be confined to cooler lakes that have higher O_2 concentrations in the summer, while perch can live in warmer lakes, because they can tolerate low O_2 levels
- The littoral zone is the most productive part of a lake
  - The size of this zone depends on the slope of the lakebed

Similarities Among Lakes

- Central Canada & Newfoundland
  - Formed when glaciers gouged out basins in granite bedrock
  - Tend to be oligotrophic since because minerals in granite do not dissolve easily
- Atlantic Region
  - Also glacial in origin
  - May be oligotrophic or eutrophic depending on the bedrock
  - As minerals dissolve,

Similarities Among Lakes

- Prairie Provinces
  - Also glacial in origin (we are in Canada after all)
  - Formed in thick sand and gravel making them rich in soluble nutrients, with productive ecosystems
  - They tend to be very shallow and collect sediments more quickly
- Arctic Lakes
  - Because of the low temperatures some lakes experience only one turnover
  - Some may not thaw

Sources of Water Pollution

- Water Pollution
  - Any chemical or physical change in the surface water or ground water that can harm living things
  - Biological, chemical and physical forms of water pollution are grouped into 5 categories

Sources of Pollution

Categories of Pollution
1. Organic Solid Waste

- Sources
  - Human sewage, animal wastes, decaying plant life, industrial waste (ex. Pulp mills)
- Effects
  - Oxygen in the water is used up as organic matter is broken down by bacteria.
  - Decomposition may cause a foul odour
- Water is often fairly clear and smelly as a result, eutrophication may take place

Categories of Pollution
2. Disease-causing organisms

- Sources
  - Human sewage and animal wastes that enter the aquatic ecosystem with runoff
- Effects
  - These organisms may cause an outbreak of waterborne diseases like cholera, typhoid, infectious hepatitis, beaver fever or dysentery
- Beaver fever has been in the Conne Water supply in the past
- Hepatitis is common in countries like Cuba

Categories of Pollution
3. Inorganic Solids and Dissolved Mineral

- Sources
  - Acids from combustion and refining of fossil fuel
  - Salts from irrigation, mining and road runoff
  - Fertilizers from farms and gardening runoff
  - Mineral solids from soil erosion after clear cutting
- Effects
  - Kills bacteria and injures trees
  - Salts kill freshwater organisms, and render water unusable and undrinkable
  - Fertilizers cause algal blooms resulting in eutrophication
  - Solids make water murky (turbid) harming plants, and increase sediment formation, harming bottom feeders

Categories of Pollution
4. Heat

- Sources
  - Electricity generating plants and other industries that use water as a coolant, and pump it back into the ecosystems
- Effects
  - Addition of warm water to ecosystems decreases the solubility of oxygen in the water
- This works in the favour of fish in Bay d'Espoire, since the salmon are able to grow faster in the waters that have been warmed by the NL hydro station

Categories of Pollution
5. Organic Chemicals

- Sources
  - Oil and grease from roads
  - Pesticides from farms, parks and gardens
  - Detergents (organic phosphates) from washing of clothes, cars, dishes, etc.
- Effects
  - Toxic to fish and waterfowl (birds), oils reduce O_2 exchange with the water from the air
  - Some pesticides damage entire food chains through bioaccumulation & bioamplification
  - Phosphates can lead to eutrophication
- And you thought you only needed those terms for chapter 1?

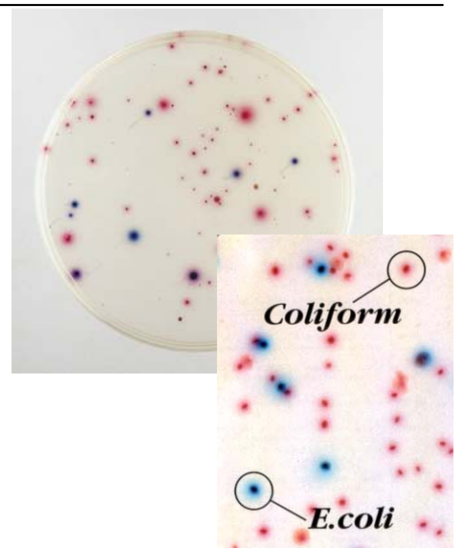
Water Quality Indicators

- Water quality is defined by its intended use
  - Water unacceptable to drink is often suitable for watering plants or industrial processes
  - Water too polluted for swimming may still be suitable for boating or fishing

- There are three main indicators of water quality:
  - Bacteria count
  - Dissolved Oxygen
  - Biological Oxygen Demand (BOD)

1. Bacteria

- **Coliform bacteria**
  - Naturally occurring in the intestines of humans and many animals
  - Presence of this type of bacteria in water indicates that there is human or animal waste polluting the water
  - Water is plated on a special medium that allows the bacteria to grow if it is present



2. Dissolved Oxygen

- There are several solutions available to detect O_2 levels. The solutions change colour in the presence of oxygen
- There are also probes attached to computers that are often used to detect dissolved O_2 levels
- The number of organisms may also indicate the level of oxygen, but this low numbers may be attributed to the toxins themselves, not simply the presence or absence of oxygen
- Normal levels are between 8 and 14 mg/L

3. Biological Oxygen Demand (BOD)

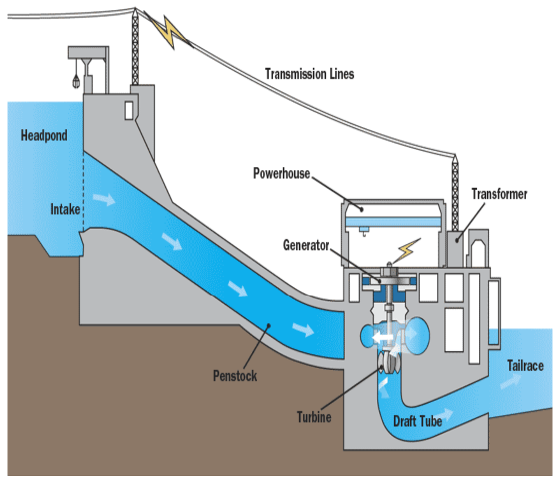
- It is possible to measure the amount of dissolved oxygen needed by decomposers (bacteria) to break down organic matter in a sample of water over a 5-day period at 20°C
- BOD indicates the amount of available organic mater in a water sample
- A cold, less productive lake may have a BOD of 2 mg/L of oxygen, while a warmer very productive lake may be as high as 20 mg/L
- As the number of organisms increases, the biological demand increases, and so dissolved oxygen levels decrease

Sewage, Decomposers and O_2 levels

- Too many nutrients can create problems for lakes
  - Think about what happens when cities dump raw sewage into water systems… What happens?
- The greater the amount of decaying matter, the greater the population of bacteria
- Eventually all fish will die, as the bacteria use up all the oxygen – this adds more detritus and thus more bacteria
- Human wastes add additional phosphates and nitrates, promoting plant and algal growth, and this more detritus still
- Each time organic matter is returned to the lake, oxygen levels are further reduced

Thermal Pollution

- Summer-like conditions are often the result of lakes polluted with warm water from industry or power stations
  - Often the warm water prevents water from freezing in the winter
- The result is organisms thriving all year round when they would normally be dormant
  - May lead to O_2 depletion in the hypoimnion, and increased eutrophication as organisms die



Point vs. Non-point Pollution Sources

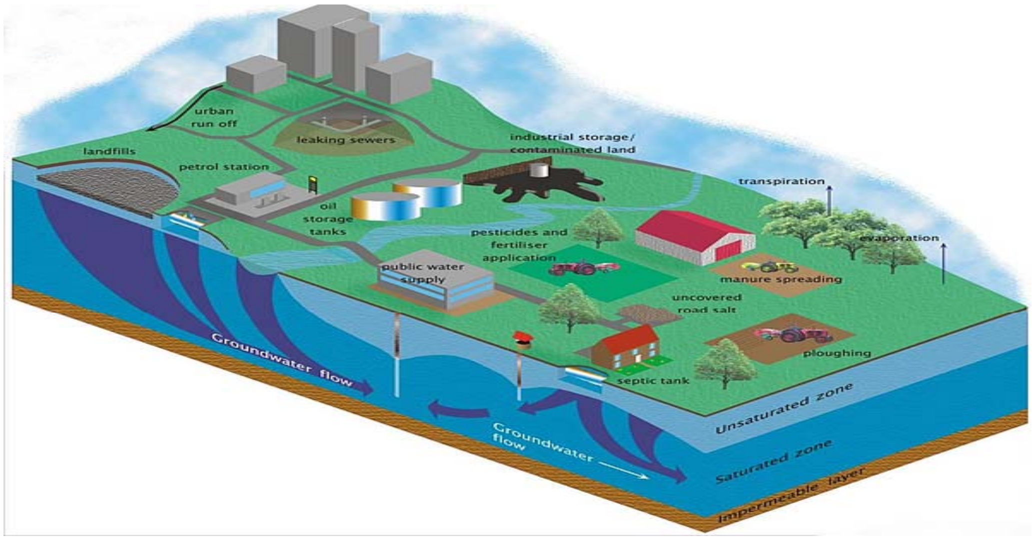
Point Sources

- Pollutants enter the water in high concentrations and slowly dilute into the ecosystem
- Point of entry at high concentration has more severe effects than further away in diluted areas
- Ex. Faulty treatment plant, oil tanker spill

Non-point Source

- Pollutant sources are widespread – not from one single source of input
- Rarely have a single area of severe damage
- Are often variable (changing) and repeating over time
- Ex. Farming fertilizers, road salt runoff

Identify the point and non-point sources of water pollution



Section Review Documentary

- In groups of two or three (created by Mr. O)
- You are going to create a documentary about aquatic ecosystems
  - How are they important?
  - What types of organisms can one find? (research)
  - How are lakes structured? How are lakes in NL formed? What types of lakes are found in Canada?
  - How do lakes change throughout the year?
  - Pollution – Sources, effects and the importance of keeping our freshwater clean

Project Instructions

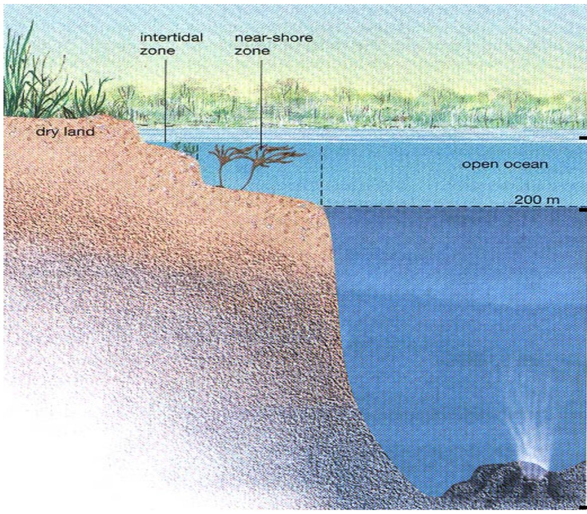
1. You will create a video documentary about aquatic ecosystems
2. You will need to create some script for the interviewer and the “experts” being interviewed
3. You will use a digital camera to record your documentary
4. Use a program like Windows Movie Maker to add your Intro titles, snip the video clips up, add visual effects and closing credits
   1. If you need help with this ask, but it is very easy with WMM, which is on every computer with Windows on it
5. Submit your final Movie and script to Mr. O Next week

BE CREATIVE

Marine Ecosystems

- Abiotic Factors
  - Salt – avg. 3.5% salt
  - Tides – gravitational pull of water by the moon
  - Sunlight – penetrates only about 200 m down
  - Nutrients – Concentrated near the bottom and near the shoreline regions
- Biotic Factors
  - Along the continental shelf life is more dense than in the open ocean

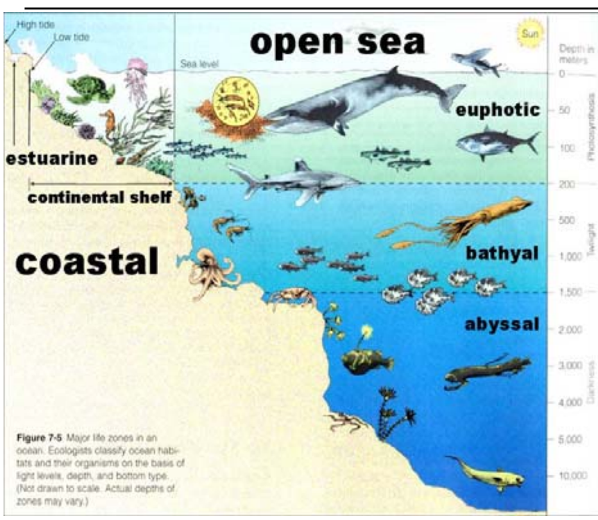
Major Life-Zones of the Ocean



Photic "light" Zone
Supports photosynthesis

Aphotic "dark" Zone
Insufficient light for photosynthesis, though chemosynthesis may occur

Ocean Regions



See figure 1 page 146 in textbook

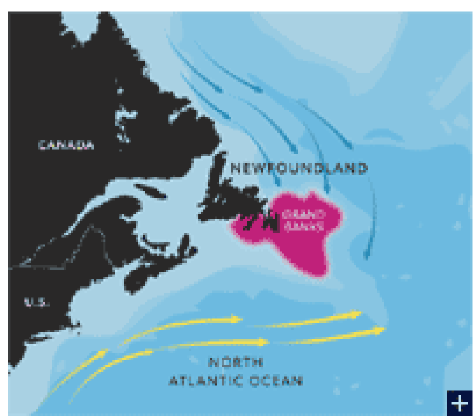
- Open Ocean
  - Cool water, contains fewer minerals and nutrients
- Coastal Zone
  - Extends from the continental shelf inward to the high-tide mark on land
  - Accounts for 10% of the ocean, with 90% of the life
  - Two areas
    - Neritic zone
    - Intertidal zone

Intertidal Zone

- Defined by low and high tide
- Organisms must be able to withstand crushing forces of the waves during high tide and drying periods during low tide
- Sucker-like feet and fibers attach organisms to the rocks
- Clams, mussels, starfish, seaweed, seagrasses

Neritic Zone

- Water just beyond of the intertidal zone
- Depth depends on the slope of the continental shelf
  - May be very shallow or very deep
  - Does not exceed 200 meters
- The Grand Banks of NL are the neritic zone of the east coast
- Clams, mussels, lobsters, crabs, various fish



Estuaries and Coastal Marshes

- Tidal Marshes are the most productive of all marine ecosystems
- Periodically flooded by high tides, but the large area allows plants to photosynthesize
- High diversity of both plants and animals

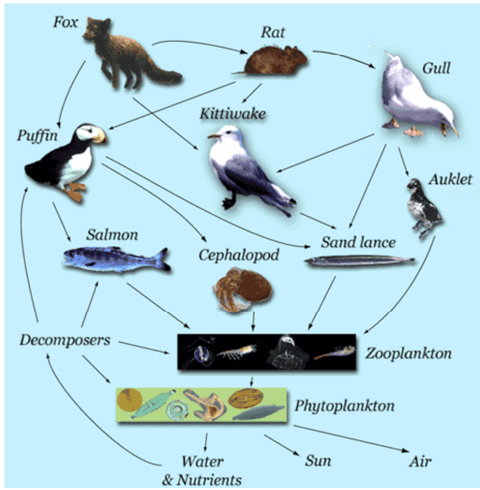
- Estuaries exist where freshwater is flowing into the ocean
  - Such as Conne River
- Water in the estuary is a combination of fresh water floating on top of the salt water
  - Salt water is more dense than freshwater
- Freshwater carries nutrients that allow the estuary to be more productive
- The drastic changes in salinity (saltiness) from tides makes it difficult for many species to live here

Estuaries and Coastal Marshes

Salt Marsh

Estuary

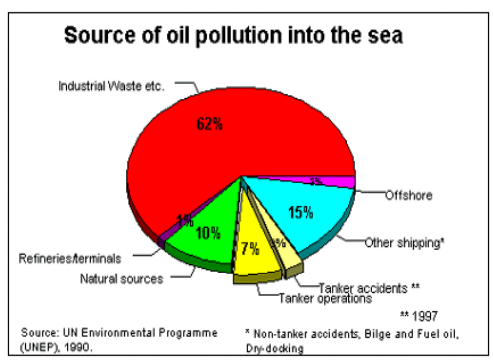
Marine Food Web Example



Marine Pollution

"All drains lead to the ocean" – Finding Nemo

- Many pollutants from terrestrial and aquatic ecosystems are carried to the oceans, where they spread out and become more diluted
- Most productive ocean areas are also the ones with the greatest productivity



Crude Oil in Marine Ecosystems

- Major sources of oil
  - Tanker accidents
  - Offshore wells
  - Daily washing of tankers
  - On-land activities
    - Waste oil disposal (50%)
  - The atmosphere
    - From oil fires

Ecological Effects of Oil Pollution

- Lighter oils float, this affects birds
  - Coats feathers, dissolving natural oils that waterproof the birds
  - Destroys the insulation, resulting in hypothermia
- Heavy oils sink and affect bottom-dwelling organisms
  - Sludge covers and suffocates organisms like crabs and oysters
- All oils eventually enter the food chains of fish, birds and people

Cleaning Up The Oil

- A very expensive task (over 3 billion dollars)
- High-pressure hoses spraying hot water clean the shoreline
  - This often does more damage than good
- Floating sponges sop up oil before it reaches land
- Crude oil may clean up naturally after 3 years, while refined oil may take more than 10 years