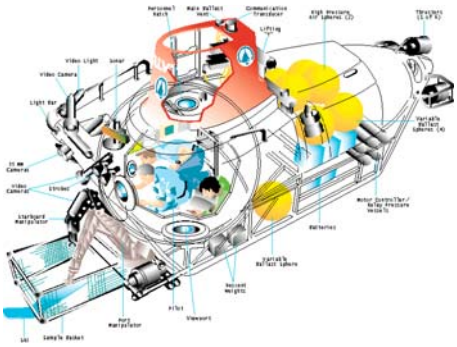
BEGIN
with Benthic Communities and
Hydrothermal Vents …

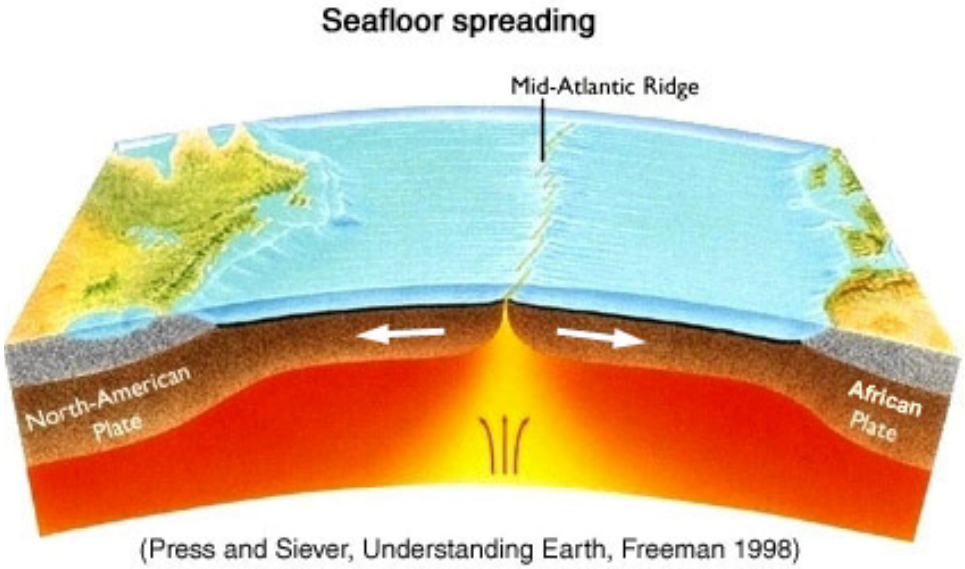
Benthic Communities and Hydrothermal Vents

Bob Seaman, Laura Marshall,
Dan Post, Nicole Hallmark

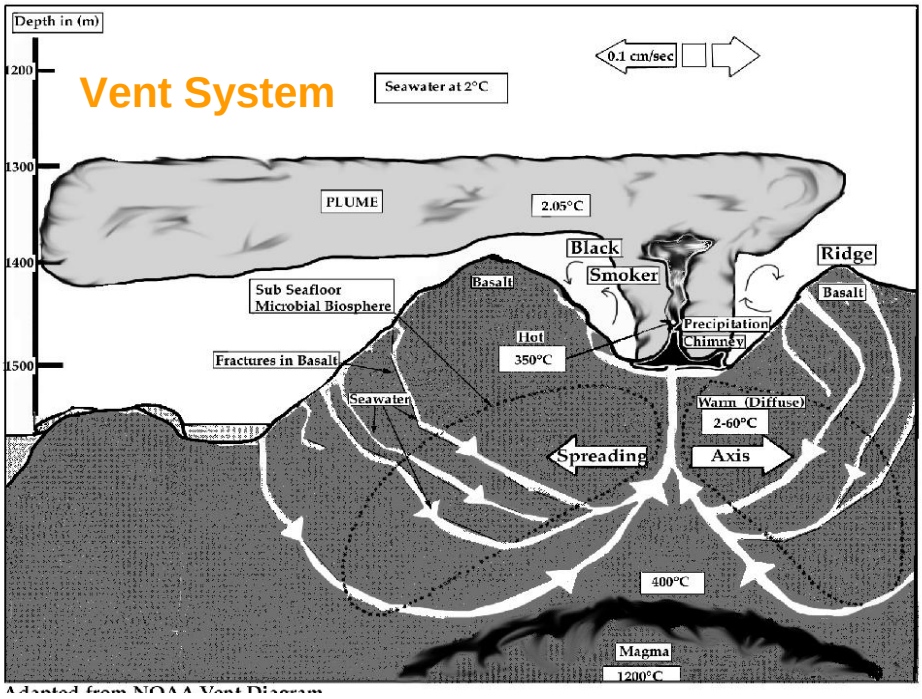
Hydro-history

- First one discovered east of the Galapagos in 1977





(Press and Siever, Understanding Earth, Freeman 1998)



Adapted from NOAA Vent Diagram

Hydrothermal Life

- chemosynthesis instead of photosynthesis

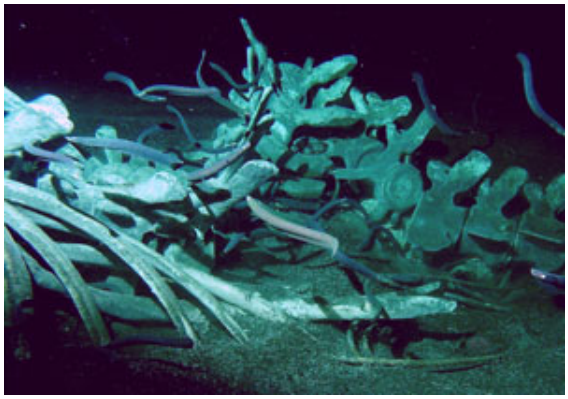
  Bacteria—primary producers, synthesize sugars from chemoautotrophy

Hydrothermal Life and Conservation

- Areas of High Biodiversity
- Possible metapopulation?
- Habitat for “relict” species:
  - less affected by extinction events
  - stable habitat
- Potential impacts (mining, energy conversion)

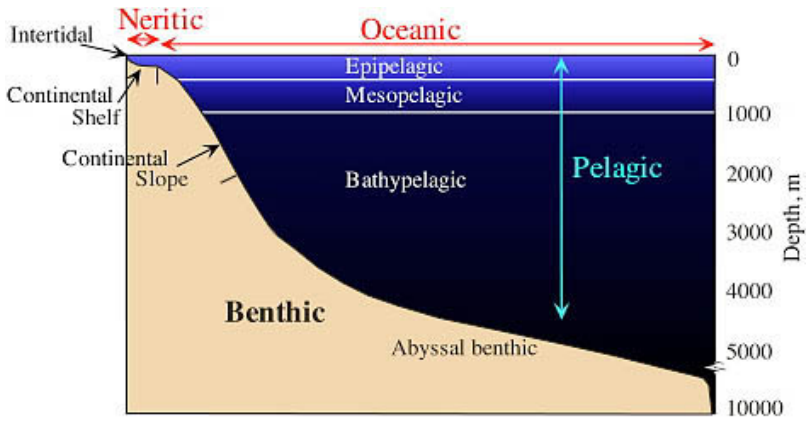
Vent Biodiversity

- Giant Worms, Clams and Crabs
  - live off Archaea (chemosynthesis)



Benthic Community

- Ocean Floor

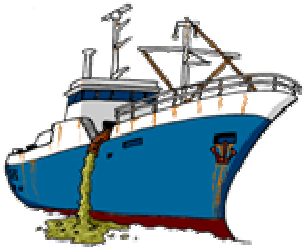


Benthic Ecosystem

- Nutrient cycling
- Marine Snow
- Estimates of marine benthic species: 500,000 – 10,000,000
- Habitats-
  - » Sea grass (breeding grounds)
  - » Extreme environments (high biodiversity)

Human Impacts (d’oh!)

- Trawling
- Pollution
- Invasive species



TRANSITION
to Fisheries Group…

Fisheries

Impact of Fisheries

- 1940's and 50's
  - Fish stocks were seen as a renewable resource where management could lead to a continual maximum sustainable yield every year
- Today's outlook
  - 70% of the world's marine stocks have been classified as heavily exploited, over exploited, or depleted.
  - 45% of all species are over-harvested

Threats to marine environments

- Overfishing and overhunting
- Alteration of physical environment
- Pollution
- Introduction of non-native species
- Global climate change

Destruction of Habitats

Trawling damage

- Trawling is the most destructive form of fishing that is widely used around the world.
- Large amounts of biodiversity in international waters at risk from trawling
- Trawling endangers rare species that may not even be currently documented

Mariculture, A part of the solution?

- Benefits: efficient and effective, reduced need to disturb natural systems, perhaps more sustainable
- Concerns: Many of the same problems associated with terrestrial agriculture, e.g., concentrated pollution and disturbance
- Increased supply could mean increased demand
- Pearl and oyster farming has been successful for centuries

Giant Clams, a mariculture example

- Includes nine species of marine clams often found on coral reefs, heavily exploited
- Large size means high demand as food
- Early life stages (egg, larval, juvenile) are raised in outdoor tanks, eventually moved into containers in the ocean.
- Large adults are then grown in the open sea.
- No apparent environmental harm, increased fish diversity around clam colonies
- Efforts to include locals in mariculture helps to avoid poaching of wild clams

Problems Associated with Marine Environmental Law and Policy

- "Present management of marine ecosystem is based on a series of regimes that are directed at the various parts rather than the whole and that are… ineffectual" (W.M. von Zharen)
- One nation's jurisdiction do not usually coincide with the movement of commercial fish populations
- Pollution from one country often affects waters and marine ecosystems of other countries
- Discharged waters may displaced non-native species to coastal waters that destroy local marine species populations
- International and national laws conflict with the conservation of marine resource

Commercial Fisheries

- Over-fishing

- Problems:
- MSY, Faulty population estimates

- Proposed Solutions:
- UNCLOS III (1982) Exclusive Economic Zones (EEZ)- Not working (yet?)
- Creation of Marine Reserves
- Rigorous monitoring

Commercial Fisheries

- Destructive fishing techniques
- Habitat destruction (Dredging/trawling)
- By-catch (Driftnets/dredging/trawling)

- Proposed solutions:
- Banning certain fishing techniques (drift netting)
- Requiring the use of devices such as TED's
- Limiting the area of commercial engagement.

TRANSITION
to Mariculture and Legislation Group…

Mariculture & Legislation

-Allison
-Libby
-Juan
-Melissa

Mariculture: a definition

- Textbook: Mariculture is “the intensive commercial cultivation of certain species in limited areas” (p. 260).
- Mariculture is an alternative to the harvesting of species from open, unprotected areas

Positive aspects of Mariculture:

- Provide large per area, per effort yield of food & other products
- Reduce the need to disturb or exploit natural systems and their populations
  - Can give back to natural populations
  - Helps support local ecosystems
- Allow for production of better-quality food

Positive Examples

- Fish production
  - Salmon
  - Tilapia (aquatic chicken)
- Oysters
- Giant Clam…

Giant Clam: A Case Study

- Symbiotic relationship with zooxanthellae.
- No deleterious environmental effects
- Big Success -> Increased Demand -> Exploitation of Wild Population -> Ban on International Trade

Negative aspects of Mariculture:

- Can concentrate disturbance and pollution on the environment where mariculture takes place
- May lead to the overexploitation of wild populations to satisfy the growing market
- “Better-quality” appeals to market value, not diversity or value of individual species
- Genetic engineering is risky
- Loss of wild populations has cultural & historical importance

Salmon: A Case Study

- Change chemistry of water
- Escape into wild populations:
  - Compete with wild populations (and win)
  - Contaminate gene pool

Freshwater Legislation

Wild & Scenic Rivers Act (1968)

- “Stream or section thereof designated as wild or scenic river is protected from any action by any federal agency that would adversely affect its water quality.”
- Sections of rivers can also be designated

Freshwater Legislation

Clean Water Act & Amendments (1972)

- “restore & maintain integrity”
- “enhance aquatic life”

Indices Biotic Integrity

- Measure water quality based on ecology

Wetlands Legislation

1971 Ramsar Convention (international)

- Protection of ecosystem instead of species
- Canada
- United States – Table 9.3, p.246
- United States – Wetlands Reserve Program

Wetlands Legislation

1982 Commission on Conservation of Antarctic Marine Living Resources (CCAMLR)

- Established marine life conservation; allows for “rational use” of resources
- Regulated harvesting - may not cause population to diminish below number that allows stable recruitment

Marine Legislation

Difficulties (Ch. 9, pp 263-264)

- National jurisdictions over territorial waters do not always coincide with the distributions and movements of commercial fish populations
- Pollution from one country may be moved, through currents and discharges, into territorial waters of another country
- Transfer of alien species (via ballast)

Marine Legislation

International Organization for Standardization (ISO)

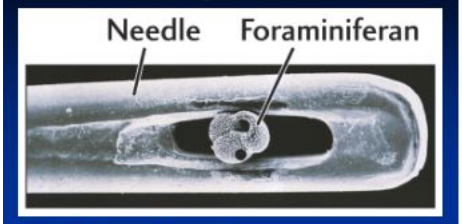
- Developed out of 1992 Earth Summit Meetings
- International and regional environmental management standards (EMSs)
- EMSs establish consistent, internationally accepted protocols for managing resource use and pollution in marine environments

Marine Legislation

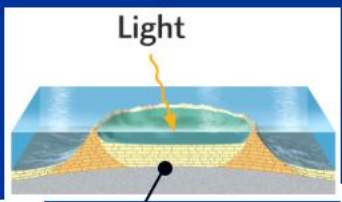
- Ecosystem restoration commission
- GIS Mapping
- Global system of parks and protected areas

TRANSITION
to Coral Reefs Group…

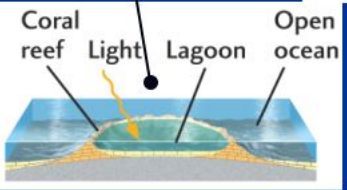
Carbonate platforms II



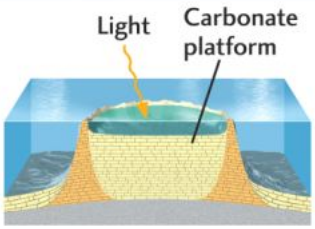
Within the reef lagoon, growth of carbonate-secreting organisms, including forminefera, coral, algae and molusks, is rapid, and carbonate sediments form quickly



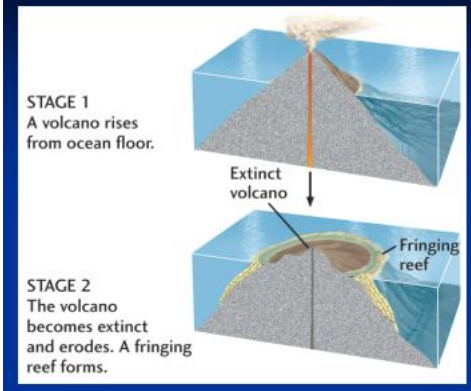
Eventually a carbonate platform grows with steep sides towards the sea



If sealevel rises, the reef continues to grow towards the light and lagoon sedimentation outpaces sedimentation in the open ocean

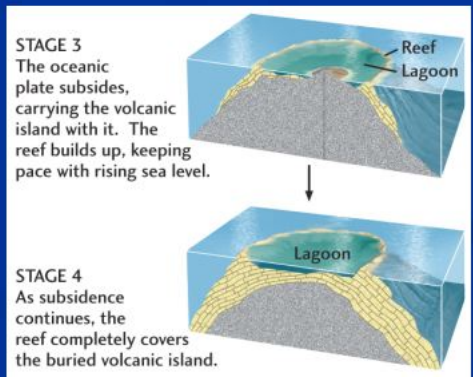


Coral reefs and atolls II



Process first described by Charles Darwin

Coral reefs and atolls I




stream
mouth
coral reef
sand channel
beach

Threats to Coral Reefs

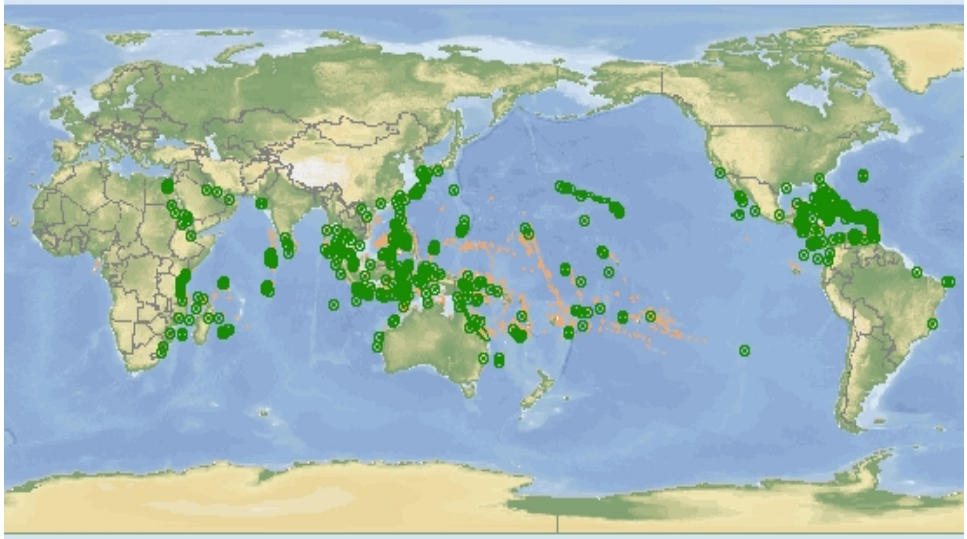
Marine Protected Areas (MPA)

- World Conservation Union: "any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (IUCN, 1988; Kelleher, 1999).

Objectives

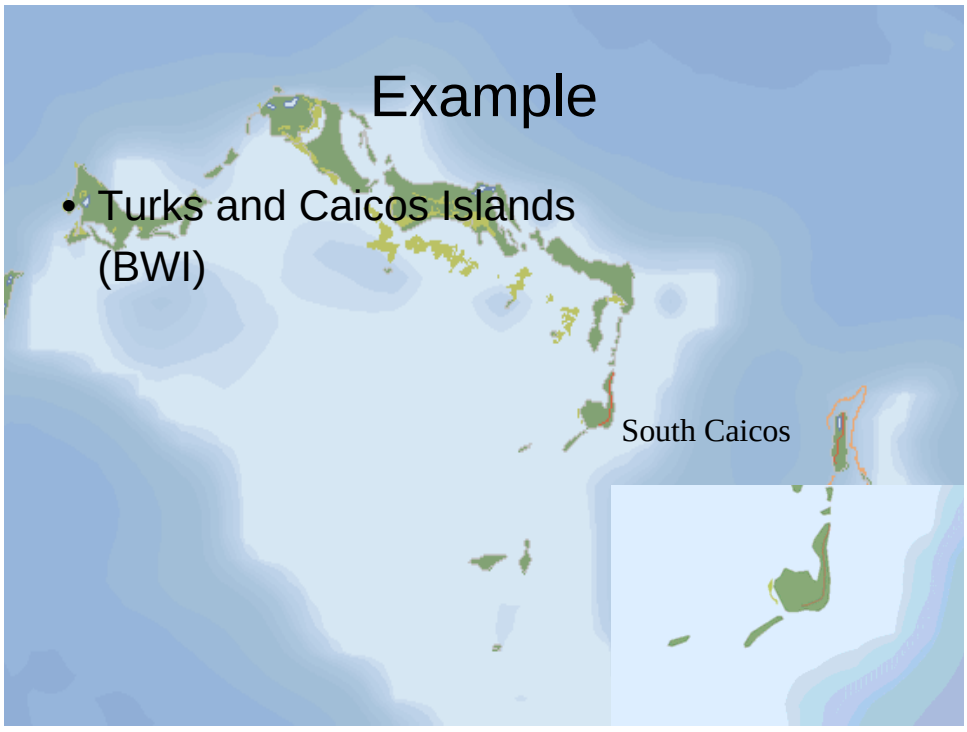
- **To increase biodiversity. (Biodiversity can be assessed at several levels: ecosystem diversity, species diversity, and genetic diversity within a species' population)**
- **To protect a representative sample of some or all of the habitats found within a region.**
- **To prevent impacts from fishing, including population decline, ecological impacts and habitat destruction.**
- **Establish undisturbed areas as control or reference sites for scientific research and fishery assessment.**
- **Prevent marine pollution by prohibiting industrial activities, like oil drilling and mining.**
- **Protect culturally important seascapes, sites and artifacts.**

Protected Marine Areas in the World



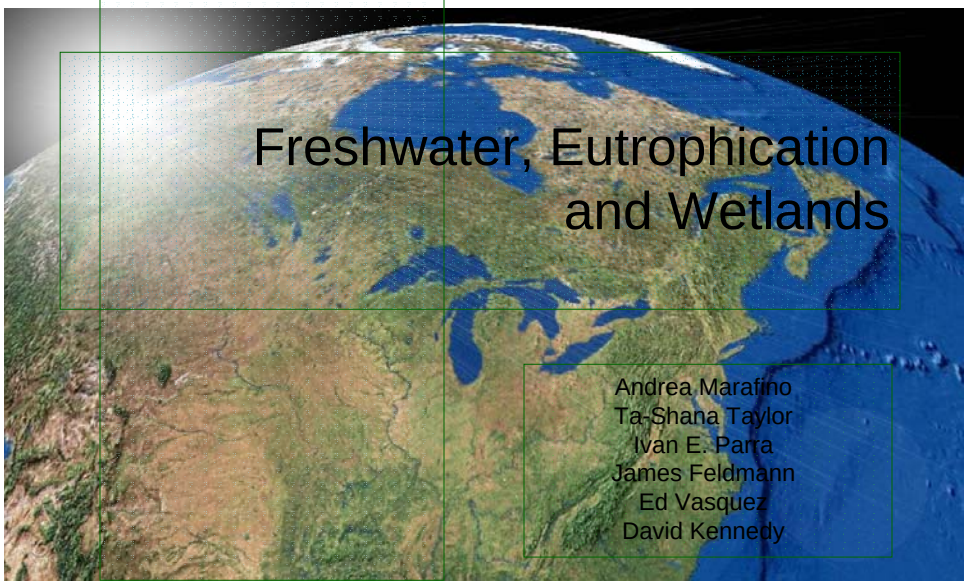
Example

- Turks and Caicos Islands (BWI)



Education - Key

TRANSITION
to Freshwater, Eutrophication,
and Wetlands Group…



Importance of freshwater environments and wetlands

An acre of wetland can store 1.0 to 1.5 million gallons of floodwater.

Water storage (and release during dry periods) and erosion control

You can drink more than 4,000 glasses of tap water for the price of a packaged beverage (based on price of a six-pack of soda).

Water filtration (improves water quality)

75% of commercially harvested fish are wetland-dependent.
95% when shellfish species are added to this figure.

Up to one-half of North American bird species nest or feed in wetlands.

Biological productivity (plant and animal habitat)

Source: EPA

Importance of freshwater environments and wetlands

Regulation Functions
Storage and recycling of nutrients
Storage and recycling of human waste
Storage and recycling of organic waste
Groundwater recharge
Groundwater discharge
Natural flood control and flow regulation
Erosion control
Salinity control
Water treatment
Climatic stabilization
Carbon sequestration
Maintenance of migration and nursery habitats
Maintenance of ecosystem stability
Maintenance of integrity of other ecosystems
Maintenance of biological and genetic diversity

Information Functions
Research, education and monitoring
Uniqueness, rarity or naturalness and role in cultural heritage

Carrier Functions
Agriculture, irrigation
Stock farming (grazing)
Wildlife cropping/resources
Transport
Energy production
Tourism and recreation
Human habitation and settlements
Habitat and nursery for plant and animal species

Production Functions
Water
Food
Fuel wood
Medicinal resources
Genetic resources
Raw materials for building, construction and industrial use

Wetlands alone have an economic value of $70 billion per year (World Conservation Union)

$4.8 trillion overall economic value (Costanza, et al)

What is a freshwater aquatic environment?

- **Lotic Systems:** flowing water environments such as streams and rivers.
- **Lentic Systems:** lake environments.
- **Wetlands:** areas where the land transitions from aquatic to terrestrial, such as marshes, swamps, bogs and fens. Very difficult to define.


Nankoweap Granary

How is a wetland defined?

A wetland is defined by the EPA by the:

1. Hydrology – it is covered by water during part of the growing season or the soils are saturated.
2. Vegetation – it has at least 50% obligate and facultative plants.
3. Hydric soils – soils that are saturated long enough to have low oxygen levels



How Much Wetland Area Has Been Lost??

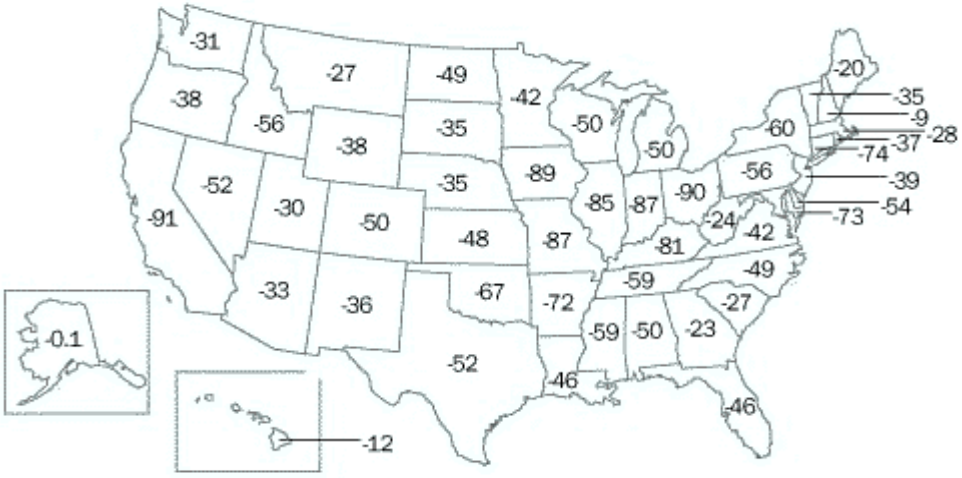
(since pre-settlement ~ 1600's)?

- **Nationwide** – 53% (in lower 48)
- **Great Lakes Basin** – 70%
- **Michigan**
  - 50% of total wetlands lost
  - 70% of coastal wetlands

- 75% of Michigan wetlands in private ownership.

(from *Living With Michigan Wetlands: A Landowner's Guide*)

Percentage of Wetlands Acreage Lost, 1780's-1980's



Twenty-two states have lost at least 50 percent of their original wetlands. Seven states—Indiana, Illinois, Missouri, Kentucky, Iowa, California, and Ohio—have lost over 80 percent of their original wetlands. Since the 1970's, the most extensive losses of wetlands have been in Louisiana, Mississippi, Arkansas, Florida, South Carolina, and North Carolina.

Source: Mitch and Gosselink, Wetlands, 2nd Edition, Van Nostrand Reinhold, 1993

Major Effects of Wetland Losses

- 50% loss of spawning grounds for fish
- 50% loss of waterfowl habitat
- 50% loss of flood control capability
- 50% loss of erosion control and sediment-trapping capability

Why So Much Wetland Loss?

- Perception of wetlands as "wastelands" and "swamps"
  (= ignorance)

- Economic incentives for development and urban sprawl

Removal of riparian vegetation next to stream due to residential development.

Farming up to edge of stream.

Livestock corral adjacent to stream

Invader Species

- Major threat to the biological diversity of wetlands
- Alteration of nutrient cycles
- Severe loss of native biodiversity
- Have significant impacts on biochemical processes
- Reduction in the abundance and species richness of native macrophytes and associated invertebrate communities
- Invasive exotic species tends to increase as ecosystems become degraded

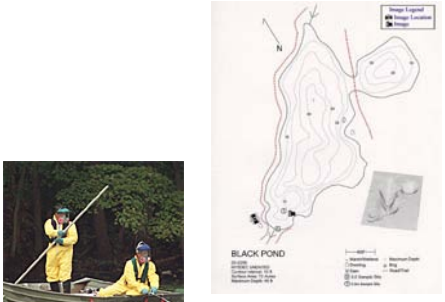
Introduced weeds and non-native plants, i.e. purple loosestrife

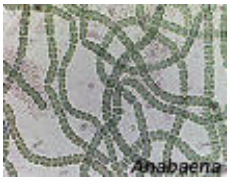
need to be controlled through biological, chemical and/or mechanical means

or prevented by proper land management, i.e. minimize disturbance.

Eutrophication – enrichment of aquatic ecosystems by inorganic nutrients (mostly P & N), causing increased primary productivity

- **Cultural eutrophication - The usual suspects: sewage, agriculture, land clearance… fisheries mgmt. practices?**
- **Did reclamation pollute Black Pond? (Stager, 2001)**
- **Anabaena blooms: Rotenone fish kills and/or fish stocking?**
- **Sediment core evidence: diatoms and organic matter**





"Natural" Eutrophication - a Paleo Perspective

- **Forest fires, droughts, climate shifts**
- **Insect infestations? Hemlock Decline ~ 4,800 yrs. BP – van Nostrand Lake, Ontario (St. Jaques et al., 2,000).**
- **Die-off = nutrient inputs, erosion**
- **Sediment cores: pollen, diatoms, organic matter**

Acidification

- H_2S & NO + atm. moisture = sulfuric and nitric acid pecip.
- Mortality and fecundity: inverts., amphibians, fish
- Mobilization of heavy metals e.g. Al, Hg
- Watershed factors: buffering capacity, climate patterns, elevation, seasonal snow cover (key)
- Big Moose Lake, Herkimer Co. NY: vulnerable in all categories

Are Eutrophication and Acidification "Good" or "Bad"?

- Mid 1900s: "oligotrophic lakes are 'wasted resources' – fertilize them!"
- 1970s – 1980s: "eutrophic lakes are scummy and 'polluted' – ban phosphates!" (so acid precipitation must be good because it makes nice, clear oligotrophic lakes?!)
- Human activity vs. non-human processes
- Perspectives: human (many), organisms, ecosystems

Conservation Activities

- Approaches in protecting freshwater and wetlands
- Legislation and management for freshwater environments

Approaches in Protecting Freshwater and Wetlands

Conservation Issue	Remedial Management	Preventative Management
Wetlands	Coordinated Management	Buffer strips
Acidification	Liming	Education
Sedimentation and Eutrophication	•Removal of fertilizers •Dredging •Chemical manipulation •Biomanipulation	• Reduce the use of fertilizers • Reduce erosion on agricultural lands • Education
Invasive Species	Intervention •Manual Removal •Mechanical Control •Chemical Control •Biological Control •Environmental Manipulation •Direct use of invasive species	• Protection • Restoration • Education
Groundwater Depletion	Reclaimed water	• Conservation • Regulation • Education

Legislation and Management for Freshwater Environments

- International Legislation
  - Ramsar Convention on Wetlands
  - Global International Water Assessment (GIWA)
- The Wild and Scenic Rivers Act
- The Clean Water Act
  - Index of Biotic Integrity (IBI)

"a thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise."

-Aldo Leopold

IBI

Table 1. Index of biotic integrity metrics as originally developed (modified from Karr and others, 1986).

Category	Metric
Species richness and composition	1. Total number of fish species 2. Number and identity of darter species 3. Number and identity of sunfish species 4. Number and identity of sucker species 5. Number and identity of intolerant species
Trophic composition	6. Proportion of individuals as green sunfish (tolerant species) 7. Proportion of individuals as omnivores 8. Proportion of individuals as insectivorous cyprinids (minnows) 9. Proportion of individuals as top carnivores
Fish abundance and condition	10. Number of individuals in sample 11. Proportion of individuals as hybrids 12. Proportion of individuals with disease, tumors, fin damage, or skeletal anomalies

Managing Freshwater Initiatives

- Conservation Priorities
  - World Wildlife Fund
  - The Nature Conservancy