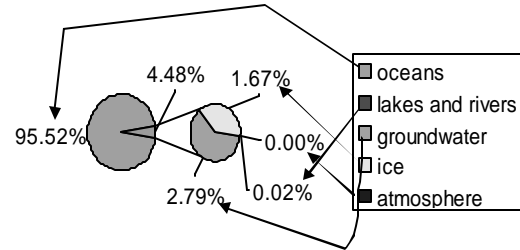


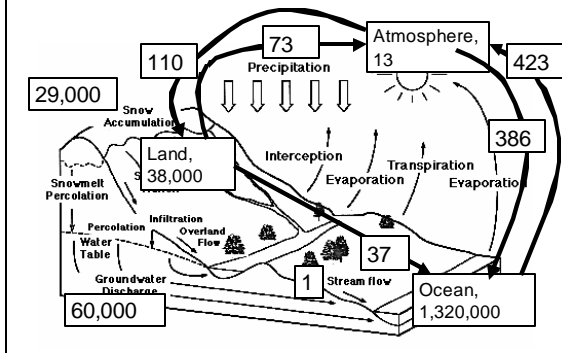
Ch. 1: Why Study Continental Aquatic Systems?

- Why are you taking this class?
- Distribution of Water
- Human utilization of water – Pressures on a key resource
- What is the value of water quality?

Distribution of Water on Earth (%)



Hydrological Budget (amounts, 1000 km³; fluxes, 1000 km³/yr)



Human Utilization of Water – Pressures on a Key Resource

- Only 1% of water in lakes, 0.01% in rivers
- U. S. water use ~2000 m³ per capita per year
- Much water use for industry and irrigation, not just home use
- Surface water provides majority of water

Water Availability in the Future

- About 30,000 km³ yr⁻¹ river runoff, only about 9,000 is geographically and temporally accessible.
- Currently humans use ½ of this.
- If all people on earth used water at the same rate as people in the U.S., all available water would be used.
- Population and resource use rates are increasing and will do so into the future.
- Sandra Postel, Pillar of Sand, 1999

What is the Value of Water?

- Global values of wetlands \$14 trillion y⁻¹
- Global values of rivers and lakes \$1.7 trillion y⁻¹
- Flood control, water supply, waste treatment
- People are willing to pay for clean water, property near clean water and recreation
- Other values include irrigation (40% of world's crops), aquaculture, fisheries (particularly in developing countries)
- Can you think of more?

Dollar Value of Ecosystem Services ('97 \$US)

Biome	Total value per Ha	Total Global Value (Billions)	Main Service
Estuaries	22,832	4,100	Nutrient cycling
Swamps	19,580	3,231	water supply, disturbance
Sea grass, algae beds	19,004	3,801	Nutrient cycling
Tidal Marsh	9,990	1,648	Waste treatment, disturbance
Lakes, rivers	8,498	1,700	water regulation
Coral reefs	6,075	375	recreation, disturbance
Tropical forests	2,007	3,813	Nutrient cycling, raw materials
Coastal shelf	1,610	4,283	Nutrient cycling
Temperate forest	302	894	climate regulation, waste
Open ocean	252	8,381	nutrient cycling
Grasslands	232	906	waste treatment, food
Cropland	92	128	food
Desert	0	0	None
Tundra	0	0	None
Ice, rock	0	0	None
Urban	0	0	None

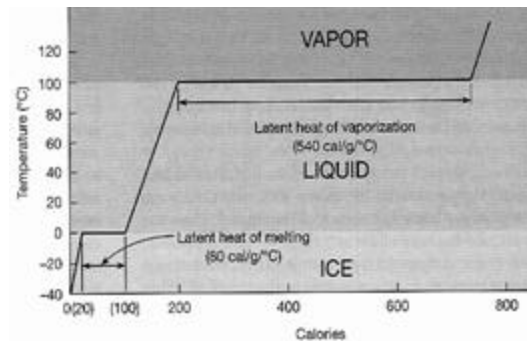
Properties of Water

- Chemical and physical properties
- Relationships among water viscosity, inertia, and physical parameters
- Movement of water
- Forces that move water

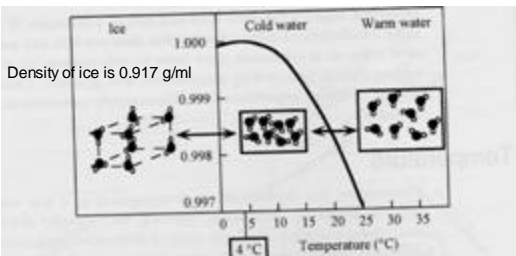
Properties of water

- Liquid on earth's surface
- hydrogen bonding yields:
 - surface tension
 - viscosity: ever run in a pool? why are fish shaped that way?
 - high specific heat: sensible heat
 - hi heat of vaporization: latent heat, cools skin, cools surface waters
 - hi heat of fusion: latent heat, keep lakes above 0°C
 - high thermal conductivity: why do otters have thick fur?
- 775 more dense than air
 - varies with temperature and salinity
 - how can whales get so large?
- relatively transparent
- an excellent solvent
 - Important in weathering
 - Ions more soluble in warm water
 - Gases less soluble in warm water
- LIVING IN WATER IS DIFFERENT FROM LIVING IN AIR

relationship between heat content and the temperature of water



Temperature-density relationship for freshwater



The density of water along a temperature gradient. At temperatures lower than 0°C, the density is lower than 1.000 and the water molecules are arranged in a crystalline structure -- ice. At about 4°C the density of water is at its maximum (i.e. the molecules are as closely packed as possible). As the temperature rises, the spaces between molecules increase, leading to a decrease in density.

Relationships among Water Viscosity, Inertia, and Physical Parameters

- Hydrogen bonding becomes more important at smaller scales, altering both viscosity and inertia
- Viscosity is the resistance to change in form (internal friction)
- Inertia is the resistance of a body to a change in its state of motion
- Reynolds number incorporates both

Reynolds Number

- Viscosity $F_v = \mu S U / l$
- Inertia $F_i = \rho S U^2$
- $Re = F_i / F_v = \rho U l / \mu$
- Units μ = dynamic viscosity (g/(ms)), ρ = density, U = velocity, S = surface area, l = length
- spreadsheet

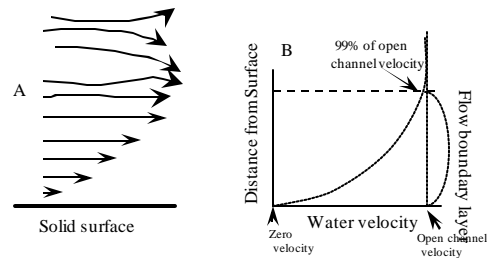
Contrast of Properties of Water Varied by Scale

Parameter	Small organism (< 100 μ m)	Large organism (> 1 cm)
Re	Low	High
Viscous Force (F_v)	High	Low
Inertia (F_i)	Low	High
Flow	Laminar or none	Turbulent
Body shape	Variable	Streamlined
Diffusion	Molecular	Transport (eddy)
Particle sinking rates	Low	High
Relative energy requirement for motility	High	Low

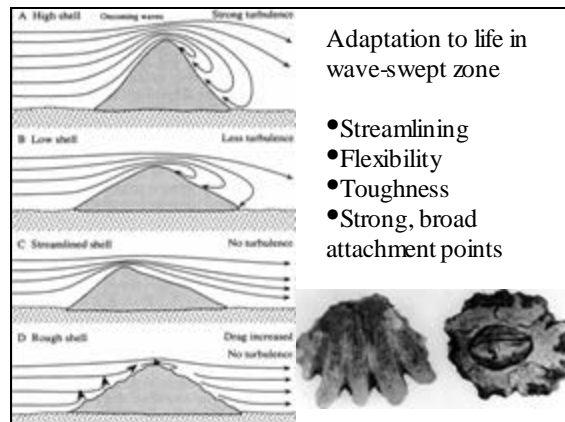
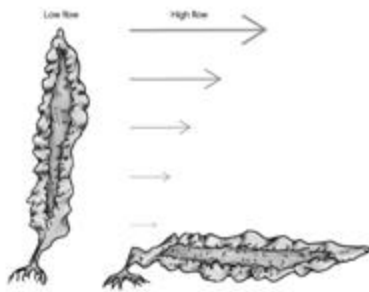
Movement of Water

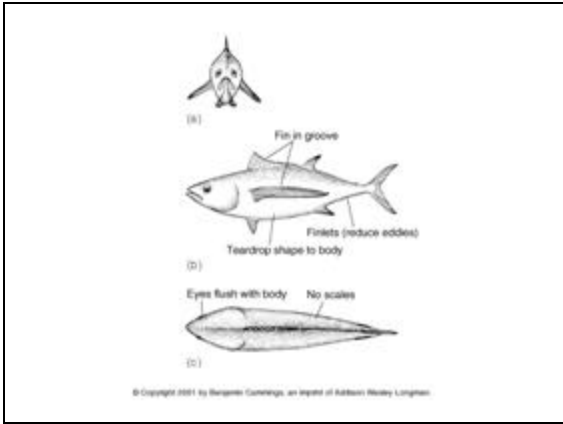
- Brownian motion takes place at the finest scales (atomic to approximately bacterium size)
- Laminar flow, unidirectional flow
- Turbulent flow, flow vectors in many directions
- Gravity (what generally flows downhill)
- Wind/waves
- Tidal forces
- Coriolis
- Organisms
- Important concepts, flow boundary layer, streamlining

Flow Boundary Layer



Flexible plants can take advantage of the reduced flow near boundaries





Stokes Law

- Sinking rate of small spheres is a function of size and density of the sphere and viscosity and density of water
- Organisms can alter shape to change sinking rate (*Melosira* example)
- $U = \frac{2gr^2(\rho_s - \rho_f)}{9\mu}$

Forces that Move Water

- Hydrologic cycle (solar energy and gravity)
- Wind
- Coriolis effect
- Organisms (bioturbation)

