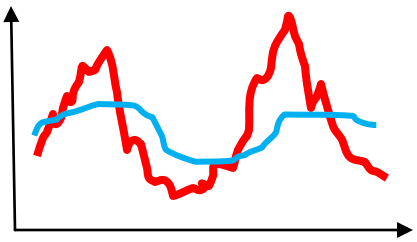
PHYSICAL—TEMPERATURE



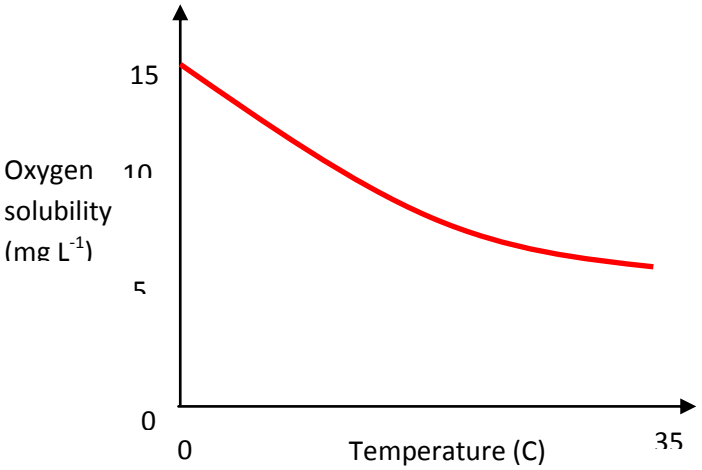
Introduction to water and temperature

- *Water has high **specific heat**.*
  - It takes a lot of energy to warm water.

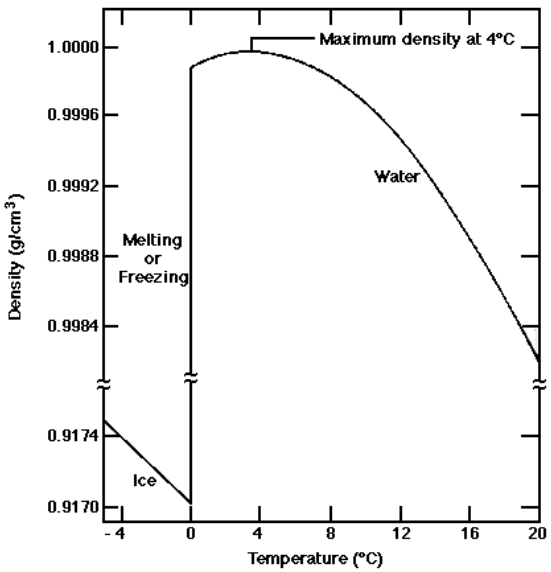
- Water temperature influenced by:
  - Inputs: groundwater is usually constant (~long term average)
  - Heating/cooling:
    - Light energy
      - Thus impacted by loss/gain of riparian vegetation
    - Earth

- Stream temperatures are often buffered compared to riparian temperatures, with lower daily and seasonal fluctuations.

- Solubility of gases in water is temperature dependent



- Water has pretty unique relationship between temperature and density.
  - Frozen water floats!!
  - This allows animals to live under the ice, otherwise, rivers would freeze from the bottom up and freeze everything.

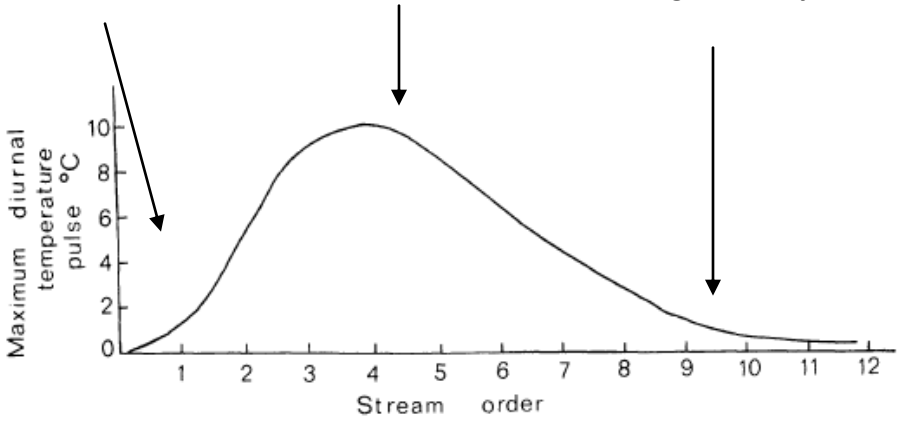


STREAM ECOLOGY

Temperature variation across time

- Diel patterns—usually have some daily fluctuations but varies depending on where in watershed.

Groundwater **Solar radiation** **Large and very buffered**



From Vannote and Sweeny 1980

- Seasonal patterns of water temperature depend on water source.

- Not surprisingly, rivers at higher latitudes are colder. But still lots of variation at fine spatial scales depending on the source of water and exposure to sun, etc.

Bioenergetics:

- Most animals in streams are **ectothermic** ("cold-blooded").
- Stream temperature thus changes the rates of consumption, growth.
- The energetic demands of fishes change systematically as a function of temperature. In general, growth increases gradually as temperature increases, and then decreases dramatically at a critical temperature.
- Stream animals thus have behaviors and life-histories that are adapted to spatial and temporal dynamics in temperatures.
    - E.g, Armstrong et al. (2010). Coho salmon in streams.

STREAM ECOLOGY

Climate change

- Annual mean river temperatures are increasing around 0.1 to 0.8 degrees C per decade.
- This also dramatically changes flow regimes
    - earlier snowmelt
    - more rain dominated hydrographs

FRASER RIVER SOCKEYE.--Example of climate change, temperature increases, and consequences

Climate change and mortality

- During years with warmer water temperature, more fish die on migration upriver

1995-present—Early migration phenomenon

- Late run fish now are migrating earlier
- They are now exposed to higher temperatures
- Why? This might be an evolutionary trap—where past evolutionary forces no longer apply today

Local adaptation in Fraser sockeye

- There are numerous locally adapted sockeye populations in the Fraser
- Eliason et al. 2011 did a physiological study of sockeye populations
- Local physiological adaptations to migrations and water temperature

Future adaptation to climate change

Adaptive potential will depend on:

1. Strong directional selection
2. Genetic variation
3. Heritability of traits
4. Plus, whether traits will evolve or come up to hard physiological blocks. . .

- Study by Reed et al. 2011 predicted evolution of migration of sockeye from now until 2100
- This study used a model to make a prediction on evolution and population consequences
- Predicted that evolution may be able to keep up with climate change
    - But great uncertainty and depends on above conditions