8.1 HUMAN IMPACTS ON AQUATIC ECOSYSTEMS

College Board Topics 8.1 and 8.2

Related Reading: chapter 15, especially pages 408 – 416

Learning Objectives and Essential Knowledge

ENDURING UNDERSTANDING

STB-3

Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.

LEARNING OBJECTIVE

STB-3.A

Identify differences between point and nonpoint sources of pollution.

ESSENTIAL KNOWLEDGE

STB-3.A.1

A point source refers to a single, identifiable source of a pollutant, such as a smokestack or waste discharge pipe.

STB-3.A.2

Nonpoint sources of pollution are diffused and can therefore be difficult to identify, such as pesticide spraying or urban runoff.

LEARNING OBJECTIVE

STB-3.B

Describe the impacts of human activities on aquatic ecosystems.

SUGGESTED SKILL

Mathematical Routines

6.B

Apply appropriate mathematical relationships to solve a problem, with work shown (e.g., dimensional analysis).

ESSENTIAL KNOWLEDGE

STB-3.B.5

Oceanic dead zones are areas of low oxygen in the world's oceans caused by increased nutrient pollution.

STB-3.B.6

An oxygen sag curve is a plot of dissolved oxygen levels versus the distance from a source of pollution, usually excess nutrients and biological refuse.

STB-3.B.1

Organisms have a range of tolerance for various pollutants. Organisms have an optimum range for each factor where they can maintain homeostasis. Outside of this range, organisms may experience physiological stress, limited growth, reduced reproduction, and in extreme cases, death.

STB-3.B.9

Increased sediment in waterways can reduce light infiltration, which can affect primary producers and visual predators. Sediment can also settle, disrupting habitats.

LEARNING OBJECTIVE

STB-3.F

Explain the environmental effects of excessive use of fertilizers and detergents on aquatic ecosystems.

SUGGESTED SKILL

Visual Representations

2.C

Explain how environmental concepts and processes represented visually relate to broader environmental issues.

ESSENTIAL KNOWLEDGE

STB-3.F.1

Eutrophication occurs when a body of water is enriched in nutrients.

STB-3.F.2

The increase in nutrients in eutrophic aquatic environments causes an algal bloom. When the algal bloom dies, microbes digest the algae, along with the oxygen in the water, leading to a decrease in the dissolved oxygen levels in the water. The lack of dissolved oxygen can result in large die-offs of fish and other aquatic organisms.

STB-3.F.3

Hypoxic waterways are those bodies of water that are low in dissolved oxygen.

STB-3.F.4

Compared to eutrophic waterways, oligotrophic waterways have very low amounts of nutrients, stable algae populations, and high dissolved oxygen.

STB-3.F.5

Anthropogenic causes of eutrophication are agricultural runoff and wastewater release.

LEARNING OBJECTIVE

STB-3.G

Describe the effects of thermal pollution on aquatic ecosystems.

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

ESSENTIAL KNOWLEDGE

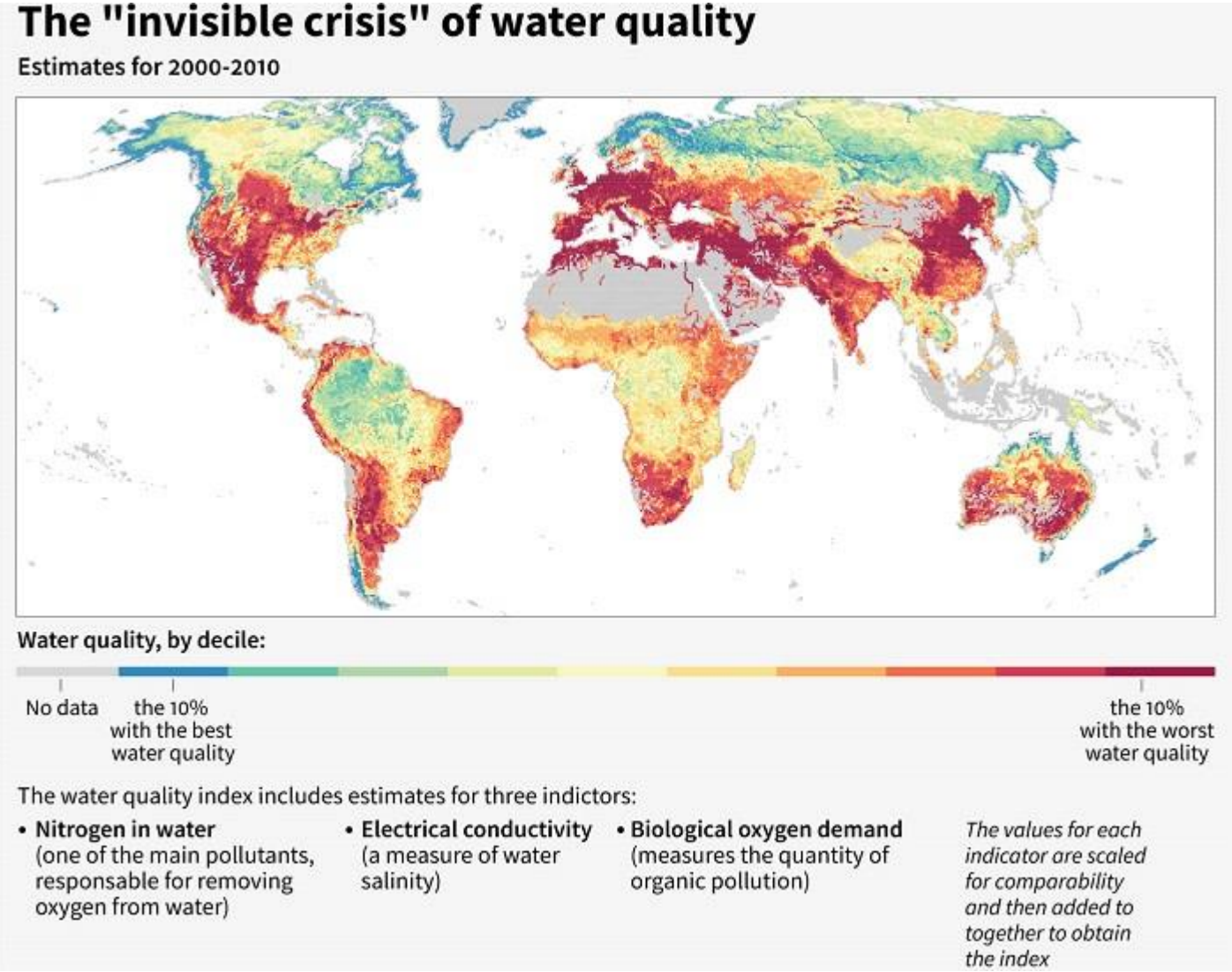
STB-3.G.1

Thermal pollution occurs when heat released into the water produces negative effects to the organisms in that ecosystem.

STB-3.G.2

Variations in water temperature affect the concentration of dissolved oxygen because warm water does not contain as much oxygen as cold water.

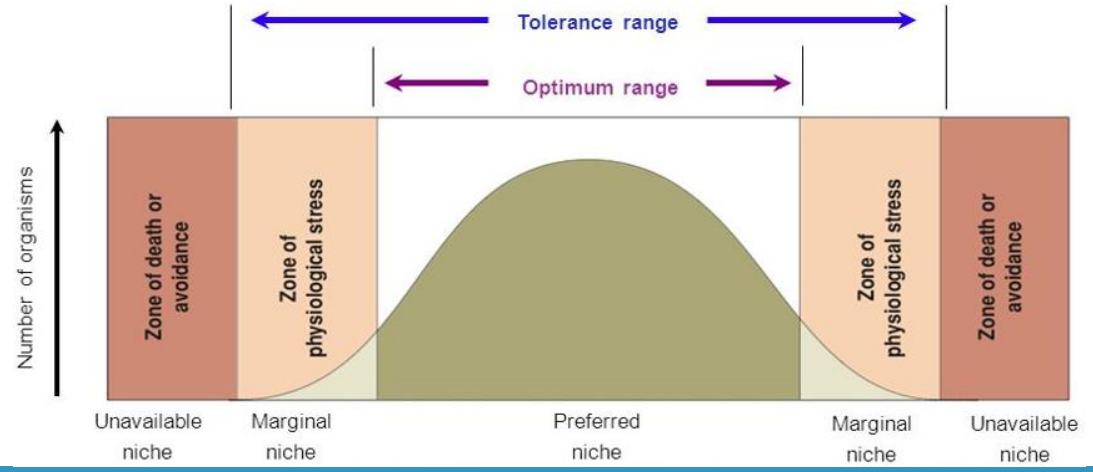
Human impacts on aquatic ecosystems



- People affect aquatic ecosystems and human health when we divert rivers, dam rivers, and introduce toxic substances and diseases.
  - Half of the world's major rivers are seriously depleted and polluted.
  - 55% of U.S. streams and rivers are in poor condition
- Oceans are downstream of everywhere, and much of our pollution ends up accumulating in the oceans.
- The invisible pollution of groundwater is a growing concern that is especially problematic
- Preventing pollution is easier and more effective than mitigating it later

Writing about pollution

- A big theme of Unit 8 is being able to explain effects of specific pollutants on organisms
- Organisms have ranges of tolerance for certain abiotic conditions and for pollutants.
  - Within this range of tolerance they can maintain homeostasis.
  - Pollutants cause physiological stress such as reduced growth, reduced reproductive success, difficulty respiring, hormonal disruption, death (if concentration of pollutant is high enough).



Pollutants

- Specific chemicals or groups of chemicals from specific sources with specific environmental & human health effects
  - Much more likely to earn you FRQ credit on any pollution-related FRQ:
    - Specific pollutant names, their sources, their environmental & human effects, their mitigation strategies

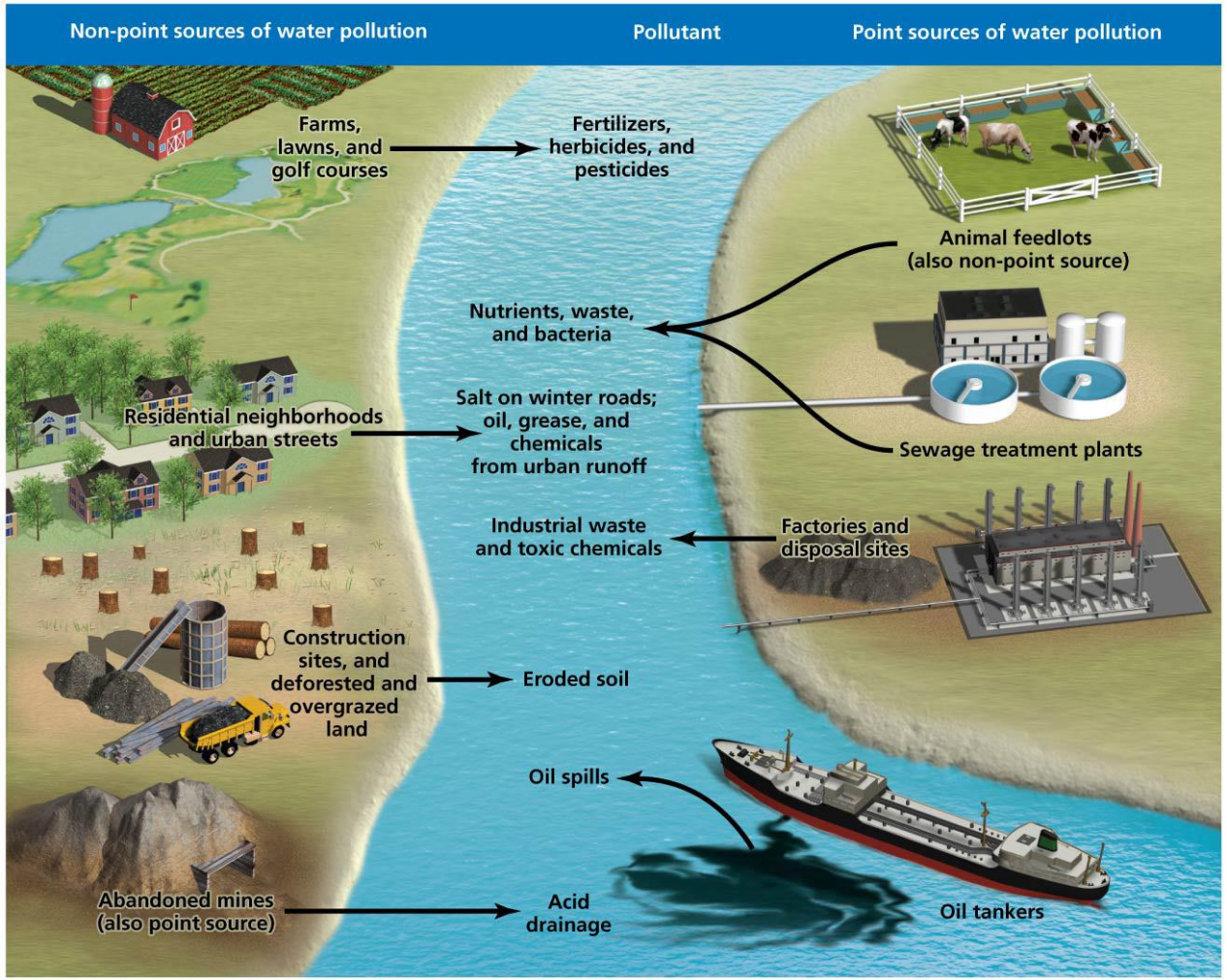
Pollution

- Vague, nondescript term for any substance that is harmful to the environment
  - Rarely acceptable on an APES FRQ
  - The exception is specific categories of pollution that aren't caused by specific chemical compounds.
  - Thermal pollution, Noise pollution, Sediment pollution

Point source vs. nonpoint source pollution

Nonpoint Source

- Pollutants entering the environment from many places at once spread out over a larger geographic region.
  - Difficult to "point" to one individual source

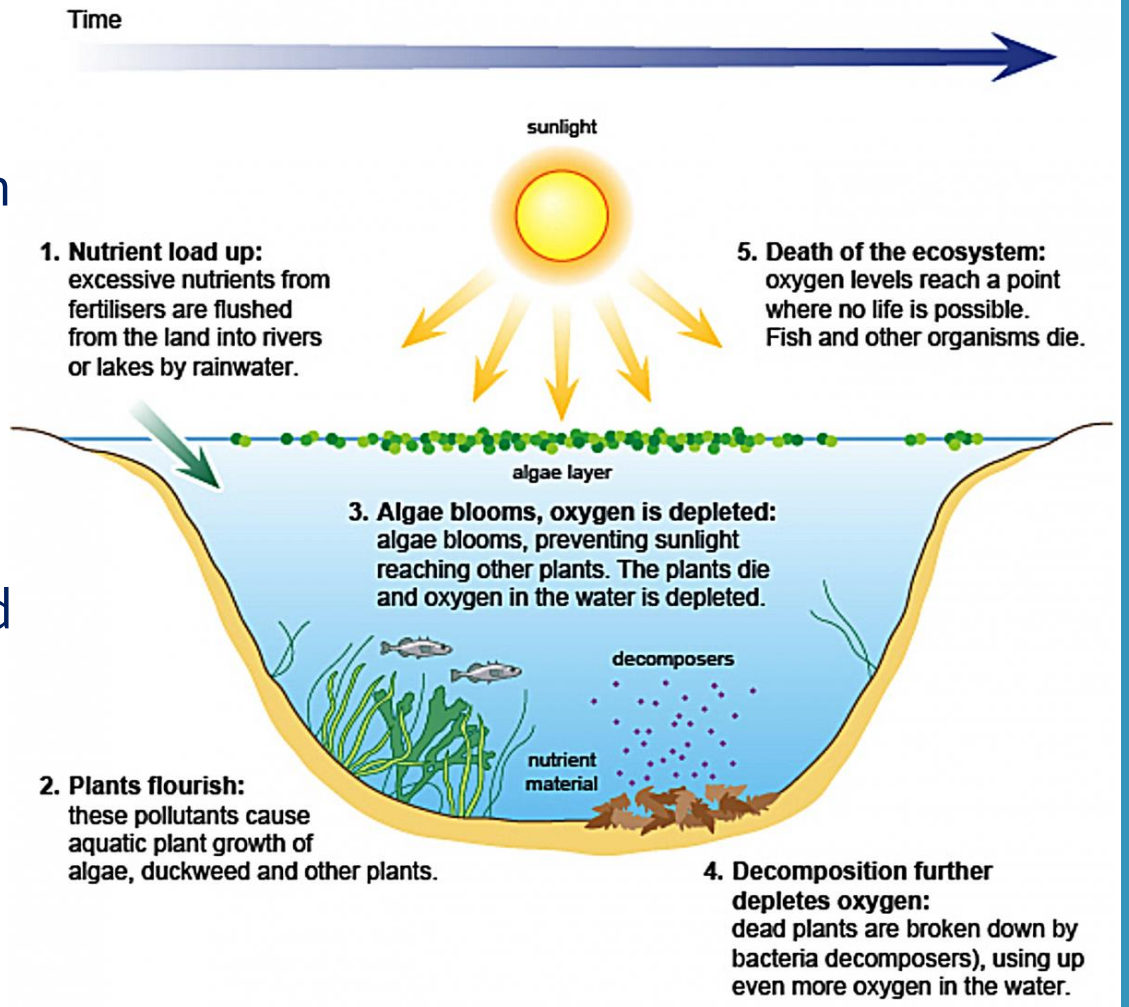


Point source

- Pollutant that enters environment from an easily identified and confined place
  - You can "point" to it.

Nutrient Pollution

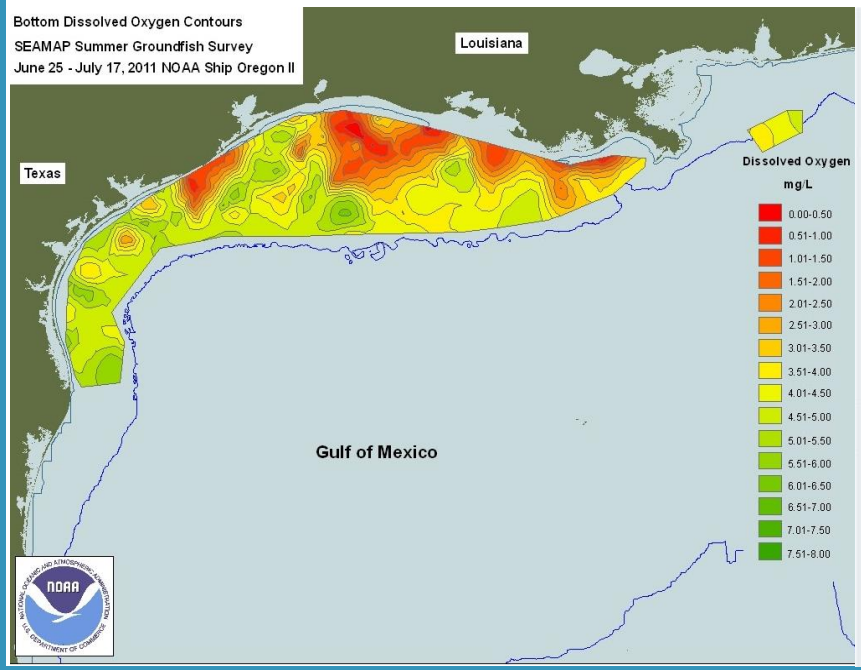
- Nitrogen and phosphorous are often ***limiting nutrients*** in aquatic ecosystems.
- Increases in these limiting nutrients leads to ***eutrophication*** of surface waters
  - Eutrophication results in increased Biological Oxygen Demand (BOD) aquatic ecosystems.
  - When BOD increases, ***dissolved oxygen levels (DO)*** decrease

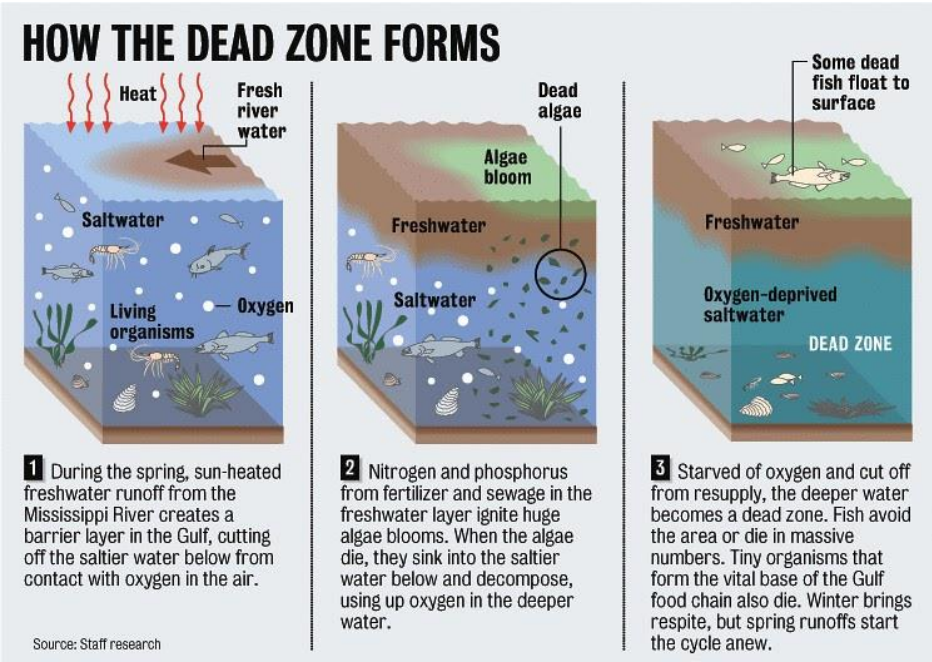


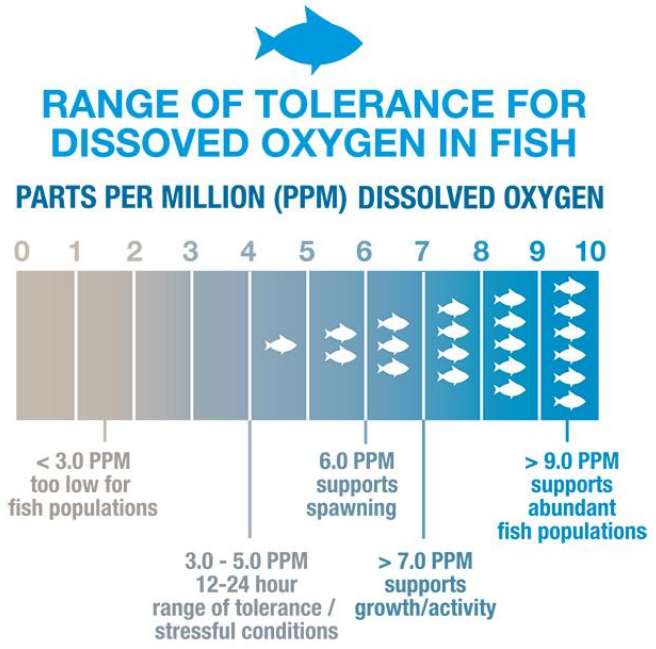
- Nutrient pollution results from:
  - runoff of fertilizers (not pesticides) from farms, golf courses, and residential lawns.
  - Sewage leaks and /or discharge into surface waters
  - Flooded or leaking manure lagoons at CAFO's.

Hypoxia and Dead Zones

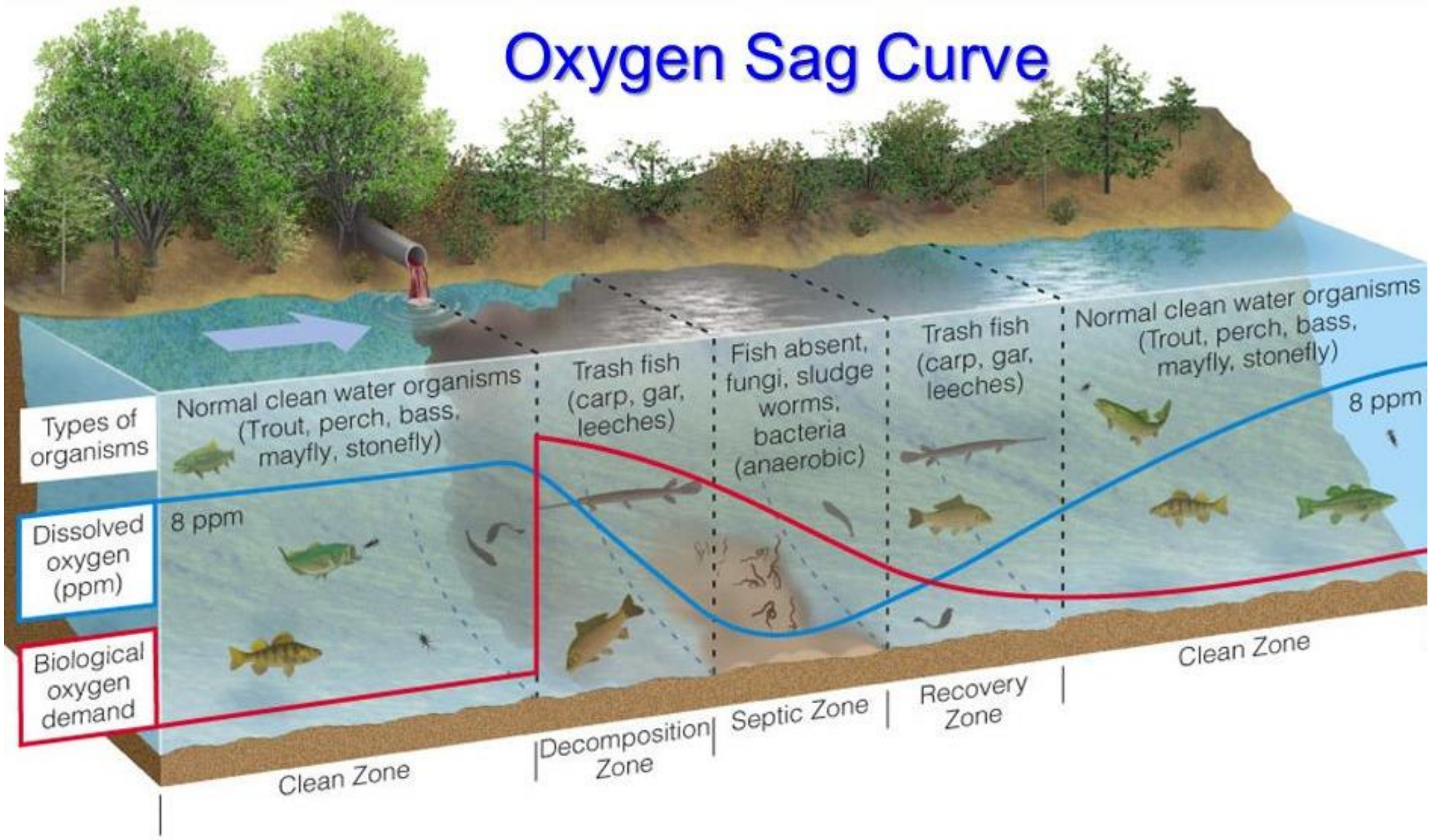
- Decreases in dissolved oxygen (hypoxia) is what causes dead zones.
  - All aquatic life requires dissolved oxygen in water for respiration.
  - Different species have different ranges of tolerance for DO levels.
  - As the DO level decreases during eutrophication, fewer species can be supported.
- The Gulf of Mexico experiences a large dead zone each spring around the Mississippi river delta.
  - Warm temperatures create poorly mixed ocean layers and fertilizer enriched runoff increases with the return of the growing season and spring rains.







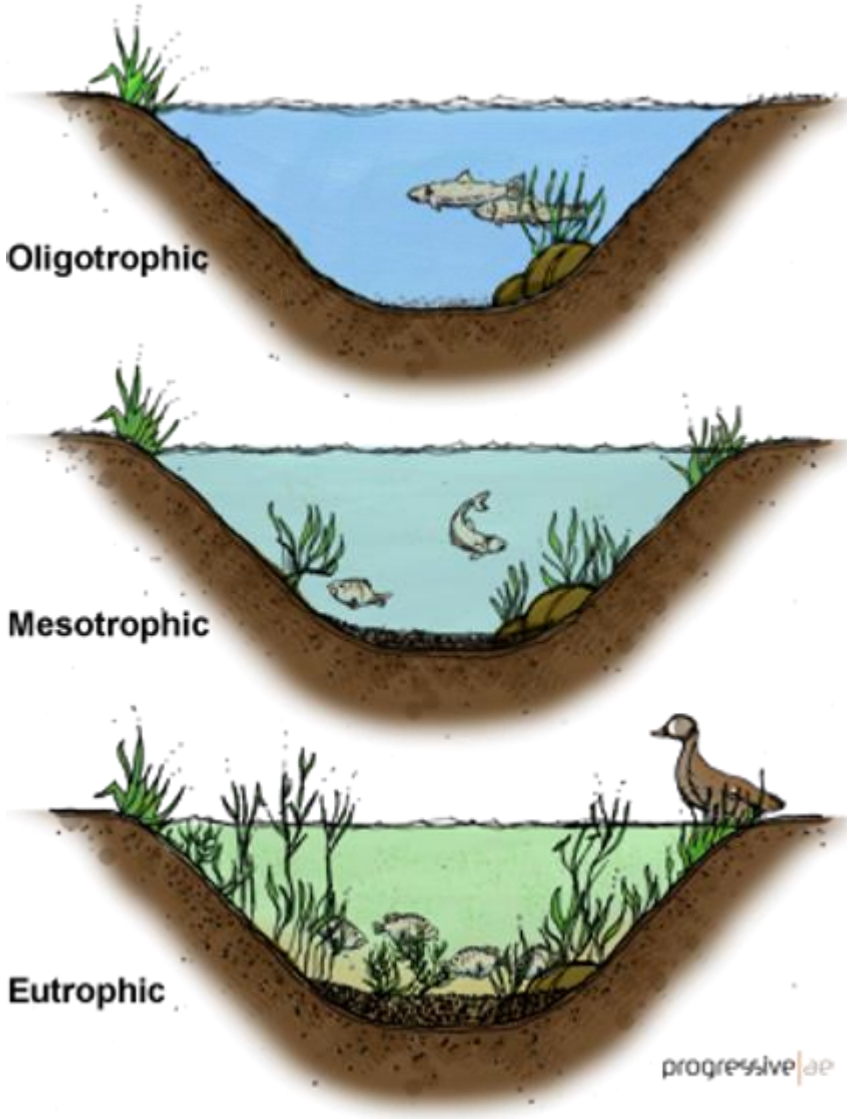
Oxygen Sag Curve



Eutrophic v. Oligotrophic

- Lakes and ponds with low nutrient (N/P) levels, stable algae populations, and high dissolved oxygen are ***oligotrophic***.
  - Can be due to lack of nutrient pollution, or age of the body of water.

- Lakes and ponds naturally undergo succession from oligotrophic to eutrophic.
  - Sediment builds up on the bottom (benthic zone) due to continuous erosion in watersheds and deposition into lakes and ponds.
  - Shallower benthic environments lead to increased sunlight reaching these environments, increasing the growth of rooted aquatic vegetation.
  - Increased growth of rooted aquatic vegetation traps more sediment and dissolved nutrients and the pond becomes shallower and more nutrient enriched.
  - Overtime, ponds naturally shift from oligotrophic, to mesotrophic, to eutrophic.

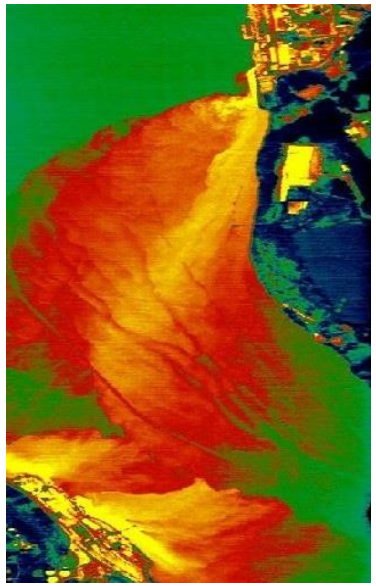


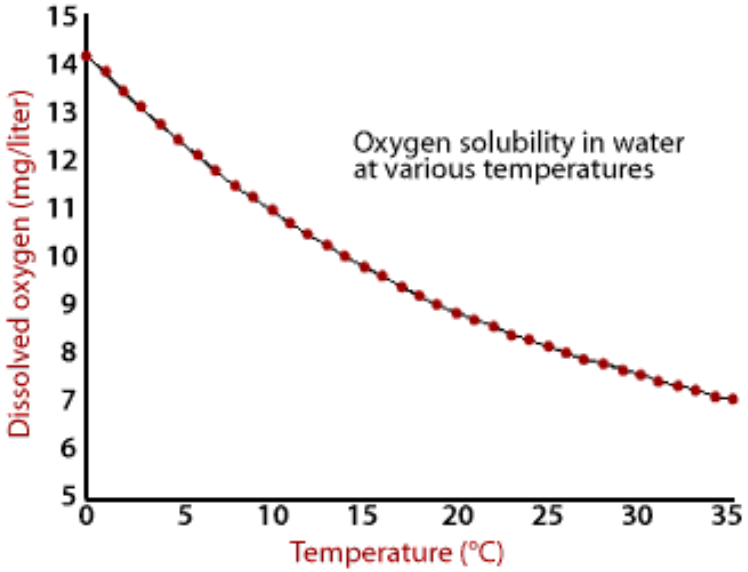
Sediment Pollution

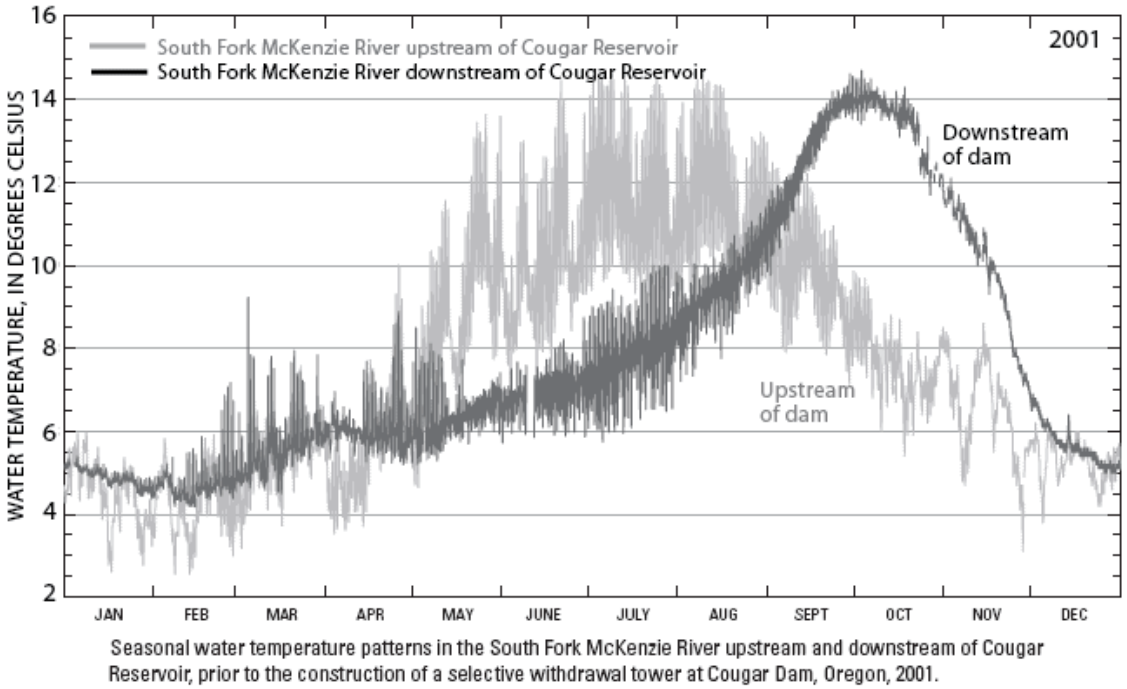
- ***Sediment*** is eroded material carried rivers and deposited in depositional basins (lakes, bays, river deltas, oceans)
  - Sediment pollution increases the turbidity of aquatic ecosystems.
  - ***Turbidity*** measures the depth that light can penetrate from the surface of the water.
  - Increased turbidity reduces the net primary productivity of aquatic ecosystems which can alter entire food webs /chains.
  - Increased turbidity affect visual predators due to reduced visibility.
- Logging, mining, construction, and farming are common causes of increased sediment pollution in watersheds and coastal regions.

Thermal Pollution

- ***Thermal pollution*** results from any process that changes the ambient water temperature.
- Heat increases respiration rate of aquatic organisms (thermal shock).
- Hot water also has less dissolved O_2
  - Gases diffuse out of solution more rapidly at higher temperatures
  - The solubility of gases in water decreases as temperature of the solution rises.
- Cold water released through hydroelectric dams, off the bottom of deep reservoirs, can also cause thermal shock.
- Reservoirs can change seasonal temperatures of water downstream, impacting the timing of migration, spawning, and egg hatching.
  - Reservoirs delay the warming of waters downstream.



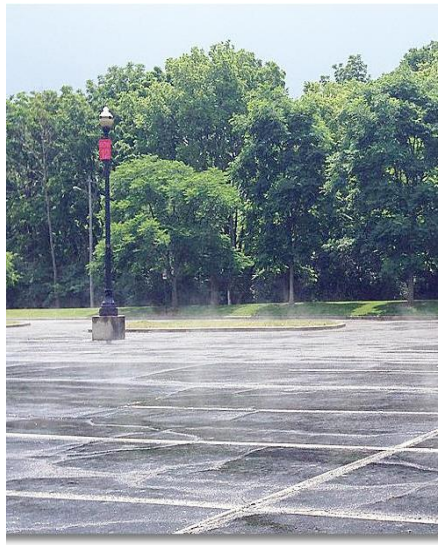


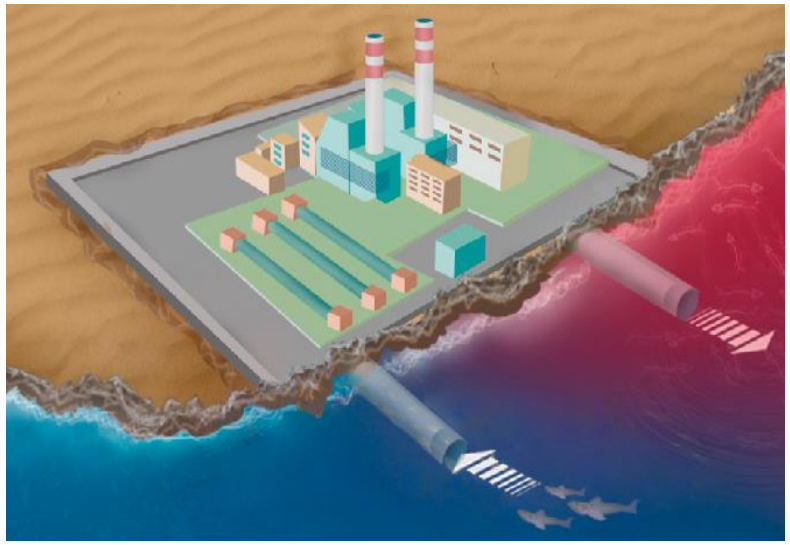


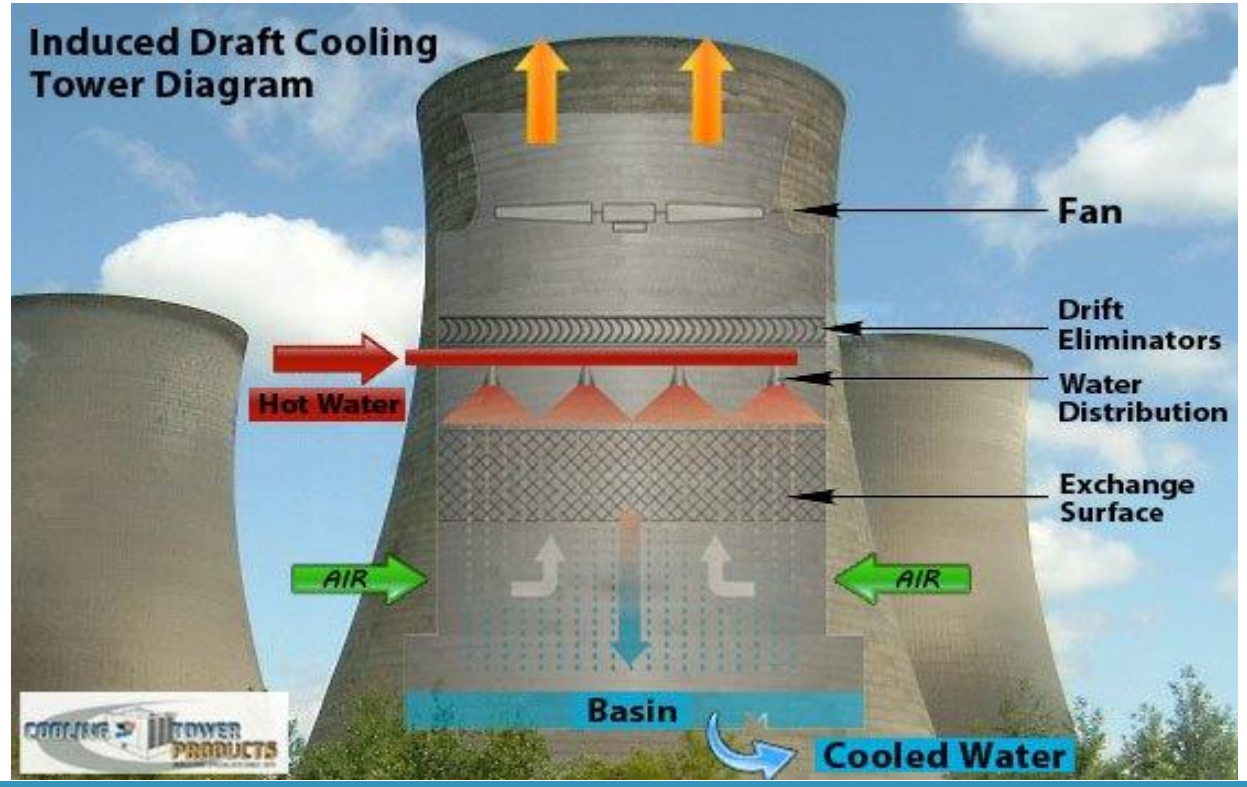
Seasonal water temperature patterns in the South Fork McKenzie River upstream and downstream of Cougar Reservoir, prior to the construction of a selective withdrawal tower at Cougar Dam, Oregon, 2001.

Causes of Thermal Pollution

- Power plants use cool water from surface/ground water sources nearby to cool the steam produced for turning a turbine back into water to reuse.
  - Nuclear power plants require especially large amounts of cool water to cool steam back into water & to cool the reactor core.
  - Cooling towers and holding ponds help to cool water before discharging it back into the environment.
- Steel mills, paper mills, and other manufacturing plants also use cool water to cool down machinery & return warmed water to local surface waters
- Urban storm water runoff can also cause thermal pollution due to heat from blacktop/asphalt.







Video Resources

- Water Pollution
  - https://www.youtube.com/watch?v=GNGKsubYJ9U