
THERMAL POLLUTION

DEFINITION

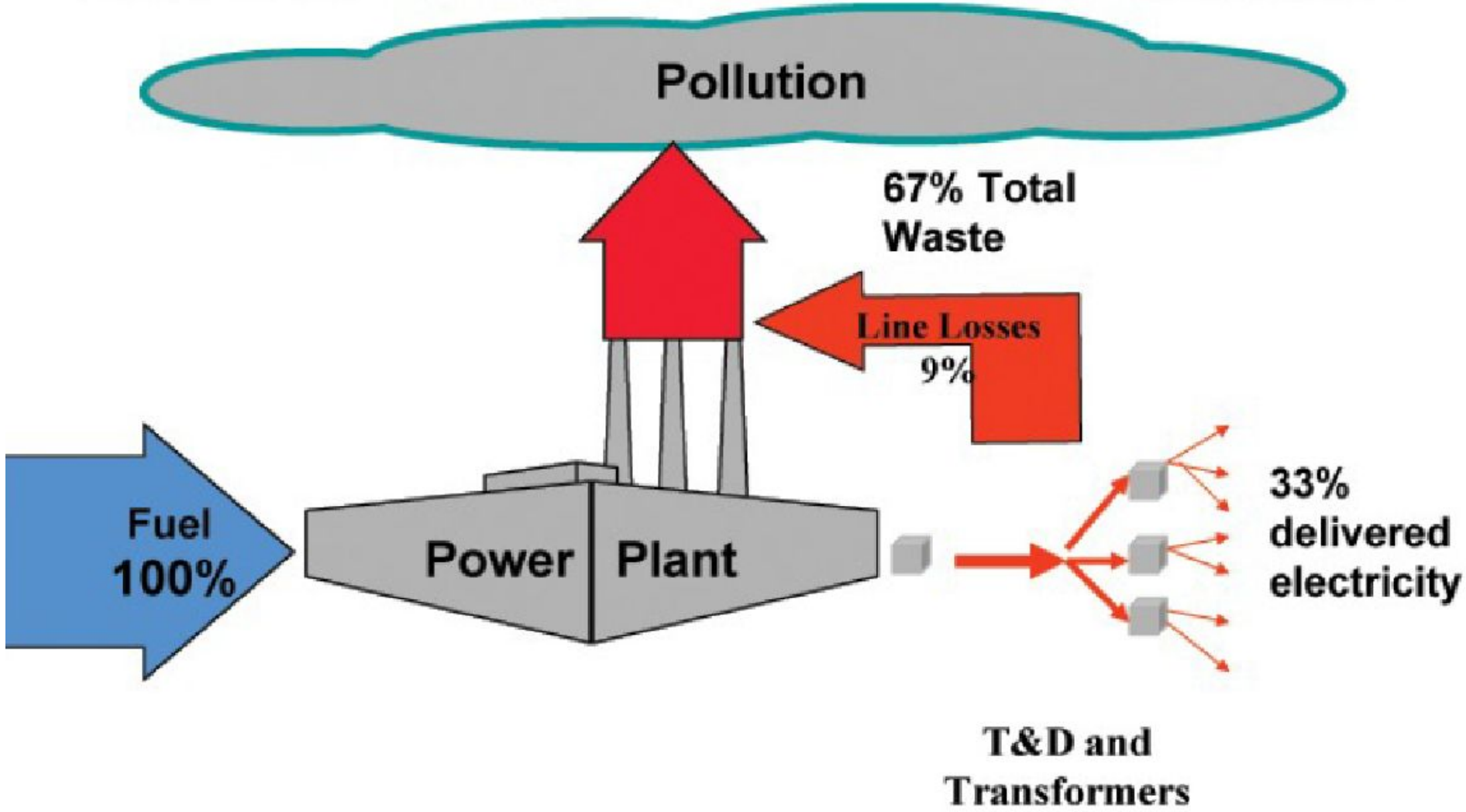
- Thermal pollution is defined as the addition of excess of undesirable heat to water thereby making it harmful to man, animal or aquatic life.
- Thermal pollution may also cause significant departures from normal activities of aquatic communities.

CAUSES

DISCHARGE OF HEATED WATER OR HOT WASTE MATERIAL INTO WATER BODIES FROM

- NUCLEAR POWER PLANTS
- INDUSTRIAL EFFLUENTS
- DOMESTIC SEWAGE
- HYDRO-ELECTRIC POWER
- COAL FIRED POWER PLANTS

Conventional Central Generation



Waste Heat from Power Plant

HEAT CHARACTERISTICS OF TYPICAL STEAM ELECTRIC PLANTS (VALUES IN Btu PER kWh)

Plant Type	Thermal Efficiency (%)	Required Heat Input	Total Waste Heat	Lost to Boiler Stack*	Heat Discharged to the Condenser	Cooling Water Requirement ($ft^3/s/MW$ of capacity†)
Fossil fuel	33	10,500	7100	1600	5500	1.6
Fossil fuel (recent)	40	8600	5200	1300	3900	1.15
Light water reactor	33	10,500	7100	500	6600	1.9

*Approximately 10 to 15% × required input for fossil fuel; approximately 3 to 5% × required input for nuclear.

†Based on an inlet temperature in the range of 70°F to 80°F and a temperature rise across the condenser of 15°F (8°C).

Source: R. Rimberg, "Utilization of Waste Heat from Power Plants," William Andrews Pub. LLC, 1974.

Nuclear power plants

- Nuclear power plants including drainage from hospitals, research institutions, nuclear experiments and explosions, discharge a lot of heat that is not utilized along with traces of toxic radio nuclides into nearby water streams.
- Emissions from nuclear reactors and processing installations are also responsible for increasing the temperatures of water bodies.
- The operations of power reactors and nuclear fuel processing units constitutes the major contributor of heat in the aquatic environment.
- Heated effluents from power plants are discharged at 10^0C higher than the receiving waters that affects the aquatic flora and fauna.

Coal-fired power plants

- Coal fired power plants constitute a major source of thermal pollution.
- The condenser coils in such plants are cooled with water from nearby lakes or rivers. The resulting heated water is discharged into streams thereby raising the water temperature by 15^0C.
- Heated effluent decreases the dissolved content of water resulting in death of fish and other aquatic organisms.
- The sudden fluctuation of temperature also leads to *"thermal shock" killing aquatic life that have become acclimatized to living in a steady temperature.*

Industrial effluents

- Industries like textile, paper, pulp and sugar manufacturing release huge amounts of cooling water along with effluents into nearby natural water bodies.
- The water is polluted by sudden and heavy organic loads result in severe drop in levels of dissolved oxygen leading to death of several aquatic organisms.

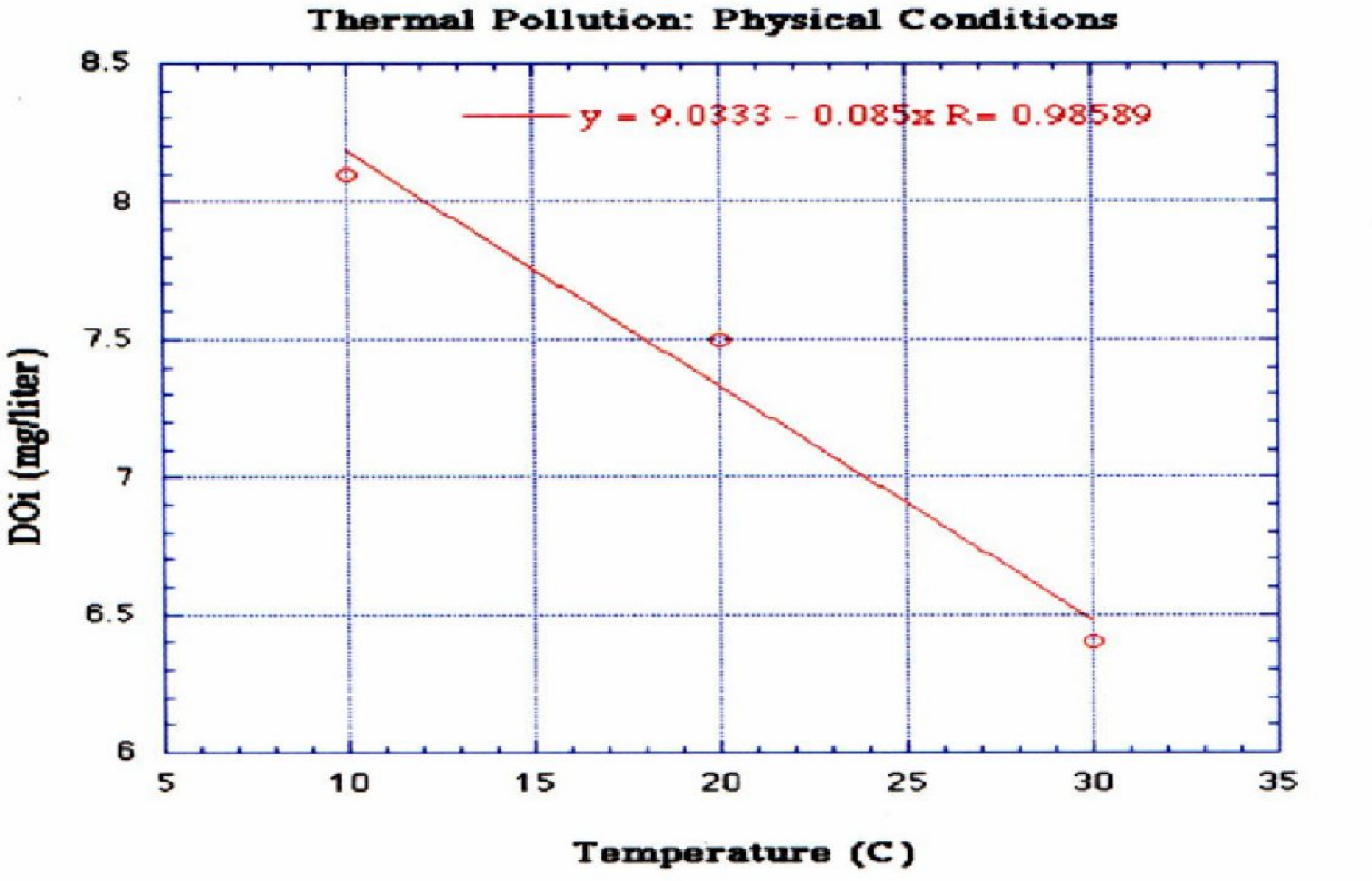
Industrial Effluents

- ✓ Discharged water from steam-electric power industry using turbo generators will have a higher temperature ranging from 6 to 9°C than the receiving water
- ✓ In modern stations, producing 100 MW, nearly one million gallons are discharged in an hour with increase in temperature of the cooling water passing by 8 to 10 °C

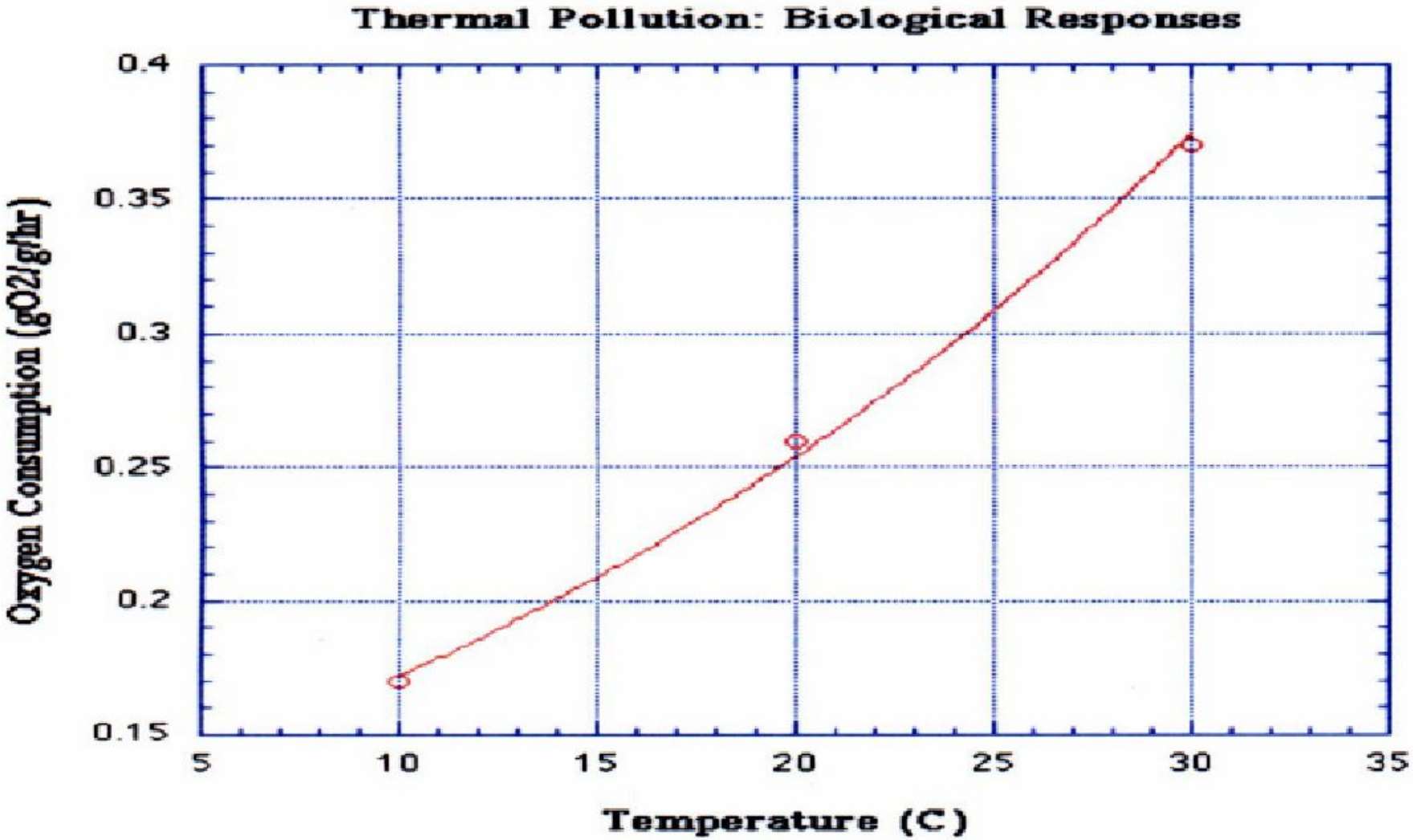
Domestic Sewage

- Domestic sewage is discharged into rivers, lakes, canals or streams with minimal treatment or without any treatment.
- These wastes have a higher organic temperature and organic load.
- This leads to decrease in dissolved oxygen content in the receiving waters resulting in the set-up of anaerobic conditions causing release of foul and offensive gases in water.
- Eventually, this leads to development of anoxic conditions resulting in rapid death of aquatic organisms.

Dissolved Oxygen vs Temp



Fish Oxygen Use vs. Temperature



Hydro-electric power

- Generation of hydroelectric power sometimes leads to negative thermal loading in water systems.
- Apart from electric power industries, various factories with cooling requirement contribute to thermal loading.

✓ Creates less heat on water sources less than nuclear power plant

Thermal pollution in streams by human activities

- Industries and power plants use water to cool machinery and discharge the warm water into a stream
- Stream temperature rises when trees and tall vegetation providing shade are cut.
- Soil erosion caused due to construction also leads to thermal pollution.
- Removal of stream side vegetation.
- Poor farming Practices also lead to thermal polloution.

Effects of Thermal Pollution

- **Reduction in dissolved oxygen:** Concentration of Dissolved Oxygen(DO) decreases with increase in temperature.
- **Increase in toxicity:** The rising temperature increases the toxicity of the poison present in water. A 10^0C increase in temperature of water doubles the toxicity effect of potassium cyanide, while 80^0C rise in temperature triples the toxic effects of o-xylene causing massive mortality to fish.
- **Food storage for fish:** Abrupt changes in temperature alters the seasonal variation in the type and abundance of lower organisms leading to shortage of right food for fish at the right time.

Effects of Thermal pollution

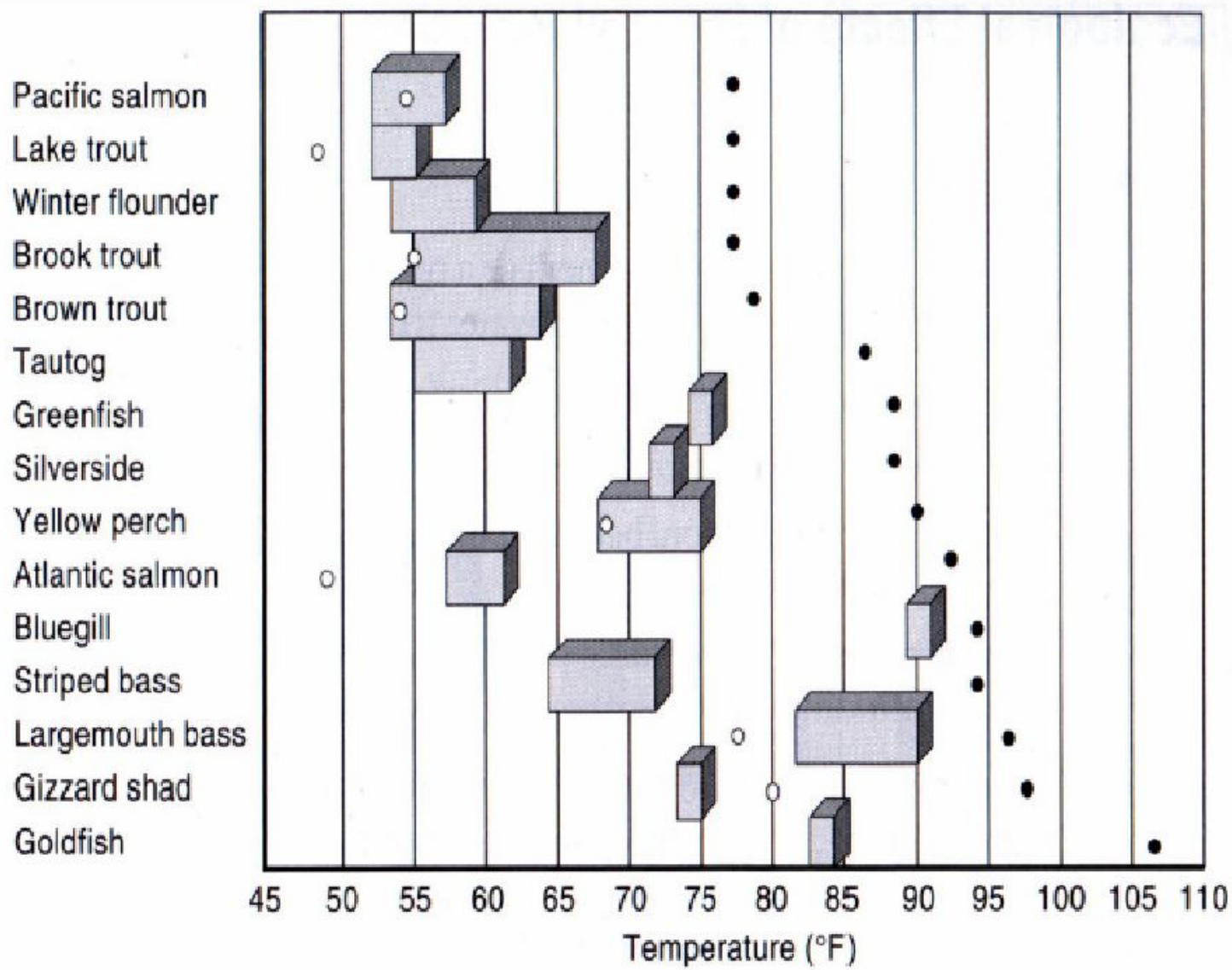
- **Interference in biological activity:** Temperature is considered to be of vital significance to physiology, metabolism and biochemical processes that control respiratory rates, digestion, excretion, and overall development of aquatic organisms. Temperature changes cause total disruption to the entire ecosystem.
- **Interference in reproduction:** In fishes, several activities like nest building, spawning, hatching, migration and reproduction depend on optimum temperature.
- **Direct mortality:** Thermal pollution is directly responsible for mortality of aquatic organisms. Increase in temperature of water leads to exhaustion of microorganisms thereby shortening the life span of fish. Above a certain temperature, fish die due to failure of respiratory system and nervous system failure.

Effects of Increased Water Temperature

- Thermal shock – aquatic life adapted to a certain water temperature can go into shock when the temp is changed even 1 or 2 degrees C.
- Oxygen dissolved in water decreases
- Increases the rate of photosynthesis, which increases the amount of plant growth, developing eutrophic conditions
- Increases the metabolic rate of fish, which increases their need for oxygen



Fish: Response to Temperature



Solid dot:
Upper lethal
Limit for a
Given species

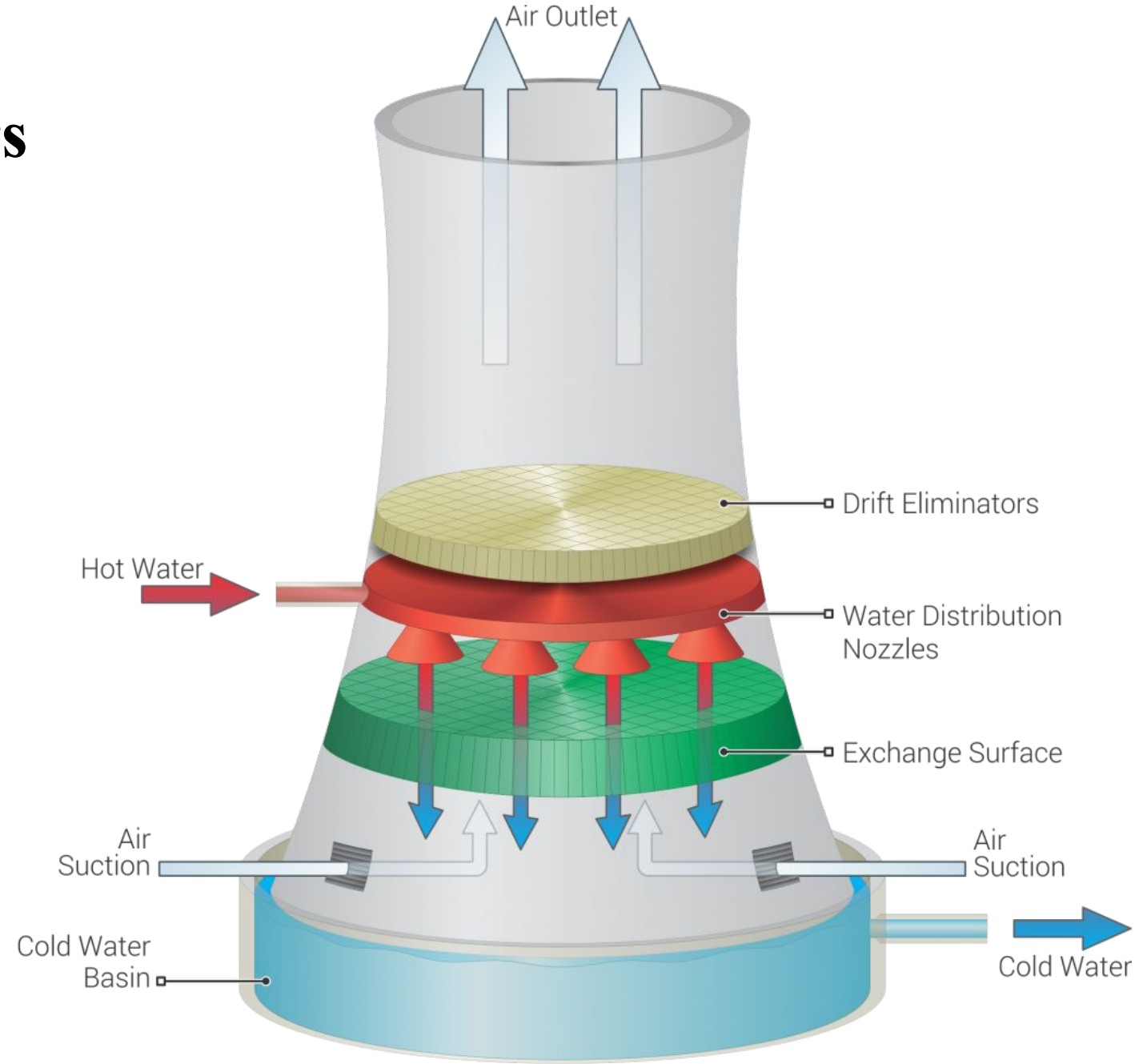
Open dot:
Best T for
spawning

Solid blocks:
Preferred
Temperature
Range

Control Measures for Thermal Pollution

- **Cooling towers:** Use of water from water systems for cooling systems for cooling purposes, with subsequent return to the waterway after passage through a condenser, is called cooling process. Cooling towers transfer heat from hot water to the atmosphere by evaporation. Cooling towers are of two types:
  - **Wet cooling tower:** Hot water coming out from the condenser (reactor) is allowed to spray over baffles. Cool air, with high velocity, is passed from sides, which takes away the heat and cools the water.
  - **Dry cooling tower:** Here, hot water is allowed to flow in long spiral pipes. Cool air with the help of a fan is passed over these hot pipes, which cools down hot water. This cool water can be recycled.

Cooling towers



Control Measures for Thermal Pollution

- **Cooling ponds:** Cooling ponds are the best way to cool thermal discharges. Heated effluents on the surface of the water in cooling ponds maximize dissipation of heat to the atmosphere and minimize the water area and volume.
- **Spray ponds:** The water coming out from condensers is allowed to pass into the ponds through sprayers. Here water is sprayed through nozzles as fine droplets. Heat from the fine droplets gets dissipated to the atmosphere.
- **Artificial lakes:** Artificial lakes are man made water bodies that offer once-through cooling. The heated effluents can be discharged into the lake at one end and water for cooling purposes may be withdrawn from the other end. The heat is eventually dissipated through evaporation.

Spray ponds



Control Measures for Thermal Pollution

- The cold water or air showers may be used in the industries to check hot gases, at the source.

- The excess heat energy that is produced in the generation of electricity may be utilized in another industry where this energy may be required. This process is called cogeneration.

- In places where residential or commercial buildings are located near the industrial plants the waste hot water may be used for heating purpose.