PART 3 – ANALYSIS – MARINE & ESTUARY

Along with biological analysis, water chemistry analysis plays an important role in determining water quality. Lack of key nutrients or excess of others can result in the degradation of the aquatic environment and harm aquatic life. The areas to be considered in Part 3 are the following:

Data Interpretation and Procedural analysis – some of the key chemical analysis areas

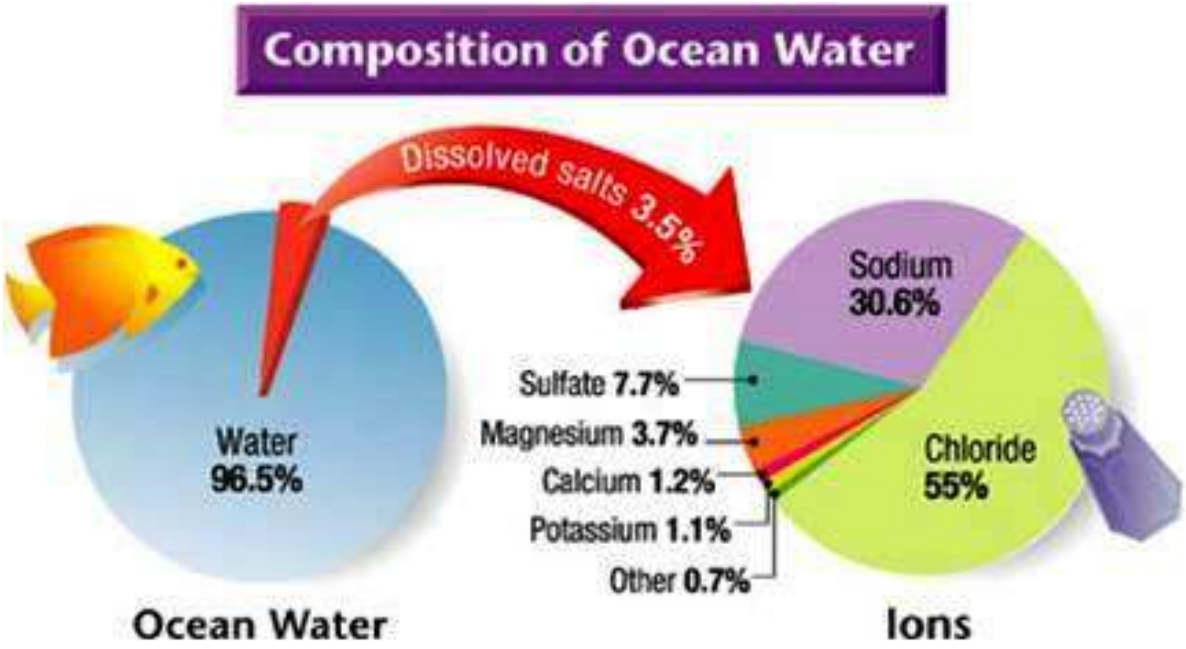
- salinity
- temperature
- **Aragonite (calcium carbonate) Saturation** – for Marine Environments esp. coral reefs
- pH
- turbidity - water clarity
- dissolved oxygen
- biochemical oxygen demand
- phosphates
- nitrates
- total solids
- fecal Coliform

Note : **The Water Quality Index used for freshwater does not apply to marine. Regions have their own marine water quality index.**

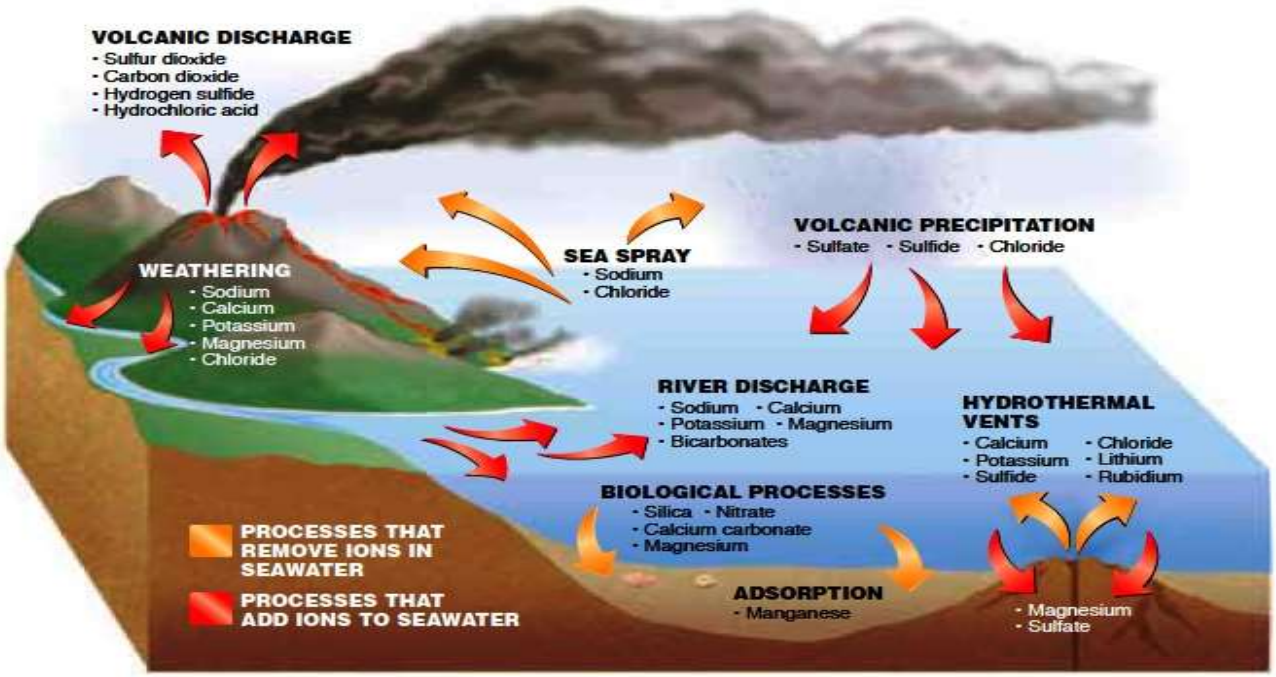
Build and calibrate a salinometer (Hydrometer) <u>prior to the competition and use in competition</u>

- Test salt water
- 1-10%

Understand the types of pollution, their effects on the aquatic ecosystem, and remediation strategies



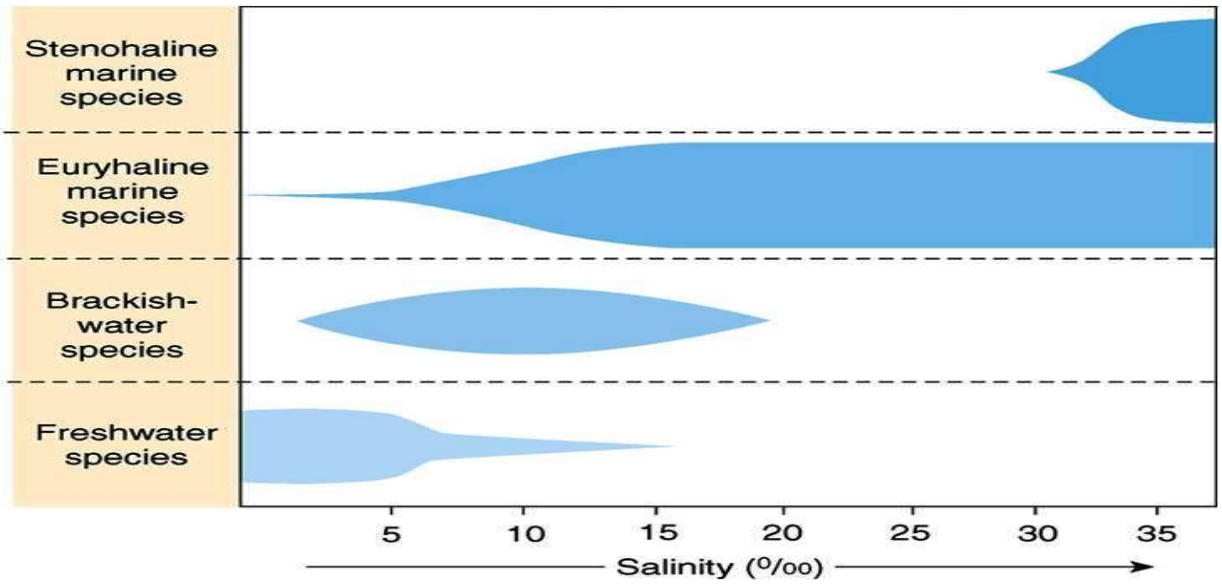
Chemical Analysis Tests



Sources of Oceans Salts

Salinity – measures the amount of salts in the water

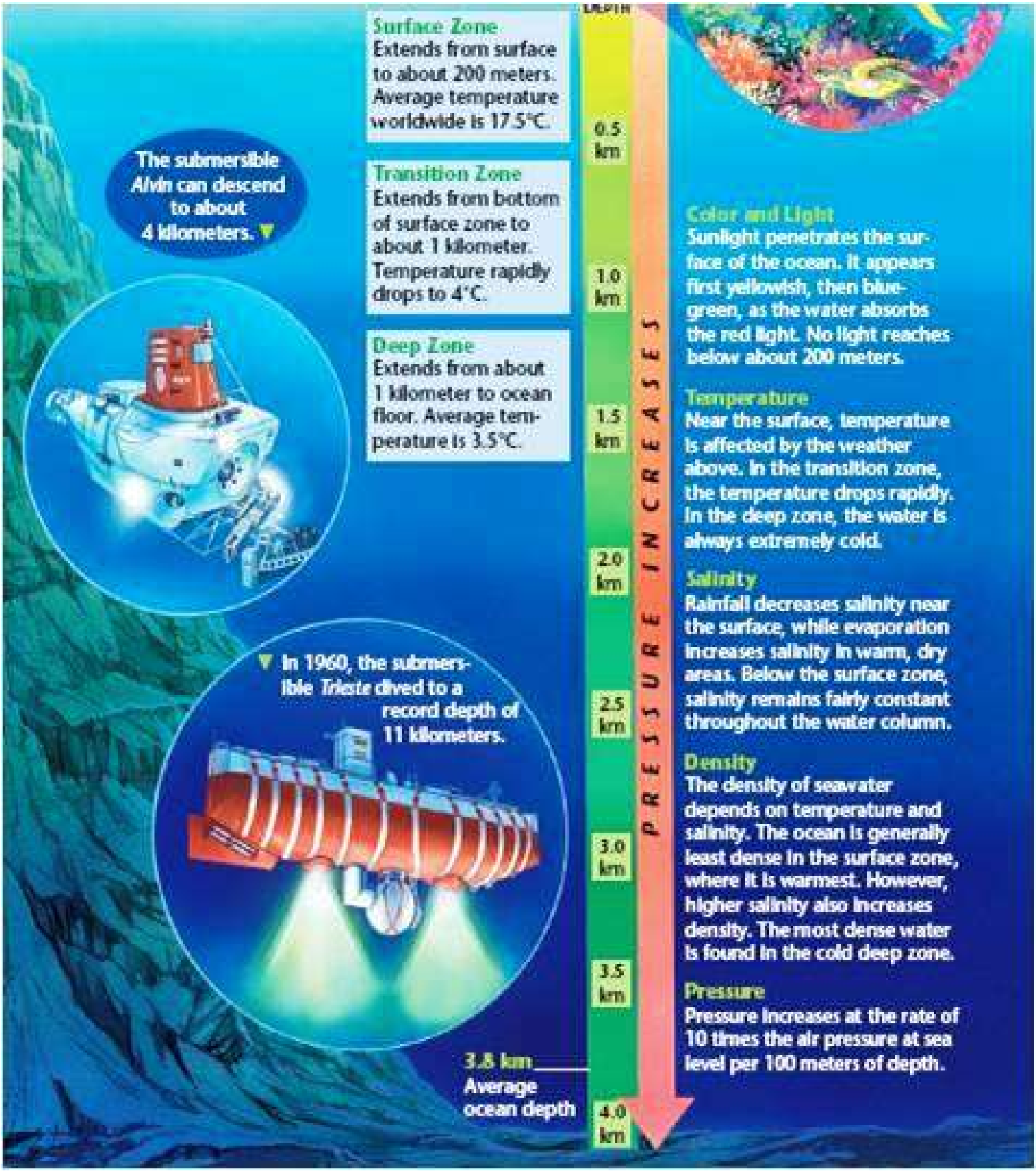
- On average 1 kg of ocean water contains about 35 grams of salts or about 3.5% (from 34-37 g)
- The main sources of marine salts are river discharge, weathering, biological processes, volcanic precipitation, and hydrothermal vents
- Salinity is lowered near the surface by rain, snow, or melting ice which adds freshwater but is increased by evaporation
- Salinity is lower near the mouth of large rivers
- The amount of salt is changing in estuaries as the freshwater from rivers flows into the salt water
- Ocean water does not freeze until the temperature drops below 29 degrees F
- Salt water has a higher density because of the salts so it has greater buoyancy and it lifts less dense objects floating in it.
- The amount of water circulation in estuaries affects the salt distribution as the fresh and salt water mix. This becomes a classification for the types of estuaries
- High levels of salt can adversely affect plant growth and water quality
- Sources of salt include seawater intrusion, human and animal wastes, industrial wastes, fertilizers, and winter highway deicing (salt spread on streets in winter can soak into adjacent soils and continue to leach into nearby waterways throughout the year)
- Vertical salt seepage of salt into shallow coastal aquifers is causing many problems
- Measuring the salt in a water sample by using a hydrometer/salinomter (water with more salt is more dense and has greater buoyancy so the hydrometer/salinometer will float at higher levels in the cylinder depending upon the concentration of salt)
- Many marine estuary organisms have developed special adaptations for salinity issues



Temperature – measures changes in the ambient water temperature

- Measured with a thermometer or temperature probe
- The surface of the ocean absorbs energy from the sun
- Warm water is less dense than cold water so warm water stays as a layer at the surface
- Near the equator, ocean surface temperatures reach 77 degrees F
- Temperature drops as you go away from the equator
- Temperature also decreases as you descend through the water column and pressure increases
- Affects the amount of gases such as oxygen that can be dissolved in the water – cold water holds more oxygen than warm water
- As the water temperature increases, the amount of oxygen that can dissolve in the water decreases
- Increases the metabolic rates of aquatic organisms
- Affects the rate of photosynthesis by aquatic plants and algae
- Increases the sensitivity of organisms to disease, parasites and pollution
- Small chronic temperature changes can adversely affect the reproductive systems of aquatic organisms
- Raising water temperature increases decomposition rate of organic matter in the water depleting dissolve oxygen supplies
- Types of temperature changes include natural seasonal changes, man's activities, industrial thermal pollution as discharge of cooling water, storm water runoff from heated surfaces as streets, roofs, parking lots, soil erosion increasing water turbidity which warms the water, removal of shade trees from along the shores
- Global Warming increasing sea water temperatures, will raise sea levels and change ocean currents affecting both the oceans, coastal areas and estuaries and their environments
- Bleaching occurs when corals respond to the stress of warmer temperatures by expelling the colorful algae that live within them

Color and Light, Temperature, Salinity, Density and Pressure of the Ocean Water Column

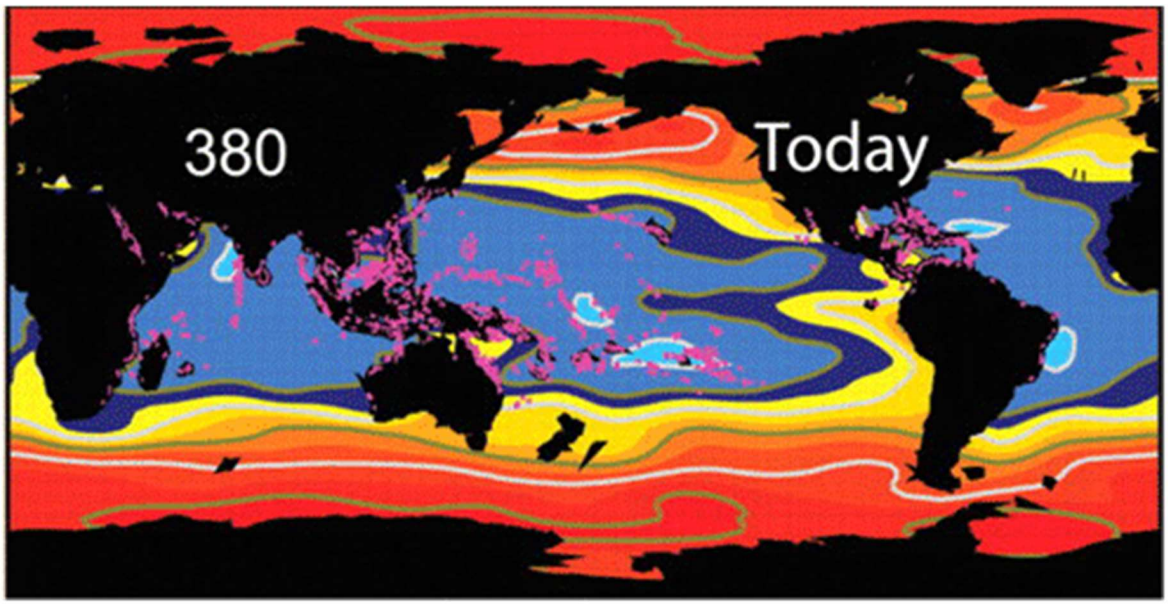


Aragonite (Calcium Carbonate) Saturation

- Saturation is the point at which a solution can dissolve no more of a particular substance and additional amounts of that substance will appear as a precipitate
- More solute can be enabled to dissolve if the conditions are change (e.g. increase the temperature of the solution) which is termed supersaturated.
- Saturation level is represented by the Greek letter omega (Ω)
- When Ω = 1, the solution is saturated, and when Ω >1, the solution is supersaturated, meaning that there is more calcium carbonate dissolved in the water than is possible under normal conditions
- The higher Ω is, the more likely precipitation (i.e., coral reef formation) is to take place.
- Conditions for Coral Reef Growth:

    - Ω > 4.0: optimal
    - 3.5 < Ω < 4.0: adequate
    - 3.0 < Ω < 3.5: marginal
    - Ω < 3.0: poor

- **Ω values are highest at low latitudes (straddling the equator)**
- **The majority of this region has Ω around 4, with a few pockets having Ω > 4.0**
- **The waters along the western coast of South America are the only exception, having Ω values around 3.0.** ***That is why there are not many coral reefs here***
- **Ocean Acidification** is affecting the Argonite Saturation and the health of coral reefs



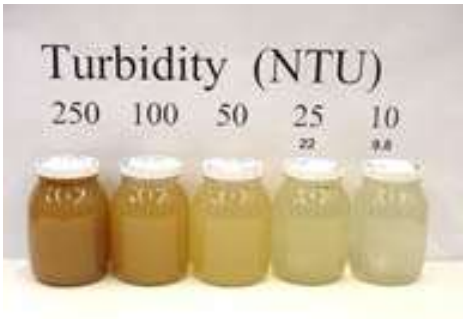
FFigure adapted from Hoegh-Guldberg et al., Coral Reefs Under Rapid Climate Change and Ocean Acidification, *Science*, 14 December 2007: Vol. 318. no. 5857, pp. 1737 - 1742. The 380 in the upper left corner indicates the atmospheric CO_2 concentration in parts per million (ppm). Coral reef locations are indicated by pink dots
http://serc.carleton.edu/eslabs/corals/4c.html

pH – measures the hydrogen ion concentration of substances in a scale of 0 to 14

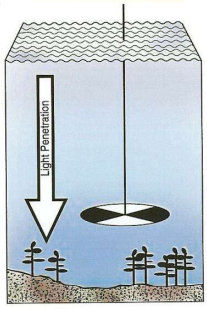
- Measured with a pH meter, pH probe or pH paper
- Water contains both hydrogen and hydroxyl ions
- pH of 0 to 7 is acidic with 0 being the most acidic
- pH of 7 is neutral – water containing equal numbers of hydrogen and hydroxyl ions
- pH of 7 to 14 is basic with 14 being the most basic
- The pH scale is lograthmic – pH change of one points indicated a 10 fold change
- Water with a pH of four is ten times more acidic than water having a pH of five
- Important examples of pH for natural waters:
  - fresh rain water 5.5 to 6.0
  - natural water 5.0 to 8.5
  - streams and ground water - 6.5 to 8.5 is optimal
  - seawater ~8.0
- **As the ocean becomes more acidic, the population of marine organisms, such as mollusks, corals, and phytoplankton, which require calcium carbonate and calcite to develop their shells, is decreasing. This is having major impacts upon reef communities, coastal communities and marine environment stability**

Turbidity – measures the clarity or haziness of the water in a given body of water

- Clear water has low turbidity and cloudy or murky water has high turbidity
- As sediments and other suspended solids increase in the water, the amount of light that can pass through the water decreases.
- Cloudiness occurs from suspended sediment, algal blooms, or dead organic matter in the water
- Turbidity can be measured using an electronic monitor. Turbidity is measured in nephelometric turbidity units (NTU's) – a comparison of the amount of light scattered by the suspended particles in the water



- Another way to measure turbidity is to lower a device called a Secci Disc can also be used - The Secci Disc has black-and-white elements. As the disc is lowered into the water, increasing turbidity will cause the black-and-white areas to fade into one another, and the disc will slowly disappear from sight. The depth that the Secci Disc disappears is record in cm.



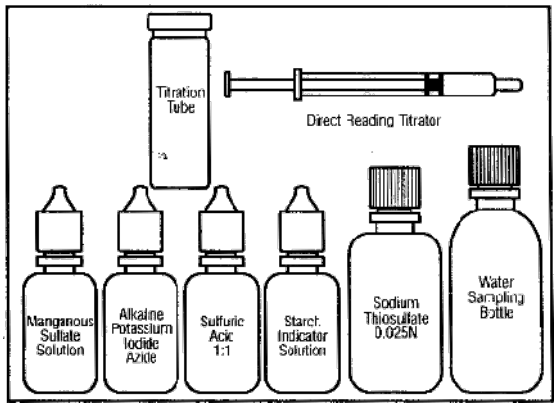
Secchi disk measurement.

- The turbidity affects the amount of light penetrating to the plants for photosynthesis
- High particulate concentrations can affect the ability of fish gills to absorb oxygen
- Contaminants as viruses and bacteria can become attached to particulate matter
- Natural color of water may affect the reading
- Seasonal variations may change the turbidity as with lake turnover in the fall due to nutrients being released from the bottom
- Algal blooms with affect turbidity
- Pollution tends to reduce water clarity
- Human activity as construction, agriculture, and land disturbances can lead to high sediment in storm water runoff
- Industries as mining can generate high levels of colloid rock particles

- Rivers bring suspended sediments to the estuaries and oceans so that turbidity is higher and more variable than in the open oceans, and the photic zone is generally shallower
- Benthic animal biomass is greater in continental shelf sediments than in the deep oceans, and benthic algae may perform primary production on the seafloor in those areas where turbidity and/or depth are low enough that light reaches the seafloor.

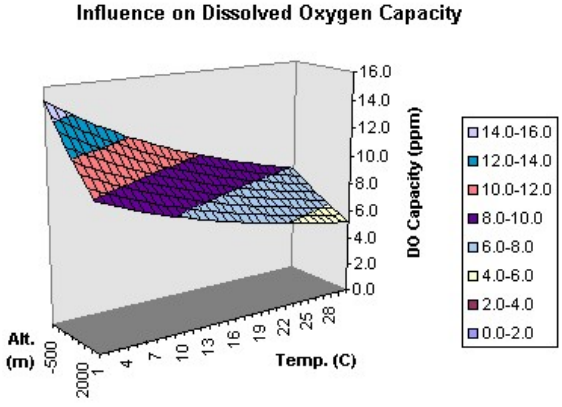
Dissolved Oxygen (DO) – measures the amount of gaseous oxygen dissolved in an aqueous solution

- Oxygen gets into the water by diffusion from the surrounding air, as a waste product of photosynthesis or by rapid movement of the water or aeration
- Kits are available for testing DO levels
- DO levels must be tested done carefully and quickly because so many factors affect DO
- Air is about 21% oxygen which is 210,000 ppm (parts per million)
- Most surface waters contain between 5 and 15 ppm of dissolved oxygen
- An appropriately high level of dissolved oxygen is essential for aquatic life
- Below 5 ppm puts aquatic life under stress, below 1-2 ppm for a few hours can kill large fish



DO Testing materials

- Absence of dissolved oxygen is a key sign of severe pollution
- Total dissolved oxygen levels should not exceed 110% - above this level can be harmful to aquatic life
- Many natural factors affect the levels of dissolved oxygen such as
  - Seasonal temperature changes – lower temperature equals more dissolved oxygen
  - Dissolved or suspended solids can reduce effectiveness dissolving of oxygen in water
  - Dry periods can lower stream discharge and raise water temperatures resulting in lower DO levels
  - The amount of plant life affects photosynthesis rates – more photosynthesis equals more oxygen being released by plants
  - The rate of respiration by all plants and animals aerobically
  - The rate of decomposition of organic matter uses oxygen so it greatly affects DO levels
  - Daily changes – night to day or /diel oxygen fluctuation - cause DO to fluctuate because plants need light for photosynthesis but respiration uses oxygen all through the 24 hr period
  - Algal blooms can cause large fluctuations in DO through the night especially in areas where there is not much current for aeration
  - Very low DO levels can cause aquatic animals to die

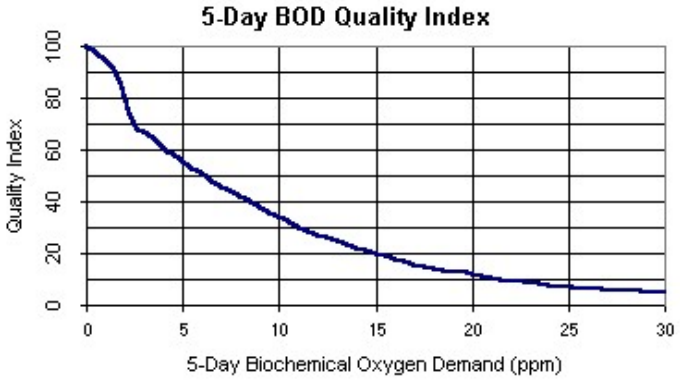


- Humans can also cause changes in DO by dumping organic waste into water increasing rates of decomposition in the water and can increase aquatic plant growth
- Urban runoff can bring pollutants, sediment, heat and other materials which raise water temperatures and lowering DO levels
- The release of water from a dam (top or bottom) release can affect the amount of DO in the water

- Removing shade vegetation as trees can increase water temperature and increase erosion to reduce DO levels

Biochemical Oxygen Demand (BOD) – measures how fast organisms use up the oxygen in the water

- Aerobic microbes use oxygen to oxidize the organic matter in the water
- BOD is tested using the maters for testing dissolved oxygen but the test is done over a period of time to determine the rate of oxygen being used
- Natural sources of organic matter may include plant decay or leaf fall
- Human waste as leaves, lawn clippings, paper waste, pet waste entering into the water can accelerate plant growth and decay because nutrients and sunlight are overly abundant
- These human wastes can increase oxygen demand
- Oxygen used for decomposition processes rob other organisms of oxygen needed to live
- Organisms with low tolerance may die off and be replaced by organisms with more tolerance for low oxygen levels



Phosphates – measures the amount of phosphates in the water (the compound for phosphorus in the water)

- The phosphorus cycle recycles phosphorus in the form of phosphates for most life forms
- Phosphorus is necessary for plant and animal growth
- Test kits are available to test total phosphates
- The ***total phosphorus*** test measures all the forms of phosphorus in the sample (orthophosphate, condensed phosphate, and organic phosphate).
- Phosphates enter waterway in a variety of natural ways such as phosphate containing rock and normal animal and plant waste in the water
- Phosphates will enter waterways from runoff
- Phosphates enter waterway in a variety of human sources such as fertilizers, pesticides, industrial and cleaning compounds, human and animal waste, power plant boilers (used to prevent corrosion), septic tanks and wastewater from sewage treatment plants
- Phosphates stimulate the growth of water plants and plankton
- Limited increases in plant growth can provide more food for aquatic macroinvertebrates and fish
- Too much phosphate can cause excess algae and aquatic weeds using up large amounts of oxygen and causing aquatic organisms and fish to die

Nitrates – measures the different forms of nitrogen in aquatic environments

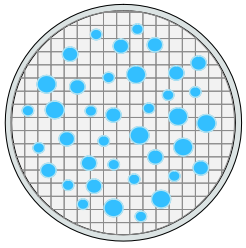
- Nitrogen is required for building proteins by all living plants and animals
- Forms of inorganic nitrogen include ammonia (NH3), nitrates (NO3), and nitrites (NO2)
- Usable forms of nitrogen for aquatic plant growth are ammonia (NH3) and nitrates (NO3)
- Test kits and probes are for testing the forms on nitrogen
- Nitrates stimulate the growth of plants and algae in the water allowing for more animal food
- Excess amounts of nitrates can cause algae to bloom wildly reducing oxygen levels for fish and sometimes causing their death (accelerated eutrophication)
- Accelerated eutrophication from excess nitrogen and phosphorus can also affect water temperature, dissolved oxygen and other key water quality indicators
- As plants and animals die, bacteria break down the organic matter
- Ammonia is oxidized to form nitrates and using up dissolved oxygen in the water
- Nitrates get into waterways from farm fertilizer, poorly functioning septic tanks, inadequately treated wastewater from sewage treatment plants, manure from farm livestock, animal wastes including fish and birds, storm drains, runoff from crop fields, parks, lawns, feedlots and car exhausts

Total Solids – measures the suspended and dissolved solids in water

- **Suspended solids** can be retained on a water filter and will settle to the bottom of a water column and include silt, clay, plankton, organic wastes, and inorganic precipitates
- **Dissolved solids** pass through a water filter and include calcium, bicarbonate, nitrogen, phosphorus, iron, and sulfur and other ions in the water
- Concentration of dissolved solids in stream water is important because it determines the flow of water in and out of the cells of aquatic organisms
- Many of the dissolved solids as nitrogen, phosphorus, and sulfur are essential nutrients for life
- Low concentrations of total solids can limit growth of aquatic organisms
- Elevated levels can lead to accelerated eutrophication of the water system and increase the turbitidy both of which decrease water quality
- Sources of elevated levels of total solids may result as a result of runoff from agricultural activities, dredging, mining, salt from streets in winter, fertilizers from lawns, water treatment plants, plant materials, soil particles and soil erosion, and decaying organic matter
- High concentrations of suspended solids can reduce water clarity, affect turbidity, reduce light reaching plants and effecting photosynthesis, increase water temperature due to increased absorption of light at the water surface and bind with toxic chemicals and/or heavy metals

Fecal Coliform – measures the amount of Fecal Coliform bacteria in the water

- Fecal Coliform bacteria live in the intestines of warm-blooded animals
- Fecal Coliform bacteria are also found in the feces excreted from humans and other warm-blooded animals
- Fecal Coliform bacteria are living organism entering the waterway
- High numbers of Fecal Coliform in water means that the water has received fecal matter from some source
- Although Fecal Coliform bacteria are not necessarily agents of disease but they may indicate the presence of disease causing microbes which live in the same environment



correct when you have 20-80 evenly dispersed colonies

- Fecal Coliform concentrations are reported in number of bacterial colonies per 100 mL of sample water
- When Fecal Coliform counts are over 200 colonies/100 mL of water sample, there is a greater chance of pathogenic organisms being present
- Diseases as dysentery, typhoid fever, gastroenteritis, hepatitis, and ear infections are associated with waters having high Coliform counts
- Primary sources of Fecal Coliform bacteria are failing septic systems, animal waste, and water treatment plant discharges
- Urbanization can cause problems with storm and sanitary sewers, sewer pipes, domestic plant wastes seeping into storm water runoff
- Higher temperatures and high levels of nutrients increase the growth rate of bacteria

Threats to Marine Environments

- **Oil spills** account for only about five percent of the oil entering the oceans. The Coast Guard estimates that for United States waters sewage treatment plants discharge twice as much oil each year as tanker spills.
- **Industrial, household cleaning, gardening, and automotive products**
- **Medical waste**
- **Plastic pieces** plastic foam, plastic utensils, pieces of glass and cigarette butts
- **Overfishing** which is damaging the health of fish populations in many areas
- **Discarding non-target fish** - Commercial marine fisheries discard twice the catch of desired commercial and recreational fishing combined.
- **Ghost nets** - lost or discarded fishing nets that entangles fish, marine mammals, and sea birds, preventing them from feeding or causing them to drown.
- **Air pollution** is responsible for almost one-third of the toxic contaminants and nutrients that enter coastal areas and oceans.
- **Excess nitrogen and phosphorus** from sources such as fertilizer, sewage and detergents enter coastal waters, causing oxygen depletion
- **"Dead Zone"** - The Mississippi River drains more than 40 percent of the continental United States, carrying excess nutrients into the Gulf of Mexico. Decay of the resulting algal blooms consumes oxygen, kills shellfish and displaces fish in a 4,000 square mile bottom area off the coast of Louisiana and Texas
- **Water-quality standards are violated** and contamination occurs due to sewage contamination
- **Invasive Species** have invaded marine and estuarine waters and disrupted ecological balance.
- **Coral Reef damage** by cruise ship anchors and sewage, by tourists breaking off chunks of coral, and by commercial harvesting for sale to tourists. One study of a cruise ship anchor dropped in a coral reef for one day found an area about half the size of a football field completely destroyed, and half again as much covered by rubble that died later. It was estimated that coral recovery would take fifty years.
- **Construction in coastal areas** as the populations along coastal regions increases

Desalination a process of removing salt from ocean water

- *Distillation*, ocean water is heated to remove salt.
- *Freezing*: This process requires about one-sixth the energy needed for distillation.
- *Reverse osmosis desalination* is a popular method

Types of Water Pollution and their Effects

If water pollution is from a single source it is called **point-source pollution** while pollution coming from many sources is called **nonpoint pollution.**

Type of Water Pollution	Cause of Pollution	Symptoms of Pollution	Effect of Pollution	Source of Pollution
Biodegradable waste	Humans and animals	Decreasing numbers of fish and other aquatic life, increasing number of bacteria	Increased number of bacteria, decreased oxygen levels, death of aquatic life	Run-off, improperly treated effluent,
Nutrients	Nitrates and phosphates	Green, cloudy, slimy, stinky water	Algae blooms, eutrophication of water source	Over use of fertilizers, run-off from fields, improper disposal of containers, wastewater treatment
Heat	Increased water temperature	Warmer water, less oxygen, fewer aquatic organisms	Decrease in oxygen levels, death of fish and plants	Industrial run-off, wastewater treatment
Sedimentation	Suspended particles settling out of water	Cloudy water, increased amount of bottom	Warms up water, decreases depth of water source, deposits toxins	Construction sites, farming and livestock operations, logging, flooding, city run-off, dams
Chemicals	Toxic and hazardous chemicals	Water colour changes, develops an odour, aquatic life die out	Kills aquatic life, can enter human food chain, leads to birth defects, infertility, cancer and other diseases in humans and animals	Human-made, improper disposal, run-off, dams, landfill leachate, industrial discharge, acid rain
Radioactive pollutants	Radioactive isotopes	Increased rates of birth defects and cancer in human and animal populations.	Kills aquatic species and leads to cancer and death in humans and other animals	Waste water discharges from factories, hospitals and uranium mines
Medical	Medicines, antibiotics	Infertility in aquatic organisms, and other unknown symptoms	Unknown	Humans dumping medicines into water systems, wastewater treatment

Source: Safe Water Drinking Foundation

Remediation for Water Pollution

Involvement at many levels to prevent sources of pollution

- individuals
- communities
- industries
- states
- federal governments

Stabilization of the ecosystem

- significant remedy to control water pollution
- the reduction in waste input
- harvesting and removal of biomass
- trapping of nutrients
- fish management
- aeration

Reutilization and recycling of water

- industrial effluents (as paper pulp or other chemicals),
- sewage of municipal and other systems
- thermal pollutants (waste water etc.) may be recycled to beneficial use.

Removal of pollutants

- Various pollutants (radioactive, chemical, biological) present in water body
- Using appropriate methods or remedy like adsorption, electro-dialysis, ion-exchange, reverse osmosis etc.
- Small plastic pipettes instead of the straw and clay work well. Hold the pipette upside down, cut the opening to make it wider and weight it putting sand into the bulb. Cover the opening with tape or clay so the sand won't get wet when you calibrate it.
- Measuring electronic conduction (the more salt the more electricity is conducted) is another possibility – just be sure that the device is made by the team