What is Dissolved Oxygen?

Shelly Krueger
Florida Sea Grant Agent
University of Florida IFAS Extension, Monroe County
ShellyKrueger@UFL.edu/305-292-4501
monroe.ifas.ufl.edu

DISSOLVED OXYGEN (DO)

Dissolved oxygen, oftentimes abbreviated as DO (dee-oh), is the measure of the amount of free oxygen (O_2) that is dissolved in the water. Fish and invertebrates use their gills to breathe oxygen gas underwater, just like humans use lungs to breathe oxygen gas from the atmosphere. It is one of the most important water quality indicators, because respiration is fundamental for life.

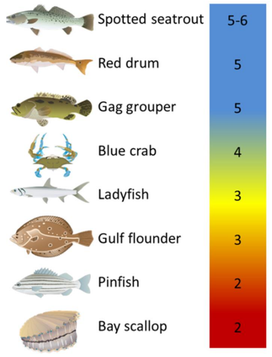

Figure 1. Minimum DO levels (mg/L) by species. Credit SCCF

In general, dissolved oxygen values 5 mg/L and above support proper metabolism, growth and reproduction for marine animals. Many fish can handle very low DO levels, which is why we still see pinfish, tarpon and mullet in canals with very low DO; however, fish with higher oxygen requirements, like grouper, will leave areas with low DO (Fig. 1).

TEMPERATURE and SALINITY

The temperature, salinity and atmospheric pressure determine the amount of oxygen that can physically be dissolved into the water. Dissolved oxygen has an inverse (opposite) relationship with temperature:

Temperature ↑ Dissolved Oxygen ↓

Salinity also effects oxygen saturation. Seawater holds about 20% less oxygen than freshwater at the same temperature and altitude. When the ocean temperature is 30°C (86°F), the oxygen content is 5 milligrams of oxygen per liter (mg/L), which is equivalent to 80% dissolved oxygen saturation (Fig. 2).

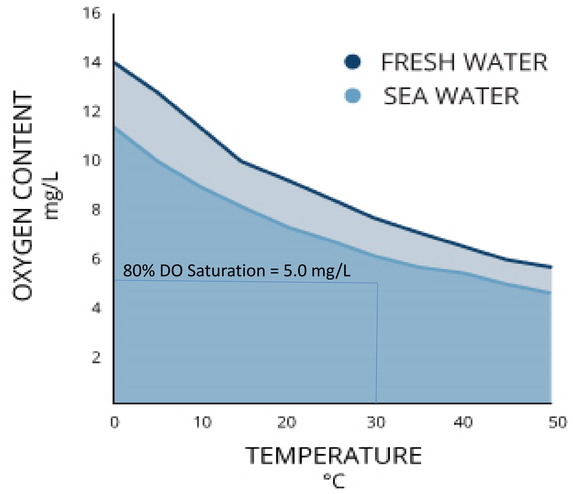

Figure 2. Dissolved oxygen concentrations as temperature increases for freshwater (top line) and saltwater (bottom line). Credit Fondriest

How does oxygen enter the water?

- **Diffusion – Atmospheric O_2 via mixing from waves, wind, currents, tides and groundwater**
- **Photosynthesis – O_2 production in the water from seagrasses, algae and phytoplankton**
- **Artificial – water over a dam, aerators and fountains**

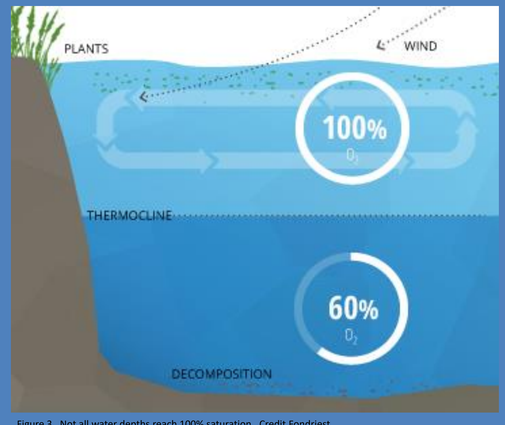

Figure 3. Not all water depths reach 100% saturation. Credit Fondriest

What Factors Affect Dissolved Oxygen (DO)?

Dissolved oxygen (DO) levels vary depending upon a number of physical and biological factors. DO levels are highest at the poles and lowest at the equator. DO levels are highest when the water is cold and lowest when the water is warm. DO levels are higher during the day and decrease at night.

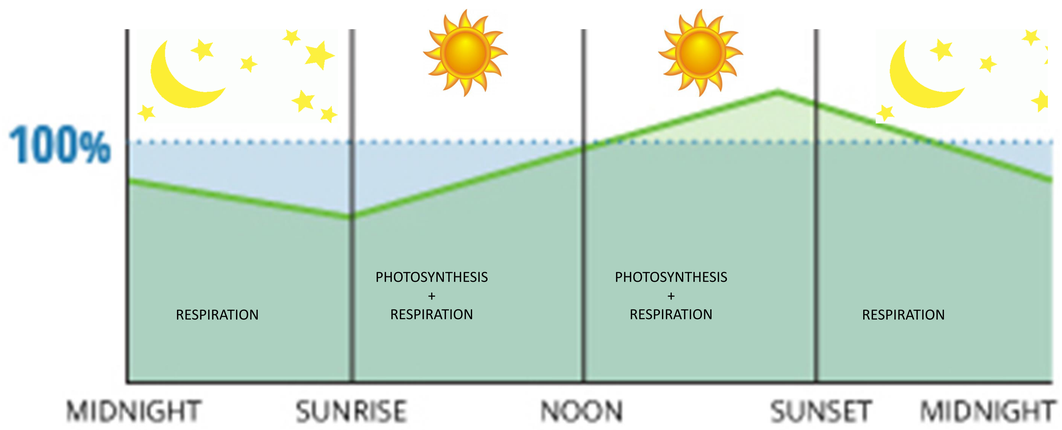

Figure 4. 24 hour (diel) variations in dissolved oxygen levels due to photosynthesis and respiration. Credit Fondriest

DIEL = NIGHT + DAY

Diurnal means during the day, and nocturnal means during the night. Diel refers to the 24 hour period of both day and night. Just like the plants and trees on Earth, the plants and algae in the water produce oxygen, and need oxygen to breathe. When the sun shines, they produce oxygen, but at night, they only consume oxygen – this is why early morning tends to have the lowest levels of dissolved oxygen -- until the sun rises, when photosynthesis starts again. Afternoon oxygen levels can exceed 100% DO saturation (super-saturated) because the rate of photosynthesis is high from solar energy (Fig. 4).

STRATIFICATION

Stratification is when the waterbody has different layers that create a barrier for mixing. These strata develop based on the different densities between the water layers and the general term is pycnocline. Warmer water is lighter than cold water, which creates a thermocline. Freshwater is lighter than saltwater, so after a rain event freshwater may sit on top of the denser, saltier water, thus creating a halocline. Wind, waves, currents and tides help these layers to mix. Many of the Keys canals are deeper than the basins they are adjacent too, which means there is really only mixing of the top layers, and oxygen saturation decreases greatly with depth when the surface oxygenated layers cannot mix with the bottom layers (Fig. 3). This can lead to very low oxygen environments (hypoxia) and even the absence of oxygen at the bottom (anoxia).

DECOMPOSITION

Decomposition is the decay of organic matter. When seagrasses and algae decay the microbes that break them down consume oxygen through their metabolism, which depletes the water of oxygen. In the absence of oxygen, the process of decomposition can create hydrogen sulfide, which releases the characteristic “rotten egg” smell.

DISSOLVED OXYGEN SATURATION

Dissolved oxygen saturation varies throughout the day and night. When there is more oxygen consumption by animals, plants and bacteria than oxygen production by plants and mixing from the atmosphere, oxygen saturation values naturally go down. The oxygen is being consumed by animals, plants and bacteria faster than it is being replenished. DO saturation also declines with depth (Fig. 3). The highest dissolved oxygen levels tend to be at the surface because oxygen concentrations are higher in the atmosphere and most mixing occurs at the surface through diffusion. In order to meet Florida Department of Environmental Protection (FDEP) state standards for water quality, coastal waters must have a diel average at or above 42% DO saturation. Percent dissolved oxygen saturation is a good calculation for marine life because it incorporates local conditions for temperature, salinity and atmospheric pressure.

Literature Cited:
Engineering ToolBox. 2005. “Oxygen Solubility in Fresh Water and Sea Water.”
FDEP. 2013. “Derivation of dissolved oxygen criteria to protect aquatic life in Florida’s fresh and marine waters.” DEP-SAS-001/13, 232 pp.
Fondriest Environmental, Inc. 2013. “Dissolved Oxygen.” Fundamentals of Environmental Measurements.
Sanibel-Captiva Conservation Foundation. 2018. “Hypoxia.”

Funding provided by the EPA South Florida Initiative Grant #00D41115