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Dissolved Oxygen

Fact Sheet

What is Dissolved Oxygen?

It is the amount of oxygen dissolved in water.

Why is it Important?

Most aquatic organisms need oxygen to survive and grow.

- Some species require high DO such as trout and stoneflies.
- Other species do not require high DO, like catfish, worms and dragonflies.

If there is not enough oxygen in the water the following may happen:

- Death of adults and juveniles
- Reduction in growth
- Failure of eggs/larvae to survive
- Change in species present

How it is Measured?

Measuring DO

- Color production: DO chemical test kit for field work with freshwater
- Winkler titration method: This method is valid for ocean water and fresh water, but not highly alkaline water.
- DO Meter: electrical conductance based on a chemical reaction

Reporting DO

- Dissolved oxygen concentration is reported in units of mg/l, or milligrams per liter (mg/l is also referred to as parts per million (ppm) because a liter is 1000 grams of fresh water, and a milligram is a millionth of that).
- Percent saturation is reported in units of percent. Oxygen dissolves in water to saturation, a value typical of a given temperature. Percent saturation tells us what part of the holding capacity is actually taken.

What Affects the Concentration in Water?

1. **Physical Factors affecting saturation (temperature, salinity, etc.)**
2. **DO Sources (inputs)**
3. **DO Sinks (outputs)**

1. Physical Factors

Temperature: As temperature increases, less oxygen can be dissolved in water. When water holds all the DO it can at a given temperature, it is said to be 100 percent saturated with oxygen. Water can be supersaturated with oxygen under cer-

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tain conditions (e.g. when algae are growing rapidly and producing oxygen more quickly than it can be used up or released to the atmosphere). The following table shows the concentration of dissolved oxygen that is equivalent to the 100 percent saturation for the noted temperature (and normal barometric pressure). Note: these values are for fresh water only!

Temperature degC	DO (mg/l)	Temperature degC	DO (mg/l)
0	14.6	16	9.9
1	14.2	17	9.7
2	13.8	18	9.6
3	13.5	19	9.3
4	13.1	20	9.1
5	12.8	21	8.9
6	12.5	22	8.7
7	12.1	23	8.6
8	11.8	24	8.4
9	11.6	25	8.3
10	11.3	26	8.1
11	11.0	27	8.0
12	10.8	28	7.8
13	10.5	29	7.7
14	10.3	30	7.6
15	10.1	31	7.5

Other Physical Factors:

- Altitude: Water holds less oxygen at higher altitudes.
- Salinity/Mineral content: As salinity or mineral content increases, dissolved oxygen decreases.

2. DO Sources

Oxygen is added to water by:

- Re-aeration: Oxygen from air is dissolved in water at its surface, mostly through turbulence. Examples of this include: Water tumbling over rocks (rapids, waterfalls, riffles); Wave action.
- Photosynthesis (during daylight): Plants produce oxygen when they photosynthesize. DO is generally highest in the late afternoon, and lowest in the early morning hours before sunrise.

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3. DO Sinks

Dissolved oxygen is used in two major ways:

- Respiration: Aquatic organisms breathe and use oxygen. Large amounts of O2 are consumed by algae and aquatic plants at night (where large masses of plants are present). Large amounts are consumed by decomposing bacteria (when there are large amounts of dead material to be decomposed, there will be significant numbers of bacteria). Examples: Dead organic matter (i.e. Algae); Sewage; Yard Clipping—yard waste; Oil and grease.
- Chemical Oxidation: Some materials are oxidized naturally (without involvement of microorganisms) and this chemical process utilizes oxygen. Oxygen uptake through chemical oxidation is very marginal compared to biological uptake (i.e., respiration).

What are generally the biggest causes of low DO?

- Increases in water temperature
- Algal blooms
- Human waste
- Animal waste—from feedlots, dairies, etc.

What are Acceptable Ranges?

The following table gives specific DO values for the survival of different species:

Biologic effects of decreasing dissolved oxygen (DO) levels on salmonids, non-salmonids fish, and aquatic invertebrates		
	Dissolved oxygen (mg L^{-1})	
	Instream	Intergravel
I. Salmonid waters		
A. Embryo and larval stages		
No production impairment	11	8
Slight production impairment	9	6
Moderate production impairment	8	5
Severe production impairment	7	4
Limit to avoid acute mortality	6	3
B. Other life stages		
No production impairment	8	
Slight production impairment	6	
Moderate production impairment	5	
Severe production impairment	4	
Limit to avoid acute mortality	3	

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	Dissolved oxygen (mg L^{-1})	
	Instream	Intergravel
II. Non-Salmonid waters		
A. Early Life stages		
No production impairment	6.5	
Slight production impairment	5.5	
Moderate production impairment	5	
Severe production impairment	4.5	
Limit to avoid acute mortality	4	
B. Other life stages		
No production impairment	6	
Slight production impairment	5	
Moderate production impairment	4	
Severe production impairment	3.5	
Limit to avoid acute mortality	3	
III. Invertebrates		
No production impairment	8	
Some production impairment	5	
Limit	4	

What are the Water Quality Objectives?

The water quality objectives for dissolved oxygen vary from region to region. Check with the Regional Water Quality Control Board in your area. Water quality objectives are included in their Basin Plan. For waters that support coldwater fishes, the objective requires that the dissolved oxygen concentration shall not fall below 6 to 8 mg/l (depending on the region of California). For waters that support warm water fishes, the objective requires that the dissolved oxygen concentration shall not fall below 5 to 6 mg/l (depending on the region of California). Some Regional Water Boards describe objectives in terms of percent saturation. For example, the dissolved oxygen shall not fall below 80% saturation.

For ocean waters, the dissolved oxygen concentration shall not be depressed more than 10 percent from that which occurs naturally.

Sources and Resources

This Fact Sheet is implemented by the Clean Water Team (CWT), the Citizen Monitoring Program of the California State Water Resources Control Board. This fact sheet has been revised by CWT from an original document authored by Gwen Starrett, former State Coordinator for Citizen Monitoring. Please contact your Regional CWT Coordinator for further information and technical support. For an electronic copy, to find many more CWT guidance documents, or to find the contact information for your Regional CWT Coordinator, visit www.swrcb.ca.gov/nps/volunteer.html. If you wish to cite this FS in other texts you can use "CWT 2004" and reference it as follows: "Clean Water Team (CWT) 2004. Dissolved Oxygen Fact Sheet, FS-3.1.1.0(DO). in: The Clean Water Team Guidance Compendium for Watershed Monitoring and Assessment, Version 2.0. Division of Water Quality, California State Water Resources Control Board (SWRCB), Sacramento, CA."