




Introduction to Biogeochemical Sensors

Sea-Bird Scientific University Module 24




## Overview

 **Introduction to Biogeochemical Sensors**

This module covers the following:

- Sensor theory and design
  - Oxygen – Electrochemical membrane and optical
  - Fluorometers, FDOM and backscatter
  - Transmissometers

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# Introduction to Biogeochemical Sensors

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**Biogeochemical Sensors:**

Biogeochemical sensors are mounted externally

Model	Measurement
SBE 43	dissolved oxygen
SBE 18	pH
WETLabs C-star	transmissometer
WETLabs ECO	backscatter, fluorometer, FDOM
SBE 63	optical dissolved oxygen


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## Introduction to Oxygen Sensors




**Oxygen: Introduction**

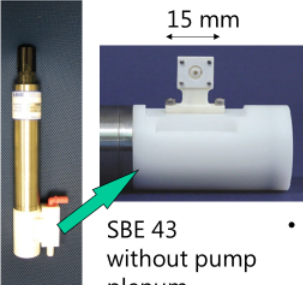
- There are many types of oxygen sensor, Sea-Bird offers two
- Electrode (Clark cell): used for shipboard profiling
  - Advantages
    - Fast response
    - Resolution
    - Easy to field calibrate
  - Disadvantages
    - Drift
- Optical: used for mooring work Argo float profiling
  - Advantages
    - Low drift
    - Easy to field calibrate
  - Disadvantages
    - Slow response



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## Electrochemical Dissolved Oxygen Sensor


 **Dissolved Oxygen Electrochemical Sensor SBE 43**



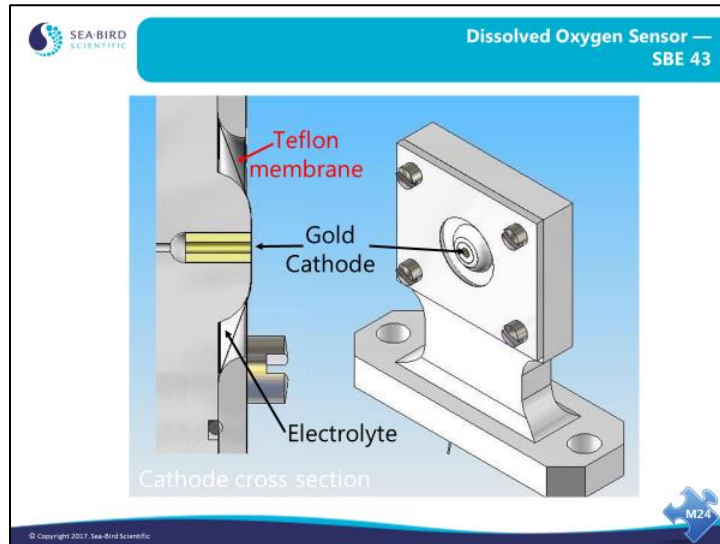
SBE 43  
without pump  
plenum

- Designed for fast profiling
  - also use on moored applications
- Fast response time (1-5 s)
- Reduced electrochemical drift
- Not sensitive to H<sub>2</sub>S poisoning
- Pumping reduces need for stirring and Bio-wipers
- Complete redesign of Clark Cell


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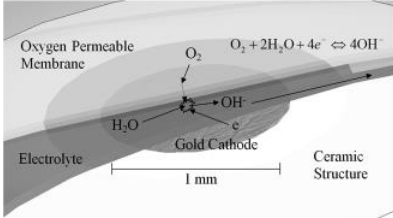
## Electrochemical Dissolved Oxygen Sensor (*continued*)




## Electrochemical Dissolved Oxygen Sensor (*continued*)


 **How the Clark Cell Works**

- Counts the number of oxygen molecules per second that diffuse through the membrane from water to working electrode
- Outputs Oxygen Voltage used to compute dissolved oxygen concentration using temperature, salinity, and pressure
  - **Derived quantity so must coordinate T, C (S) and Oxvolts before computing dissolved oxygen concentration**






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## Optical Dissolved Oxygen Sensor

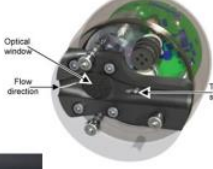

 **SBE 63 Optical Oxygen Sensor**

- Designed for moored and slow profiling applications
- Onboard temperature measured near sensing window
- Currently available as integrated sensor
  - SBE 41 Argo CTD
  - SBE 37 MicroCAT
- Add on for
  - SBE 16*plus* V2 SeaCAT

Argo CTD

SBE 37 ODO

Optical window

Flow direction

Temperature sting

SBE 16*plus* V2

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## Optical Dissolved Oxygen Sensor (*continued*)


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### Optical Oxygen Sensing



- Luminescence
  - Sensing material is an organometallic molecule
  - Excitation in the blue
  - Emission in the red
  - Oxygen decreases the quantum yield: more oxygen, less energy as photons


The diagram illustrates the mechanism of optical oxygen sensing. It shows two states of an organometallic molecule. In the top state, a platinum (Pt) atom is coordinated to a ligand. Blue light excitation (represented by a blue arrow) causes energy transfer (blue arrow) to the Pt atom, which then emits a photon (red arrow). In the bottom state, the Pt atom is coordinated to a ligand and an oxygen molecule (O<sub>2</sub>). Blue light excitation (blue arrow) causes energy transfer (blue arrow) to the Pt atom, but the presence of oxygen leads to quenching, resulting in less photon emission (red arrow). Labels include 'Organometallic Molecule', 'Metal Atom', 'Energy Transfer', 'Blue Light Excitation', 'Pt', 'Ligand', and 'Photon Emission'. A copyright notice '© Copyright 2017 Sea-Bird Scientific' is at the bottom left, and 'M24' is at the bottom right.

## Optical Fluorescence and Backscatter Sensors

 **Optical Sensors:  
ECO Fluorescence and Backscatter**

- Configuration options for ECO suite of sensors
  - Fluorescence
    - Chlorophyll
    - FDOM
    - Rhodamine
    - Phycocyanin
    - Phycoerythrin
  - Backscatter
    - 124 degrees
  - Turbidity
    - 140 degrees
    - 124 degrees
- Single channel for profiling applications, multiple channels for moored applications.



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## How Optical Fluorescence and Backscatter Work

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### How ECOs Work: Light interactions with particles

- Interactions between incident light  $I_0$  and particles in a volume of water:
  - Absorbance
  - Scattering
  - Fluorescence
- Relate the attenuation of light to the properties of the material through which light is traveling.
  - Beer's Law
  - $I = I_0 e^{-cz}$

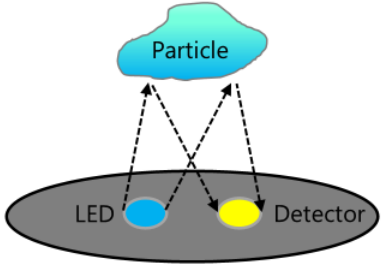
The diagram shows a grey particle in the center. To its left, horizontal lines represent incident light labeled  $I_0$ . From the particle, several arrows point outwards: two are labeled 'absorbed', two are labeled 'scattered', and two are labeled 'fluoresced'. Below the particle, a green double-headed arrow is labeled 'z'. To the right of the particle, there is a label 'dissolved materials and water'.

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## How Optical Fluorescence and Backscatter Work (continued)

 **How ECOs Work:**  
**Understanding light interacting with meters**


- The meter emits incident light, then detects scattered or fluoresced light from particles.



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## Measuring Fluorescence




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How ECOs work:  
Fluorescence

- Fluorescence:
  - The emission of light by a substance that has absorbed light or other electromagnetic radiation.
- How a fluorometer works:
  - Fluorometers excite particles in the water at a specific wavelength
  - Particles in turn emit light at a longer wavelength, (lower energy), than the absorbed radiation
  - Fluorometers measure the light emitted by particles in the water to determine concentration levels
- Isotropic

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## Measuring Backscatter




How ECOs work:  
Backscatter

- Backscattering:
  - The portion of light scattered in the backward direction at a particular angle to the detector
- How backscatter works:
  - Backscattering sensors illuminate particles in the water at a specific wavelength
  - Light hits particles, scatters.
  - Measure the portion of light scattered back at a particular angle to the detector. Energy is a function of the angle.
  - Measurement primarily of particle concentration.
  - Convert to particle concentration.




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## Introduction to Optical Transmissometers




### Optical Sensors: C Star Transmissometers


- Measuring attenuation:
  - Compact solution for in-situ beam transmittance measurement at 470 nm, 530 nm, or 650 nm
  - Optional 10 cm or 25 cm path length
  - 14 bit analog and digital output options
  - Operates with ECOView host software
  - Optional flow tube for pumped/underway system
  - Available in 6000 meter rated version



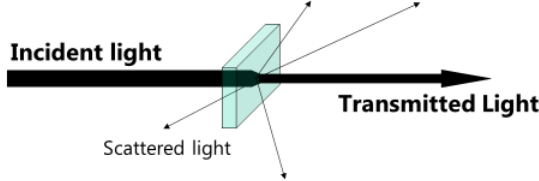
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## How Transmissometers Work

 **How transmissometers work:  
Understanding light attenuation**

- Transmittance is how much effective light passes through a volume.
- Light is attenuated and transmittance is reduced due to particles in seawater that absorb, reflect and scatter light.
- More particles = less transmittance or more attenuation
- Incident light – transmitted light = attenuated light.




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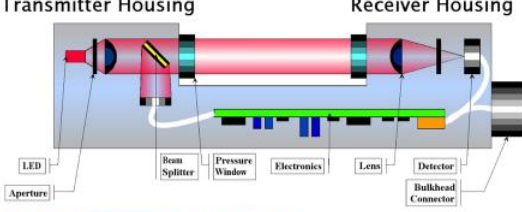


## How Transmissometers Work (*continued*)

 **How transmissometers work:  
Measuring attenuation**

- Transmissometers send a collimated beam of light through seawater.
- The receiver measures light arriving at the detector.
- Transmittance or attenuation is calculated as the amount of light sensed by the receiver.

**Transmitter Housing**                      **Receiver Housing**



LED    Aperture    Beam Splitter    Pressure Window    Electronics    Lens    Detector    Bulkhead Connector

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