Seasonal Dissolved Oxygen Dynamics in the Central and Southern California Current System: high-resolution observations from a sustained glider network

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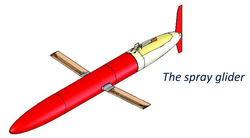


The spray glider

MOTIVATION

Dissolved oxygen is important to measure in the California Current System to describe hypoxic conditions that may influence species of marine organisms. The observations over 4 years from Spray underwater gliders from 2017-2020 provide data to create an annual cycle along Lines 66.7, 80.0, and 90.0. The annual cycle shows that seasonal upwelling causes lower dissolved oxygen concentrations in the upper ocean near the coast. The processes of atmospheric gas exchange and the transition from the upwelling regime close to shore and the more oligotrophic offshore regime in the California Current are also described.

METHODS

Underwater gliders are buoyancy-driven machines that can collect profile data while also navigating through the ocean on a set path. In the CalCOFI region, the California Underwater Glider Network (CUGN) has been sampling along select CalCOFI grid lines continuously using Spray underwater gliders since 2007. Along lines 66.7, 80.0, and 90.0, dissolved oxygen measurements were taken starting in 2017 using a Sea-Bird 63 optode sensor mounted on the glider. The dissolved oxygen optode sensor receives pumped seawater while sampling.

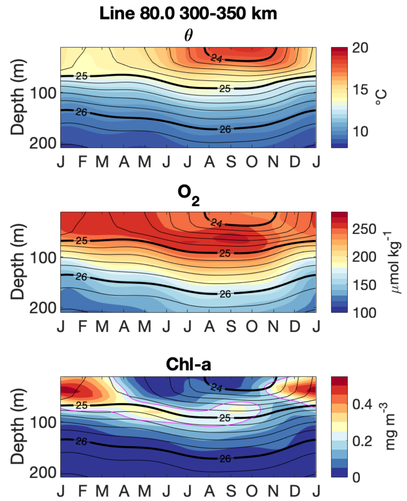
A consistent calibration procedure was put in place to correct the optode sensors for long time drift. The drift over five years since calibration at Sea-Bird was a decrease in measured dissolved oxygen by about 7% compared to the actual concentration. The error on the correction procedure was found to be 0.6%, which is low enough to calculate surface dissolved oxygen gas flux. A paper on the calibration procedure and findings for drift properties based on the usage on gliders in CUGN is under review at *Journal of Atmospheric and Oceanic Technology*.

Future Directions

A manuscript on the annual cycle of dissolved oxygen in the upper 500 m in the CalCOFI region is in preparation for submission. The interannual anomalies of dissolved oxygen are going to be analyzed by graduate student Ben Werb and Dr. Dan Rudnick. The data product of the annual cycle and the interannual anomalies will be available on the CUGN spray glider website: spraydata.ucsd.edu/climCUGN/. We hope for members of the CalCOFI community to use the available dissolved oxygen data and data products.

Offshore Subsurface Dissolved Oxygen Maximum

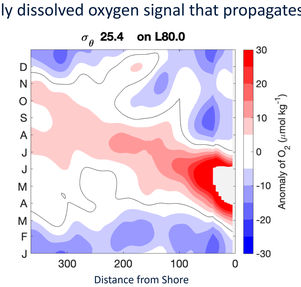
In contrast to the dynamics nearshore where seasonal upwelling plays a major role, offshore on Line 80.0, a summer subsurface dissolved oxygen maximum forms. The summertime formation of light waters and increased primary production likely cause the subsurface feature.



Seasonal temperature, dissolved oxygen concentration, and chl-a concentration over the top 200 m on line 80.0, averaged from 300-350 km from shore. Black lines indicate potential density surfaces. The thin magenta line denotes the 0.2 mg m^{-3} chl-a contour.

Ventilation

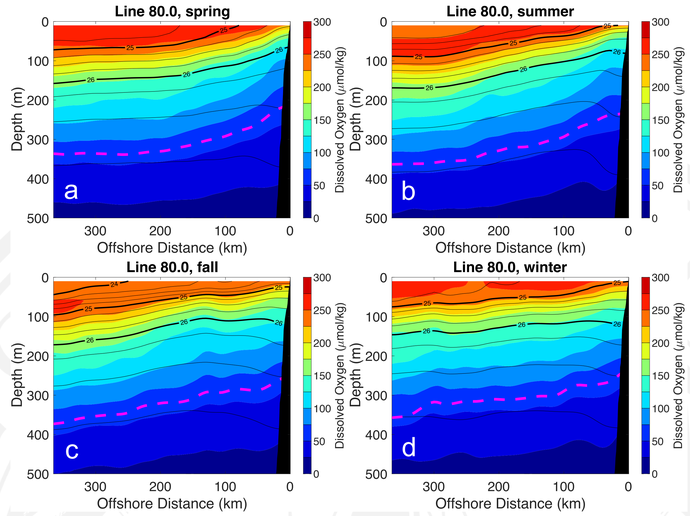
The oxygenation of the surface ocean during upwelling creates a positive anomaly dissolved oxygen signal that propagates offshore.



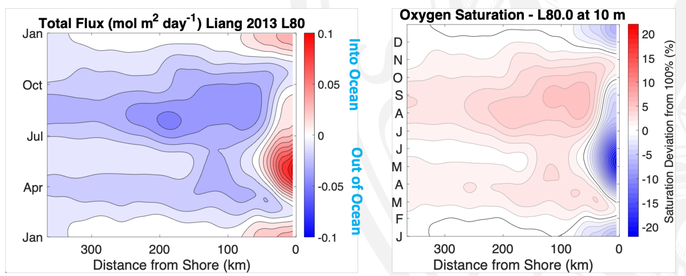
Seasonal anomaly of dissolved oxygen from the mean on potential density surface 25.4 kg m^{-3}. The grey region April-May indicates that the isopycnal has outcropped.

Annual Cycle of Coastal Dissolved Oxygen

Calibrated dissolved oxygen observations from 2017-2020 are used to study the seasonal dynamics of coastal upwelling. The CCS is prone to hypoxic conditions, defined as an oxygen concentration that has negative effects on marine organisms. On line 80.0, the four seasons (winter defined DJF) show the seasonal evolution of the 60 µmol kg^{-1} oxygen contour (dashed, magenta).



Seasonal plots of dissolved oxygen on Line 80.0. (a) Spring (b) summer (c) fall and (d) winter. The winter season is defined as December through February. Thin black lines denote potential density surfaces. Thick black lines denote σ_θ 24 kg m^{-3}, 25 kg m^{-3}, and 26 kg m^{-3}. A hypoxic boundary of 60 µmol kg^{-1} is plotted in a dashed magenta line.



Seasonal 10-m dissolved oxygen saturation deviation from 100% and estimated air-sea gas flux, following the Liang 2013 parameterization including bubble effects.

Dissolved Oxygen Gas Exchange

On Line 80.0, a distinct pattern of oxygen undersaturation in winter and spring is found at 10 m close to the coast. Offshore, dissolved oxygen concentrations are generally oversaturated. The air-sea gas flux also shows the reversal in sign; the nearshore region takes up dissolved oxygen from the atmosphere while the offshore region outgasses dissolved oxygen. It is expected that the CO_2 flux has a similar pattern but with the opposite sign, outgassing nearshore and absorption offshore.

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I am a Scripps PO alum. I will be at Scripps in Jan. 2023 if you would like to meet.