Coding Project: Dissolved Oxygen and The Salas y Gómez Ridge

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Abstract

The Salas y Gómez Ridge lies off the coast of Chile and contains dozens of seamounts. The eastern end of the ridge experiences hypoxic conditions where it coincides with the Eastern South Pacific Oxygen Minimum Zone. The ridge was surveyed in 2019 with a towed camera in order to study the benthic community, habitat, and megafauna of seamounts and oceanic islands from 900 to 200 meters. During the survey, environmental data such as dissolved oxygen were collected. Using Python 3 in JupyterLab, analyses of these oxygen data from two sites were completed including depth profiles and linear regressions. Oxygen was found to vary significant by depth, and but did not appear to vary by site. As only two sites were included, both of which are outside the oxygen-minimum zone, this was unsurprising. Further work will need to include the five additional sites, and more differences may become apparent.

Introduction

Seamounts are an important source of benthic habitat on the sea floor, and they cover up to 21% of the seafloor, though many have never been studied (Yesson et al., 2011). It has been proposed that seamounts have high levels of endemism, though newer studies suggest that this was likely due to under-sampling in the past (Rowden et al., 2010). However, this doesn't mean that some seamounts don't have high endemism, but that there must be a reason for it than simply being a seamount. Oxygen minimum zones can be found around the world, and can have varying effects on diversity, but along the boundary of

an oxygen minimum zone biodiversity and endemism may be increased due to increased habitat heterogeneity (Gooday et al., 2010; Rogers, 2000).

The Salas y Gómez Ridge lies off the coast off Chile and extends east to west approximately 2,900 kilometers. Along the ridge are the Desventuradas Islands on the east end, Easter Island on the west, and dozens of seamounts throughout the ridge sometimes extending into the mesophotic zone. The east end of the ridge extends into the Eastern South Pacific Oxygen Minimum Zone and experiences low-oxygen condition, while the west end experiences high-oxygen conditions, and this likely affects the composition of the communities in these areas. A cruise in 2019 surveyed seamounts and oceanic islands with a towed camera and collected environmental data including dissolved oxygen. In this project, I analyze two of these sites, and dissolved oxygen in particular to see how it varies by depth and by site.

Methods

Sites on the Salas y Gómez Ridge in the southeast Pacific were survey in 2019 with a towed camera, and environmental data were collected. Survey sites included one seamount (SPG6) and the northeast slope of Easter Island (SPG7). All the analyses conducted, and plots created described below were completed in JupyterLab using Python 3. The packages used included numpy, matplotlib, pandas, xarray, scipy, datetime, and cartopy. Each survey corresponded to a .csv file containing conductivity, temperature, and depth (CTD) data, a second containing the latitude and longitude coordinates of the towed camera throughout the dive, and a third file of habitat analysis including the times at which images were taken. The timestamps in each file were converted to datetime indices. Datetime indices were used to find CTD data and longitude and latitudes corresponding to the datetime indices at which each image was taken, and compile these data into one dataframe (Supplemental Materials).

Each survey transect was mapped using the latitude and longitude at which images were taken at one-minute intervals. Using matplotlib, depth profiles including dissolved oxygen in mL/L, salinity, and

temperature in Celsius were plotted for each site. Linear regressions were performed to determine the relationship between depth and dissolved oxygen.

Data from the CSIRO (Commonwealth Scientific and Industrial Research Organisation) Atlas of Regional Seas (CARS) 2009 was used to plot the Eastern South Pacific Oxygen Minimum Zone where it overlaps with the Salas y Gómez Ridge at intervals of 200 meters from 200-800 meters, as well as a global plot of dissolved oxygen at 300 meters. Overlaid on the regional maps were the five research sites not included in further analysis in this project.

Results

The survey transect for SPG6 begins on the southwest slope of the seamount at a depth of 900 meters and moves northeast to end at the summit at a depth of approximately 250 meters (Figure 1). For SPG7, the transect starts around a depth of 1000 meters on the east slope of Easter Island, and moves west to end at a depth of approximately 400 meters (Figure 2).

The depth profiles for the two sites are very similar. Both show decreasing oxygen, temperature, and salinity from the surface to 800 meters for SPG6 (Figure 3), or 1000 meters for SPG7 (Figure 4). Temperatures ranged from 4.5 °C to 25 °C, dissolved oxygen from 3 mL/L to 5.5 mL/L, and salinity from 34 PSU to 36.5 PSU, excluding outlying data points from the surface. A linear regression showed that dissolved oxygen varied with depth at SPG6 ($r = -0.93$, $p = 7.58 \times 10^{8}$, $y = -0.0015x + 4.45$, Figure 5), and SPG7 ($r = -0.95$, $p = 4.84 \times 10^{74}$, $y = -0.0057x + 3.81$, Figure 6).

The color map plot using the CARS 2009 oxygen data show that the eastern edge of the Salas y Gómez Ridge has less dissolved oxygen while the western end has more dissolved oxygen (Figure 7). In the top plot at 200 meters, there is both more hypoxic area to the northeast, and more hyperoxic area to the southwest, whereas in deeper conditions, the range of oxygen values decreases somewhat. This also fits with the global trend, with more hypoxic water near the equator and along the continents (Figure 8).

Discussion

While these results were not unexpected, they are still important, and may vary with the addition of more sites. Oxygen did not appear to significantly vary between the sites, but it was found to vary with depth. However, I used a linear regression in my analysis, and while my results were still significant as they had very small p values, by looking at the graph it is apparent that a non-linear regression may have been more appropriate, particularly for SPG6 (Figure 5 and 6).

The Eastern South Pacific Oxygen Minimum Zone can also be seen to vary by depth, with the most hypoxic conditions to the north east of the Salas y Gómez Ridge along the coast of Chile (Figure 7). This likely has significant effects on the composition of the communities residing within that area, as they must be able to withstand such extreme conditions. While the sites which lie in that area were not used in this project, they will be studied in my thesis project where this question will be investigated, and it has been found that areas at the boundaries of oxygen minimum zones can have increased diversity, including in the deep sea (Gooday et al., 2010).

Additional further work will include repeating several of these processes on the additional five research sites, in particular processing the multiple files into a single file indexed by the times at which transect images were taken. Ideally, I would like to create oxygen profiles by depth and longitude across all sites to assess the dissolved oxygen for the region. I also tried unsuccessfully to import bathymetry shape files from this same cruise the images were taken and would like to continue attempting this process in the future.

Bibliography

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Yesson, C., Clark, M.R., Taylor, M.L., Rogers, A.D., 2011. The global distribution of seamounts based on 30 arc seconds bathymetry data. Deep Sea Research Part I: Oceanographic Research Papers 58, 442–453. https://doi.org/10.1016/j.dsr.2011.02.004

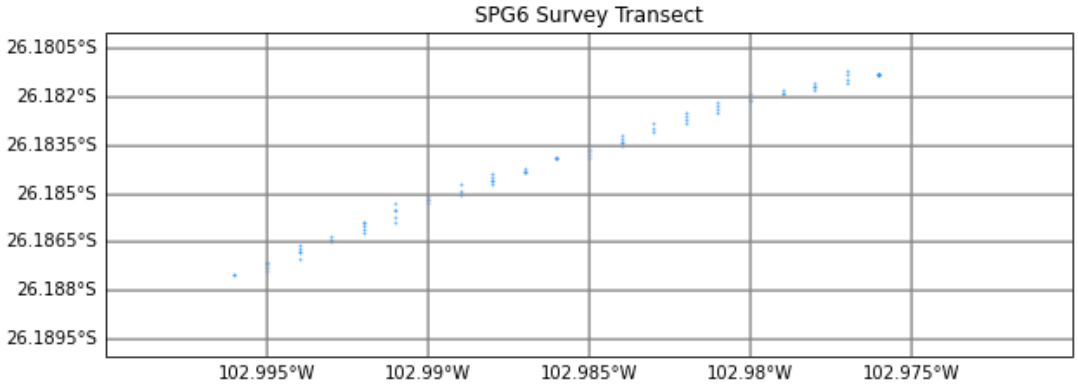

Figure 1: Survey transect of SPG6 mapped by image locations.

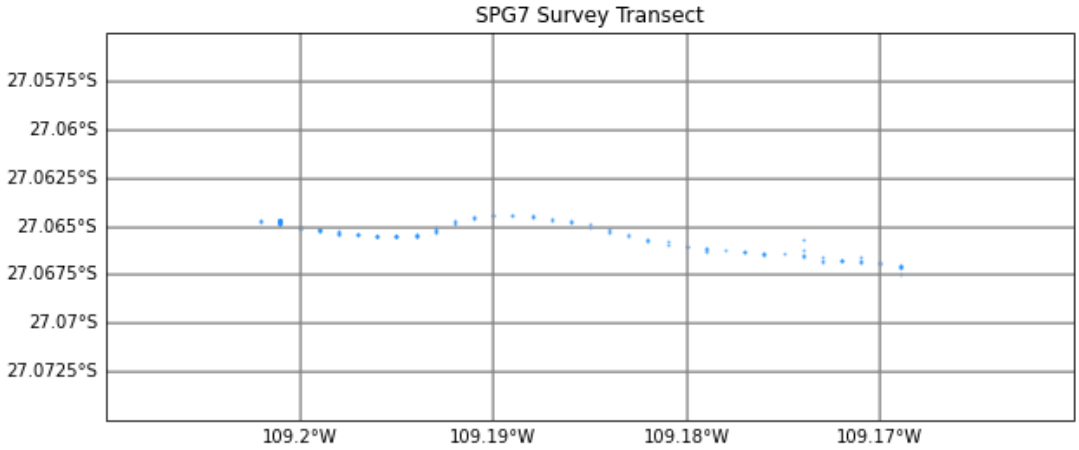

Figure 2: Survey transect of SPG6 mapped by image locations.

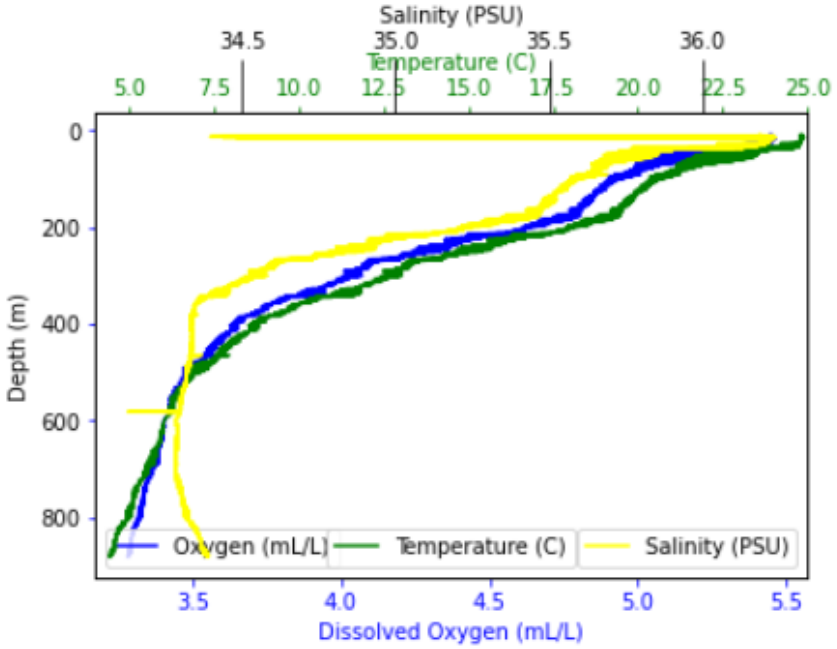

Figure 3: Depth profile for SPG6 showing dissolved oxygen (mL/L), temperature (Celsius), and salinity (PSU).

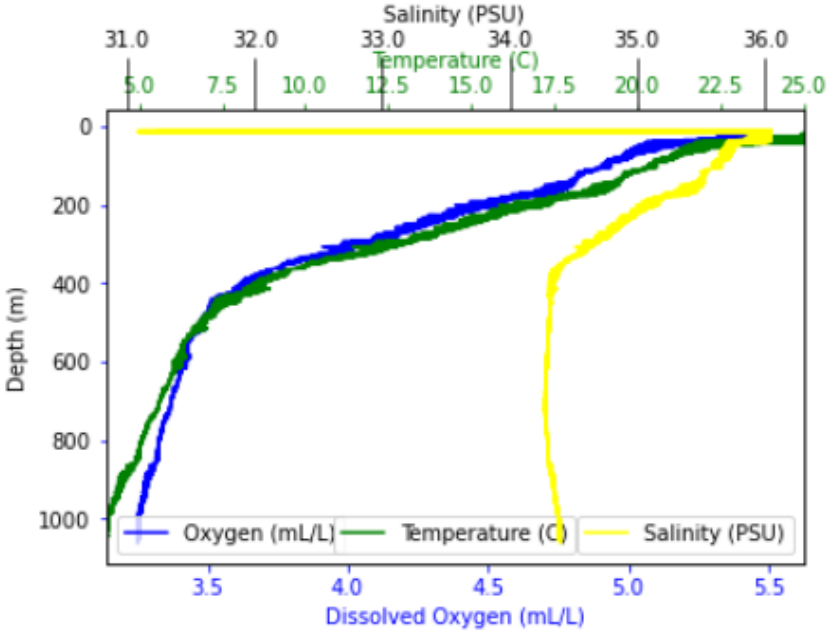

Figure 4: Depth profile for SPG7 showing dissolved oxygen (mL/L), temperature (Celsius), and salinity (PSU).

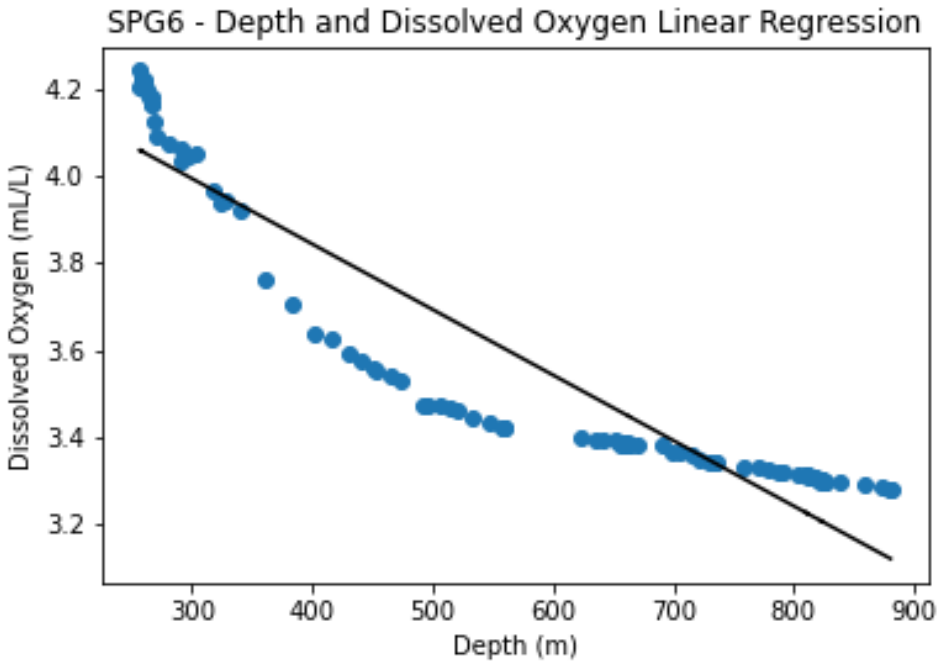

Figure 5: Scatter plot for SPG6 of depth (meters) and dissolved oxygen (mL/L, blue) with linear regression model (black).

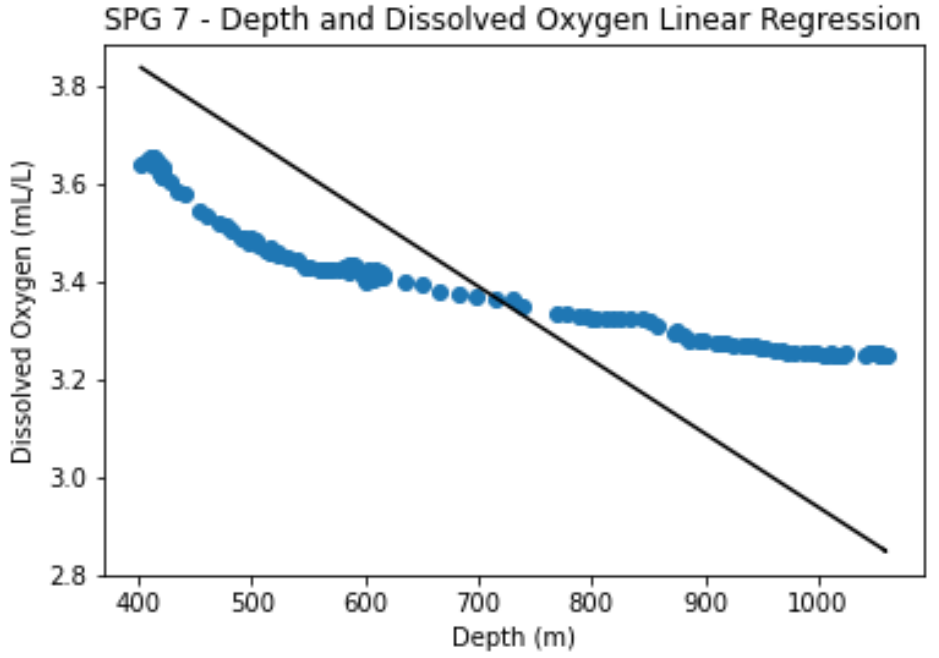

Figure 6: Scatter plot for SPG7 of depth (meters) and dissolved oxygen (mL/L, blue) with linear regression model (black).

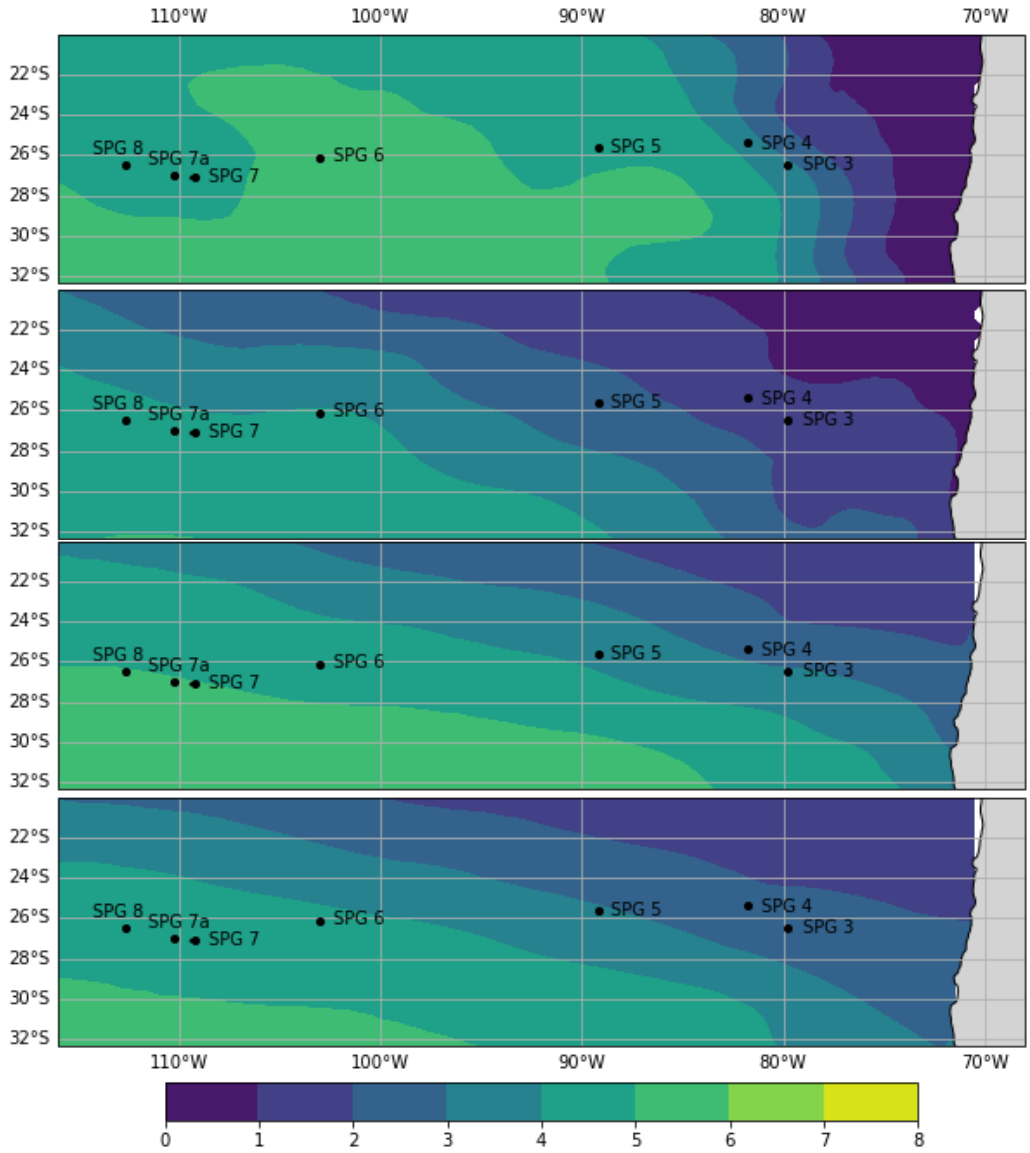

Figure 7: Dissolved oxygen (mL/L) along the Salas y Gómez Ridge and research sites at 200 m, 400 m, 600 m, and 800 m (top to bottom). Easter Island (SPG7) and one seamount (SPG6) are used in earlier analysis.

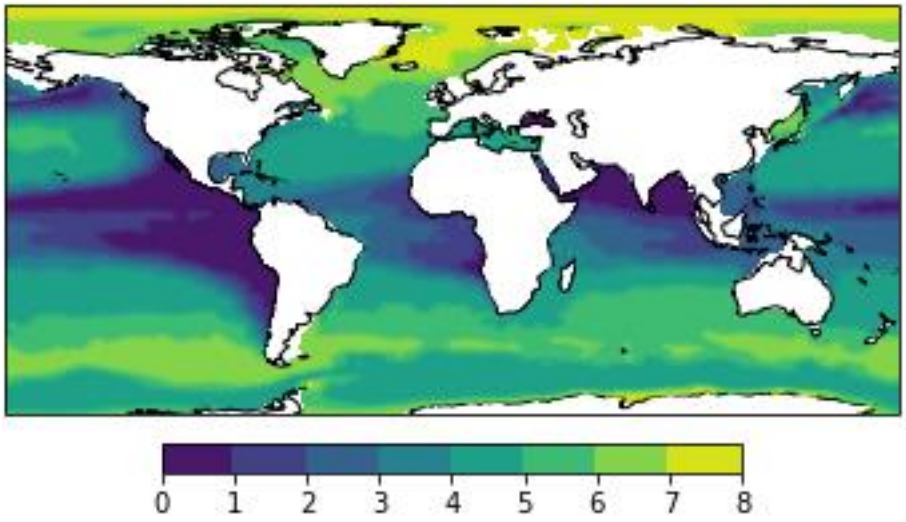

Figure 8: Worldwide dissolved oxygen (mL/L) at 300 meters.