Interactive spatio-temporal visualization of long-term physical characteristics of California coastal waters

California Cooperative Oceanic Fisheries Investigations

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Background

- Goal: visualize the variation of oceanic chemical properties over time and space to help understand changing ocean conditions and identify potential impacts on marine life.
- Create exploratory tool for data collected by CalCOFI — an ocean observing and monitoring program
- Data: Quarterly measurements from 1970-2020
- Parameters explored: dissolved oxygen, temperature, salinity, and chlorophyll
- Hypoxia has a negative impact on the chemical and biological compositions and cycles within the ocean[1]
  - Defined as dissolved oxygen concentration less than or equal to 1.4 ml/l[1]
- Rosette of bottles collects water from different depths as it travels down to 1000m depth[2]

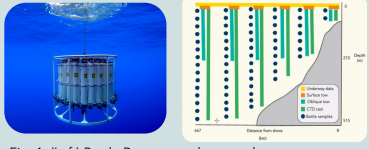


Fig. 1. (Left) Bottle Rosette used to sample ocean parameters. (Right) How samples are collected on cruises. The blue discrete data points are the data that we visualize with our application

Depth Profile:

- "Ponytail" plots of the dissolved oxygen concentration by depth for the individual stations, shown as the "strands" (stations) of the "ponytails" (cruises).
- "Strands" quickly declining in DO at shallower depths during Summer and Fall could indicate hypoxia.

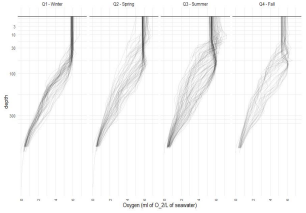


Fig. 2 (Left) . The Ponytail plots shown for four quarters in the year 1992. The plot shows the variation of dissolved oxygen with depth for each station on a cruise.

Data Visualizations

Transect Profiles:

- Average values of dissolved oxygen concentration, salinity, temperature, or chlorophyll concentration by depth and distance from shore for each transect line
- Note the graphs where the red and black colors, indicating hypoxia, invade into shallower depths in Summer and Fall

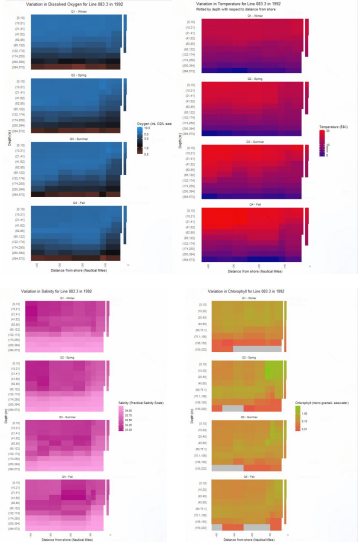


Fig. 3. The transect profile plots for each quarter in 1992, for Oxygen, Temperature, Chlorophyll, and Salinity (going clockwise).
For all: Distance from shore is plotted along the x-axis with distance increasing from the right to the left as you move further West off the coast. Depth (binned) is plotted along the y-axis

Spatial Interpolation - Kriging

- Creating continuous data from discrete data
- Selectable range of depths to view
- Light blue to black to red color gradient, with black and red indicating hypoxic zones
- Interested in appearance of black and red colors at the surface during Summer and Fall

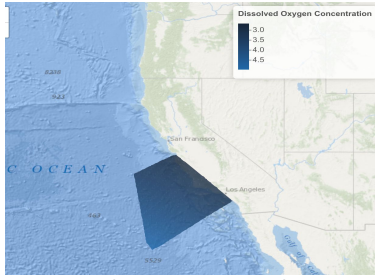
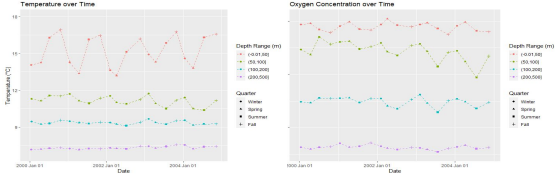


Fig. 4. Kriging for 2010, depth layer 0-50m for dissolved oxygen concentration

Time Series

Users select a parameter and view how its median value changes over a specified period of time, at various depth ranges using all available station data.

Fig. 5. (Left) Median temperature from 2000 to 2004.
(Right) Median oxygen concentration from 2000 to 2004.
In both, colors represent depth ranges, shapes represent quarters.



Interactive Shiny Application

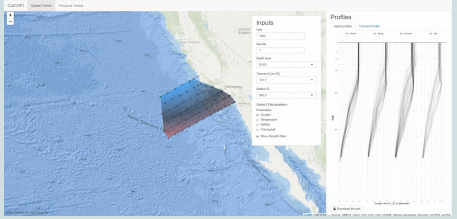


Fig. 6. The Spatial Page of the CalCOFI Data Visualization Shiny App

Spatial Page

This page shows the variation of the sampling patterns and parameters with space. On this tab are two plots, the Depth Profile Plots and the Transect Profile Plots. Central focus is the map and plots, and inputs are easily accessible and interpretable.

Temporal Page

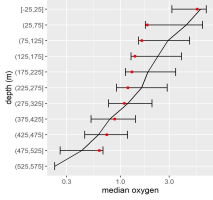
This page shows the variation of the sampling patterns and parameters with time. On this tab are two plots, the Time Series Plot and the Depth Average Plot.

https://shiny.calcofi.io/capstone/
(Not Mobile Friendly)

Depth Average Plots

Users select a date range and parameter to see the minimum and maximum value of the parameter at various depth intervals. By using the slider, the user can also see the selected value of the parameter at a given depth.

Fig. 7. (Right) A plot showing the min and max values of oxygen (the horizontal bars), the current value (red dot) and median value (vertical line)



References & Acknowledgements

1. Chan, F., J.A. Barth, K.J. Kroeker, J. Lubchenco, and B.A. Menge. 2019. The dynamics and impact of ocean acidification and hypoxia: Insights from sustained investigations in the Northern California Current Large Marine Ecosystem. Oceanography 32(3):62–71, https://doi.org/10.5670/oceanog.2019.312.
2. Satterthwaite, E.V., Semmens, B., Bowlin, N., Coates, J., Goericke, R., Swalethorp, R., Thompson, A. Brady, B. & CalCOFI personnel. 2021. Long-term marine ecosystem observations to support sustainability & resilience in the California Current System: California Cooperative Oceanic Fisheries Investigations (CalCOFI) 2017 - 2021.a