Dissolved Oxygen on the California Coastline

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SpringBoard Data StoryTelling

Motivation: California Coastal Economies / Food Source

- **Scale: Order 100-500 M lbs. of fish landed per year.**
- **Value of order $200M USD/year.**

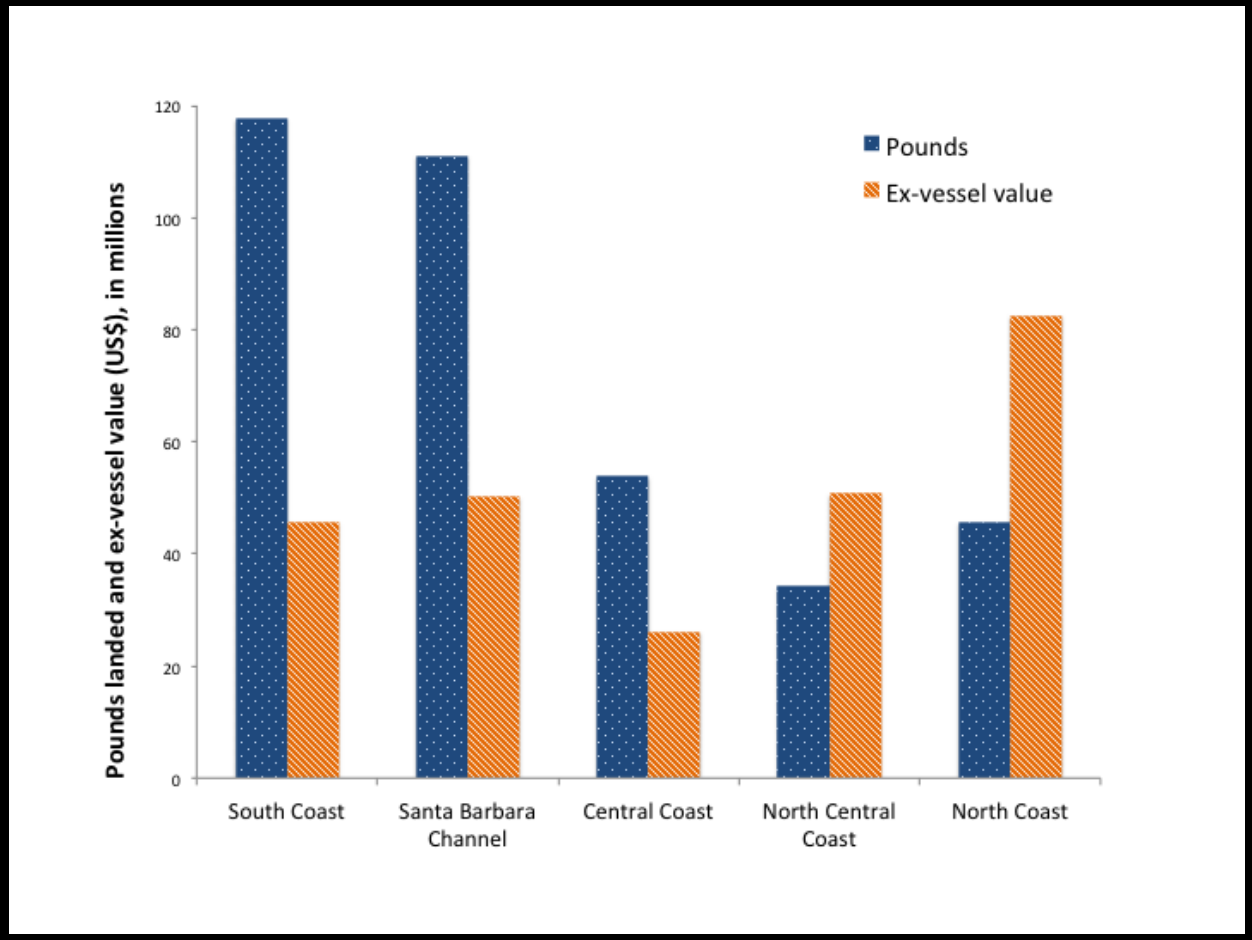
Sardines, Mackerel, etc.

> 30M lbs./year

Flounder, sole, halibut, etc.

> 15M lbs./year

2013 California Fisheries: Catch and Value

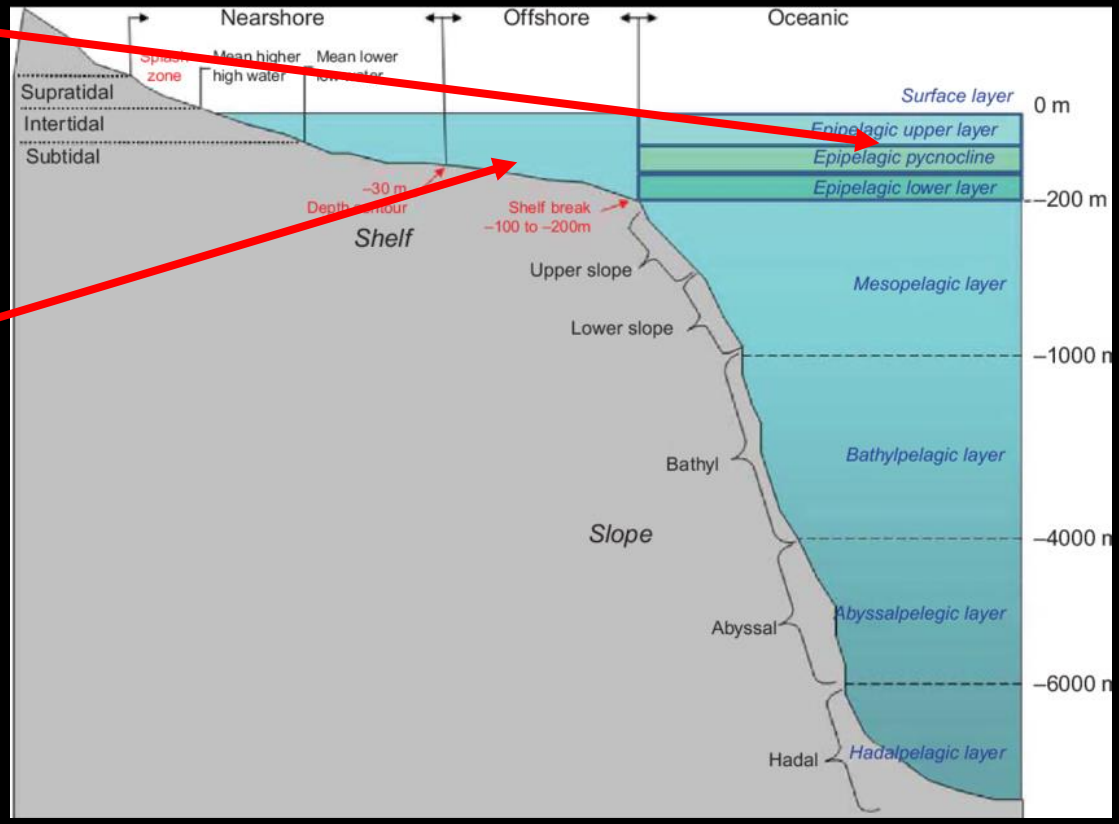


Motivation: Ocean-life Health/Diversity

Pelagic Fish

Demersal Fish

Water Column



Species health depends on physical properties through water column and from shelf to open ocean

Dissolved Oxygen

Dissolved O2 is key for: Fish, mollusks, bacterial life.

<u>Questions:</u>

How is O2 distributed in coastal oceans?

What are driving factors?

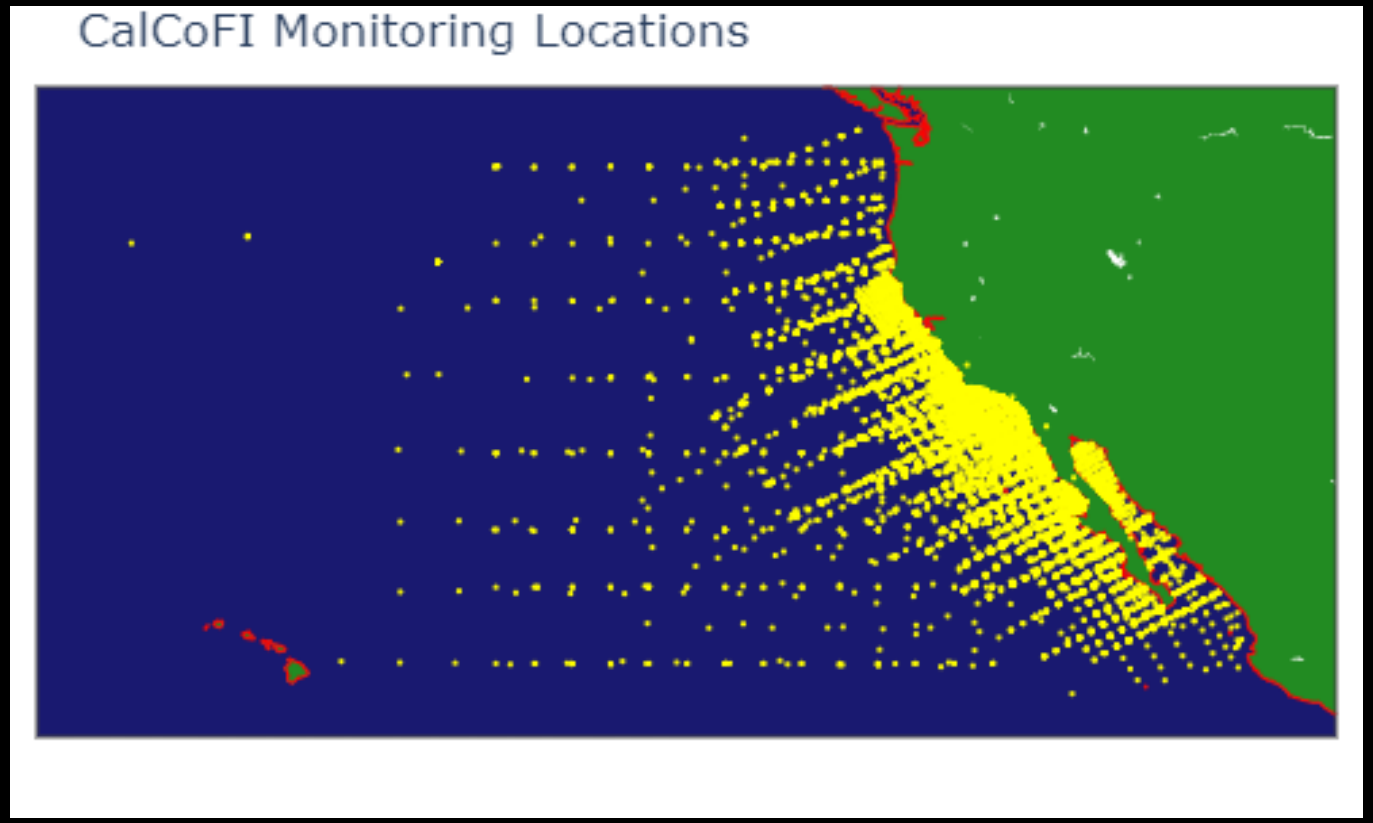
Are there signs of oxygen stress that could be affecting coastal fish communities?

California Cooperative Fisheries Investigation (CalCoFI)

Ongoing study since 1949.

Collect bottle samples at depth from over 1000 stations at regular time intervals.

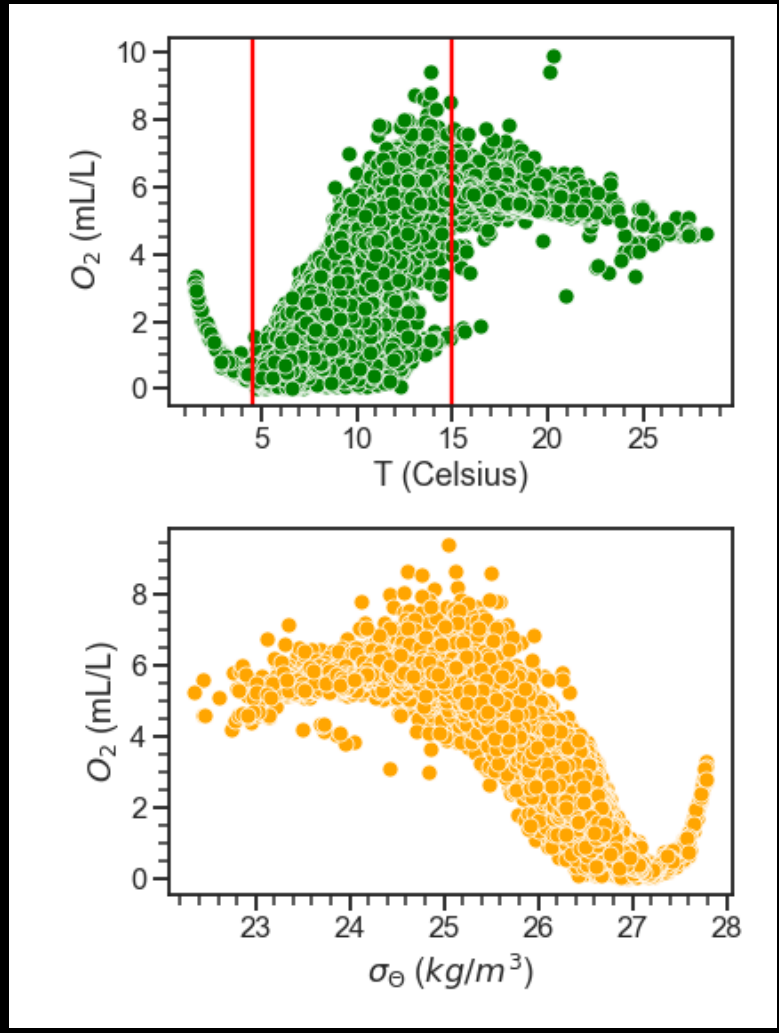
Measure physical variables (Temp, Salinity, O2, etc.)



Dissolved Oxygen and Temperature/Water Density

1. O2 vs T and water density – mirror each other

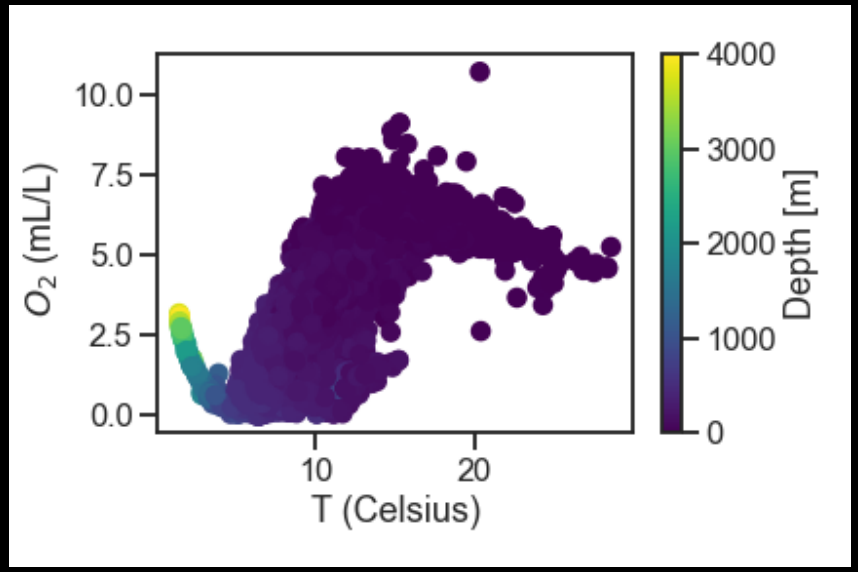
2. Very clearly there are 3 different regimes

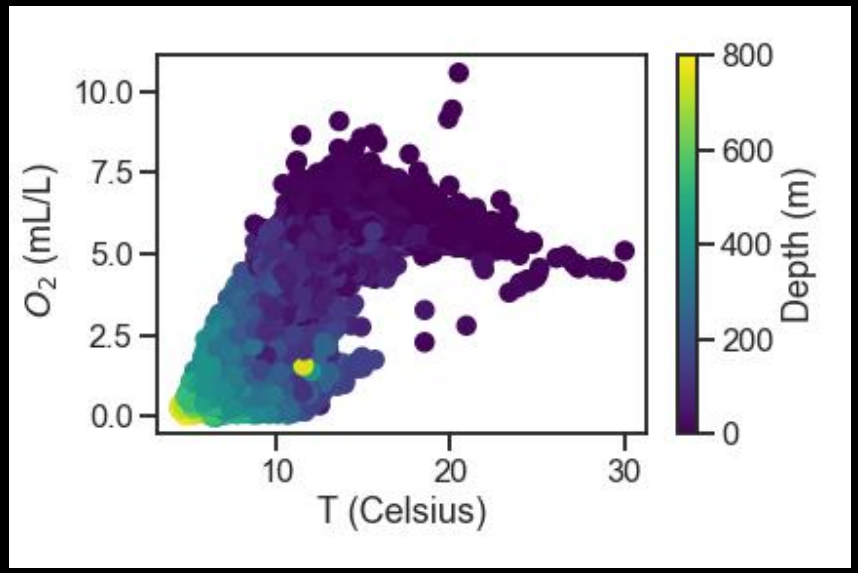


Depth-Stratified O2 vs T behavior

Three different regimes of dissolved O_2 vs T

Three different depth ranges





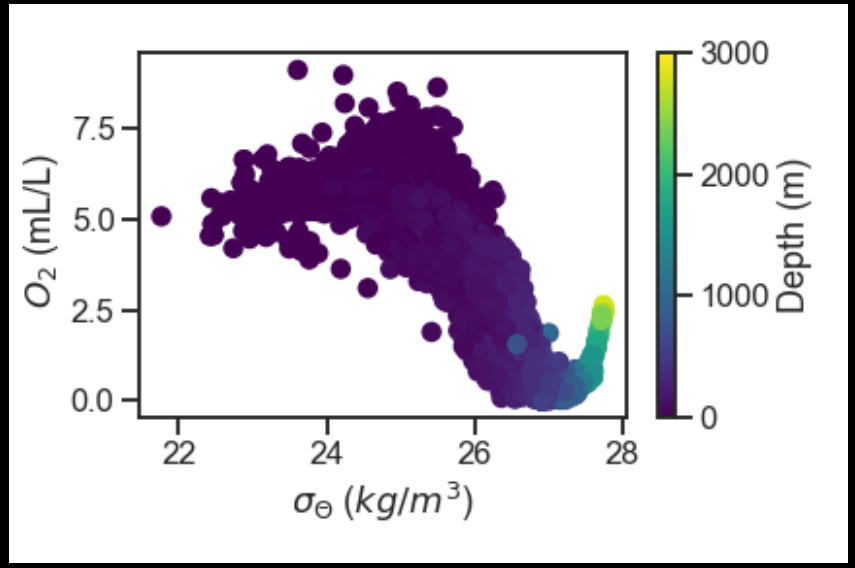
Depth-Stratified O2 vs T behavior

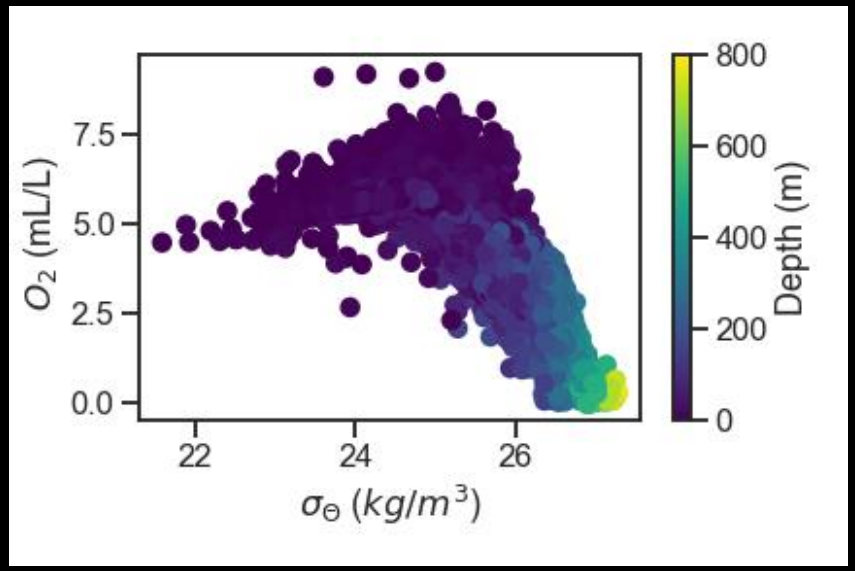
Density follows similar trend.

In upper layer: O2 increases as density increases.

In middle layer: situation reverses.

In deep: Oxygen recovers as water starts to get denser and denser.





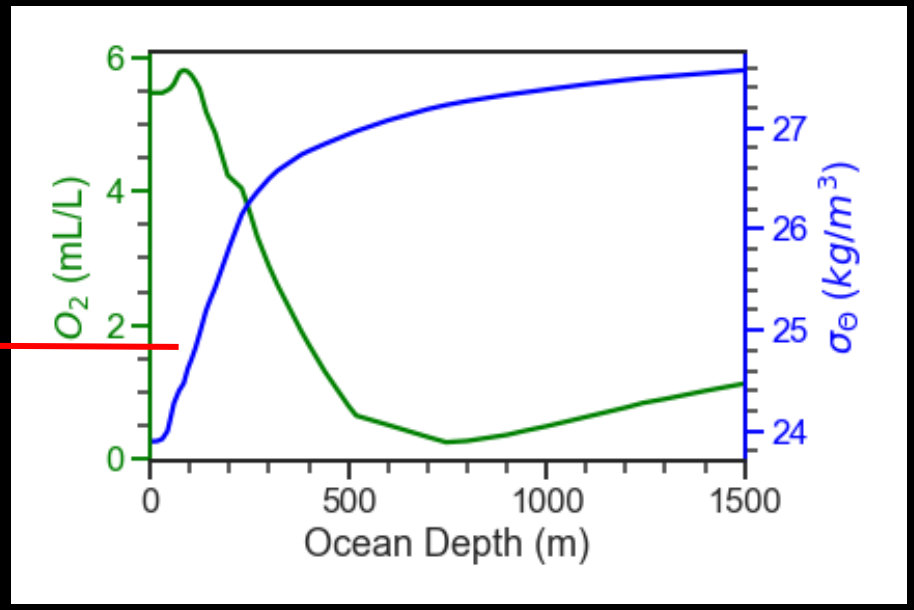
Temperature, Salinity and dissolved O_2

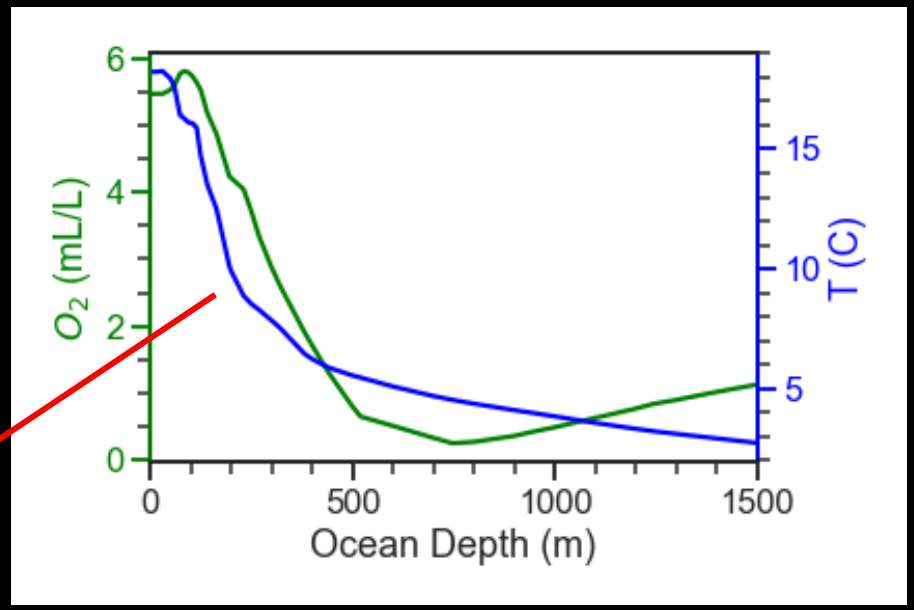
Initial constant density/temperature at shallowest depths.

<u>Steep T, density gradient:</u>
Prevents oxygen rich surface water from mixing effectively into the deep.

O2 minimum

Factor in O2 level plummeting.

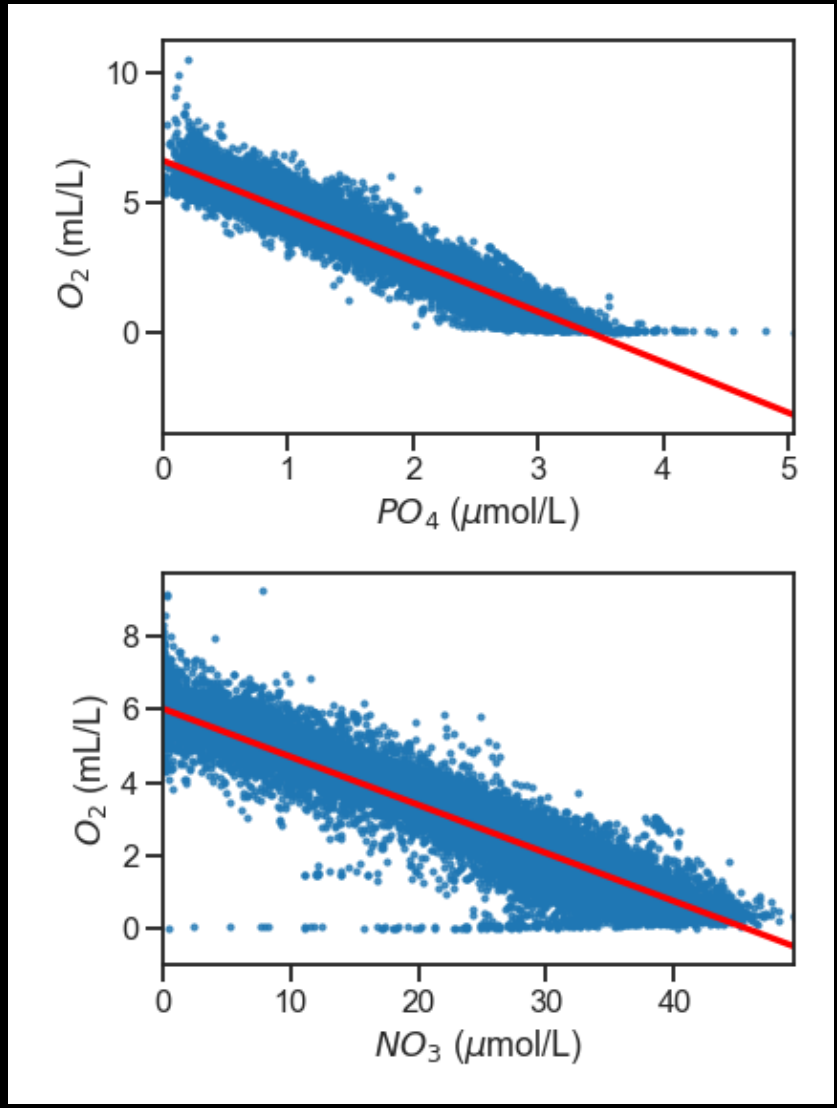




Dissolved Oxygen and Nutrients

Dissolved O_2 concentration decreases with increasing phosphate/nitrate nutrient concentration linearly.

Dissolved O_2 at high PO_4 goes to total oxygen absence.



Dissolved Oxygen and Nutrients

In first 200 m :

Nitrates/phosphates drop, O_2 increases

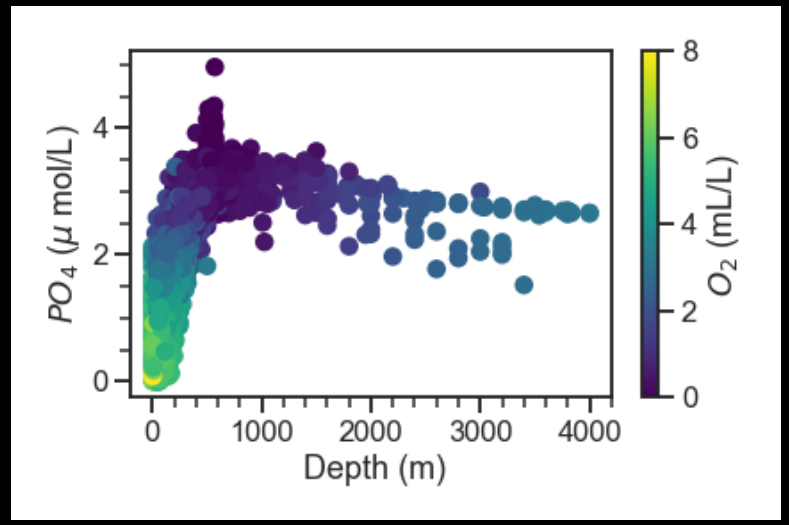
Process for creating phytoplankton:

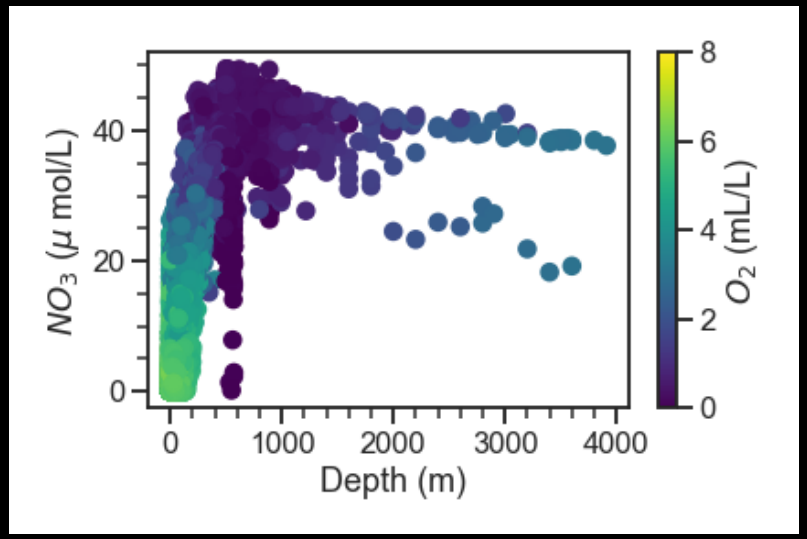
$$106\ CO_2 + 120\ H_2O + 16\ HNO_3 + 1\ H_3PO_4 \rightarrow \text{light} \rightarrow (CH_2O)_{106}(NH_3)_{16}PO_4 + 137O_2$$

+ Photosynthesis

Phosphates/Nitrates from deep ocean
and sediment (mid-depth): upwelling, diffusion

Max in PO4 at mid-depth (not being eaten at fast enough rate).





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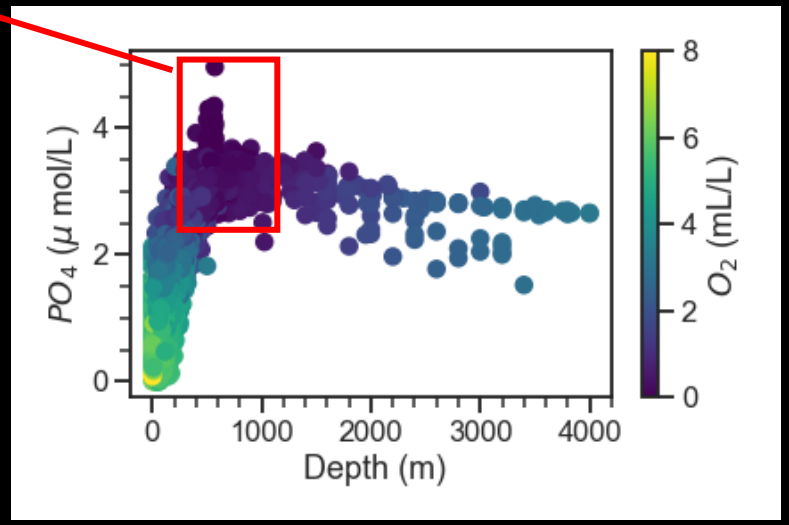
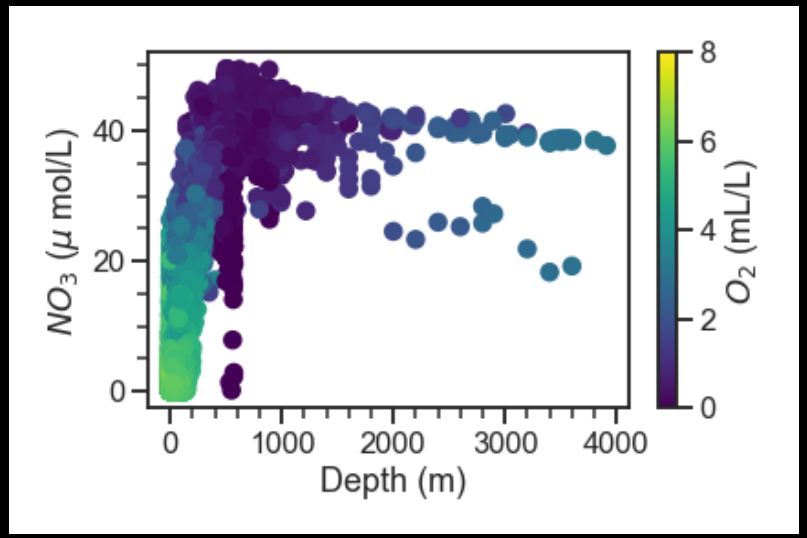
Low light, hypoxic

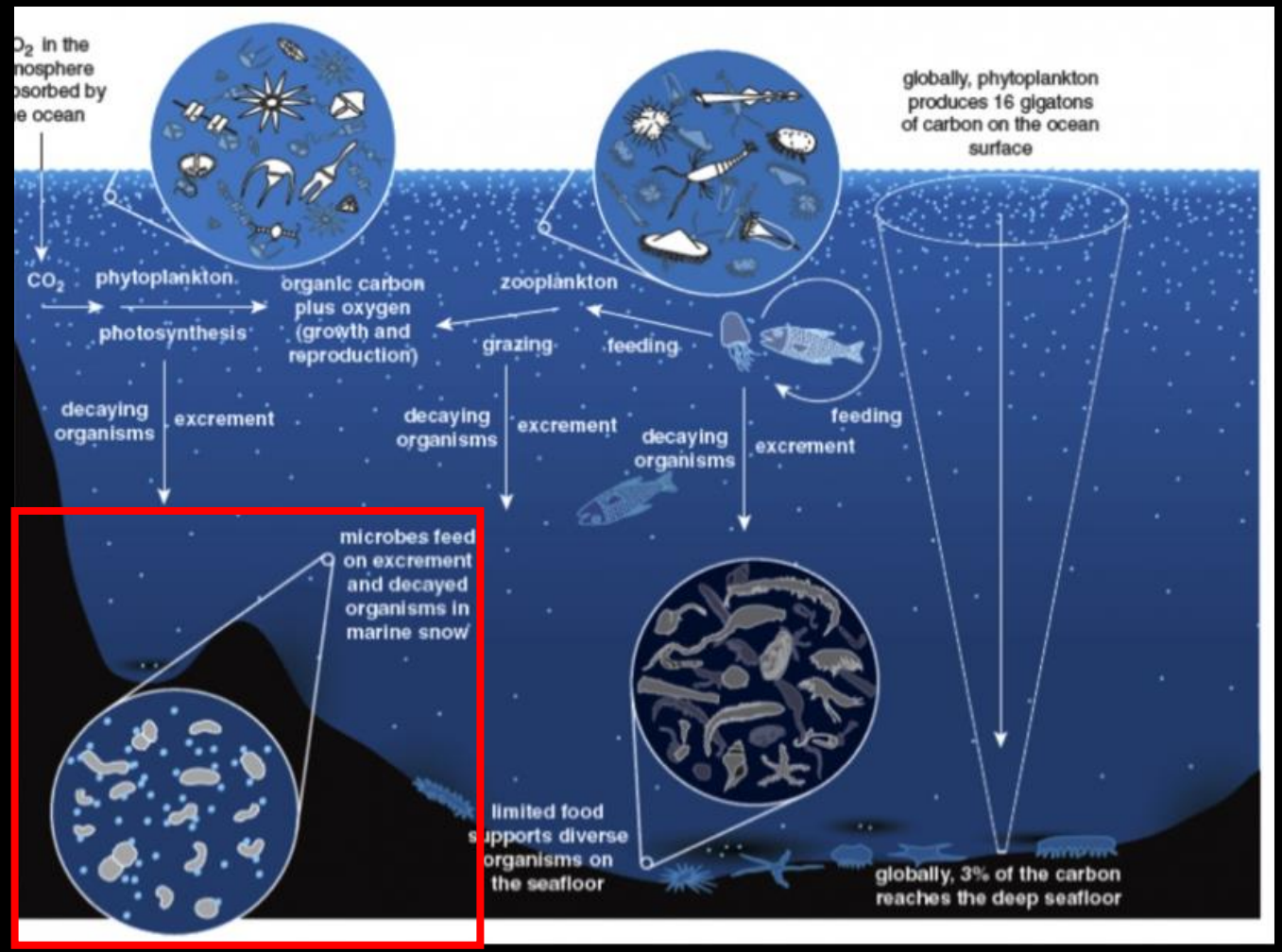




Aerobic Bacteria

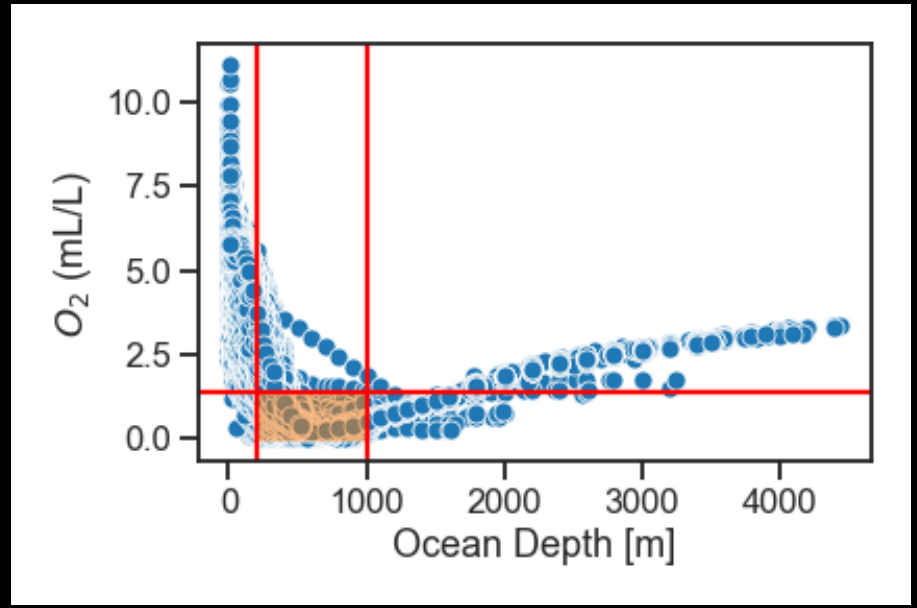
Consume organic decay, O2 for respiration

O2 plummets, low O2 resupply

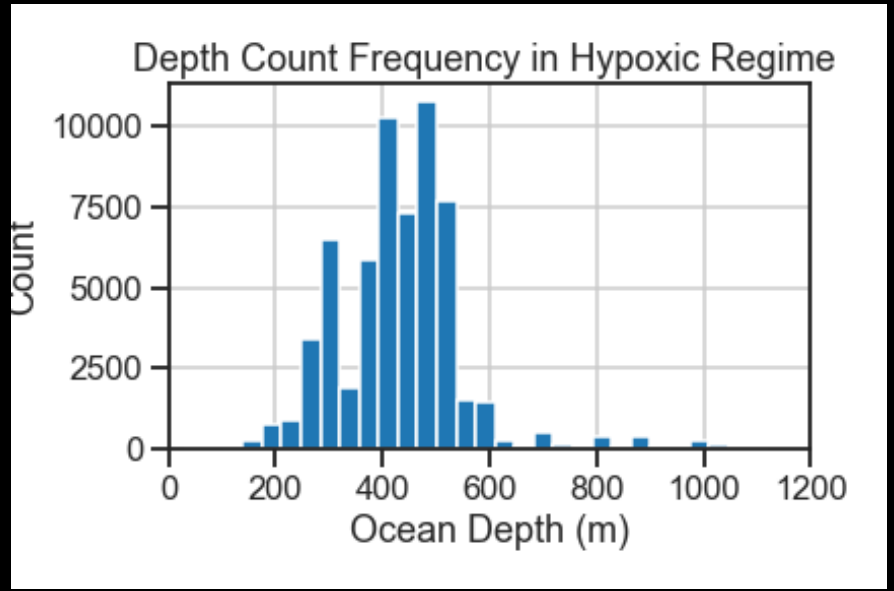


Dissolved Oxygen and Depth

Dissolved oxygen levels hit a minimum in a depth region of ~ 200 – 1000 m.



Dissolved O_2 < 1.4 mL/L: most hypoxic water samples at depths of ~ 200 -1000 m.



Count histogram not best way to represent this.

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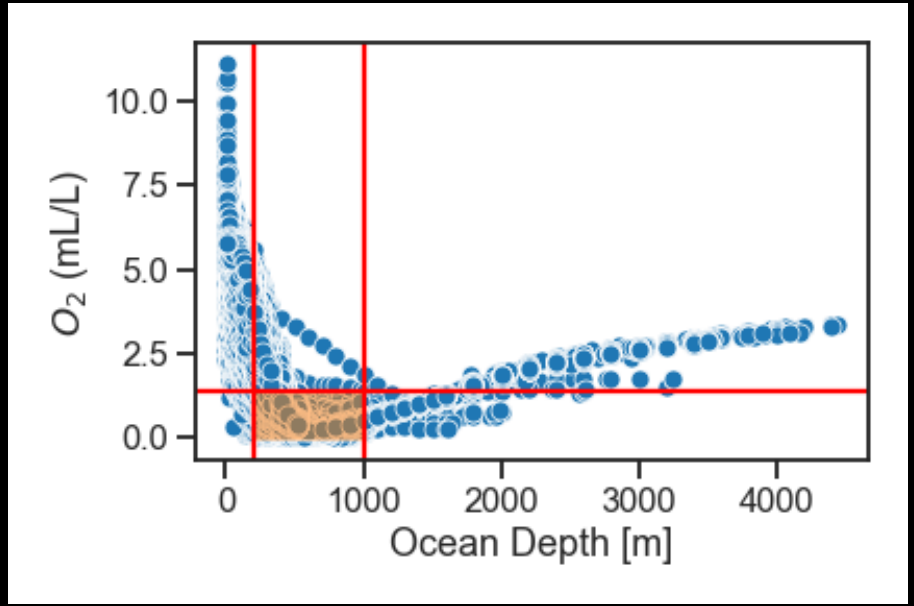
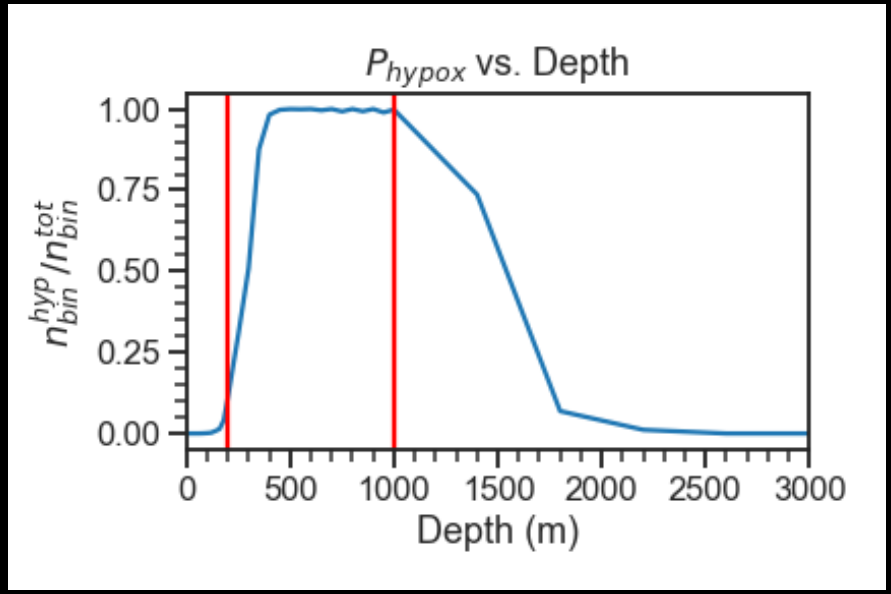


Probability of in a depth range of water being hypoxic vs. ocean depth (O_2 < 1.4 ml/L).

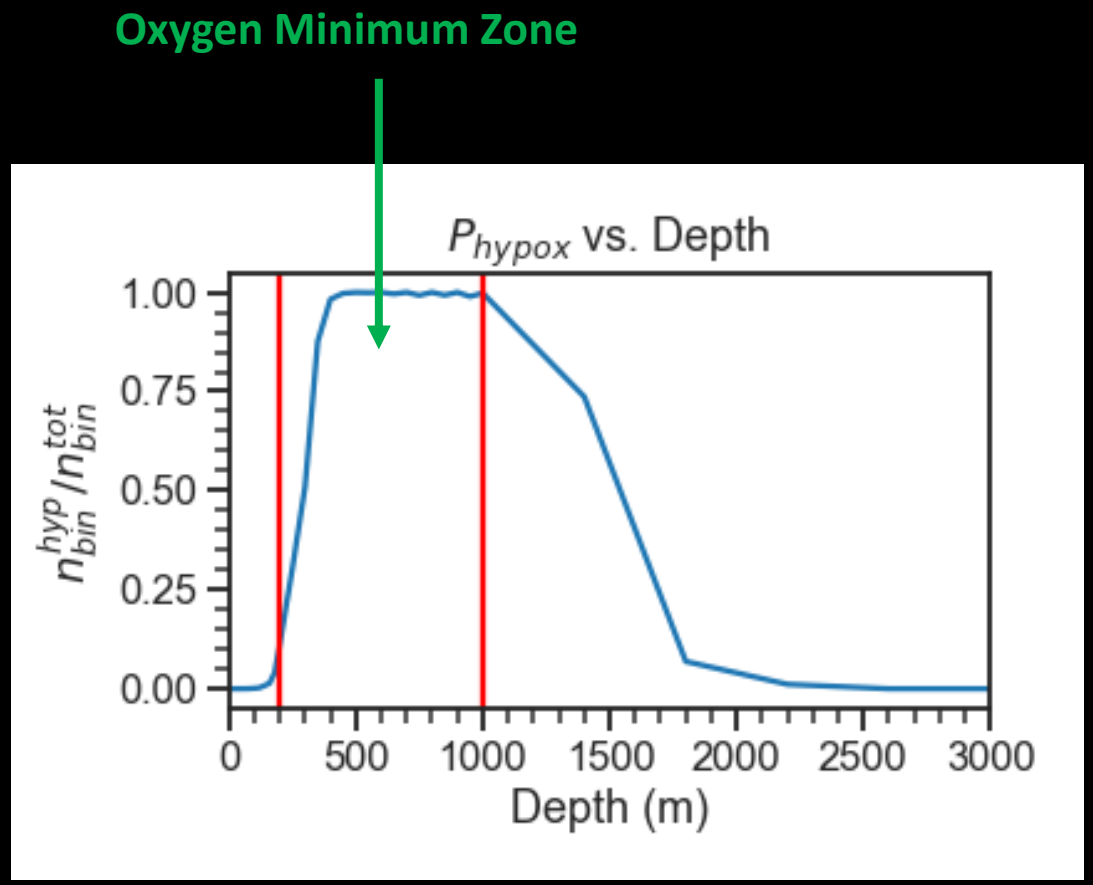


Dissolved Oxygen and Nutrients

Dissolved oxygen levels hit a minimum in a depth region of ~ 200 – 1000 m.

Nearly all water from 400-1000 m is hypoxic.

Where does this occur?



Spatial Mapping of Oxygen Minimum Zone

Oxygen minimum zone (OMZ) extends from continental shelf break out to open ocean.

High concentration off Southern California.

Latitude/Longitude Coords of Hypoxic points at 200 m – 1000 m.

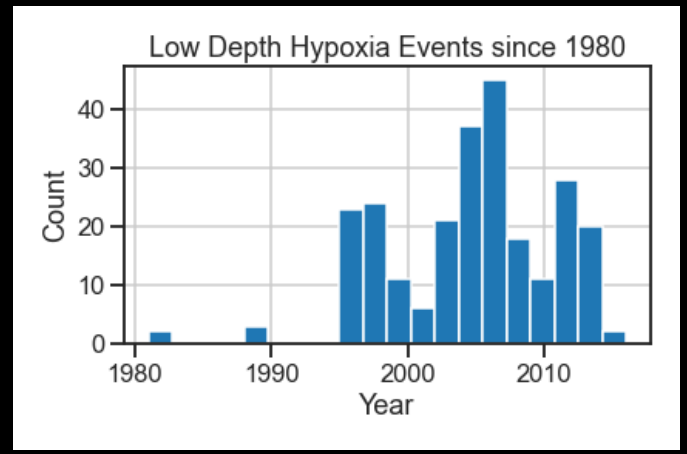
Coastal Hypoxia Leakage?

Mid-depth OMZ is natural and persistent feature on many western coasts

But leakage into shallow waters: increasing threat with rising global temperature (thermocline into shallower waters)

Possible leakage of OMZ from deep into continental shelf

Recent increase in coastal hypoxic events



Conclusion

Hypoxia at mid-depths / OMZ → natural phenomenon off Southern Cal coast

But areas of low oxygen should be payed attention to as climate warms.

Small changes in physical variables can lead to large and drastic changes in entire system.

<u>Future work</u>

Time series analysis of dissolved O2 levels on coastal shelves

+

Time series analysis of coastal and connected open ocean surface temperatures/chlorophyll.

Time series regression models may be useful here.