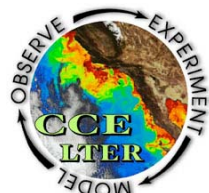


# Trends in Spiciness, Oxygen, and Nutrients in the Southern California Current System

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Helen Bailey, Daniel Palacios, Francisco Chavez,  
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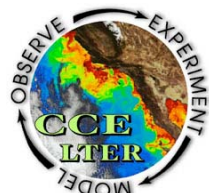
\*SWFSC, Environmental Research Division  
Pacific Grove, California  
steven.bograd@noaa.gov



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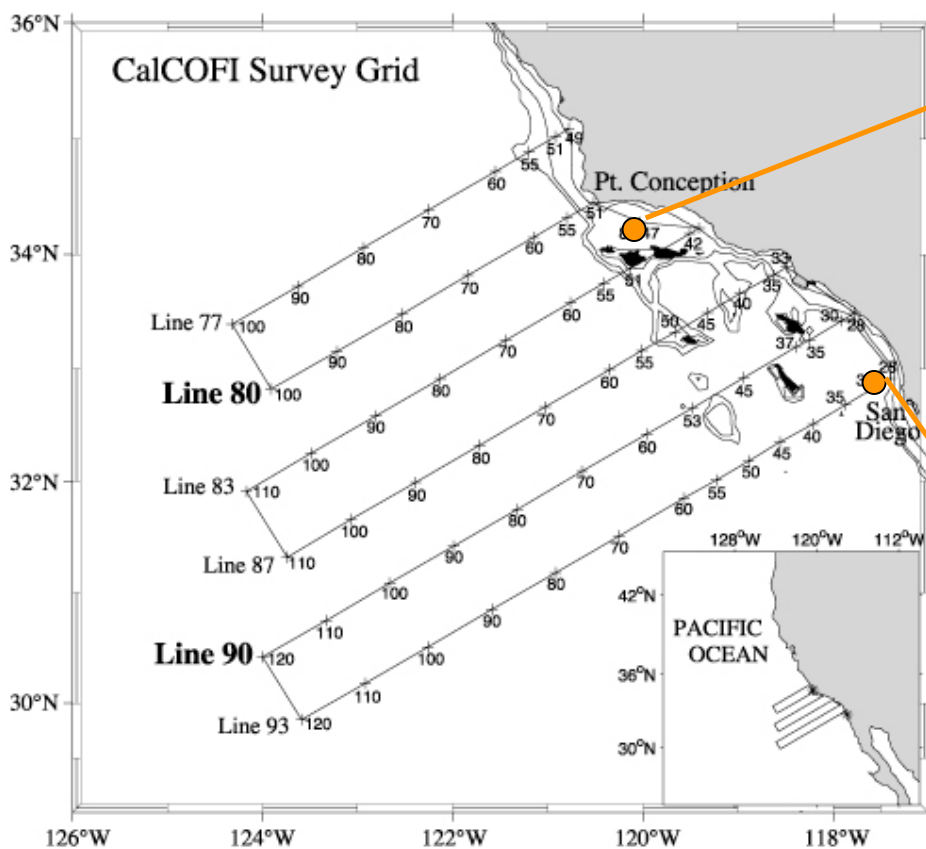


# Objectives



1. Describe temporal trends & spatial patterns of  $O_2$  in southern California Current
2. Expansion of the Oxygen Minimum Zone?
3. Variability in California Undercurrent source waters
4. Ecological implications
5. Future work

# CalCOFI Hydrographic Data

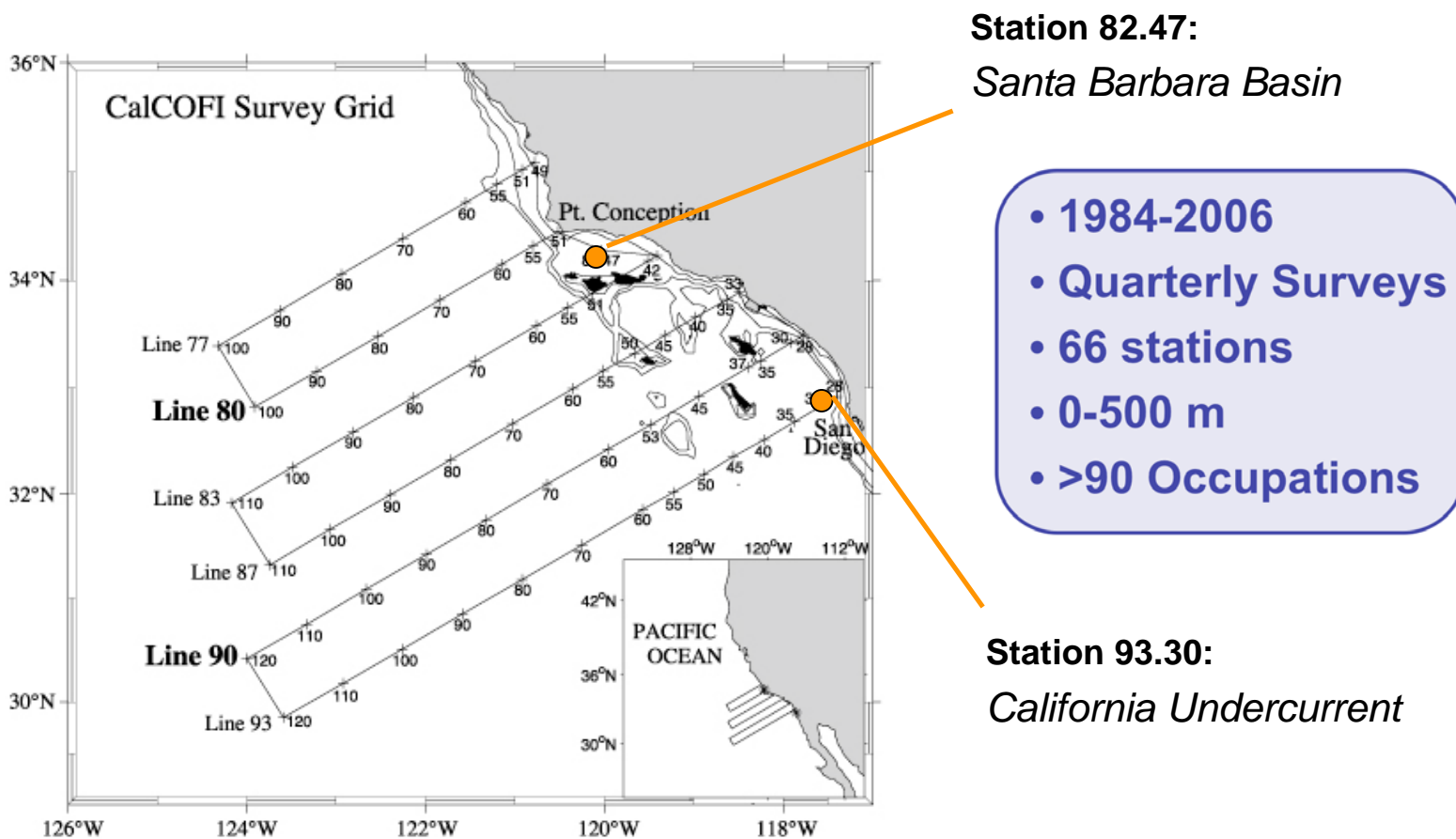


**Station 82.47:**  
*Santa Barbara Basin*

- 1984-2006
- Quarterly Surveys
- 66 stations
- 0-500 m
- >90 Occupations

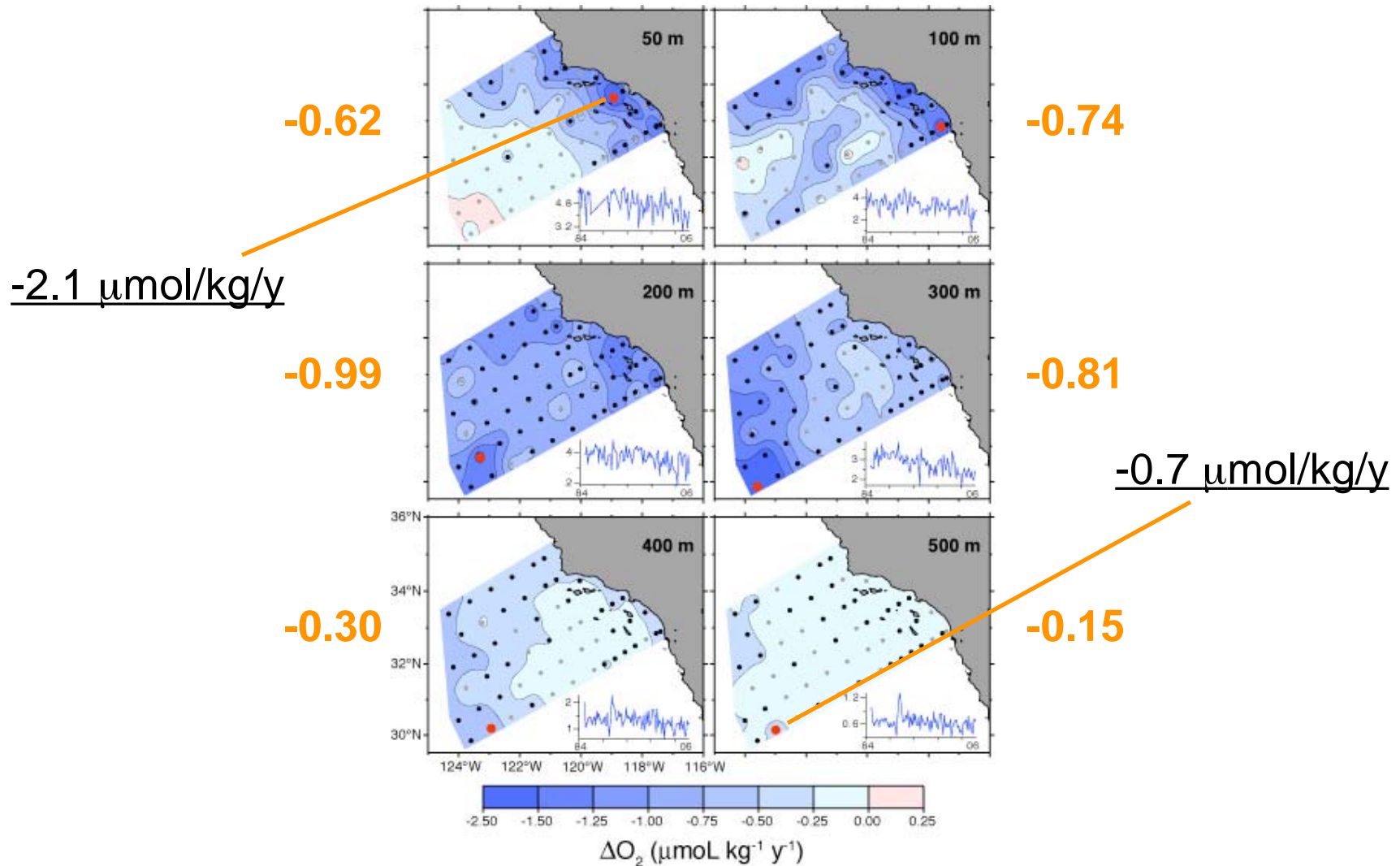
**Station 93.30:**  
*California Undercurrent*

# CalCOFI Hydrographic Data



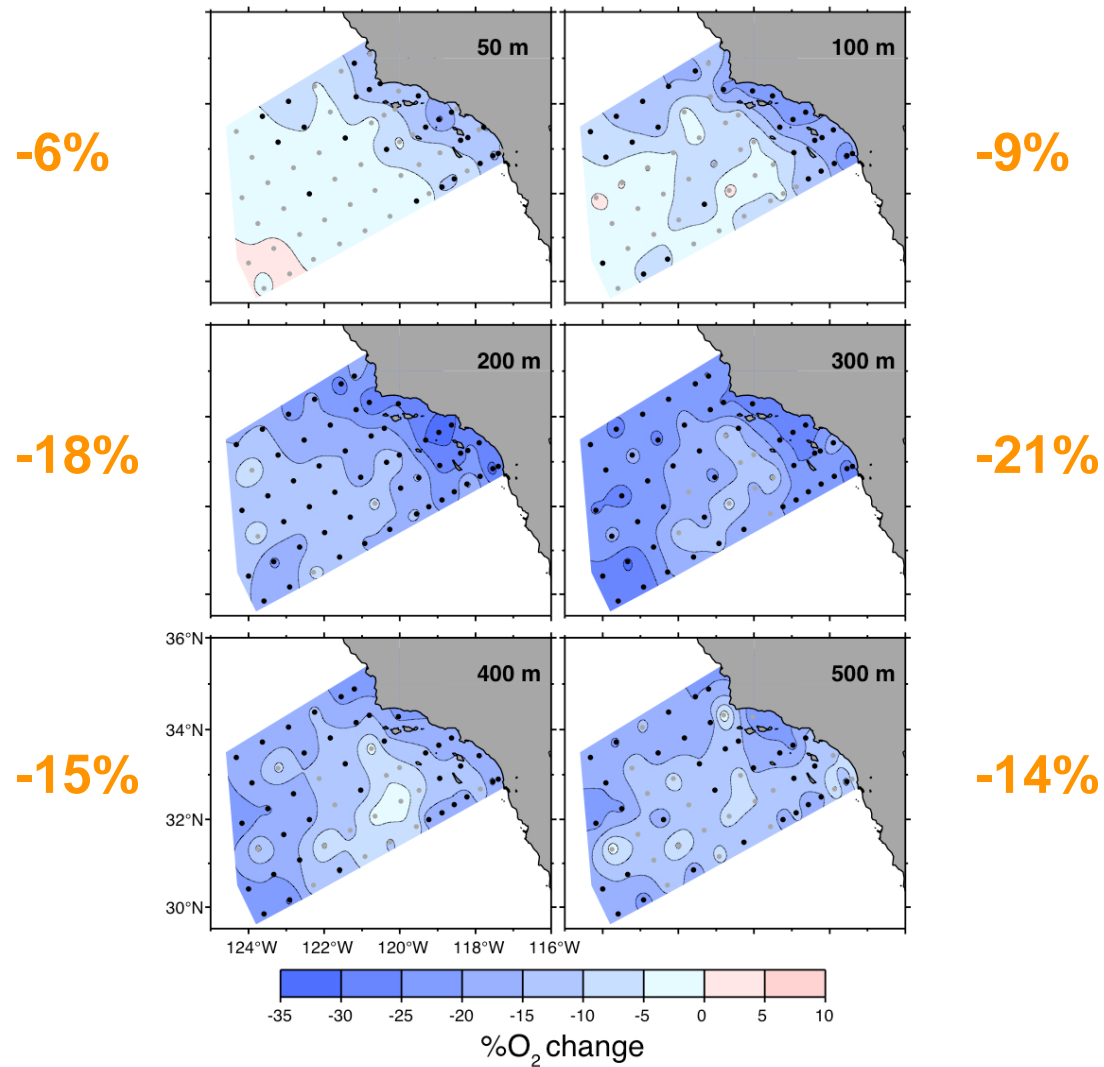
**Derive linear trends of dissolved oxygen**

# Long-Term Trends in Dissolved Oxygen: magnitude of change



Bograd et al. (2008)

# Long-Term Trends in Dissolved Oxygen: % change



Bograd et al. (2008)

# Long-Term Trends in Dissolved Oxygen: Summary

1. Oxygen declining at 0.2-1  $\mu\text{mol/kg/y}$  (*mean*)
2. Largest absolute declines at 50 - 100 m
3. Largest relative declines at 200 - 300 m
4. Largest declines within CC (shallow) & CUC (mid-depths) waters, offshore (deep)

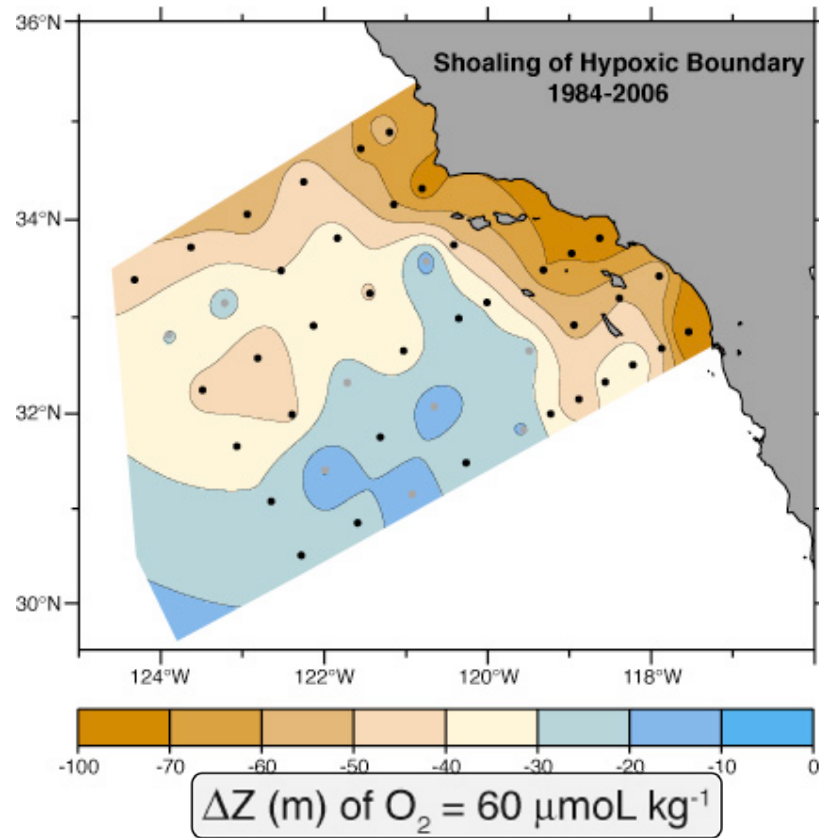
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**How much has the hypoxic boundary shoaled?  
What are the mechanisms?**

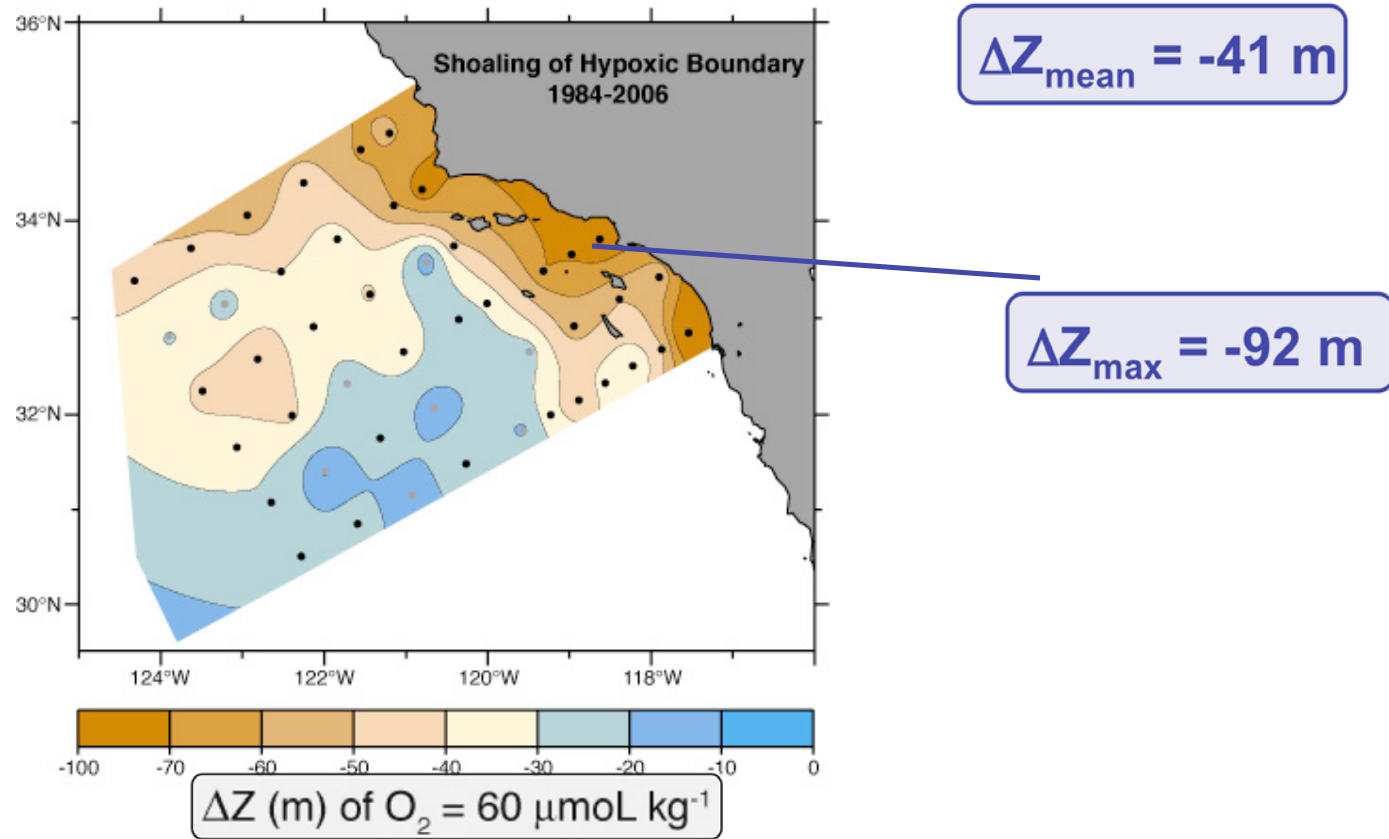
# Expansion of Low-Oxygen Habitat



$$\Delta Z_{\text{mean}} = -41 \text{ m}$$

Bograd et al. (2008)

# Expansion of Low-Oxygen Habitat



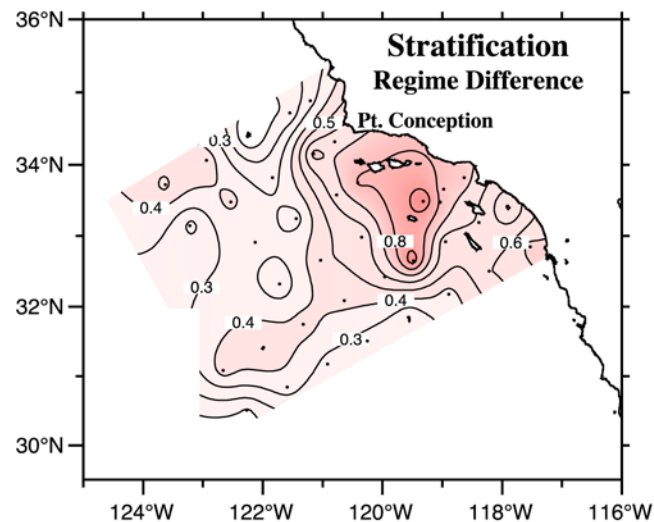
Bograd et al. (2008)

# Expansion of Low-Oxygen Habitat: Mechanisms

- **Surface Warming  $\Rightarrow$  Enhanced Stratification  $\Rightarrow$  Reduced O<sub>2</sub> Flux**  
*Keeling and Garcia (2002)*
- Local Biological Processes
- Advection of Low O<sub>2</sub> Waters (California Current, California Undercurrent)

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**Increased stratification,  
but recent near-sfc cooling**

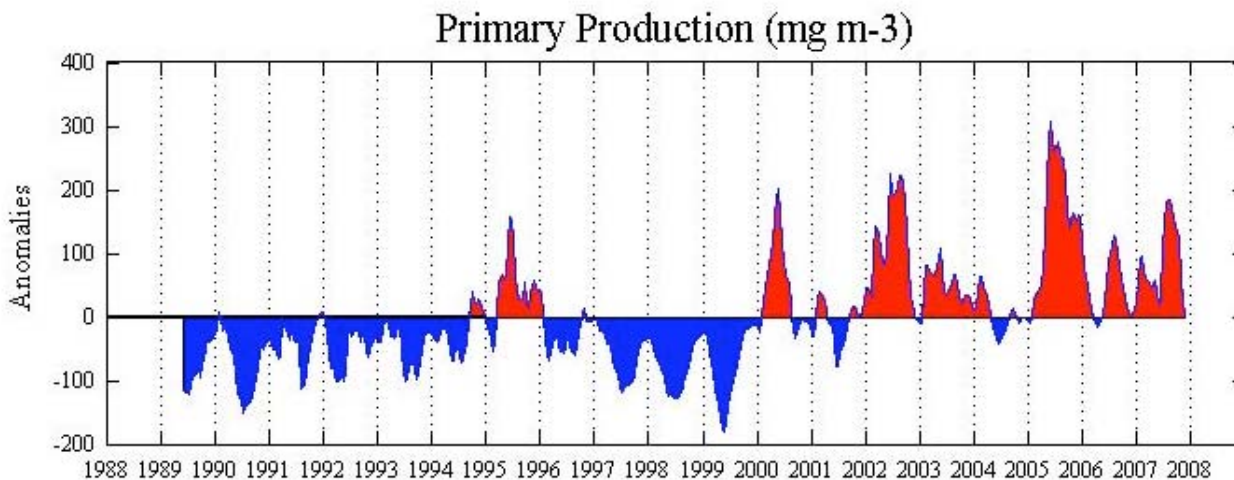
**Bograd & Lynn, 2003**

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**Production up?  
Respiration ... ?**

MBARI Mooring M1: Monterey Bay

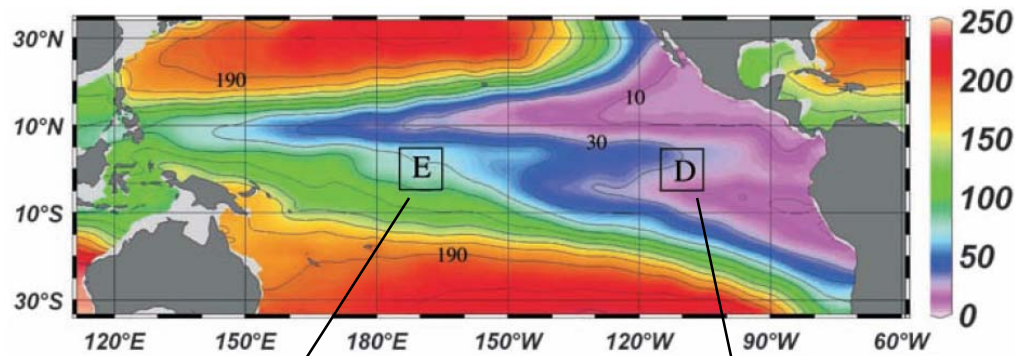
**F. Chavez**

# Expansion of Low-Oxygen Habitat: Mechanisms

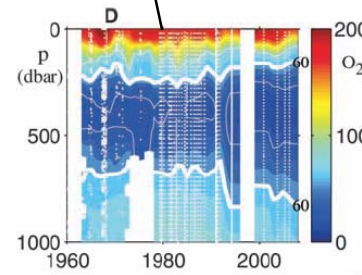
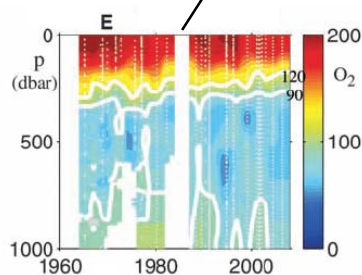
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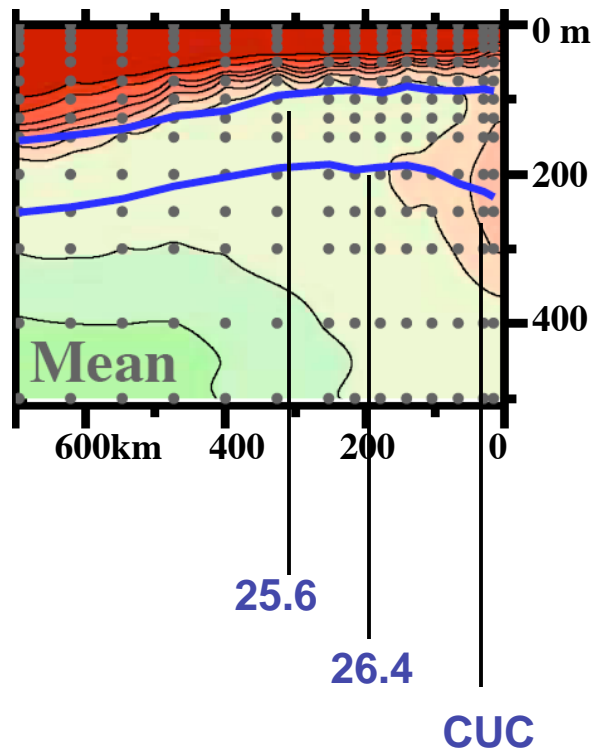


Expansion of tropical OMZs



# California Undercurrent Property Trends

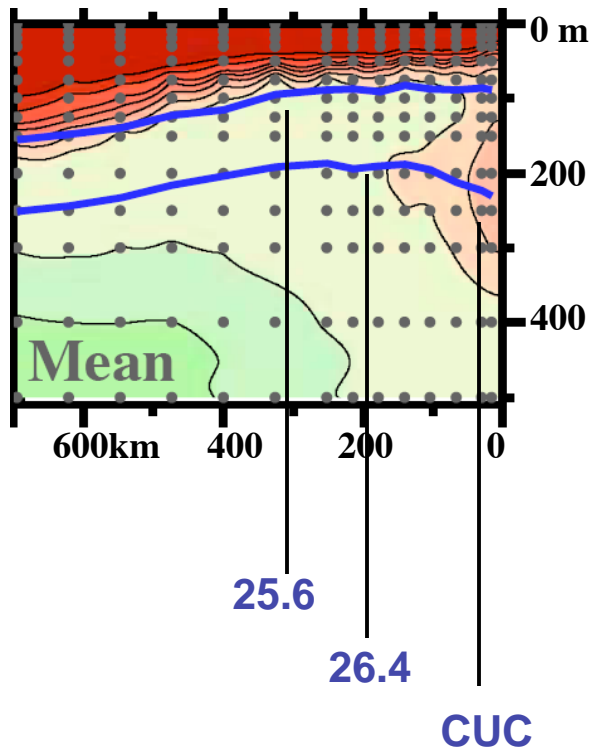
Line 93 Mean Autumn Spiciness



# California Undercurrent Property Trends

CalCOFI Station 93.30  
1984-2006

Line 93 Mean Autumn Spiciness



Isopycnal Depth

Spiciness

Apparent Oxygen Utilization

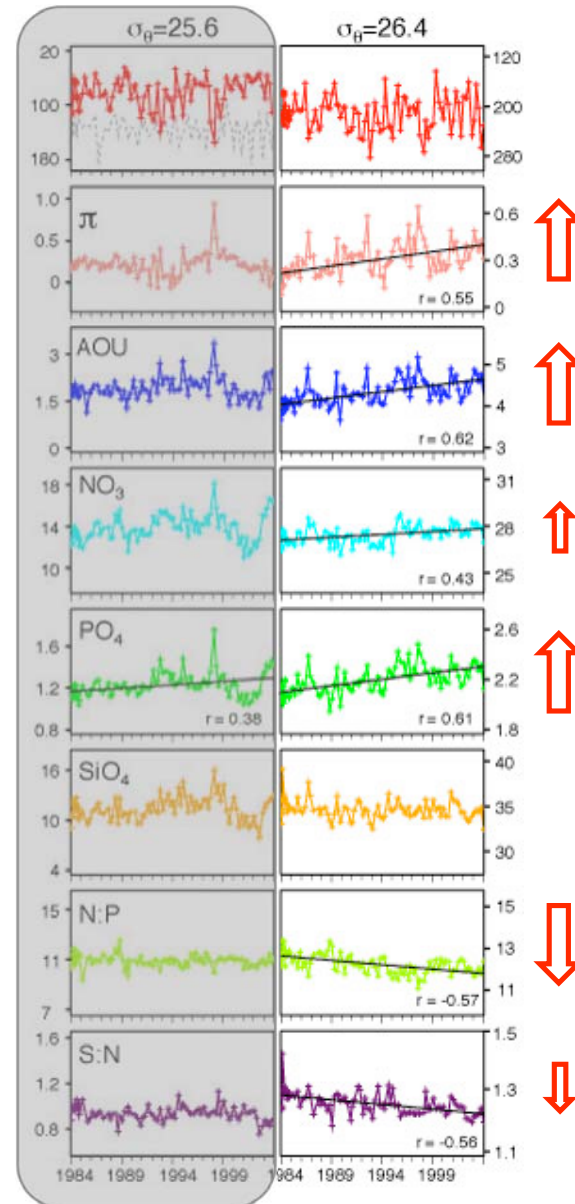
Nitrate

Phosphate

Silicate

N:P Ratio

S:N Ratio



# **SUMMARY and Next Steps**



- 1. Significant O<sub>2</sub> declines in southern California Current**

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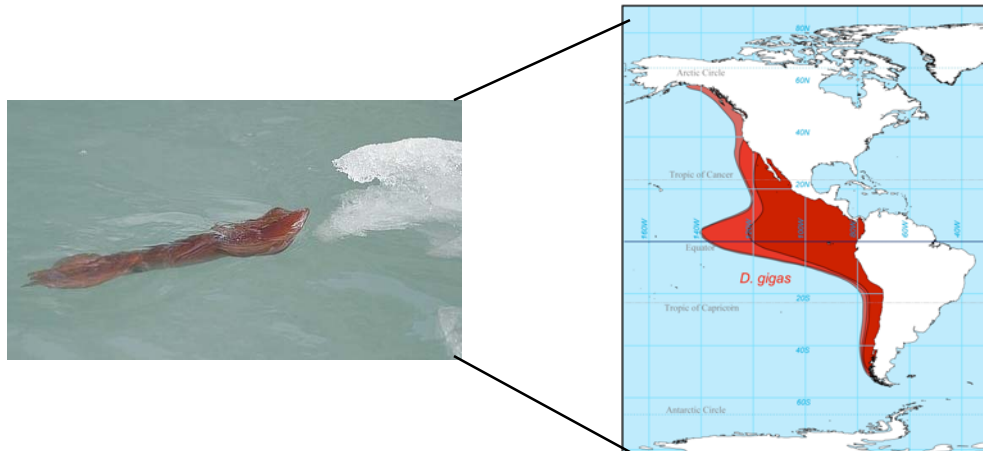


1. Significant  $O_2$  declines in southern California Current
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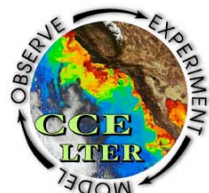
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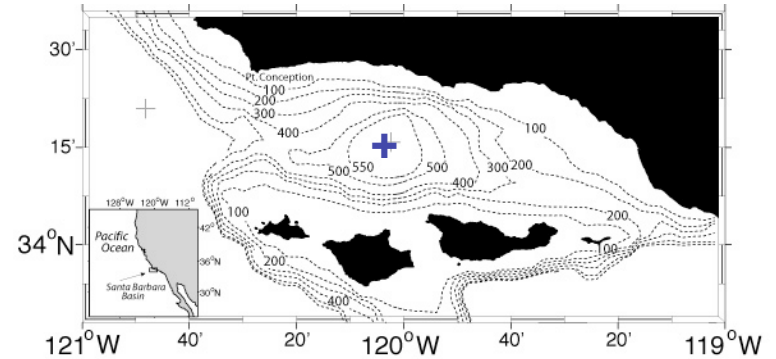
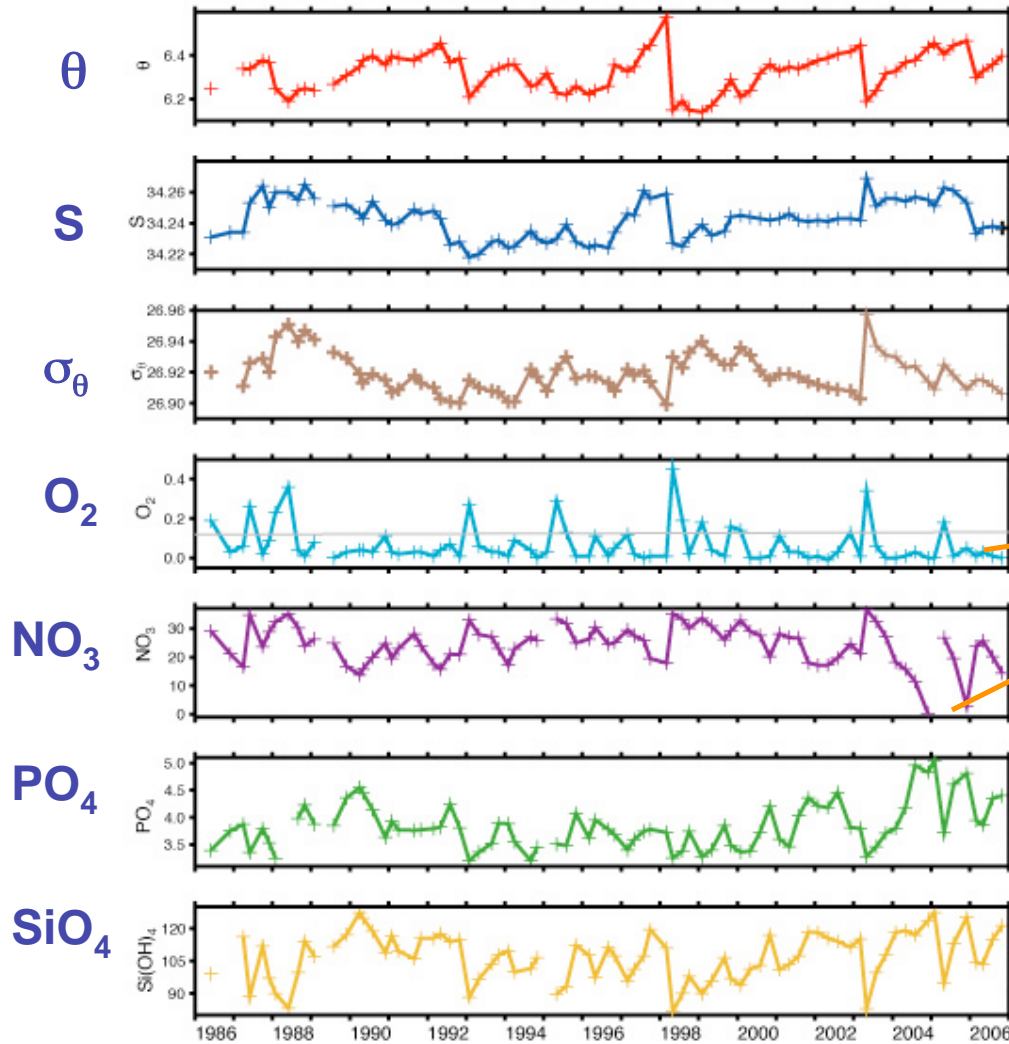
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4. Ecosystem impacts: shifts in habitat & community structure
5. Coupled physical-biological model to quantify relative importance of  $O_2$ -change mechanisms



# Anoxia in the Santa Barbara Basin

Station 82.47

CalCOFI Station 82.47



$O_2 \sim NO_3 \sim 0$

## Increasing Anoxia in SBB?

- near-surface warming
- less dense waters at western sill
- fewer basin flushing events
- lower oxygen content

Deepest Sample