



First Results from the Catalina Dynamic Ocean Chemistry Project

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Catalina Marine Society

Southern California Academy of Sciences Annual Meeting

California State University Northridge

May 3, 2019

Introduction



- Ocean acidification (decrease in pH) is the result of increasing atmospheric CO_2 which enters the ocean and produces carbonic acid
 - Affects sea life, especially shell-bearing (calcium carbonate) animals
- Realizations of acidification depend on local factors, including upwelling, plant growth, metabolic activity
- Goal is to understand the dynamics of pH at Santa Catalina Island for insight into how to accommodate climate change

Sites: Two Harbors and Avalon



Mooring

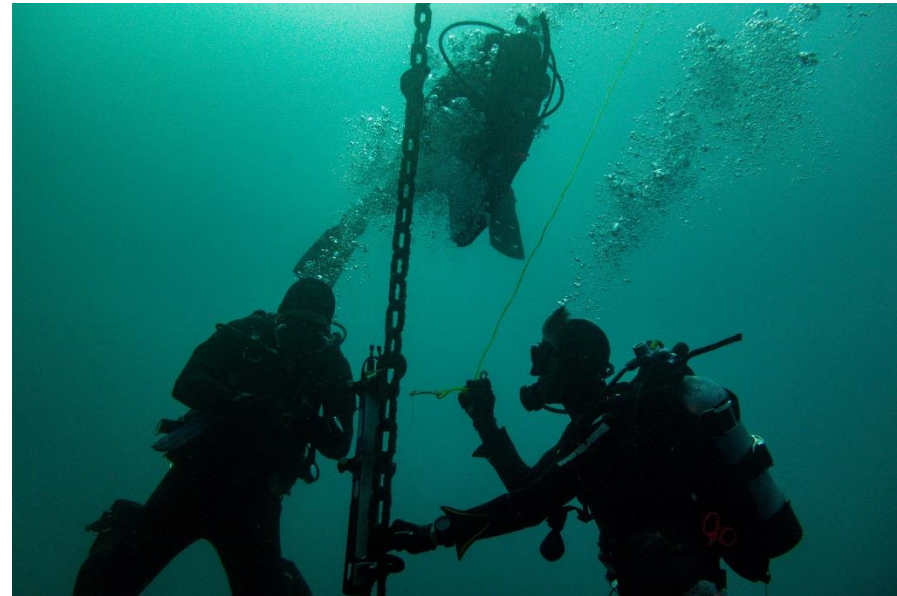
Seabed ~ 100ft



Depth profiling
from boat

Mooring

- Instrumentation
 - YSI EXO2 sonde with sensors for:
 - pH,
 - dissolved oxygen,
 - chlorophyll,
 - Conductivity/temperature
 - Thermographs
 - 6, 12 and 24 m
- Deployed 4 times to 18-m depth
 - 7/2018
 - 9/2018
 - 12/2018
 - 3/2019
- Depth chosen to reduce biofouling and take advantage of internal waves

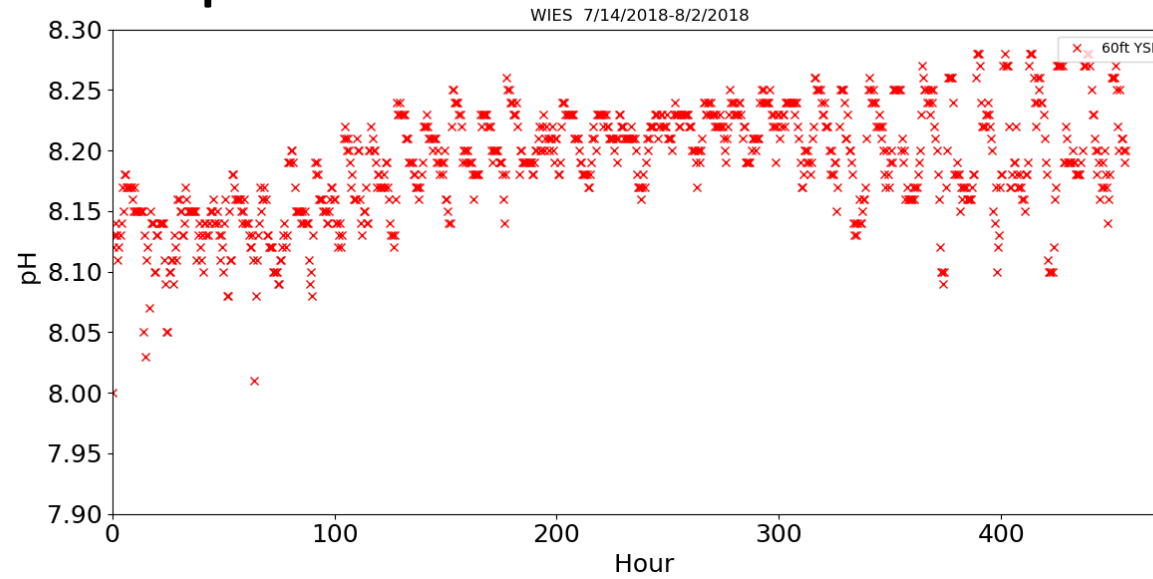


Credit: Adam Fram

pH, Extremes at Depth

July 2018

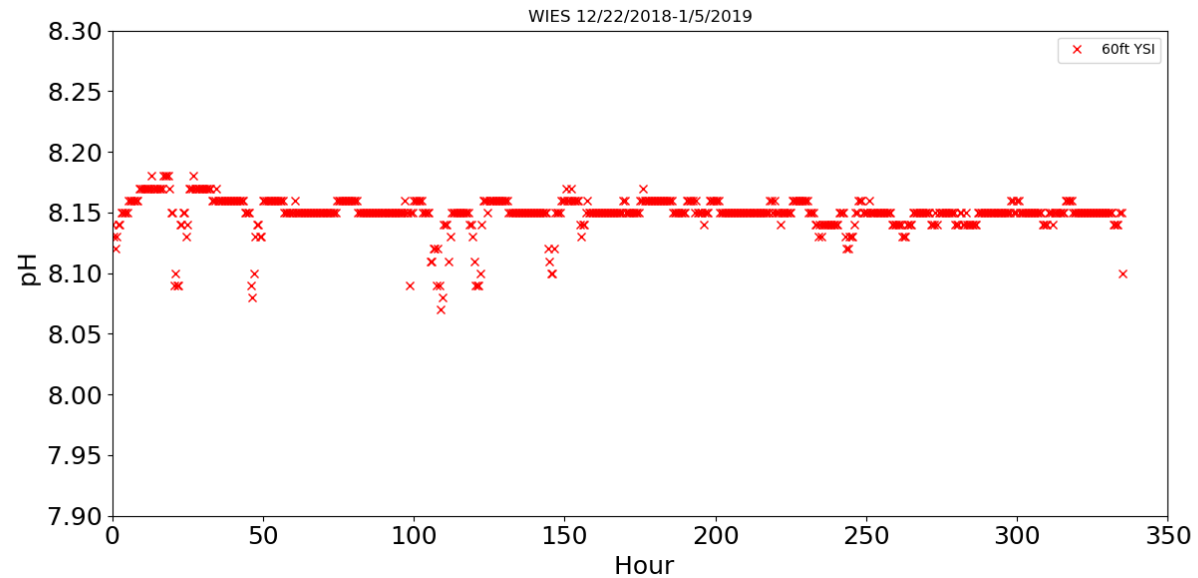
accuracy



0.2 pH unit



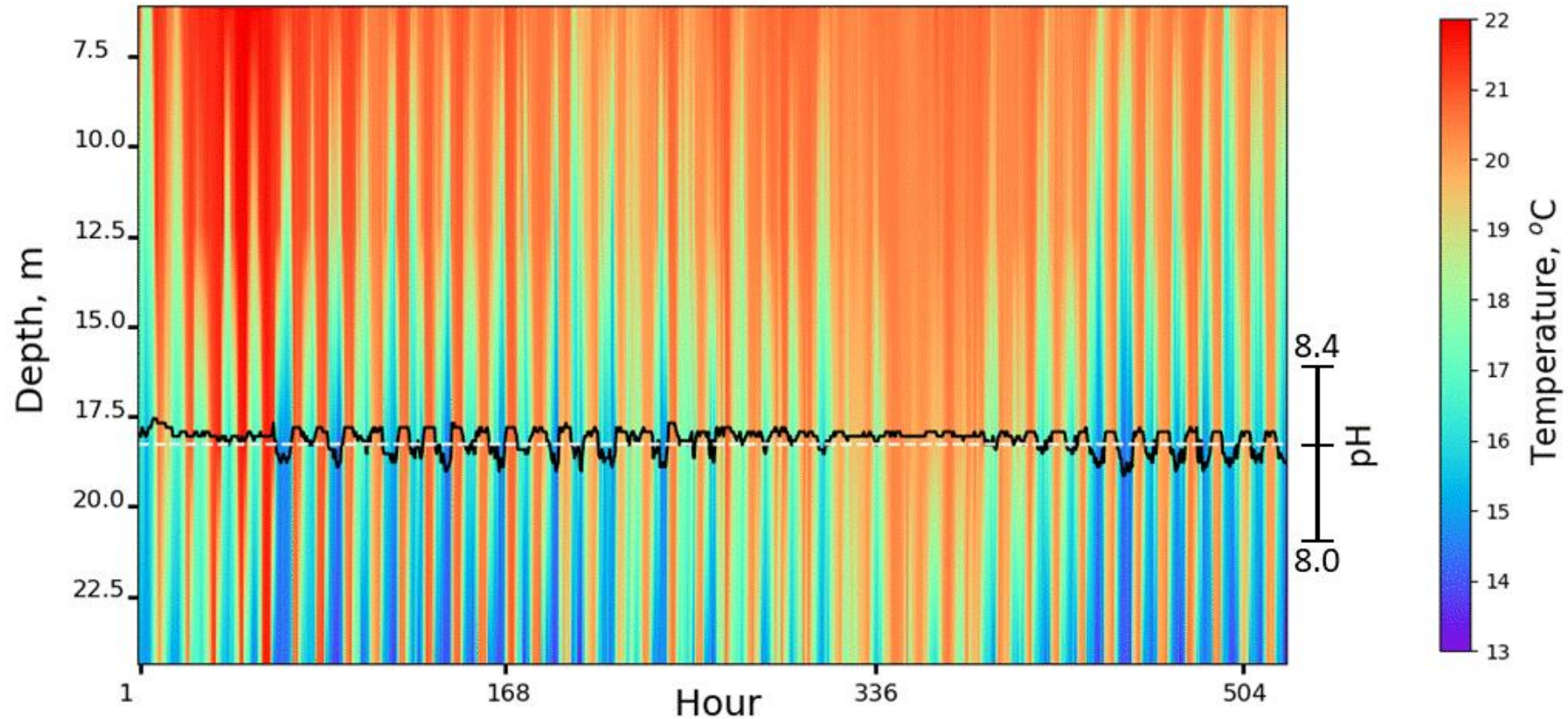
December 2018



pH Modulations Correlated with Temperature

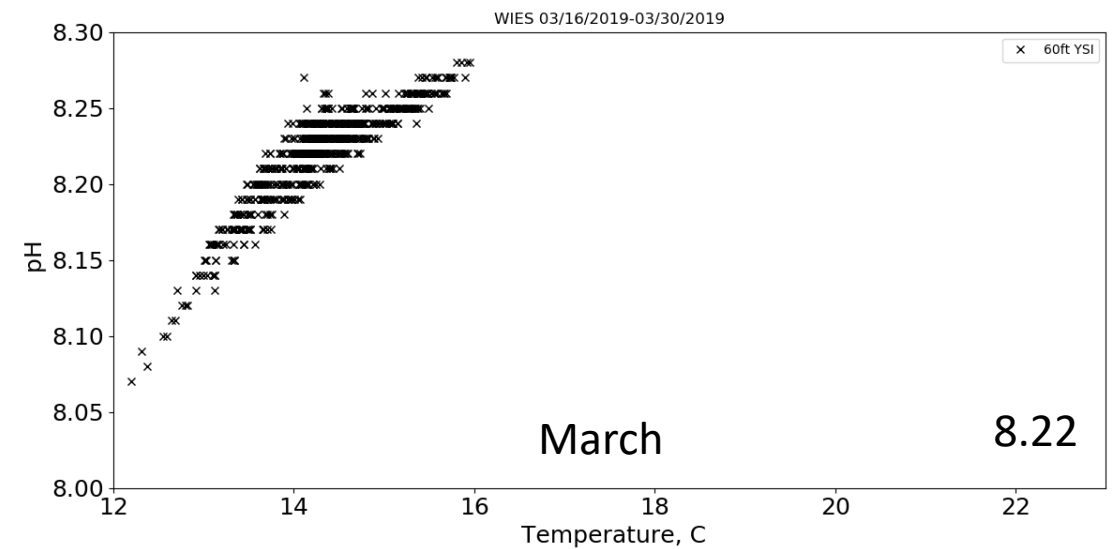
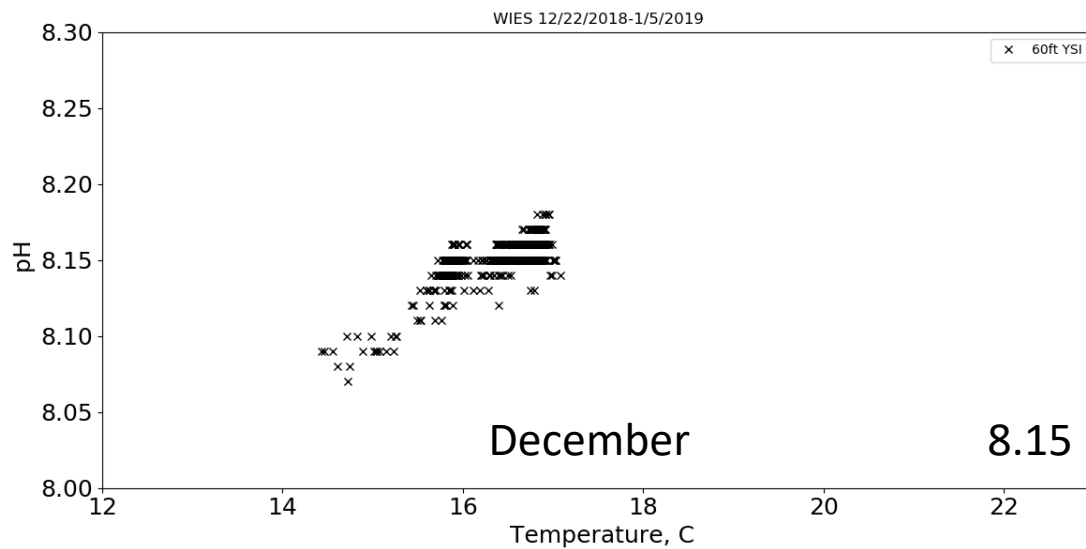
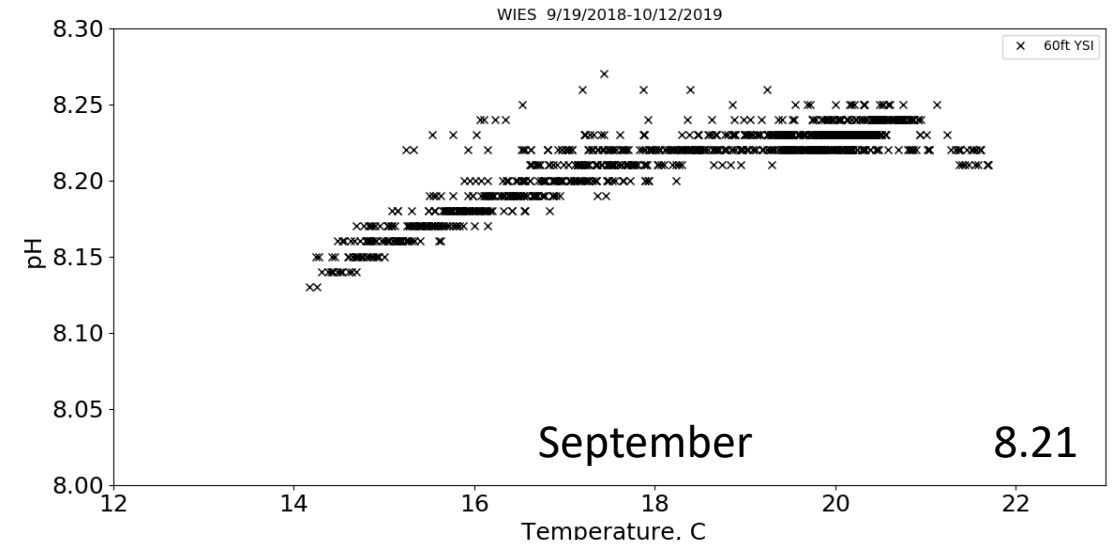
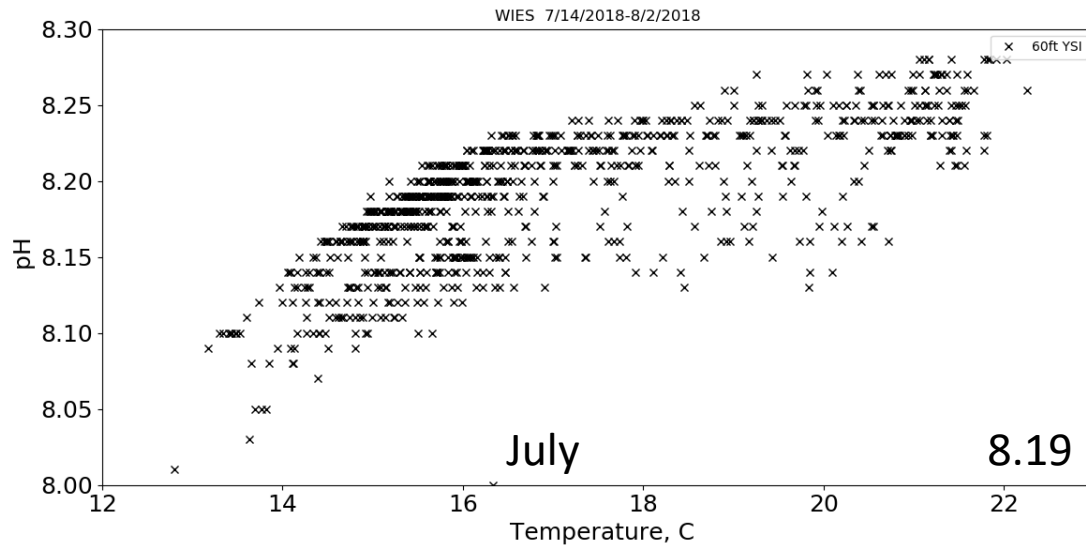
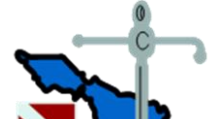


September 20 - October 12

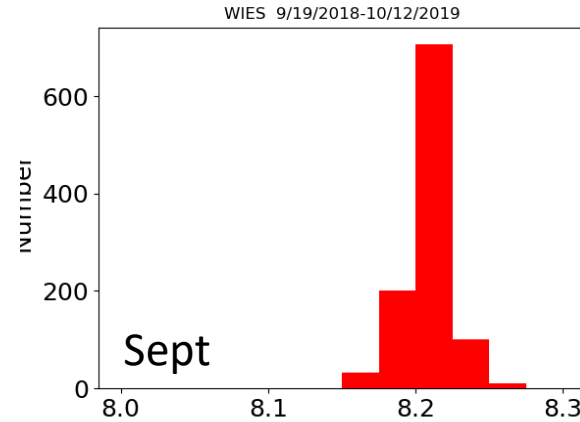
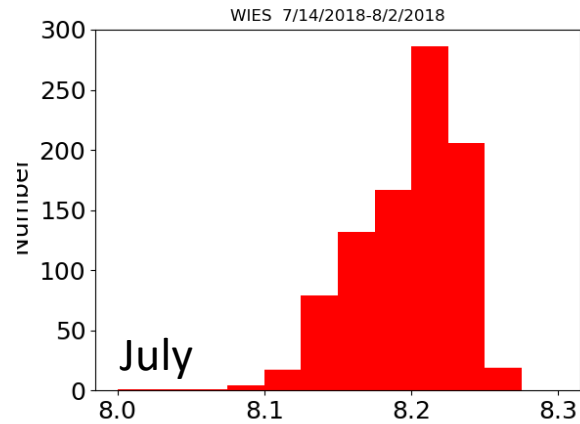


pH modulations are probably not biological in origin, but driven by internal wave advection

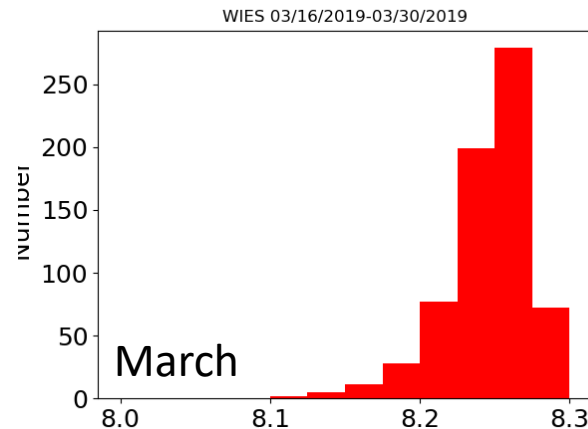
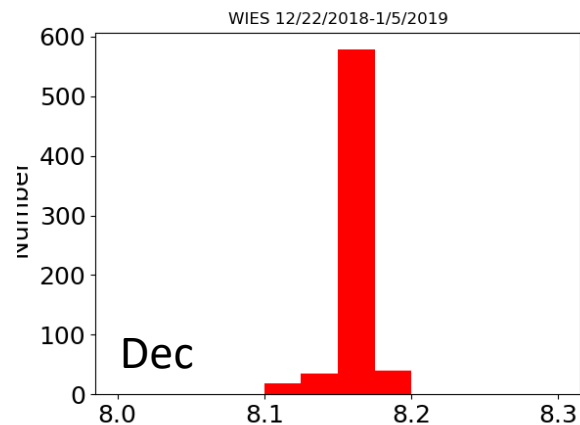
pH vs Temperature



pH Distributions, Equalized for Temperature to 18°C



pH value depends on temperature
 $\Delta\text{pH} \sim -0.007/^\circ\text{C}$ at pH = 8



pH Depth Gradient



- $\frac{\partial pH}{\partial t} = v_z \frac{\partial pH}{\partial z}$

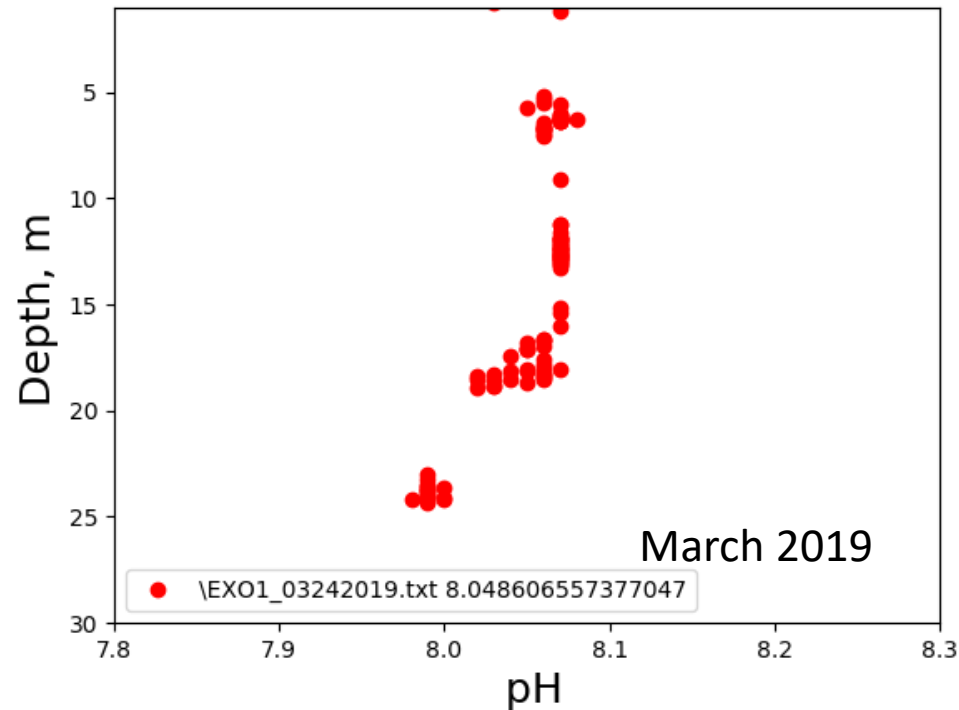
- $\frac{\partial pH}{\partial z} = \frac{\partial pH}{\partial t} \frac{\partial t}{\partial T} \frac{\partial T}{\partial z}$

- $\frac{\partial pH}{\partial z} = -0.0036/\text{m}$

- $\frac{\partial pH}{\partial z} = \frac{\partial pH}{\partial T} \frac{\partial T}{\partial z} = 0.041 \frac{\partial T}{\partial z} = -0.0068/\text{m}$

Split difference yields
-0.005 units/m

Depth profiling: Same Instrumentation Lowered from Boat



| Date | pH (average between 6 and 30 m) |
|------------|---------------------------------|
| 08/20/2017 | 8.17 |
| 10/04/2017 | 8.15 |
| 12/29/2017 | 8.19 |
| 03/18/2018 | 8.18 |
| 04/29/2018 | 8.16 |
| 05/20/2018 | 8.04 |
| 06/16/2018 | 8.18 |
| 09/09/2018 | 8.18 |
| 11/17/2018 | 8.09 |
| 03/24/2019 | <u>8.04</u> |

8.14±0.032 cal err

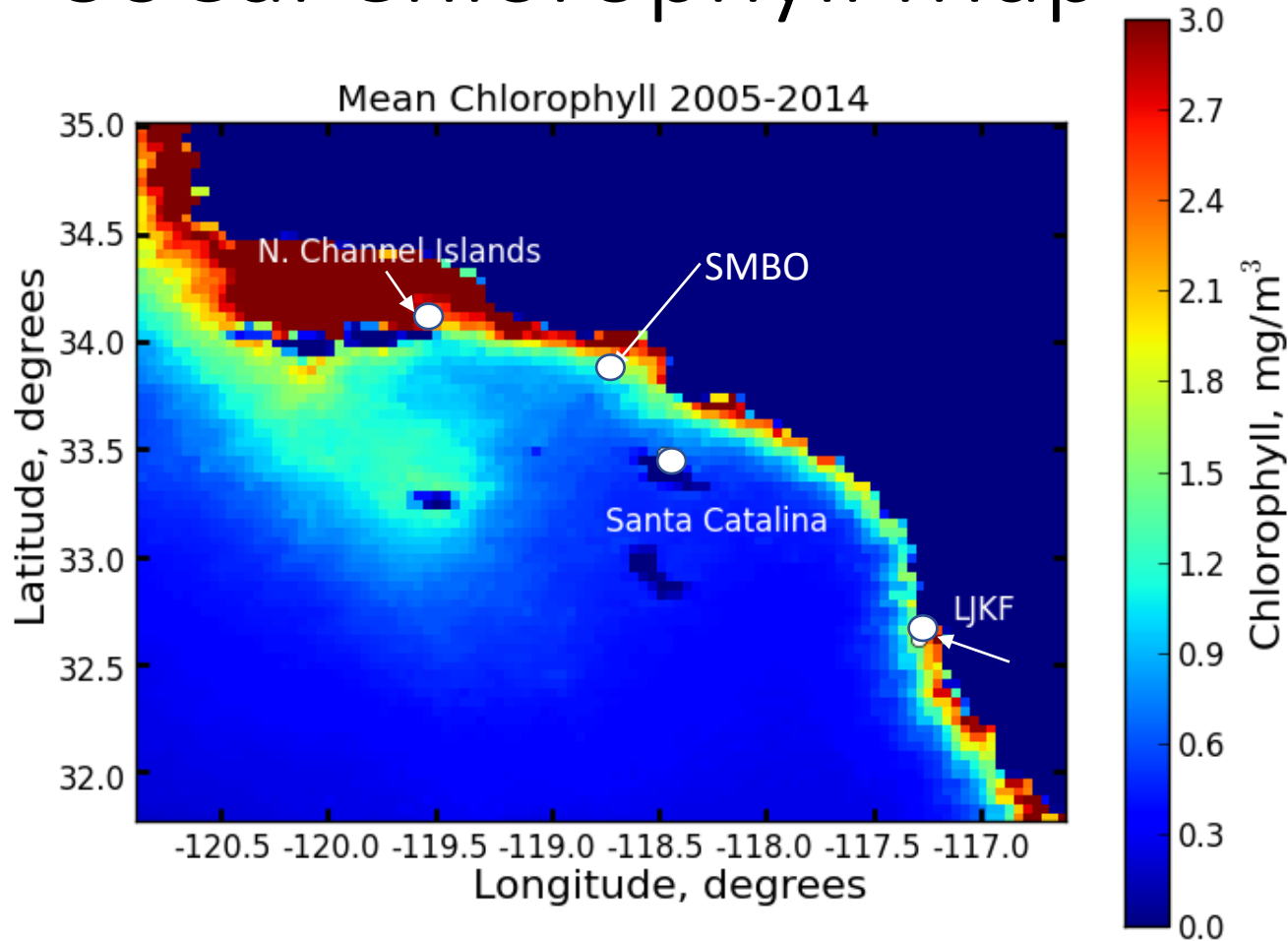
March pH change at thermocline, unusually well defined



pH Comparisons Amongst Locations

- Frieder et al., (2012) La Jolla Kelp Forest pH measurements
 - 7.9 median value (17-m depth)
- Leinweber and Gruber (2013) at Santa Monica Bay Observatory
 - 8.08 median value (surface to 20 m)
- Kapsenberg and Hofmann (2016) N. Channel Islands
 - 8.00 +/- 0.043 Anacapa Landing Cove (6-m depth?)
- Catalina Marine Society (2019) Santa Catalina Island
 - 8.19 +/- 0.05 (18.3-m depth mooring)
 - 8.13 +/- 0.04 (6- to 30-m depth profiles)

Higher Catalina pH? SoCal Chlorophyll Map



Phytoplankton increase pH by uptake of CO₂.

Upwelling decreases pH

Phytoplankton thrive in upwelled waters

Catalina has little phytoplankton and upwelling but high pH

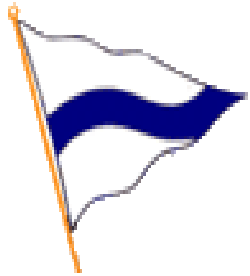
Suggests that abiotic upwelling dominates biology in determining pH in the bight

Findings



- Average pH value is 8.16
 - Catalina pH less acidic than other SoCal Bight sites
- Internal waves modulate pH
 - Provides up to 0.2 units of pH modulation at 18 m
 - pH depth gradient
 - ~ -0.005 units/m

THANKS!



Bonnell Cove Foundation

The Kenneth T. and Eileen L.

NORRIS
FOUNDATION



TED SHARSHAN



USC Wrigley Institute for Environmental Studies