Apr 5th, 10:45 AM - 11:00 AM

Sources of acidic bottom water in Bellingham Bay, Washington

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Sources of acidic bottom water in Bellingham Bay

Results of research performed by Huxley College undergraduates in the class “Oceanography of the Salish Sea”

David Shull (Huxley College, WWU)

and 22 senior undergraduates

WESTERN WASHINGTON UNIVERSITY

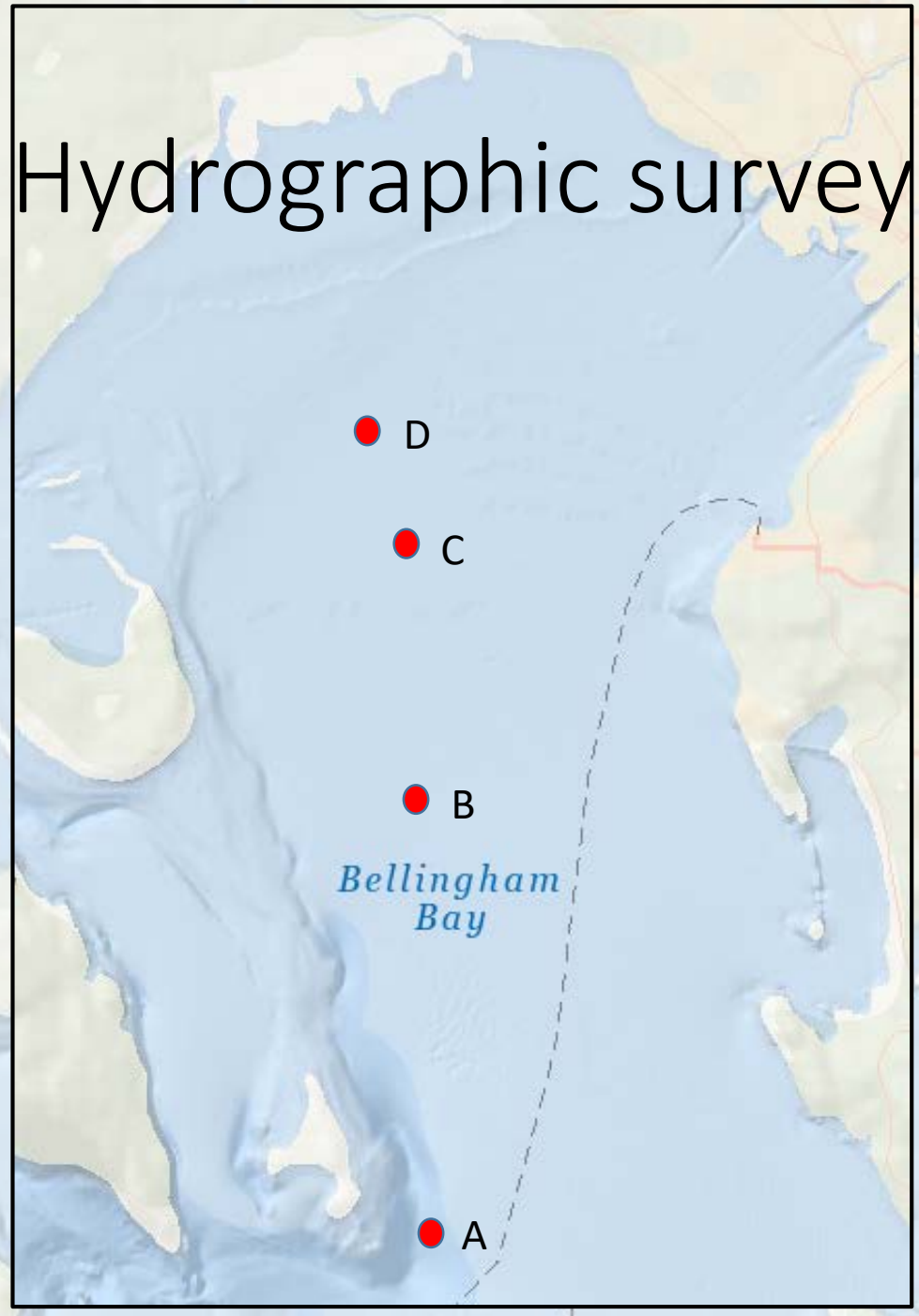
Shannon Point Marine Center

Quantifying Bellingham Bay Carbonate system

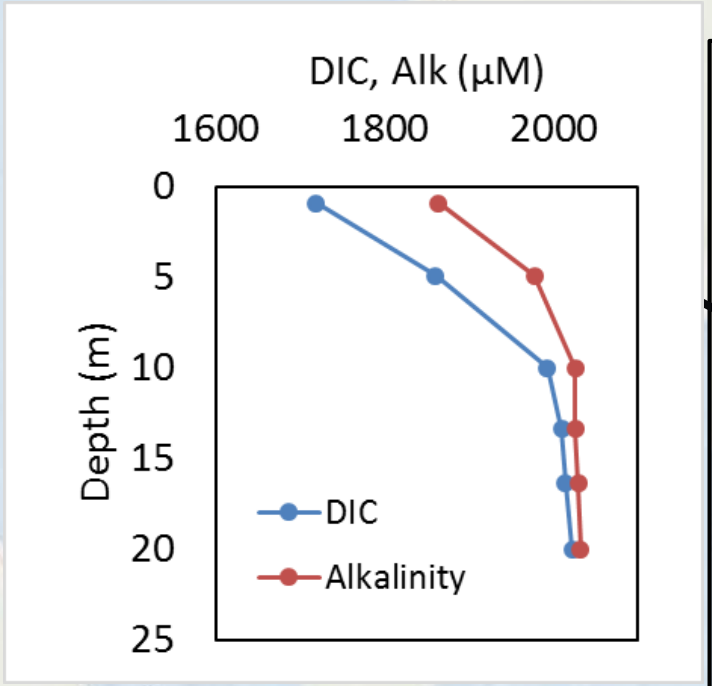
- Hydrographic survey
  - Hydrographic survey. Measure DIC, pH, T, S
  - Calculate alkalinity and Ω_{arg} using CO2SYS
- Water column and sedimentary respiration
  - Measure water column oxygen consumption rates and calculate DIC input
  - Measure sedimentary DIC and pH fluxes, calculate alkalinity flux
- Other sources of DIC and Alkalinity
  - Calculate DIC and alkalinity flux from the Nooksack R and from inflowing deep water
  - Use data on pH, alkalinity, and flow to calculate the DIC and alkalinity flux from the Post-point WWTP
- Modeling
  - Generate box-model of northern Bellingham Bay
  - Use data from the Bellingham Bay Se'lhaem buoy. Determine the sources of DIC and Alkalinity to Bellingham Bay the cause of corrosive bottom water.

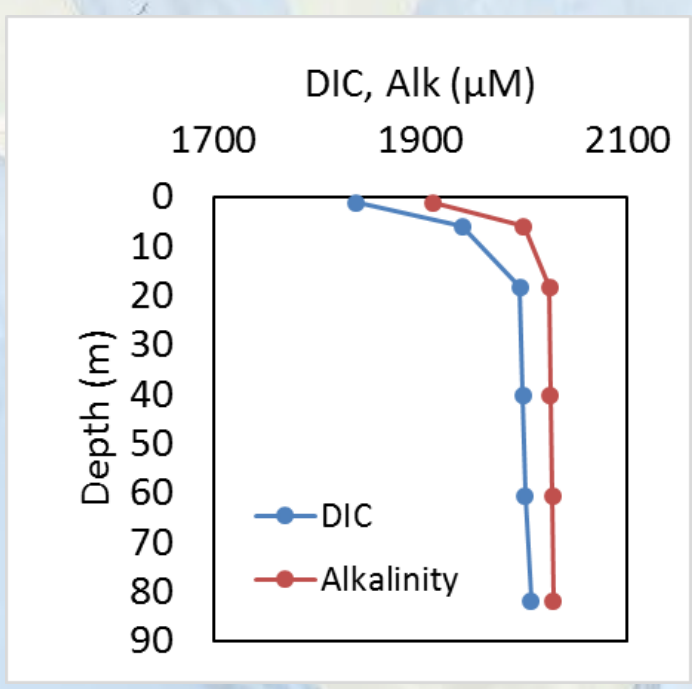
Hydrographic survey

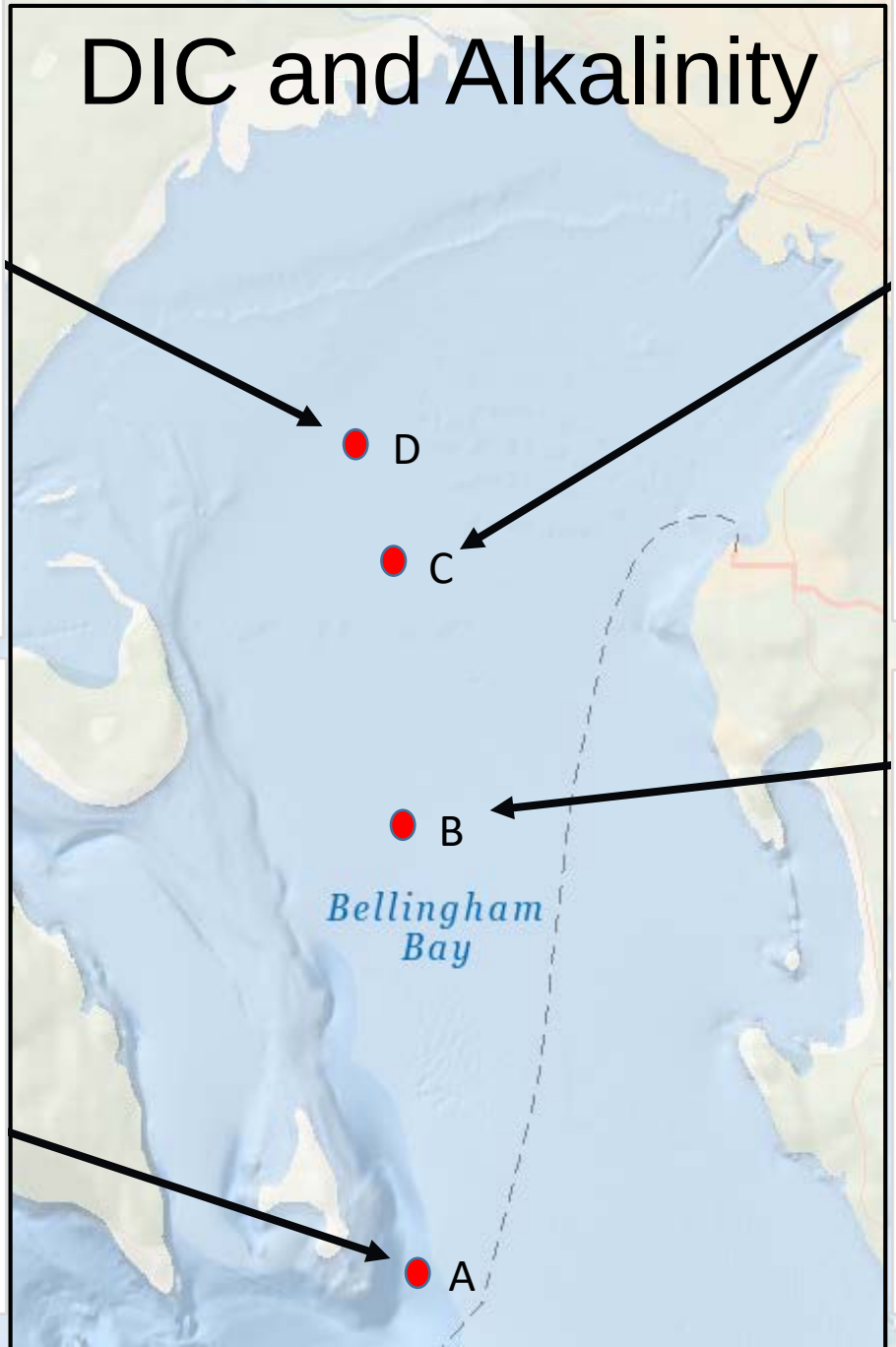
- Samples collected by CTD-rosette at 4 sites
- DIC measured by NDIR
- pH measured by cresol purple absorbance
- Respiration rates
- Sediment incubations
- Nooksack R samples
- WWTP data

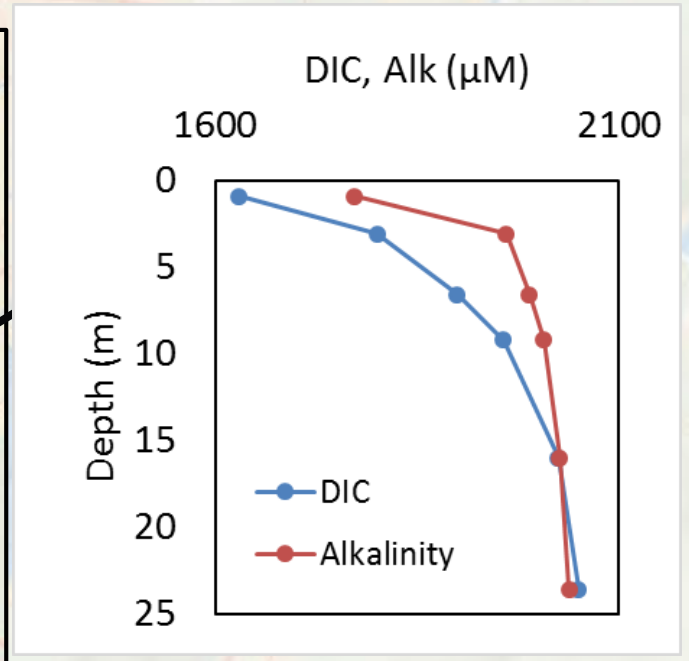


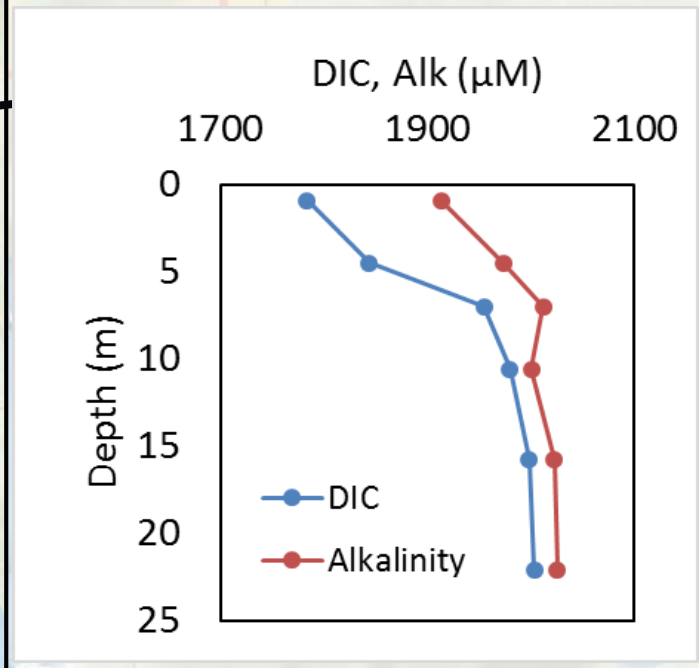
DIC and Alkalinity

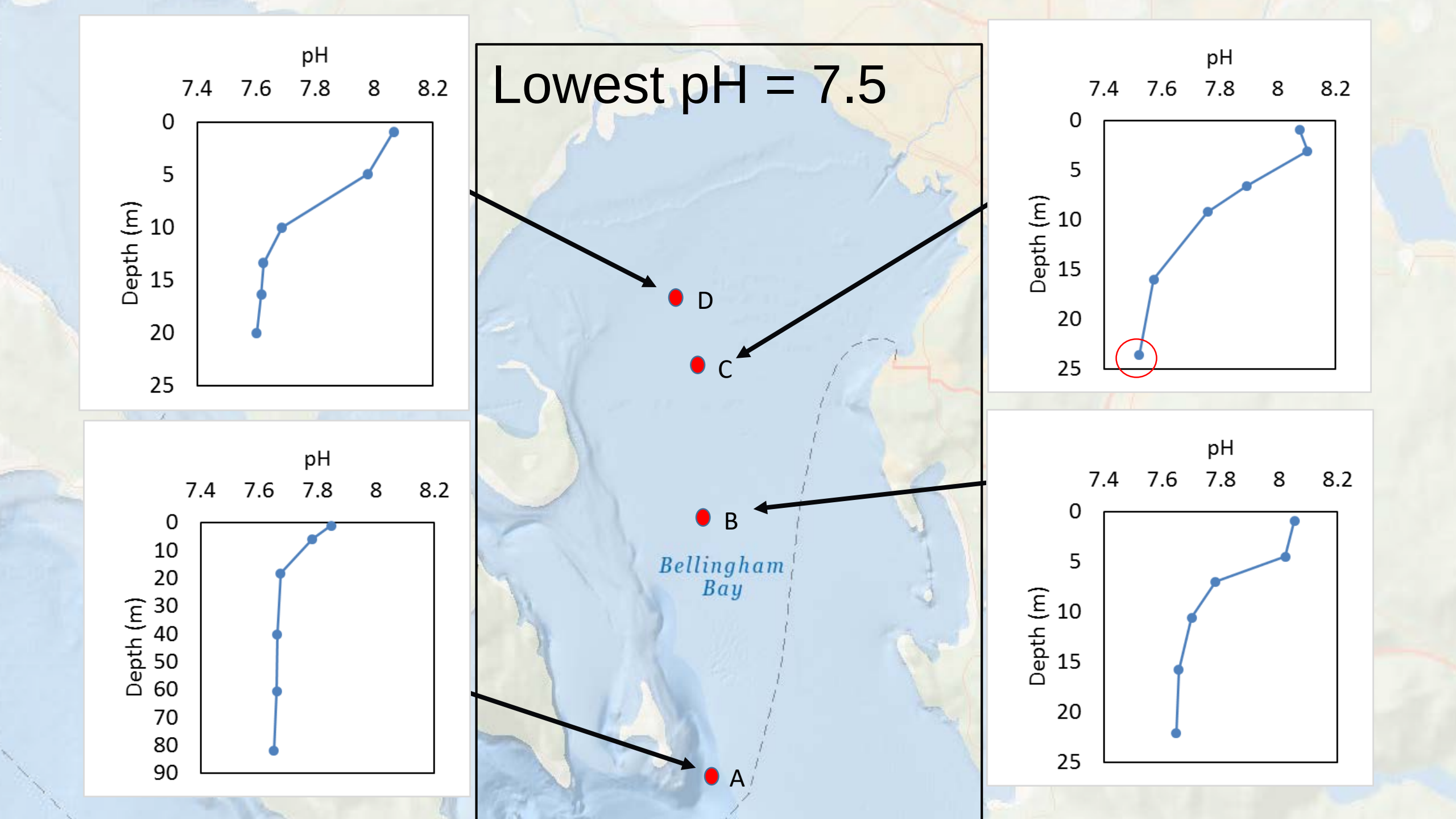








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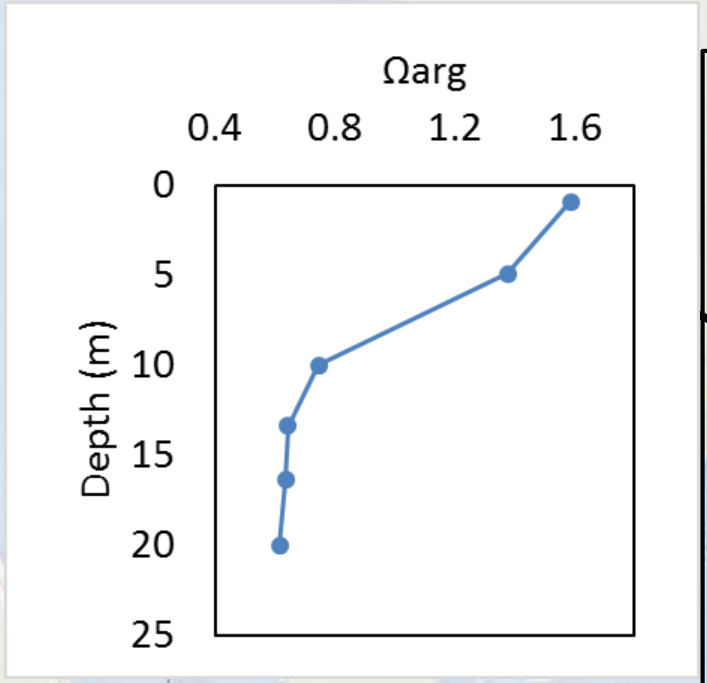
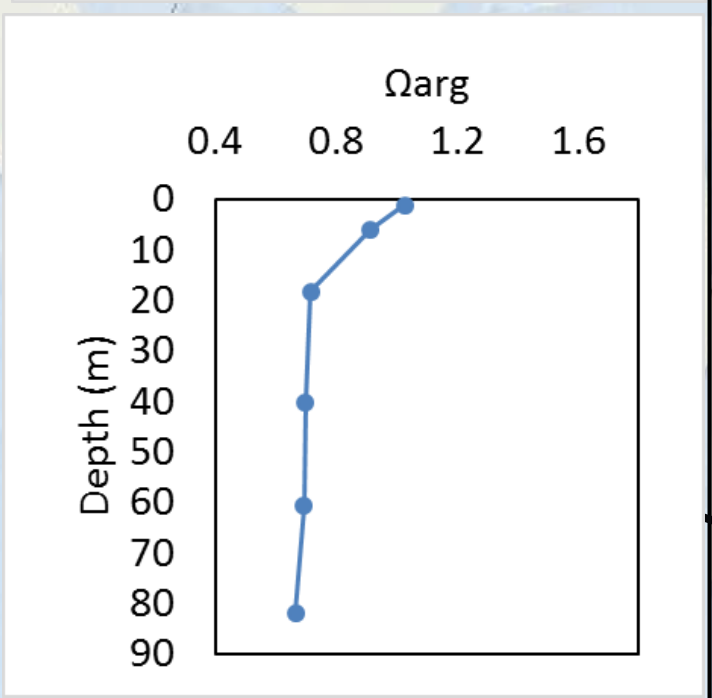
7.4 7.6 7.8 8 8.2
Depth (m)
0 5 10 15 20 25
pH
7.4 7.6 7.8 8 8.2
Depth (m)
0 10 20 30 40 50 60 70 80 90
pH
7.4 7.6 7.8 8 8.2
Depth (m)
0 5 10 15 20 25
pH
7.4 7.6 7.8 8 8.2
Depth (m)
0 5 10 15 20 25
D
C
B
A
Bellingham Bay


Ωarg
0.4
0.8
1.2
1.6
Depth (m)
0
5
10
15
20
25


Ωarg
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1.2
1.6
Depth (m)
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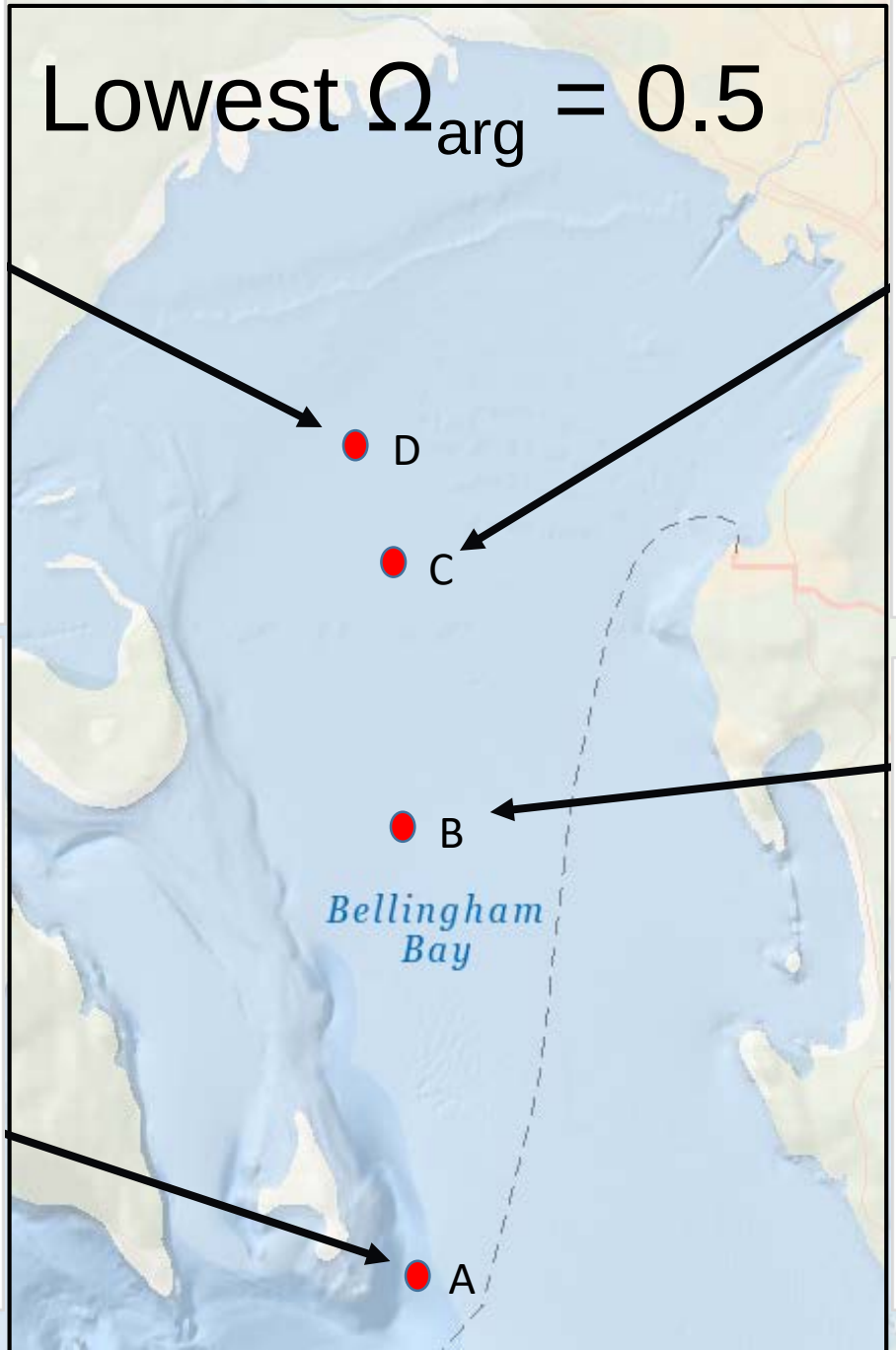
10
20
30
40
50
60
70
80
90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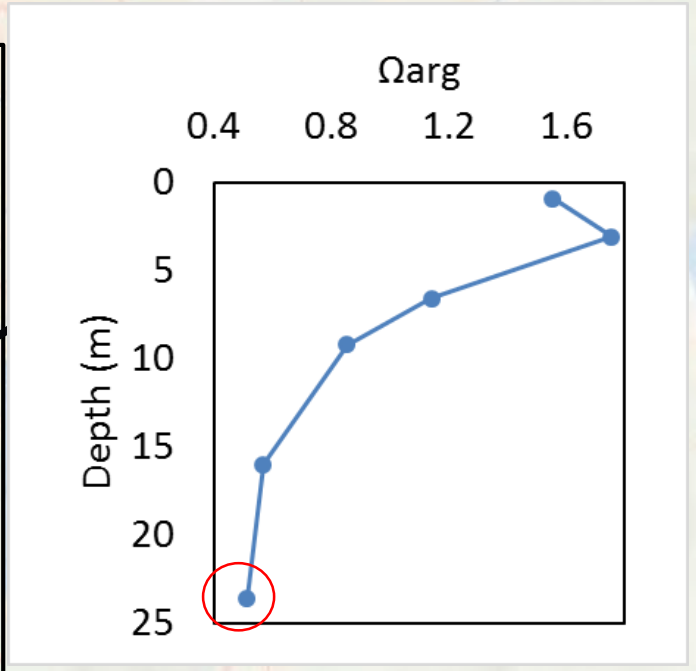
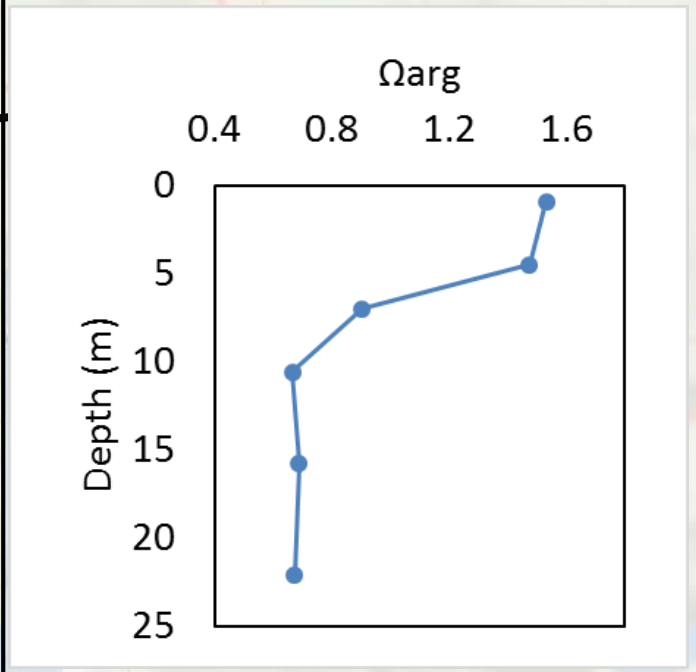
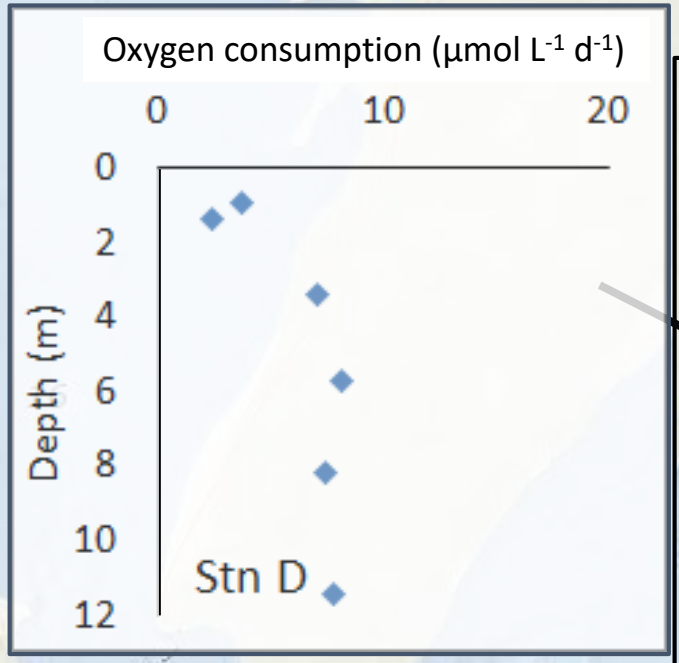
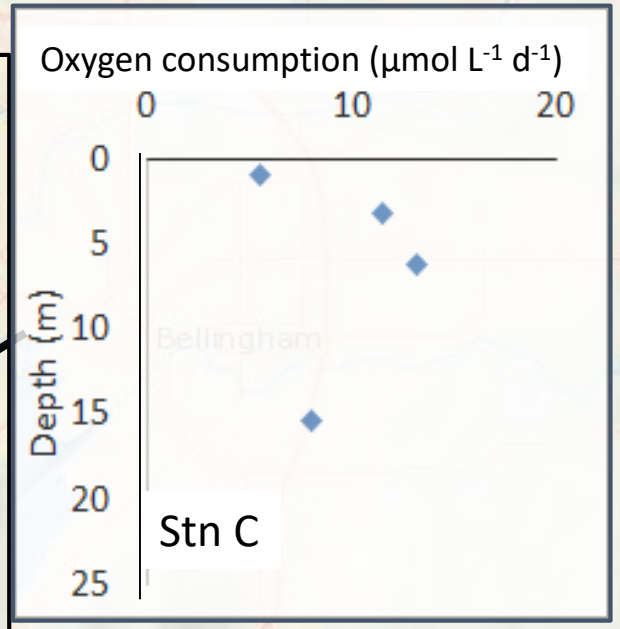
D
C
B
Bellingham
Bay
A

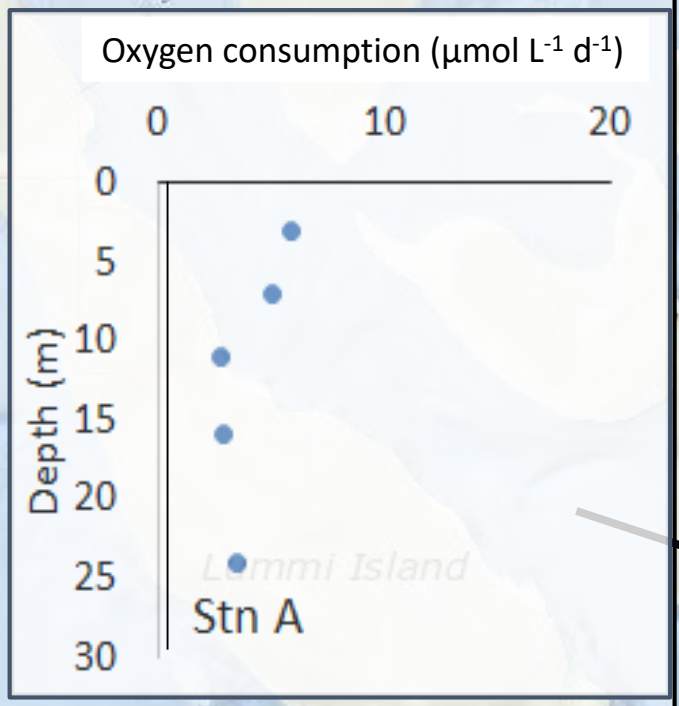

Ωarg
0.4
0.8
1.2
1.6
Depth (m)
0
5
10
15
20
25

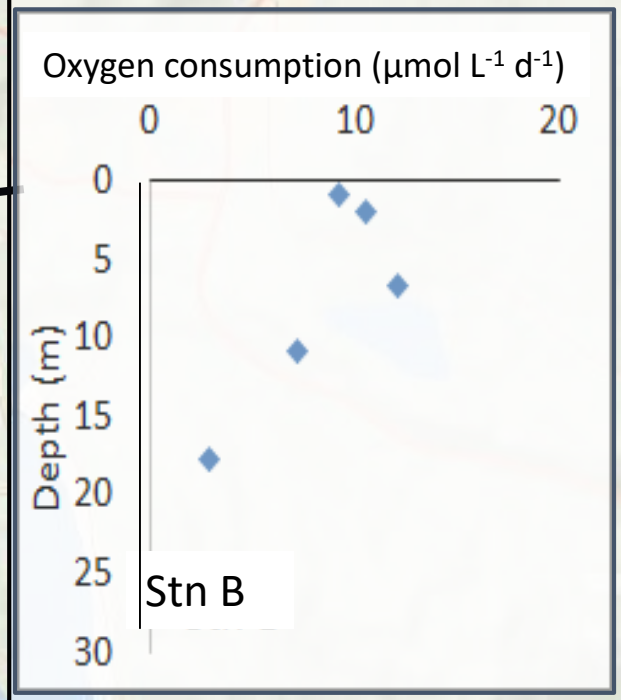

Ωarg
0.4
0.8
1.2
1.6
Depth (m)
0
5
10
15
20
25

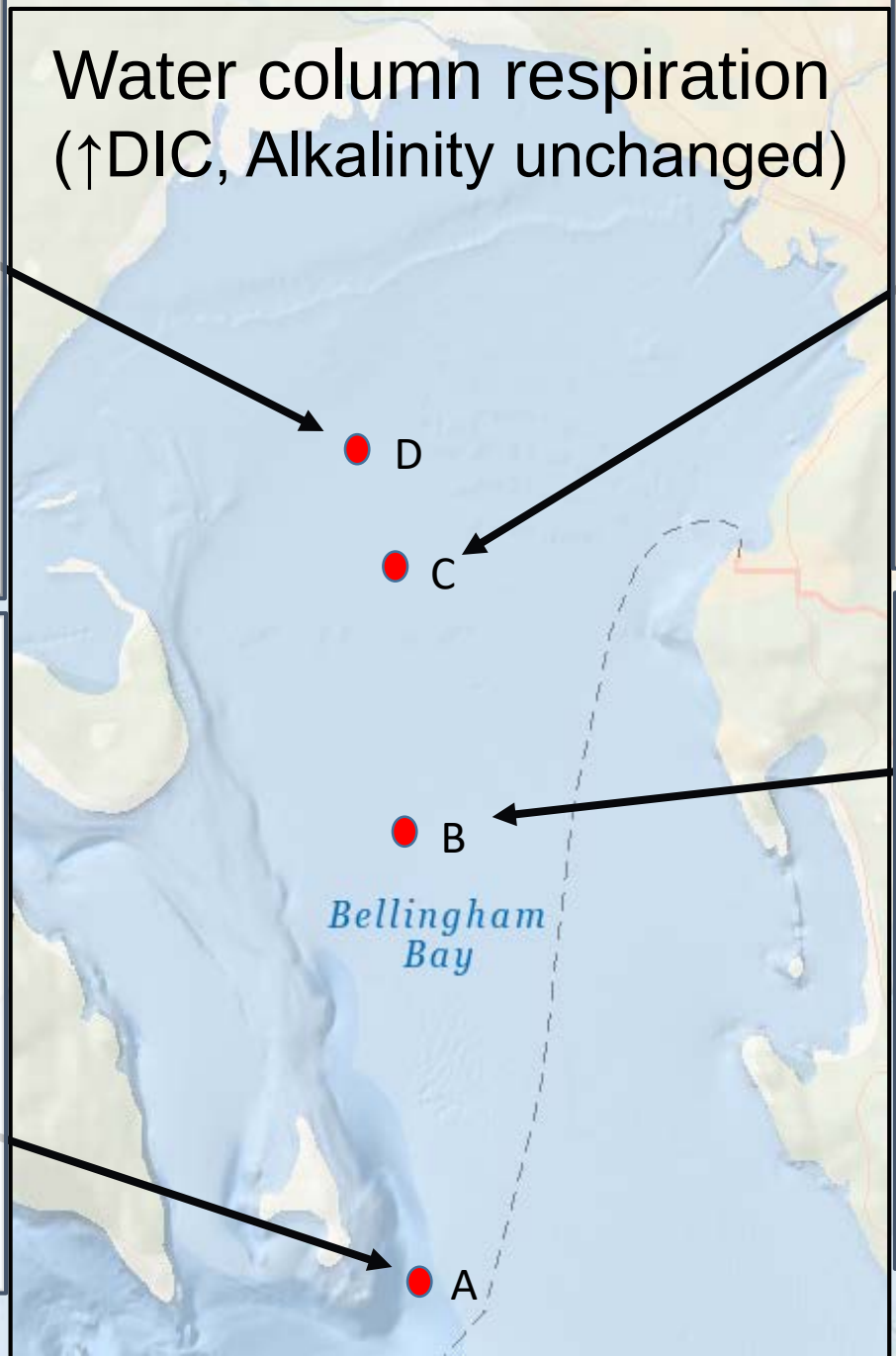
Water column respiration
(↑DIC, Alkalinity unchanged)







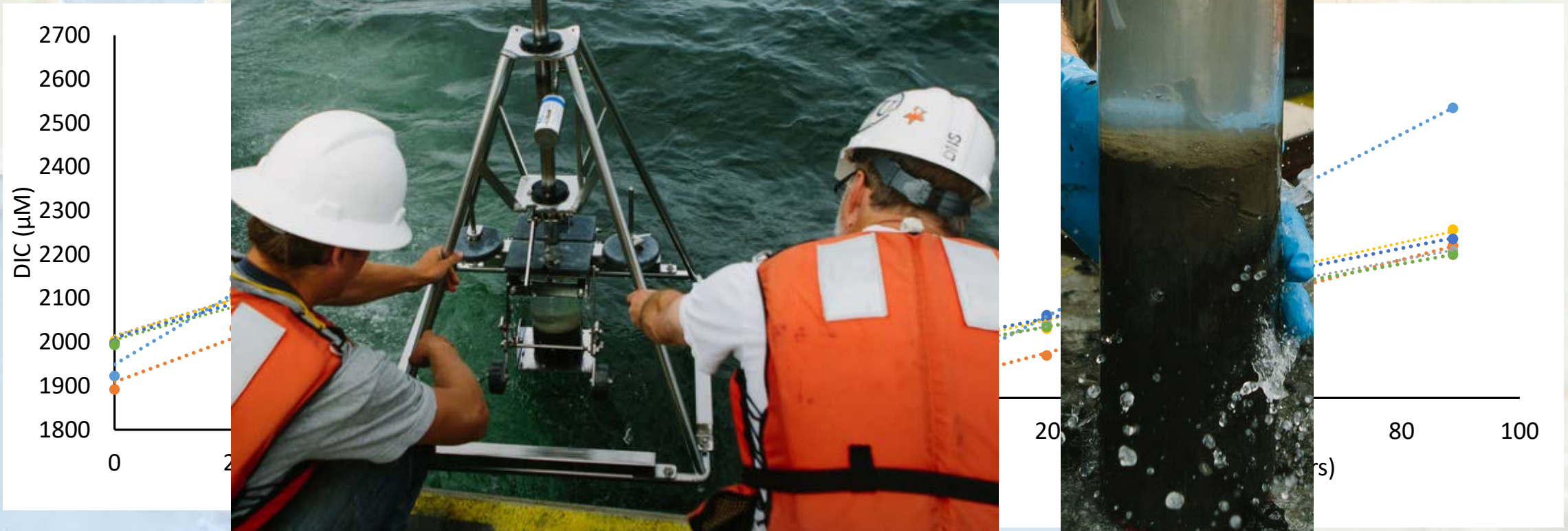




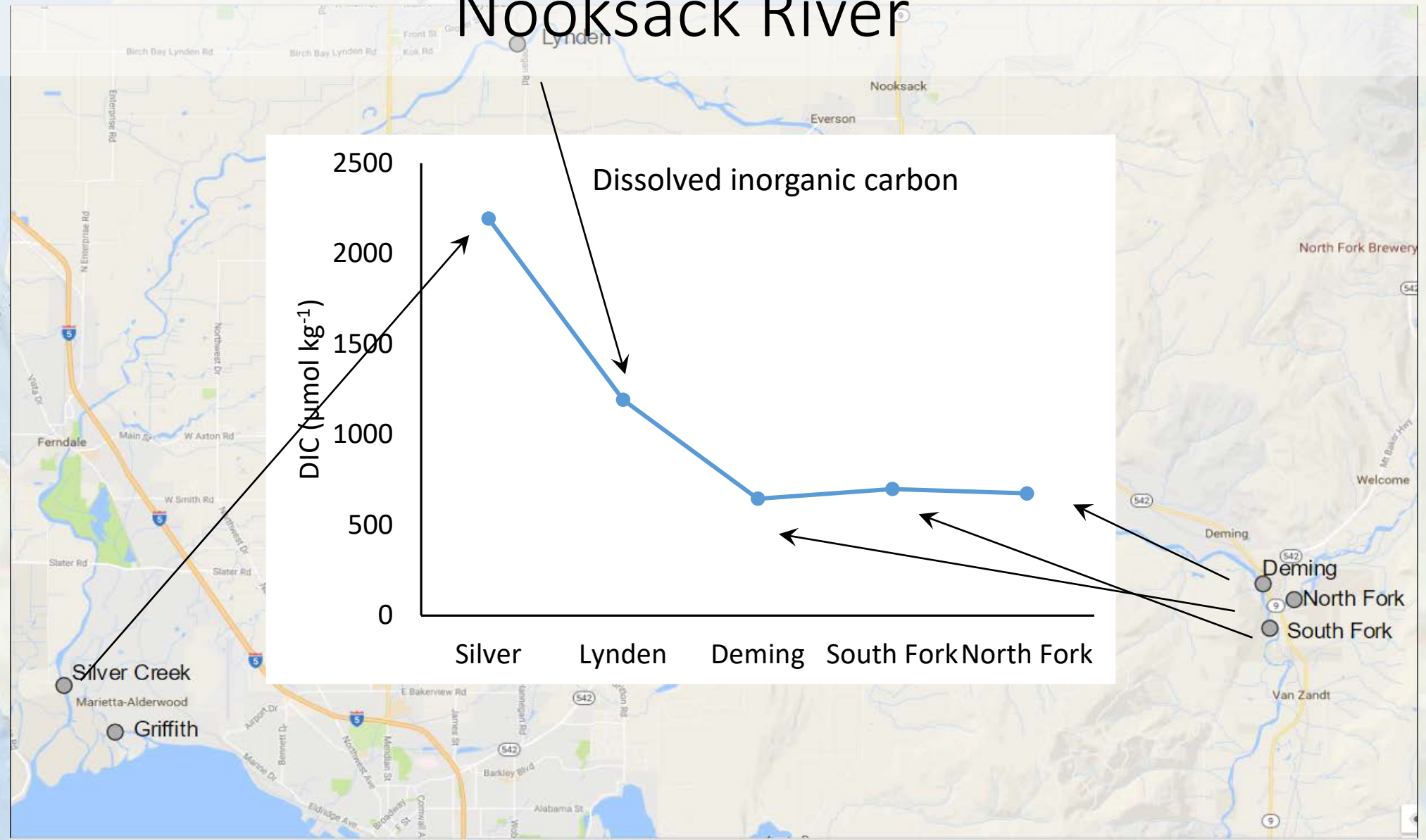
DIC and Alkalinity sources to Bellingham Bay

S… DI…nity

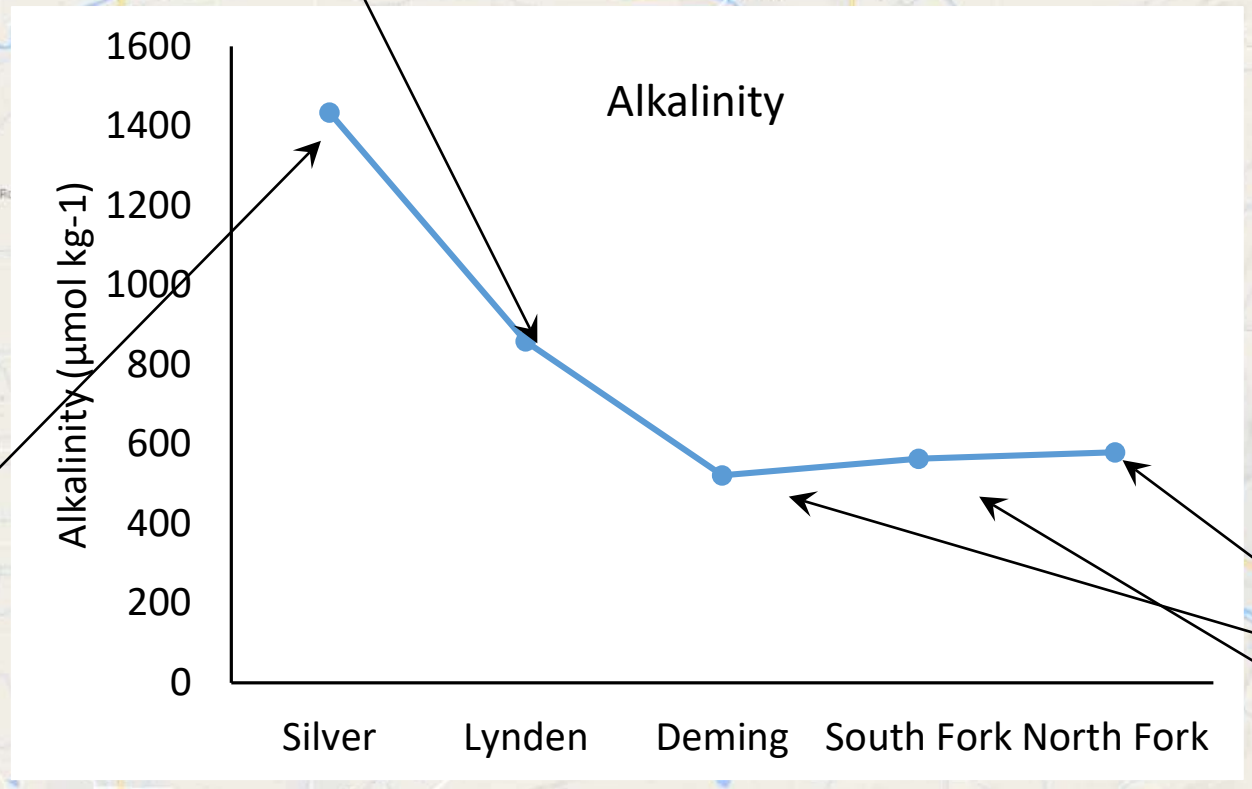
Change in DI… lkal… …ted sediment cores



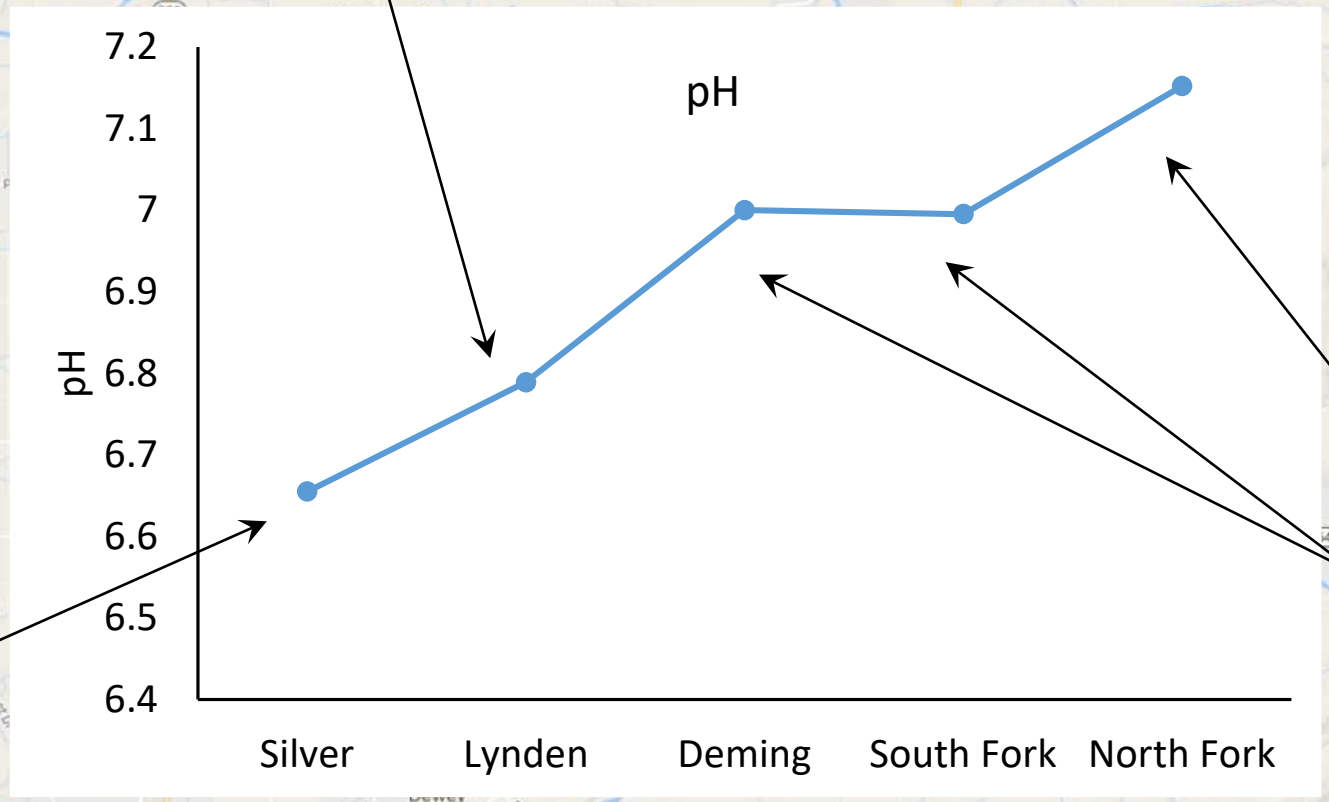
DIC and Alkalinity sources to Bellingham Bay: Nooksack River



DIC and Alkalinity sources to Bellingham Bay: Nooksack River

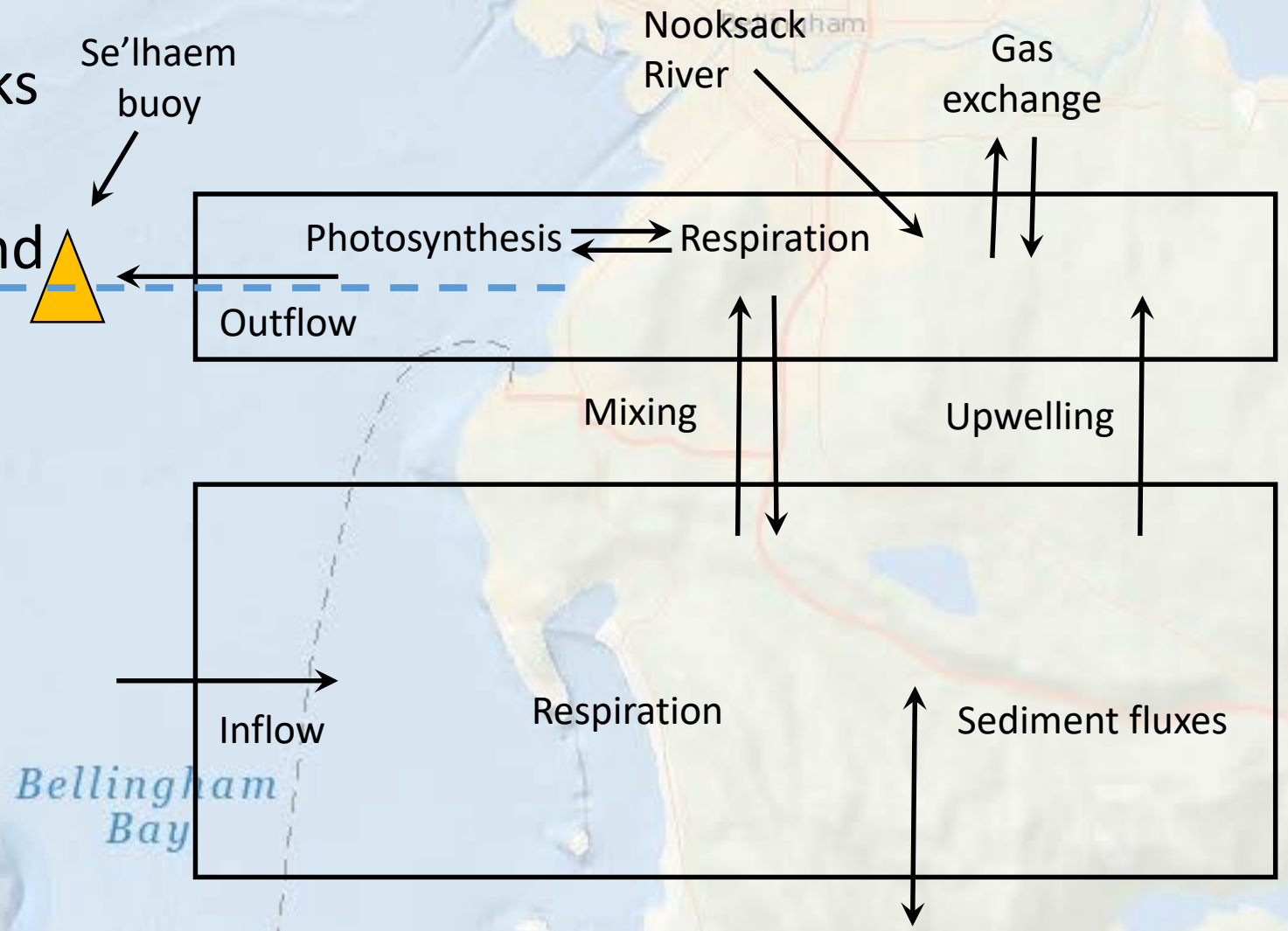


DIC and Alkalinity sources to Bellingham Bay: Nooksack River



Box model of northern Bellingham Bay pH

- Measured sources and sinks of DIC and Alkalinity
- Calculated change in pH and Ω_{arg} in bottom water
- Questions:
  - How were pH and Ω_{arg} changing?
  - What processes create low pH bottom water?



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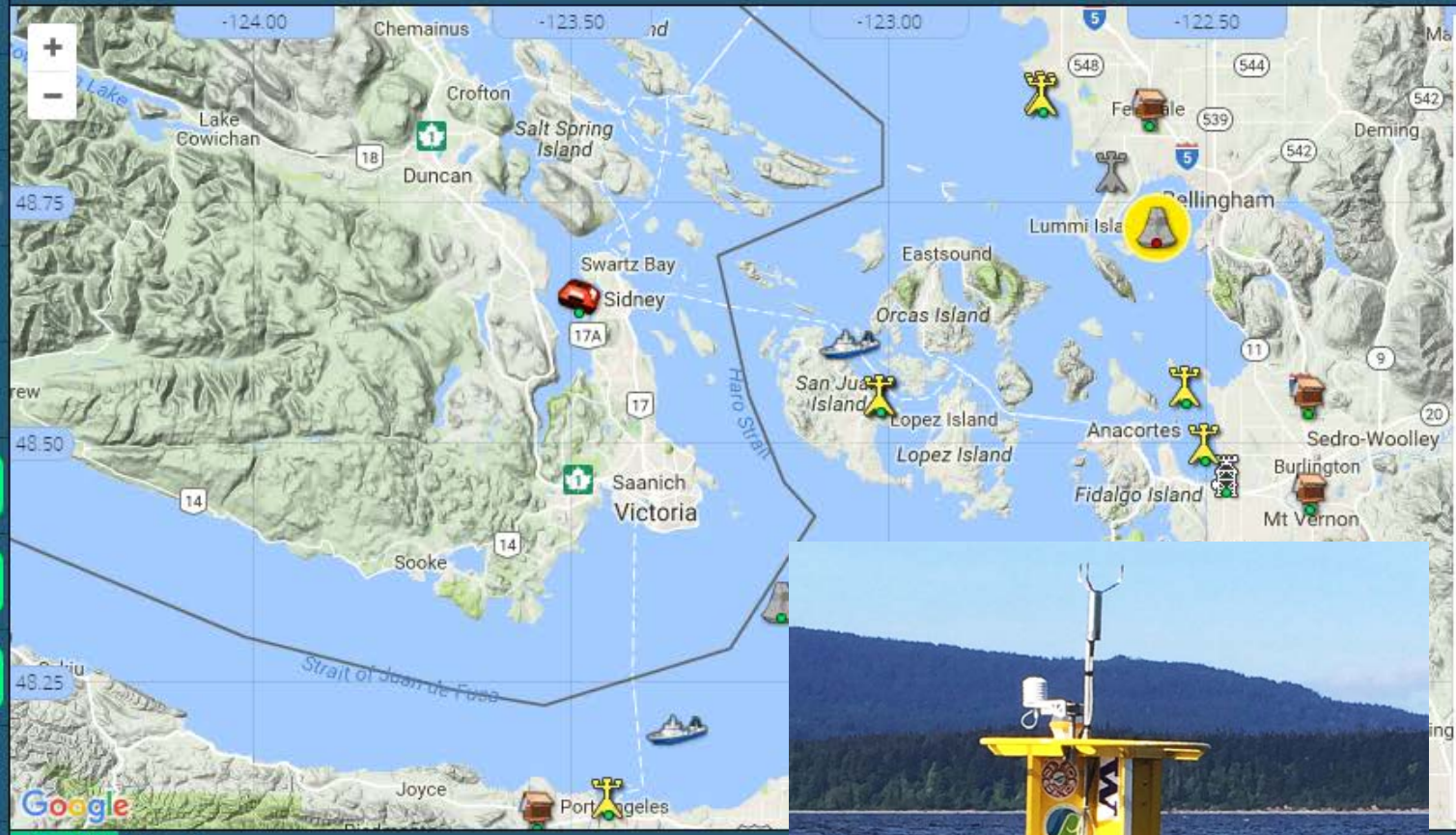
Regions
Filters
Routes
Current Conditions
Fixed Platforms
Mobile Platforms
Remote Sensing
Models
Retired Platforms
Legend

Lat: Lon:

Terrain



Se`lhaem Bellingham Bay buoy

Observations Forecasts Details History

Data Updated: 16 Oct 2017 13:10 PDT **Provider:** NWIC

ATMOSPHERIC

Air Temperature (7 ft)	53.1	°F
Baro. Pressure (7 ft)	30.1	inHg
Dew. Temp. (7 ft)	48.9	°F
Relative Humidity (7 ft)	85.5	%
Wind Direction (10 ft)	71.1	deg (from)
Wind Gust (10 ft)	11.9	knots
Wind Speed (10 ft)	4.9	knots

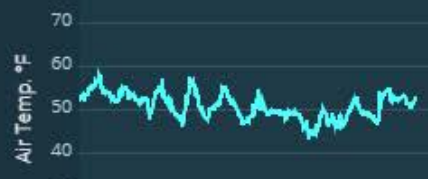
HYDROGRAPHIC

Chlorophyll (-2 ft)	2.1	µg/L
Colored DOM (-2 ft)	6	ppb

Link

Air Temp.

Dec 2017



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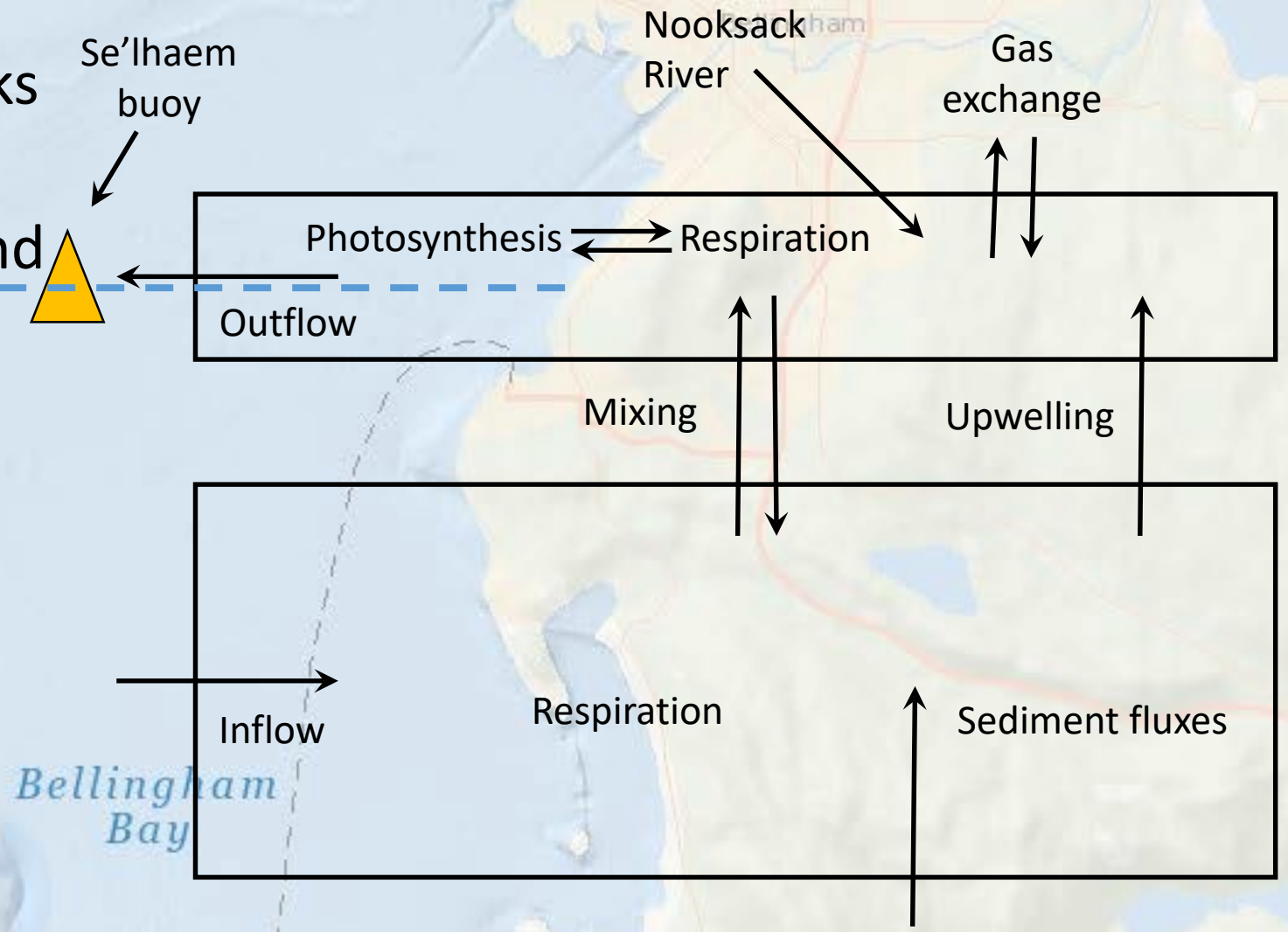
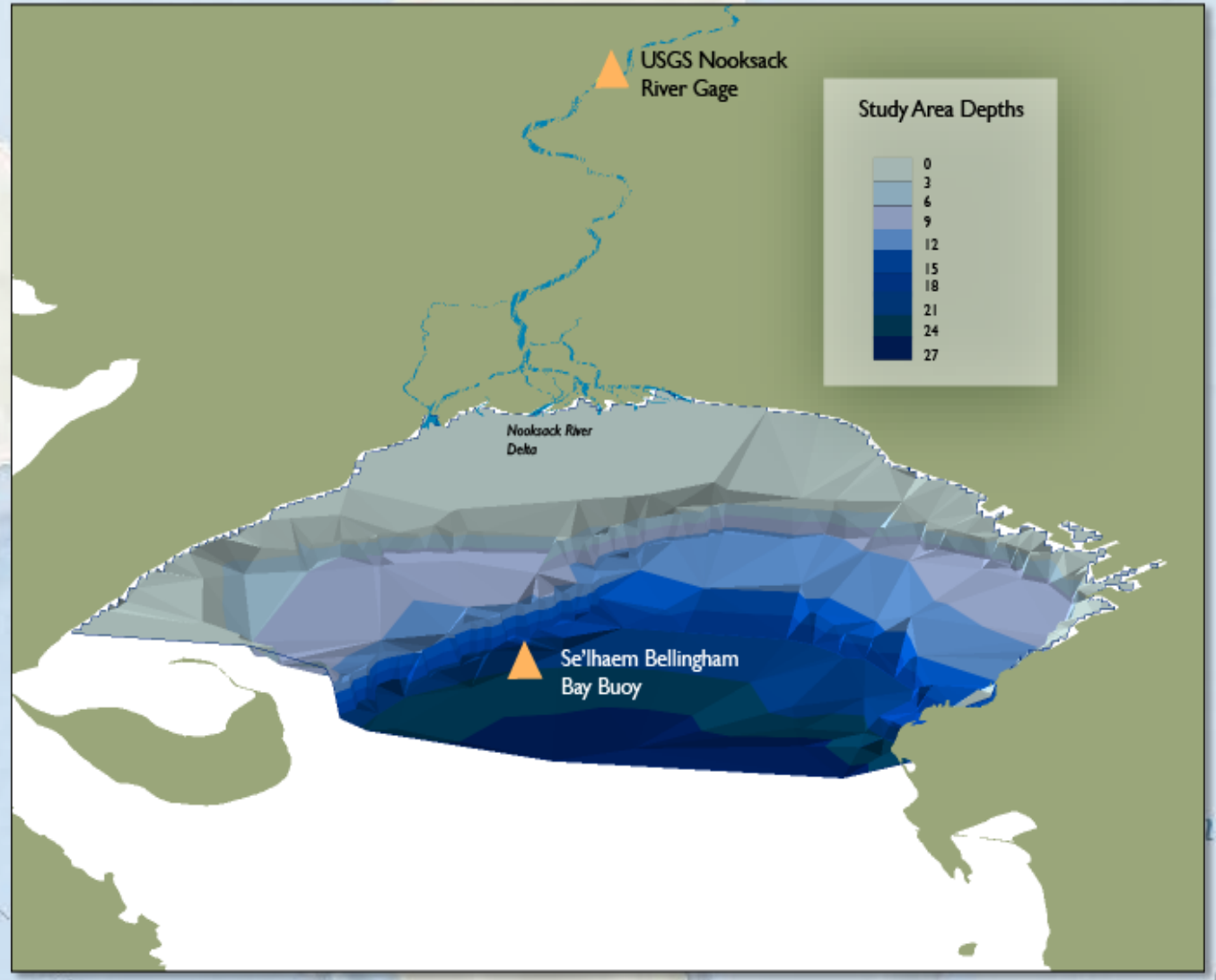
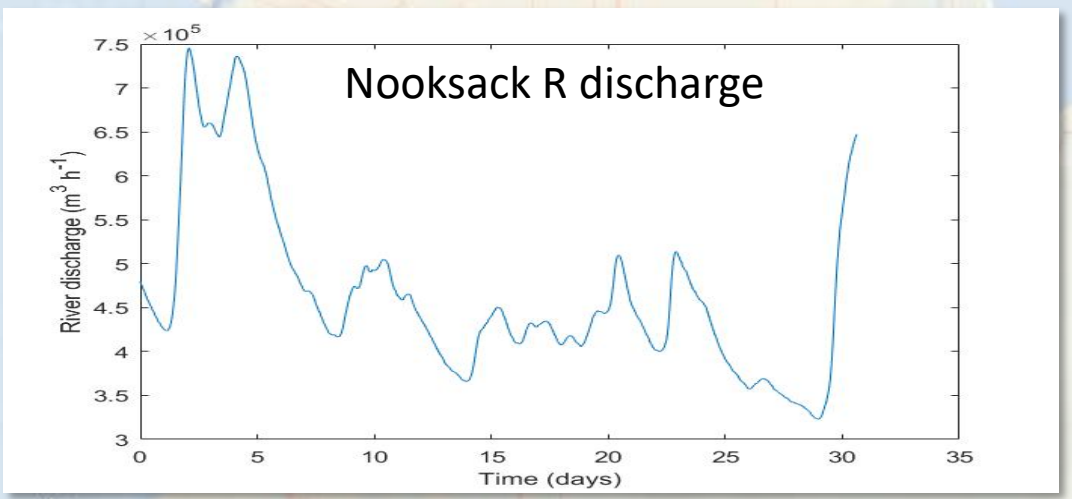
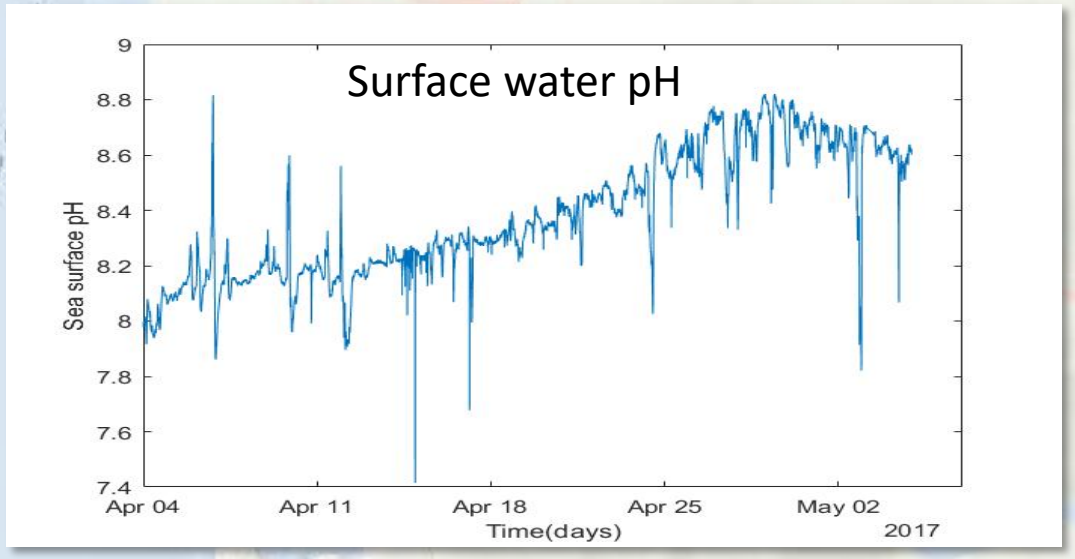


Box model geometry, measurements



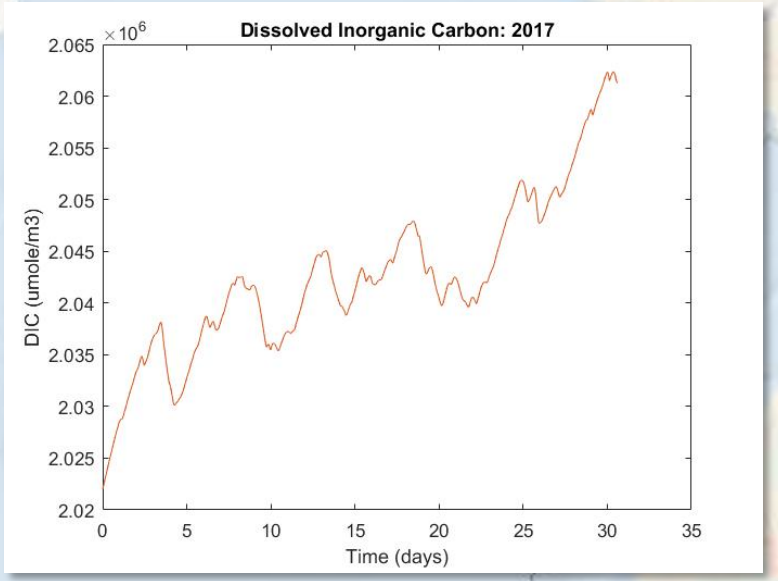


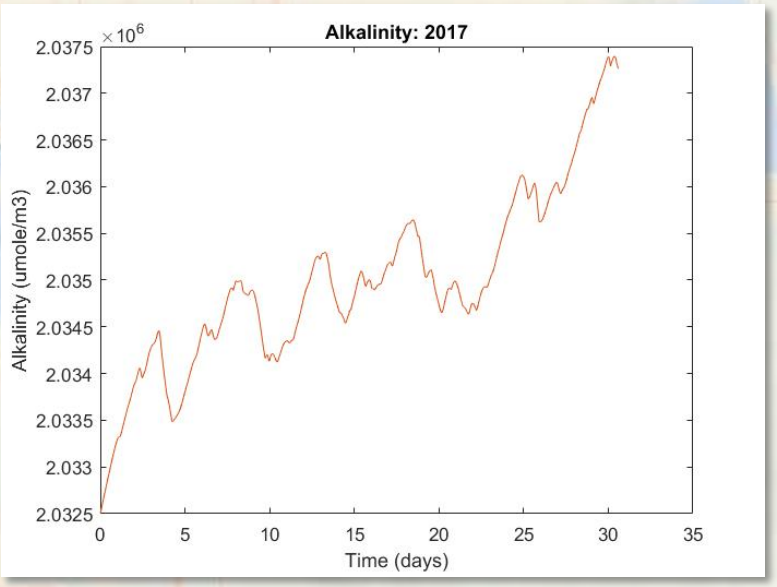


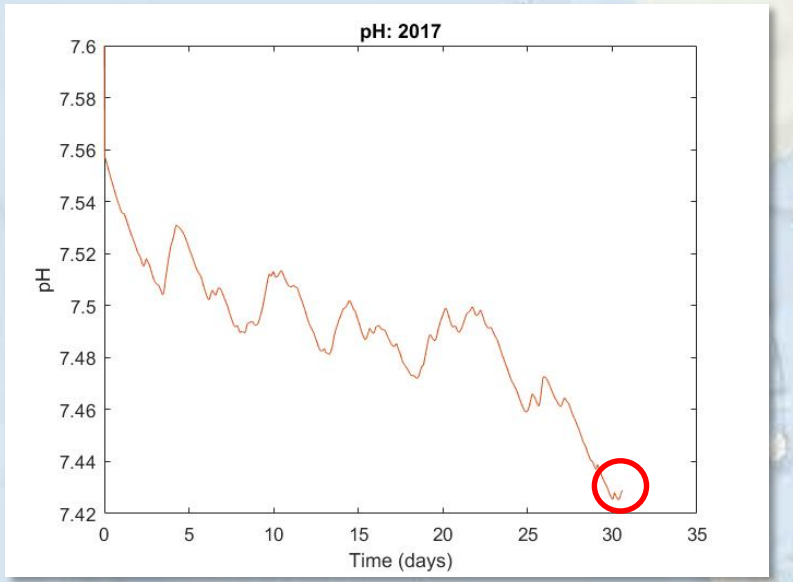
Bottom water changes in DIC, pH, Alkalinity and Ω_{arg}

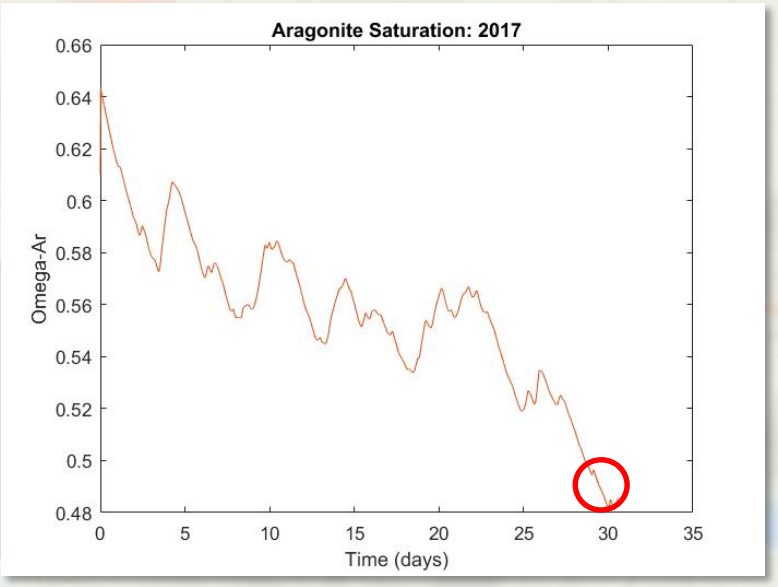
DIC and Alkalinity **increasing** Apr 4-May-4

pH and aragonite saturation **decreasing** Apr 4-May-4



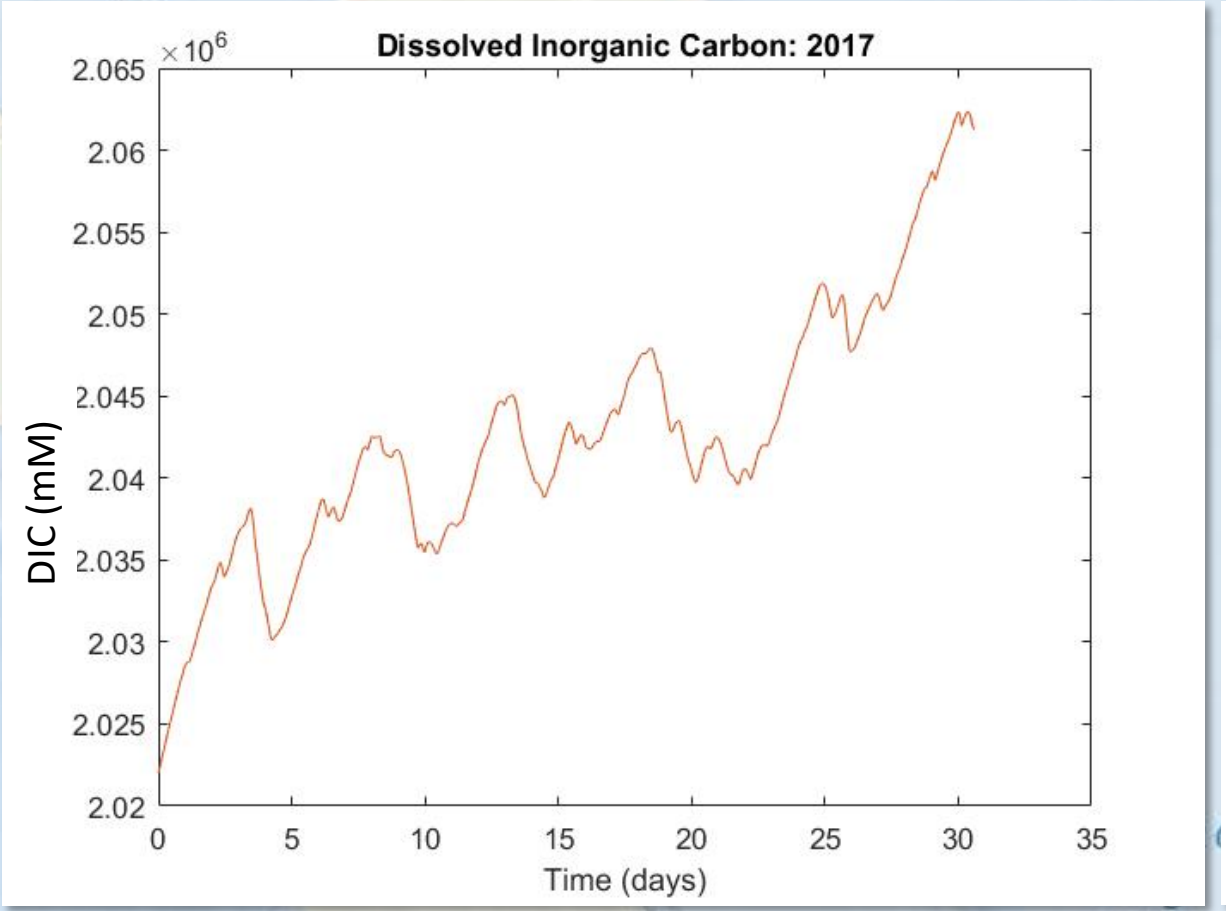


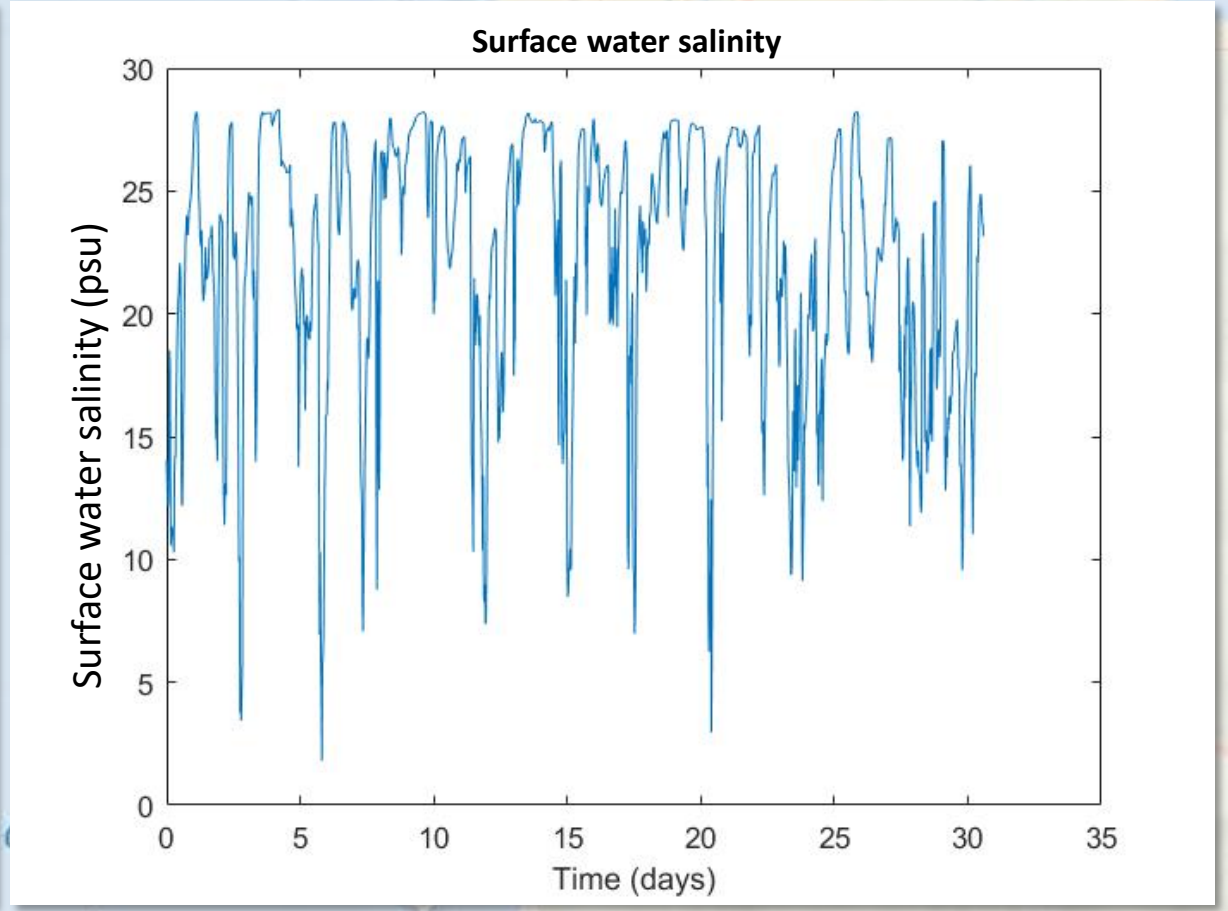




Modeled changes in DIC, pH, Alkalinity and Ω_{arg}

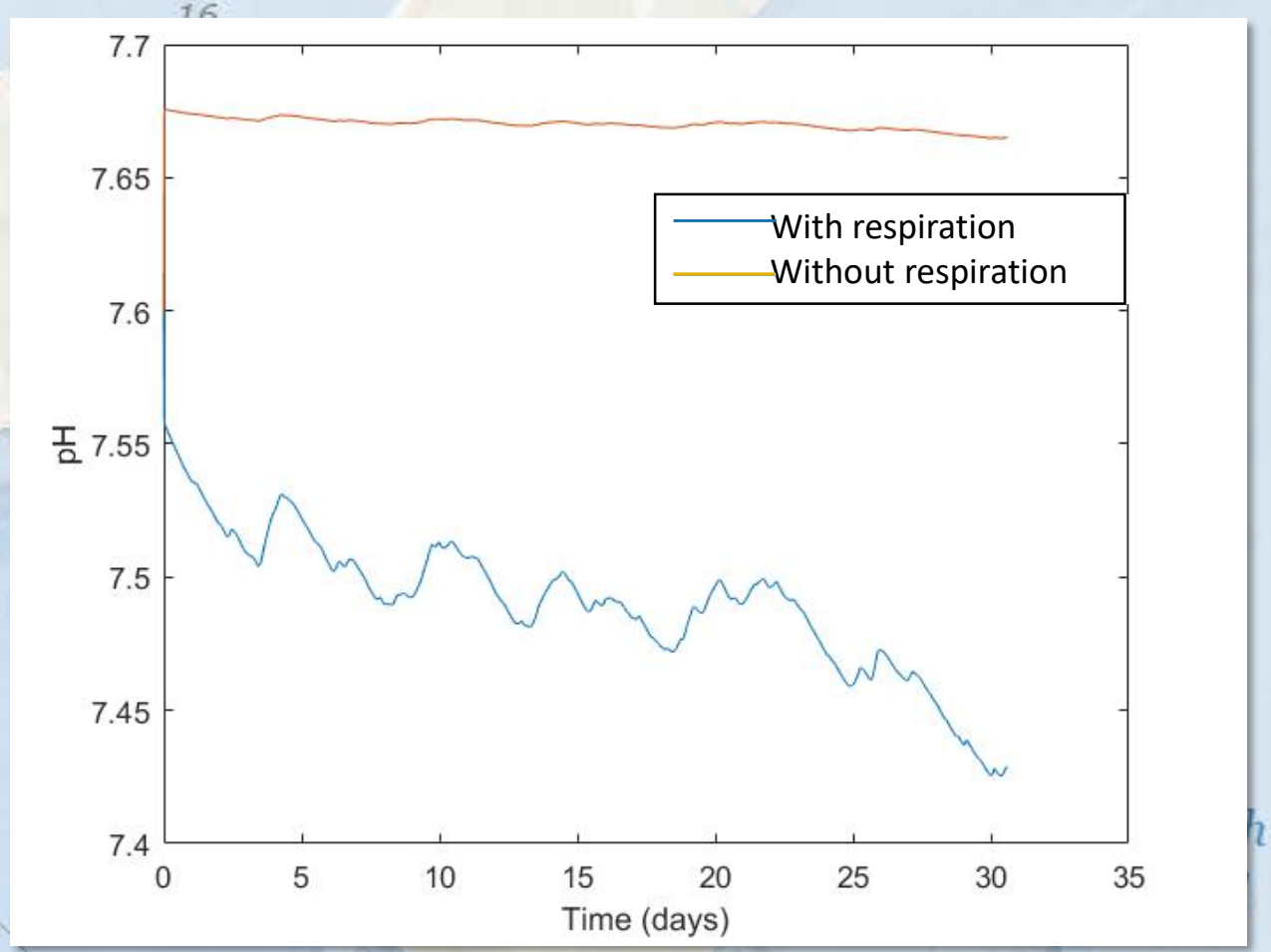
Slower estuarine circulation leads to increased DIC and decreased pH

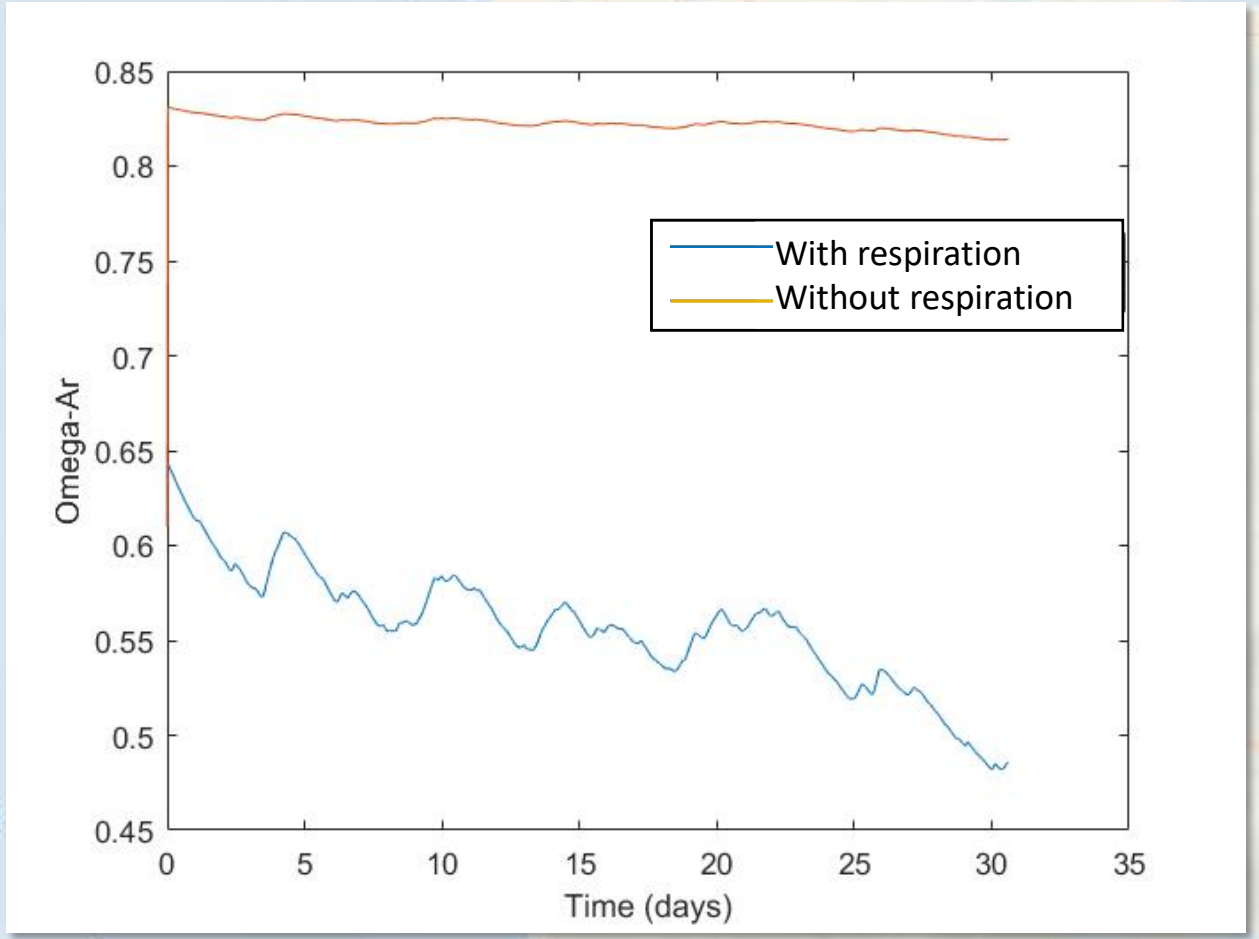




Modeled changes in DIC, pH, Alkalinity and Ω_{arg}

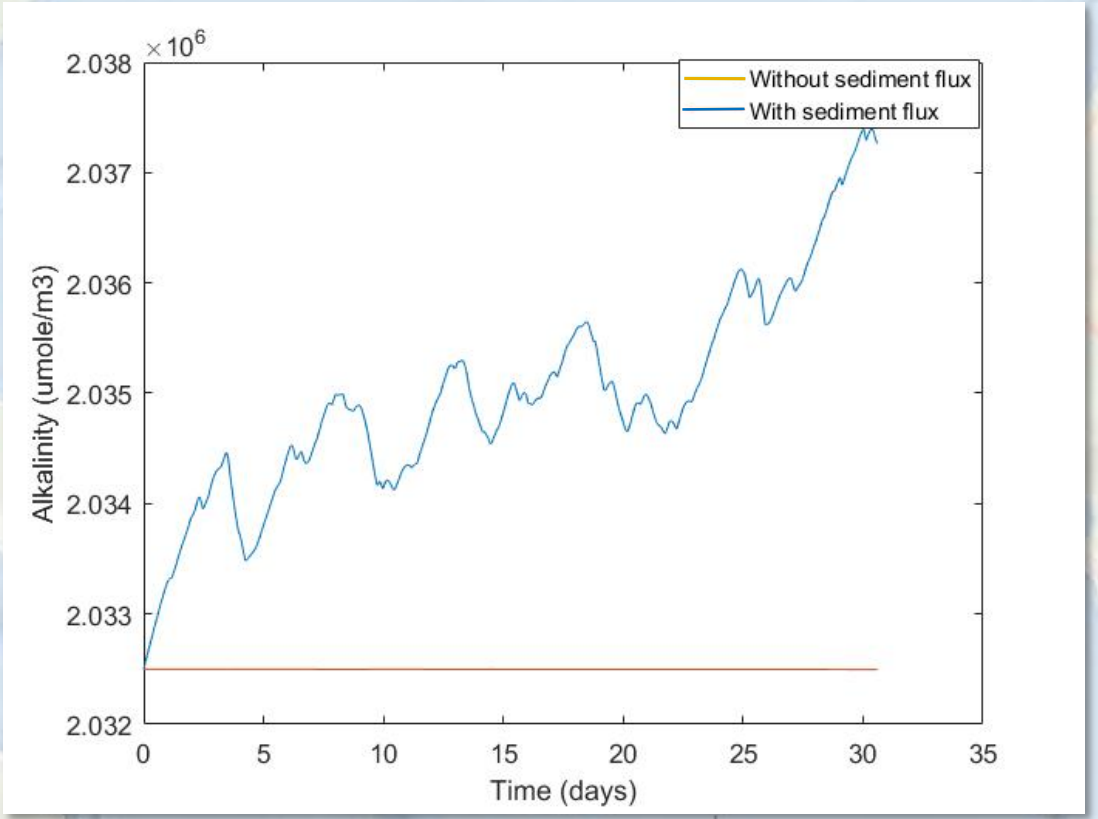
Water column respiration drives the decline in pH and aragonite saturation





Modeled changes in DIC, pH, Alkalinity and Ω_{arg}

Sedimentary alkalinity flux drives the change in bottom water alkalinity



Sources of acidic water in Bellingham Bay

- Bottom water pH and Ω_{arg} are low compared to elsewhere in Puget Sound
- Water column and sedimentary respiration drive declining pH
  - Water column respiration increases DIC but not alkalinity
  - Sedimentary processes supply BOTH DIC and alkalinity
- Bottom water acidity likely varies seasonally
- The rate of mean circulation in the bay (and thus bottom water residence time) also contributes to low pH.
- Reduced Nooksack R flow in summer (predicted by regional climate models) along with increasing atmospheric CO_2 will lead to future declines in bottom water pH and Ω_{arg}

Thanks to

- ESCI 491 – *Oceanography of the Salish Sea*

  Zach Barker, Nick Bartish, Nilza Chodon, Kastin Ellis, Kristen Fagerstrom, Kaya Fletcher, Shay Hengen, Saraanne Inglin, Alice Lazzar-Atwood, Amanda MacFadden, Stephan, Neu-Yagle, Cecily Ofstad, Gina O'Kelley, Jackson Osborn, Mark Quick, Lauchlan Ray, Talulah Corrina, Ben Smith, Jayme Street, Nick Sturman, Nick Tedford, Gabby Whitehall
- Brooke Love and Kelly Bright (WWU)
- UW Applied Physics Laboratory – Thanks for the buoy!