

Boothbay Coastal Water Monitoring Program

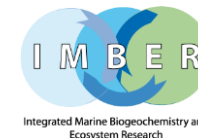
Background

- BRLT initiated water monitoring program in April 2015
 - Capitalized on Kennebec Estuary Land Trust (KELT) program headed by Ruth Indrick
- Early planning meeting with Bigelow Labs (Nick Ullo, Ed Green, and Ruth Indrick)
- KELT donated use of their monitoring equipment
- BRLT was included as part of the approved KELT QAP
- BRLT in 2016 purchased their own equipment and executed independently
- Participant in the Ocean Acidification Workshop at Bowdoin /Harpwell 2018
- Boothbay data sent to UMaine for NOAA study

Things you should know about **ocean acidification**

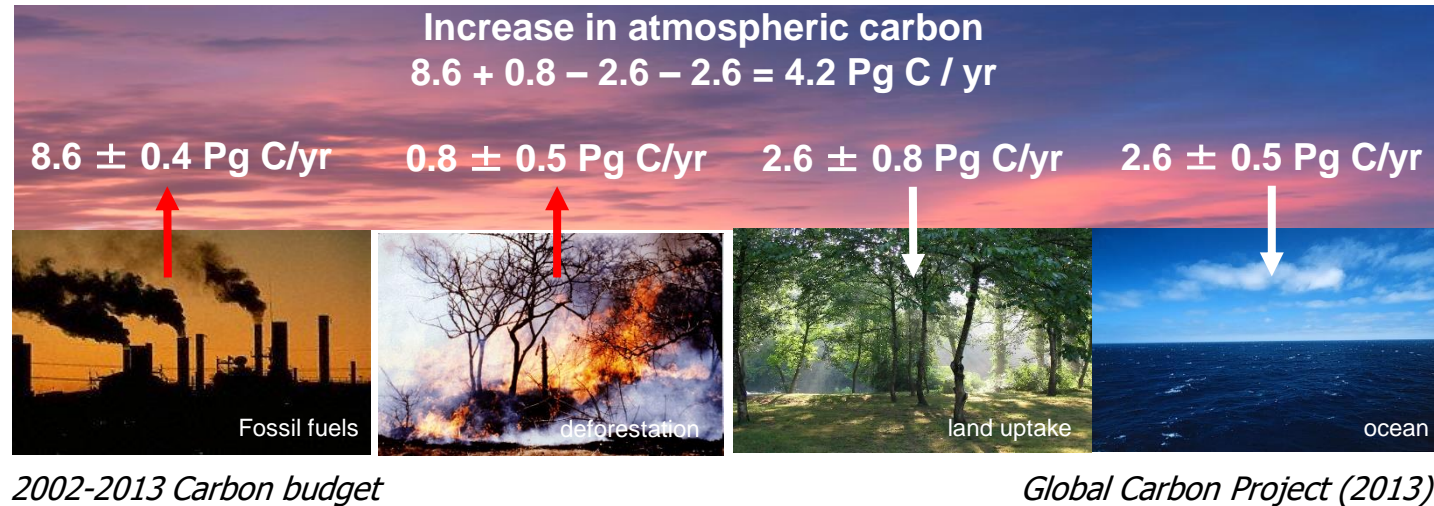
17 February 2014

SOLAS-IMBER Ocean Acidification Working Group
Ocean Acidification International Coordination Centre (OA-ICC)



Ocean Acidification
International
Coordination Centre
OA-ICC

Ocean absorbs one-fourth of man-made CO₂ emissions

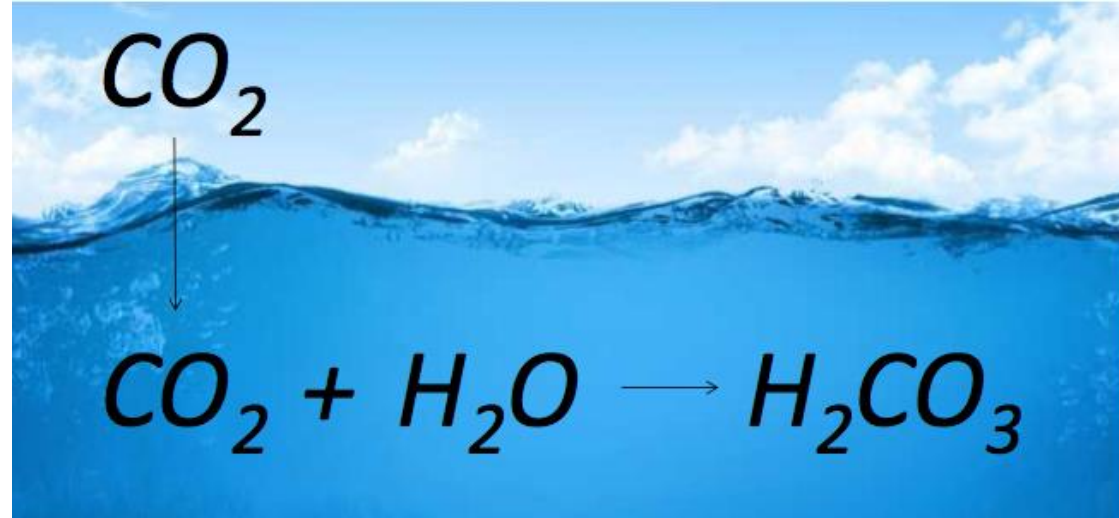


Half of emitted CO₂ remains in atmosphere (causing global warming)

Half absorbed by ocean & land (trees, plants, and soils)

Ocean absorbs 24 million tons of CO₂ every day (4 kg per person, daily)

More atmospheric CO₂ means increased ocean acidity



Schematic: Sam Dupont, University of Gothenburg

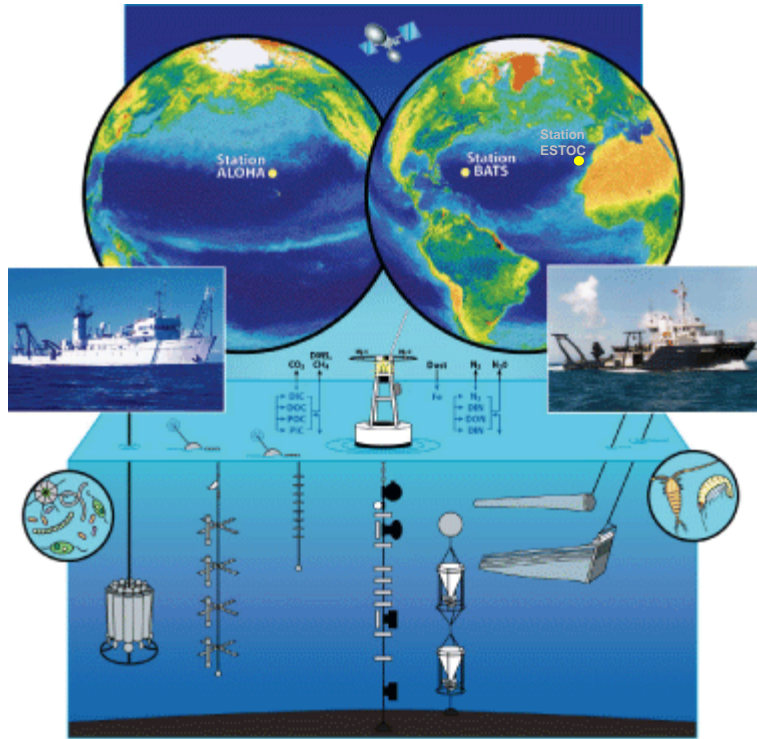
CO₂ is an acid gas (it produces acid when combined with water)

Each of us adds 4 kg CO₂ per day to the ocean (increasing acidity, reducing pH)

Ocean acidity up by 30% since start of industrial age

Most of that only in last 40 years

Change in pH from ocean acidification already measurable



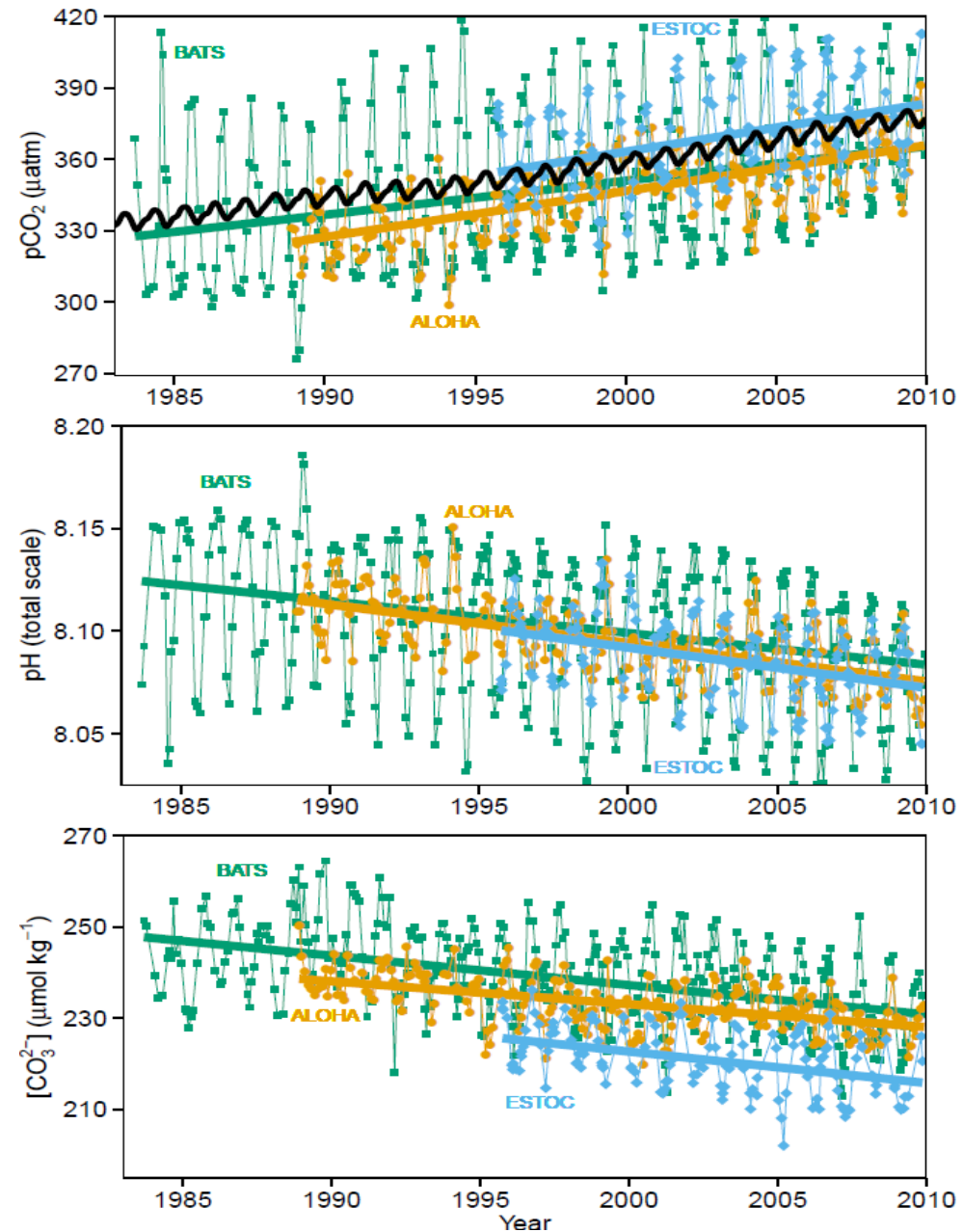
Data:

Bates (2007)

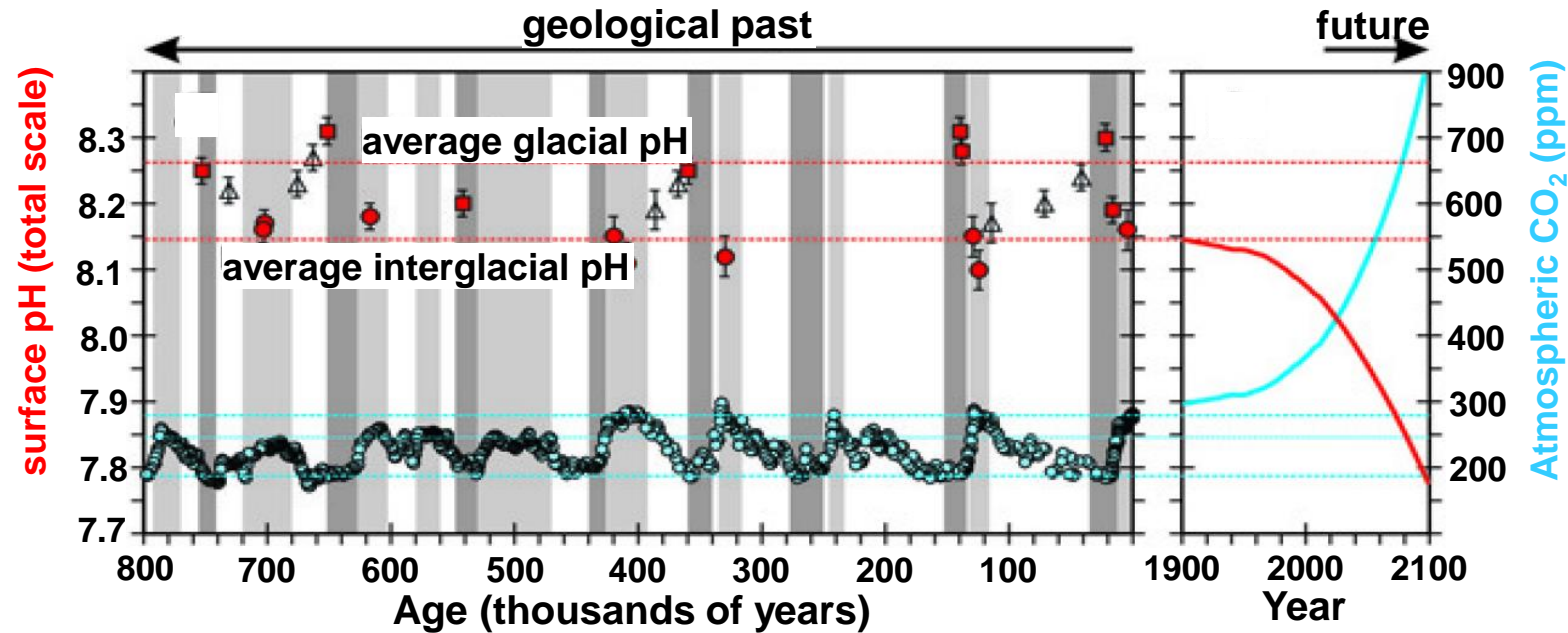
Dore et al. (2009)

Santana-Casiano et al. (2007)

Gonzàles-Dàvila et al. (2010)



Today's rate of ocean acidification may be unprecedented



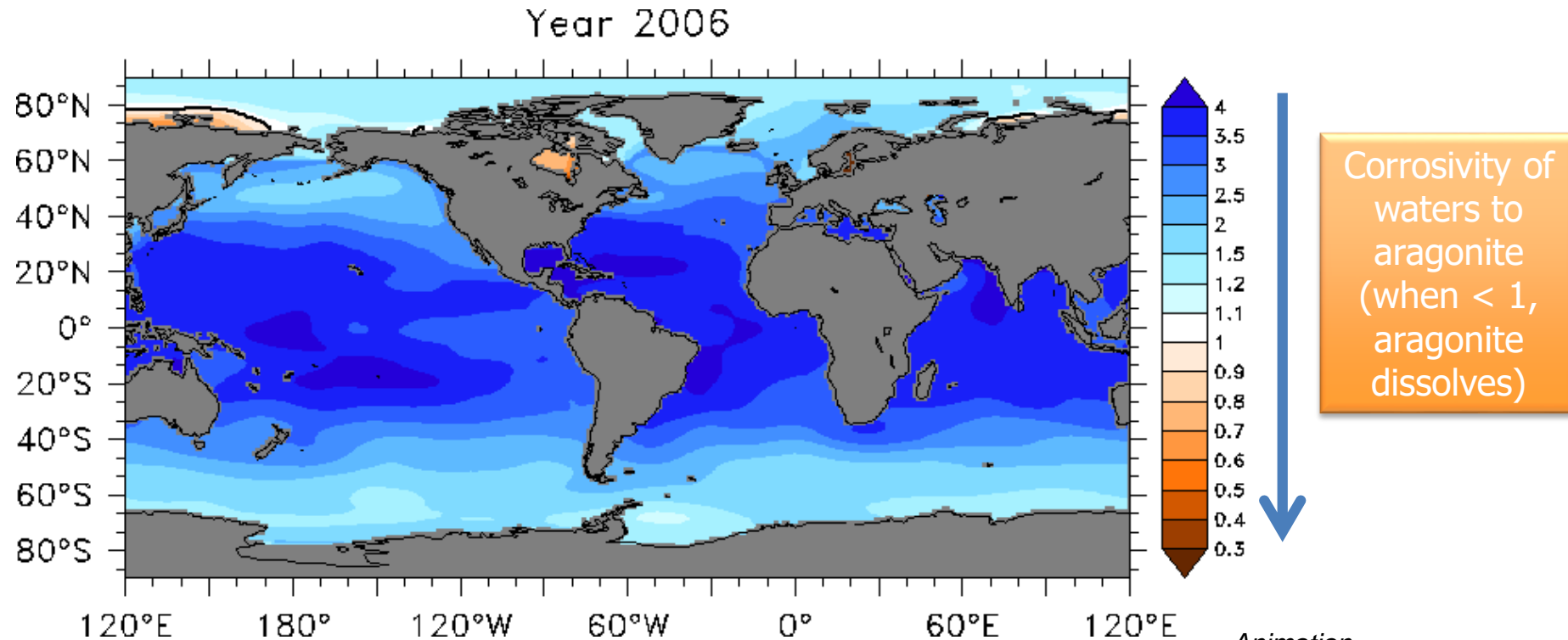
Barker and Ridgwell (2012)

Current change:

- overwhelms natural variations (last 800 000 years)
- may be 10 times faster than natural event (55 million years ago)
- rate may be unprecedented (over last 300 million of years)
- 30% increase in acidity (H⁺) during industrial era
- 100% increase (or more) projected by 2100

Polar oceans become corrosive to shell material within decades

Models project that cold waters soon become corrosive to aragonite, a (CaCO_3) mineral in some marine shells & skeletons



Animation
Copyright: James C. Orr

Latest model projections (IPCC AR5 WG1, 2013)

Confirms original warnings: Orr et al. (2005), Caldeira & Wickett (2005), Steinacher et al. (2009)

see also Bopp et al. (2013)

Ocean acidification will also affect humans

- Fish is primary source of animal protein for 1 billion people, mostly in developing countries (FAO)
- Coral reefs provide
 - home for millions of species
 - storm protection for coastlines
 - income from tourism
 - biodiversity legacy for future
- Ocean acidification already affecting oyster industry (U.S. west coast)
- Ocean acidification may generally affect aquaculture, fisheries, and human livelihoods



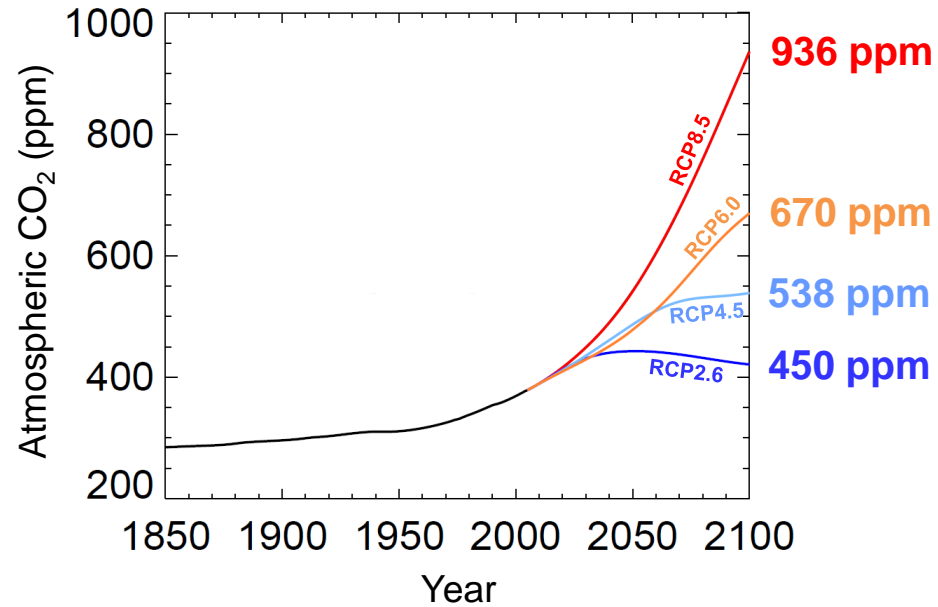
Photo: Rodolfo Quevenco, IAEA



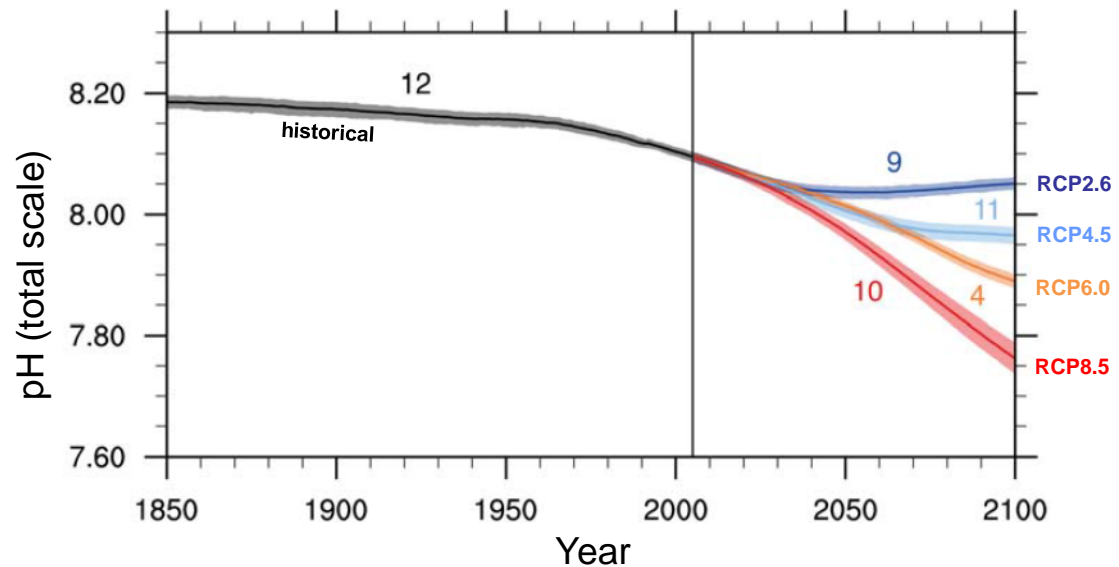
Photo: Jean-Louis Teyssié, IAEA

The intensity of ocean acidification depends on us

Future atmospheric CO₂
(latest IPCC scenarios)



Intensity of ocean acidification (change in pH)
varies by a factor of 3

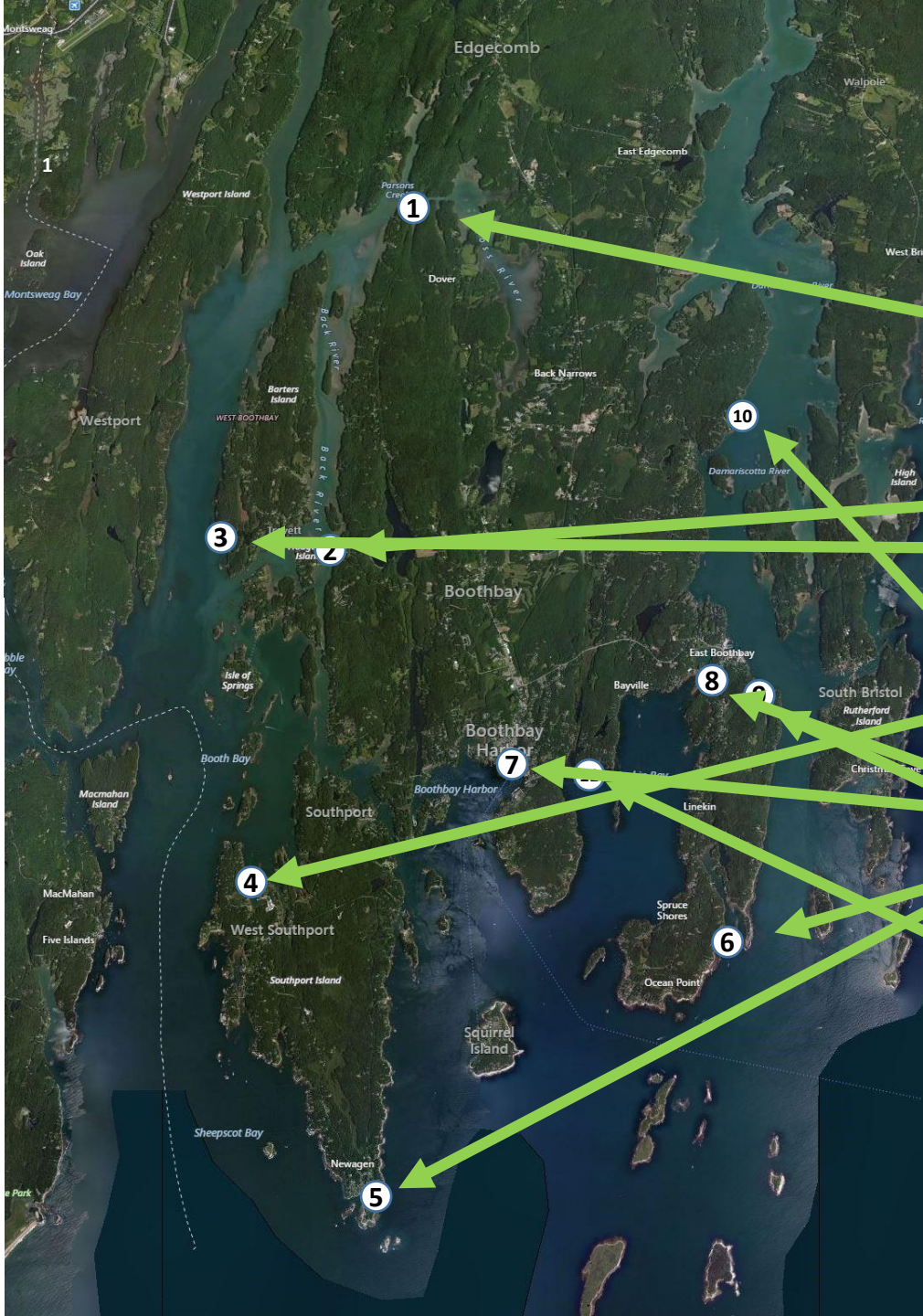


Data Review

Measurements

- What we measure
 - pH, salinity, water temp, dissolved oxygen
 - Climatological conditions, turbidity, biota, boats, odd color, debris, sea state
- How we measure
 - Dissolved Oxygen: Extech Model DO600
 - Salinity: Extech EC170 Digital Salinity Meter
 - pH: Extech Model pH100
 - Secchi Disk, 8in., black and white
- When we measure
 - High tide, 9am
- Where we measure
 - Next slide

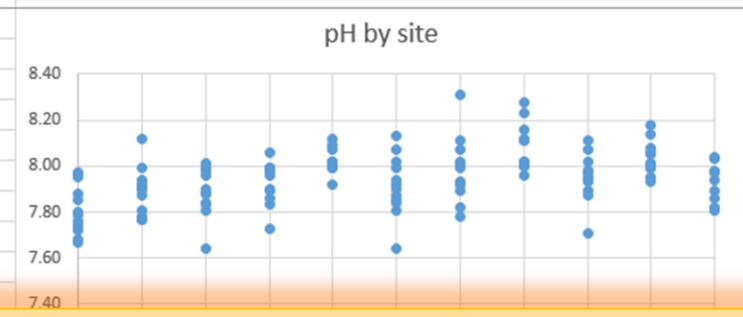
Where we measure



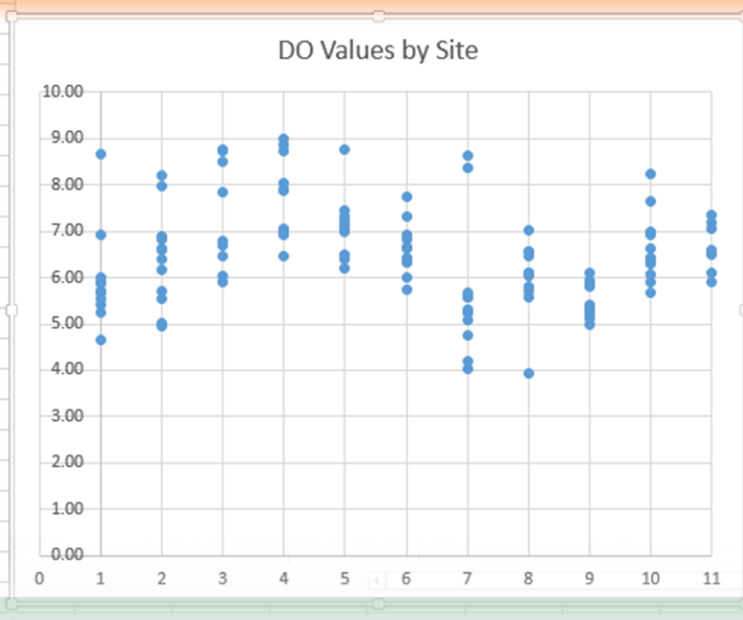
Site ID	Site Description
B 1	Oven's Mouth
B 2	Knickercane Landing
B 3	Robert's Wharf
B 4	Dogfish Head
B 5	Newagen Town Landing
B 6	Little River
B 7	Boothbay Harbor Footbridge
B 8	Linekin Bay
B 9	Bigelow Dock
B 10	Damariscotta River
B 11	Linekin Bay Resort

Microsoft Excel interface showing the ribbon (HOME, INSERT, PAGE LAYOUT, FORMULAS, DATA, REVIEW, VIEW, DEVELOPER) and various toolbars for font, alignment, and styles. The 'Styles' section includes 'Normal 2', 'Normal', 'Bad', 'Good', 'Neutral', 'Calculation', 'Check Cell', 'Explanatory...', 'Input', and 'Linked Cell'.

Site #	Location	Date	Time	Water Temp	Sal ppt	pH	Avg of 2 closest DO
5		5/15/2018		9.80	27.30	7.88	8.68
6	Little River	8/8/2018	9:00:00 AM	9.50	27.40	7.77	8.20
7	footbridge	8/8/2018	9:00:00 AM	9.00	24.30	7.98	7.86
8	Murray Hill Boat dock	8/8/2018	9:00:00 AM	9.70	23.20	7.83	8.72
9	Bigelow Lab Damariscotta River	8/8/2018	9:00:00 AM	10.60	29.60	8.12	6.99
10	Linekin Bag	8/8/2018	9:00:00 AM	11.20	28.10	7.81	7.74
11	Ovens Mouth	8/22/2018	9:00:00	11.00	30.10	8.31	8.38
1	Knickerbocker	8/22/2018	9:00:00	12.80	30.90	8.11	6.03
2	Roberts' wharf	8/22/2018	9:00:00	9.60	30.30	8.02	5.82
3	Ebenecock Harbor	8/22/2018	9:00:00 AM	9.30	28.70	8.14	8.24
4	Newagen	8/22/2018	8:35:00 AM	11.00	23.30	7.30	8.07
5	Little River	8/22/2018	9:00:00 AM	11.60	30.50	8.02	8.75
6	footbridge	8/22/2018	9:00:00 AM	12.80	29.50	8.13	7.31
7	Murray Hill Boat dock	8/22/2018	9:00:00 AM	13.90	31.50	8.07	8.65
8	Bigelow Lab Damariscotta River	8/22/2018	9:00:00 AM	14.70	30.60	8.02	6.58
9	Linekin Bag	8/22/2018	9:00:00 AM	12.20	30.50	8.11	5.23
10	Ovens Mouth	8/22/2018	9:00:00 AM	12.10	30.10	8.06	7.66
11	Knickerbocker	8/22/2018	9:00:00 AM	13.20	29.50	7.95	5.87
1	Roberts' wharf	8/22/2018	9:00:00 AM	12.70	29.60	7.91	6.82
2	Ebenecock Harbor	8/22/2018	9:00:00 AM	12.10	27.10	7.01	6.70
3	Newagen	9/5/2018	8:00:00 AM	12.10	26.00	7.73	7.92
4	Little River	9/5/2018	8:00:00 AM	11.10	30.30	7.92	7.47
5	footbridge	9/5/2018	8:00:00 AM	14.90	31.20	8.07	6.93
6	Murray Hill Boat dock	9/5/2018	8:00:00 AM	16.50	31.80	8.11	5.68
7	Bigelow Lab Damariscotta River	9/5/2018	8:00:00 AM	16.30	30.60	8.11	6.57
8	Linekin Bag	9/5/2018	8:00:00 AM	12.60	31.30	7.95	5.27
9	Ovens Mouth	9/5/2018	8:00:00 AM	12.80	30.20	8.18	6.99
10	Knickerbocker	9/5/2018	8:00:00 AM	15.30	30.60	8.04	7.05
11	Roberts' wharf	9/5/2018	8:00:00 AM	13.70	30.50	7.97	5.72
1	Ebenecock Harbor	9/5/2018	8:00:00 AM	14.10	30.40	7.99	6.62
2	Newagen	9/27/2018		13.60	26.70	7.99	8.49
3	Little River	9/27/2018		13.00	25.30	8.06	9.00



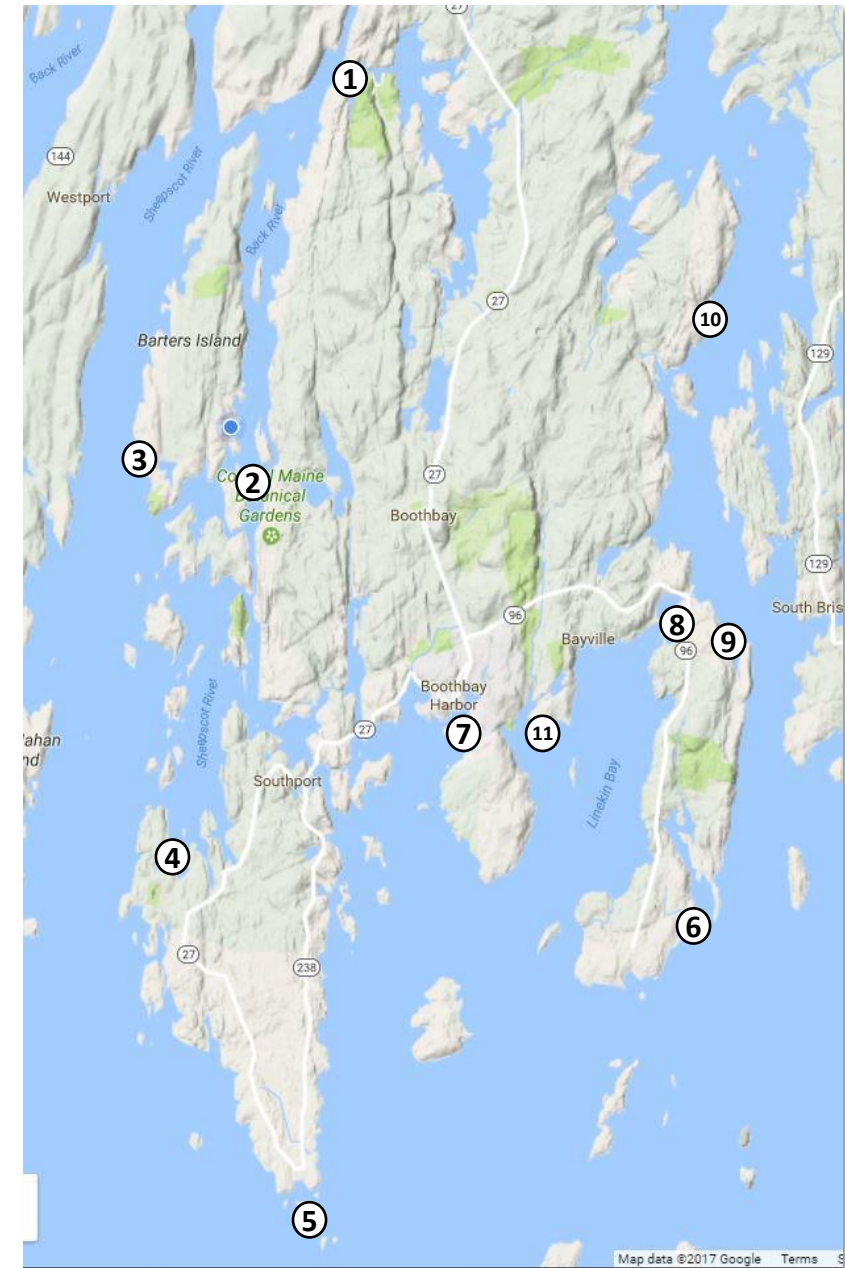
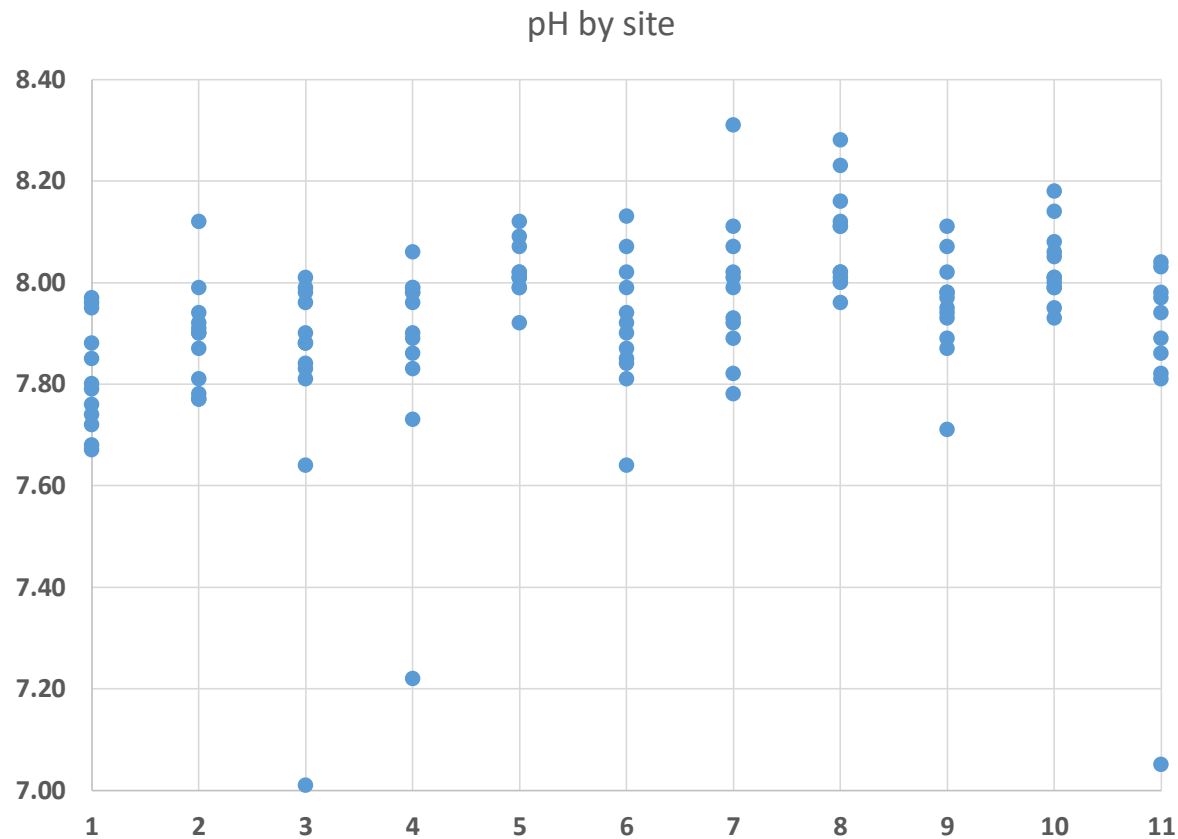
Site #	Location	lowest DO	middle DO	lowest DO	avg1	avg2	Avg of 2 closest DO
2	AA	6.35	6.31	0.04	6.33	6.31	6.33
3	AB	5.20	4.97	0.23	5.09	4.97	5.09
4	AC	6.13	6.05	0.08	6.09	6.05	6.09
5	AD	6.06	5.83	0.23	5.95	5.83	5.95
6	AE	6.36	6.35	0.01	6.36	6.35	6.36
7	AF	6.20	5.6	0.60	5.90	5.60	5.90
8	AG	6.94	5.9	0.04	5.92	5.90	5.92
9	AA	6.31	6.88	0.03	6.90	6.88	6.90
10	AB	6.63	6.27	0.36	6.45	6.27	6.45
11	AC	6.10	7.99	0.11	8.05	7.99	8.05
1	AD	6.00	#NUM!	#NUM!	####	####	####
2	AE	6.48	6.36	0.12	6.42	6.36	6.42
3	AF	5.48	5	0.48	5.24	5.00	5.24
4	AG	5.86	5.76	0.10	5.81	5.76	5.81
5	AA	5.49	5.34	0.15	5.42	5.34	5.42
6	AB	6.53	6.33	0.20	6.43	6.33	6.43
7	AC	7.35	6.52	6.5	0.83	6.94	0.02
8	AD	6.10	5.93	0.17	6.02	5.93	2.97
9	AE	6.18	6.13	0.05	6.16	6.13	3.07
10	AF	0.00	0	0.00	0.00	0.00	0.00
11	AG	6.99	6.96	0.03	6.98	6.96	3.48
1	AA	0.00	0	0.00	0.00	0.00	0.00
2	AB	5.90	5.55	0.35	5.73	5.55	2.78
3	AC	4.07	4.01	0.06	4.04	4.01	2.01
4	AD	7.07	6.98	0.09	7.03	6.98	3.49



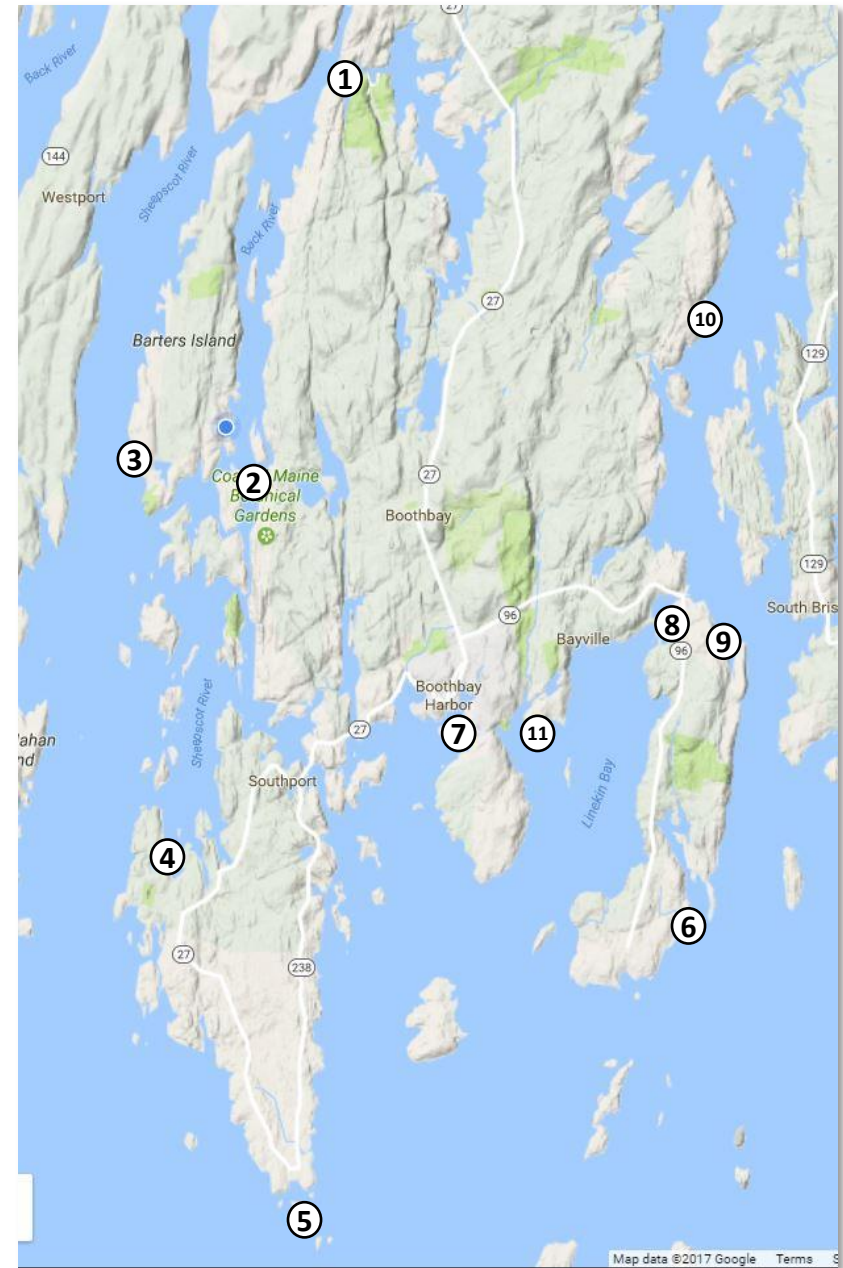
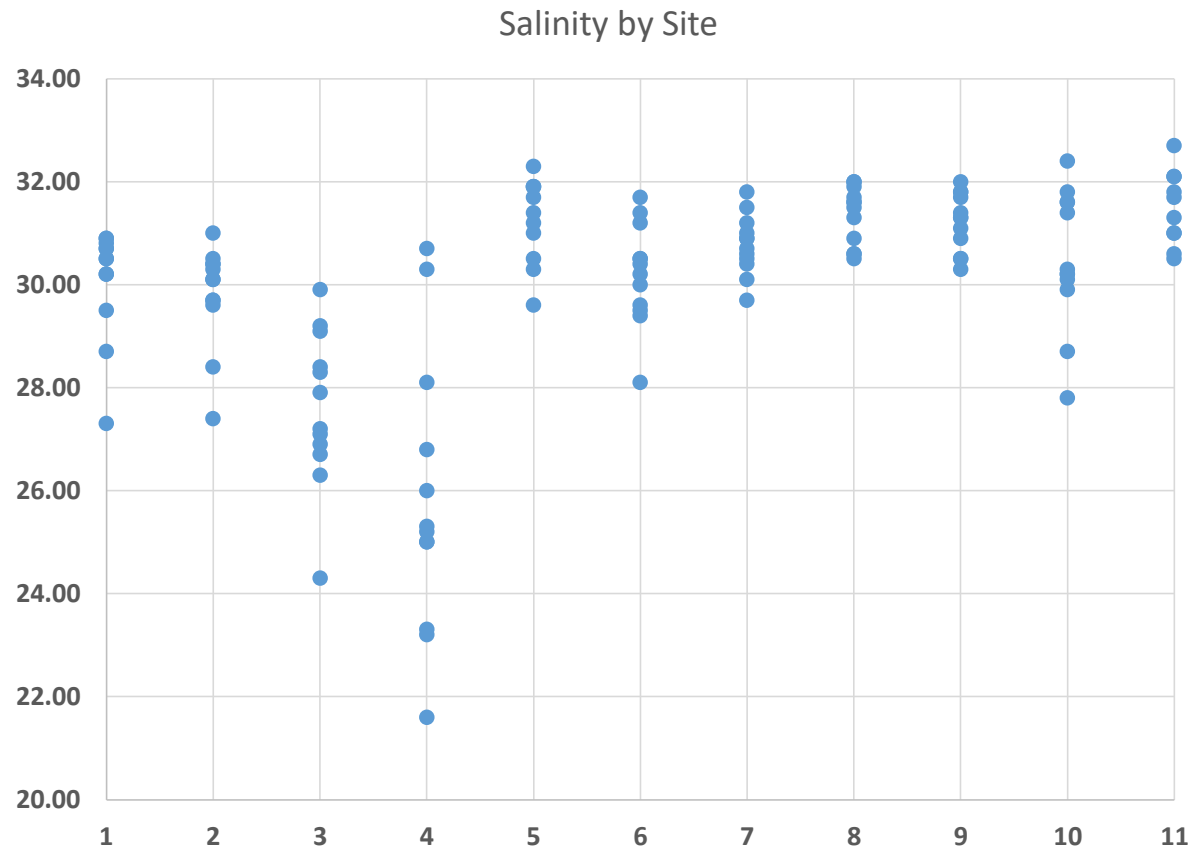
Data collected by volunteers are entered into Excel

Summary of Key Parameters

2018: pH by site

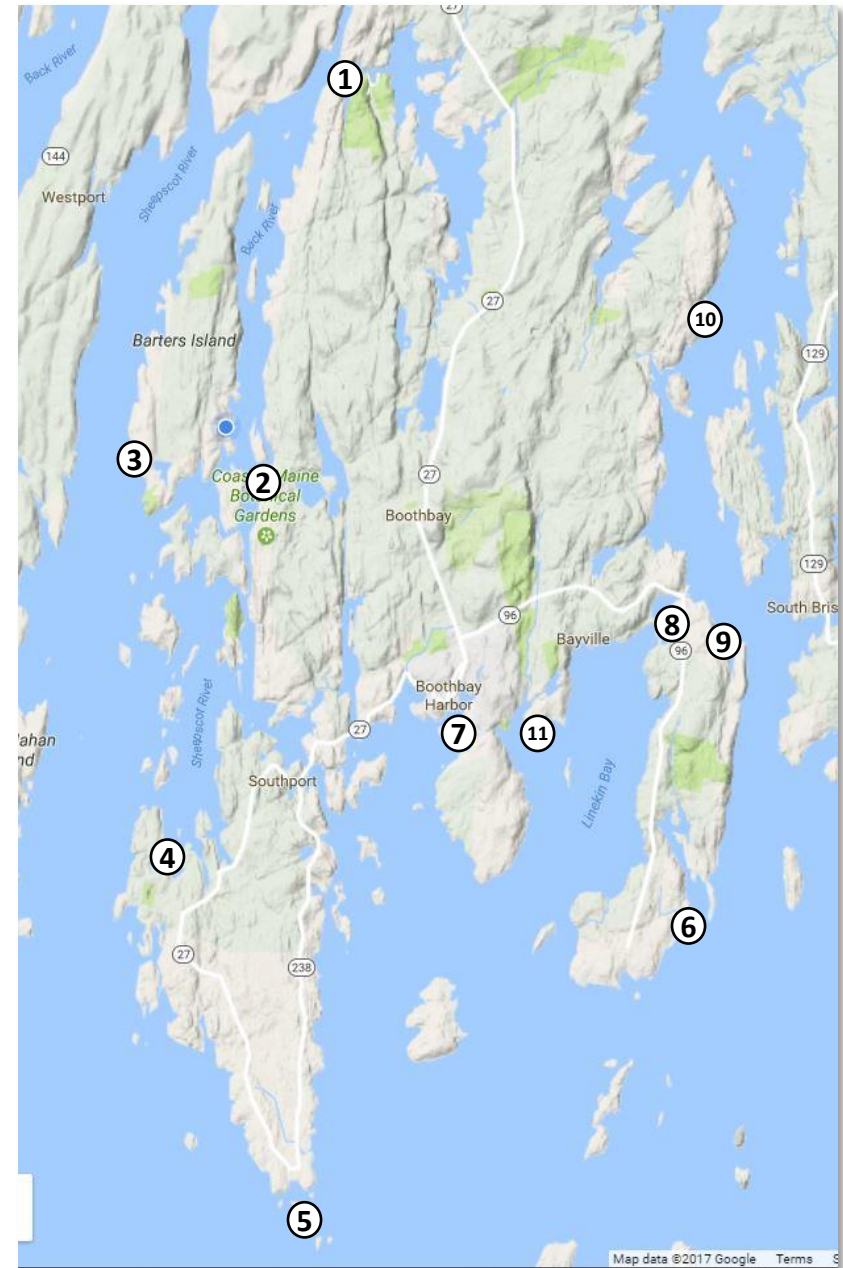
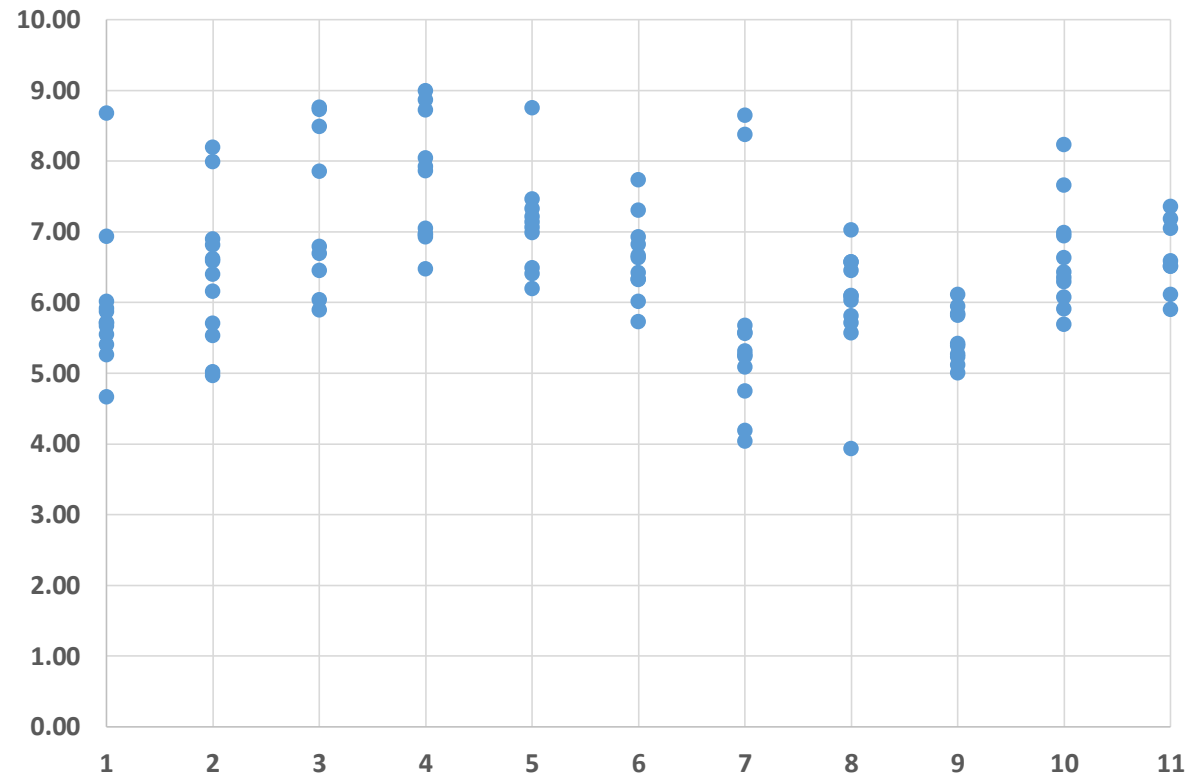


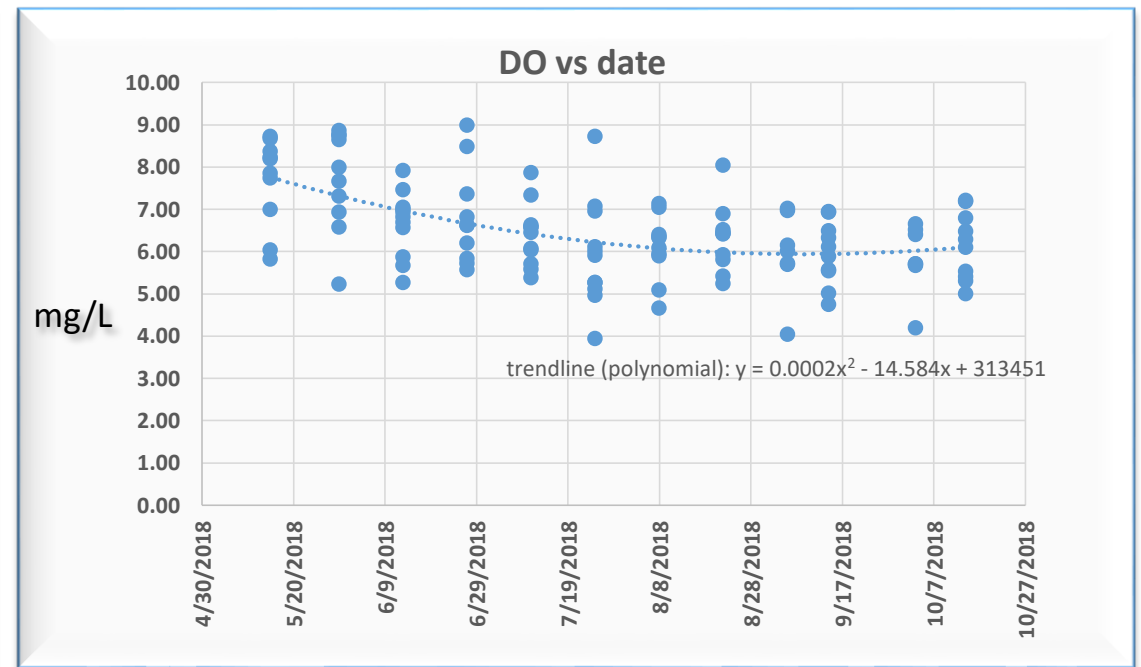
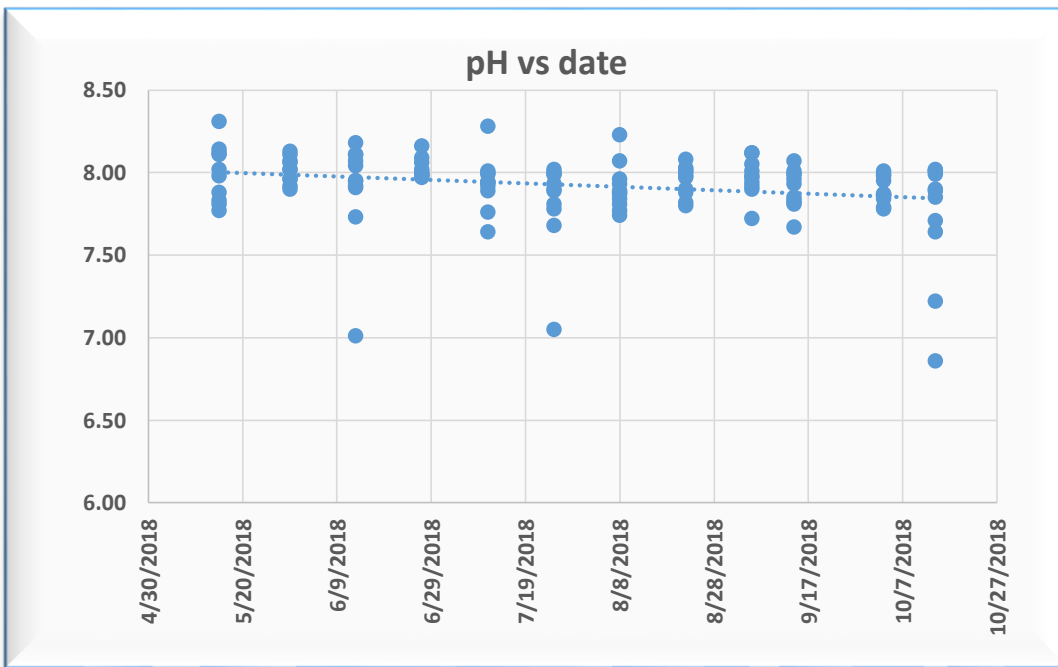
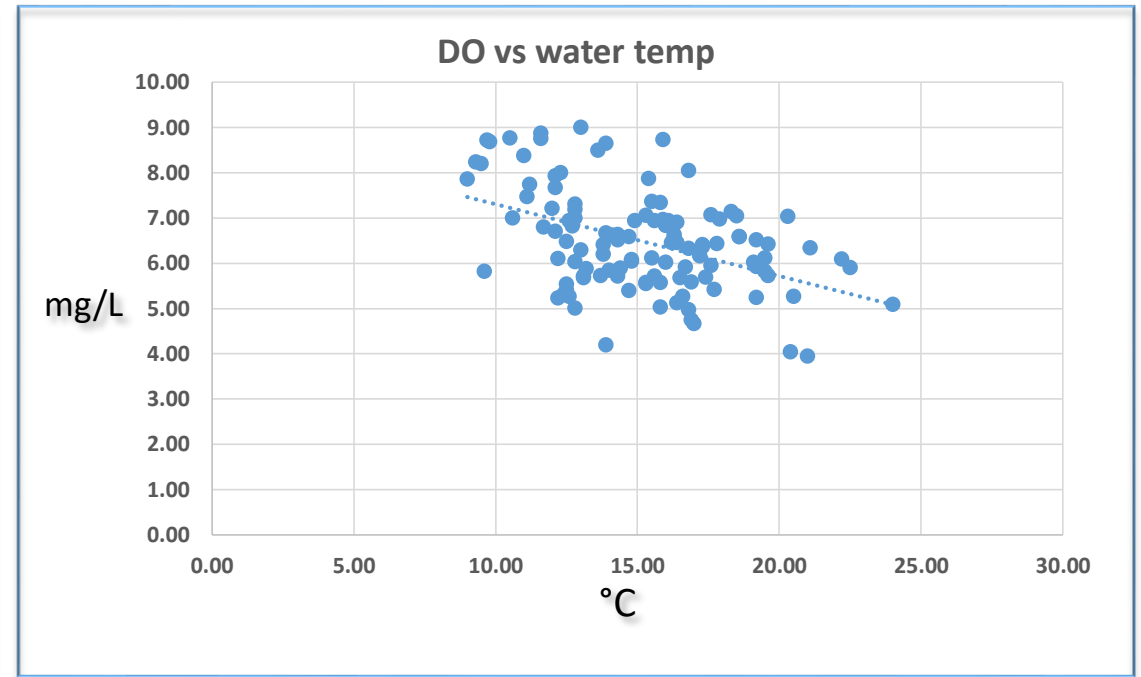
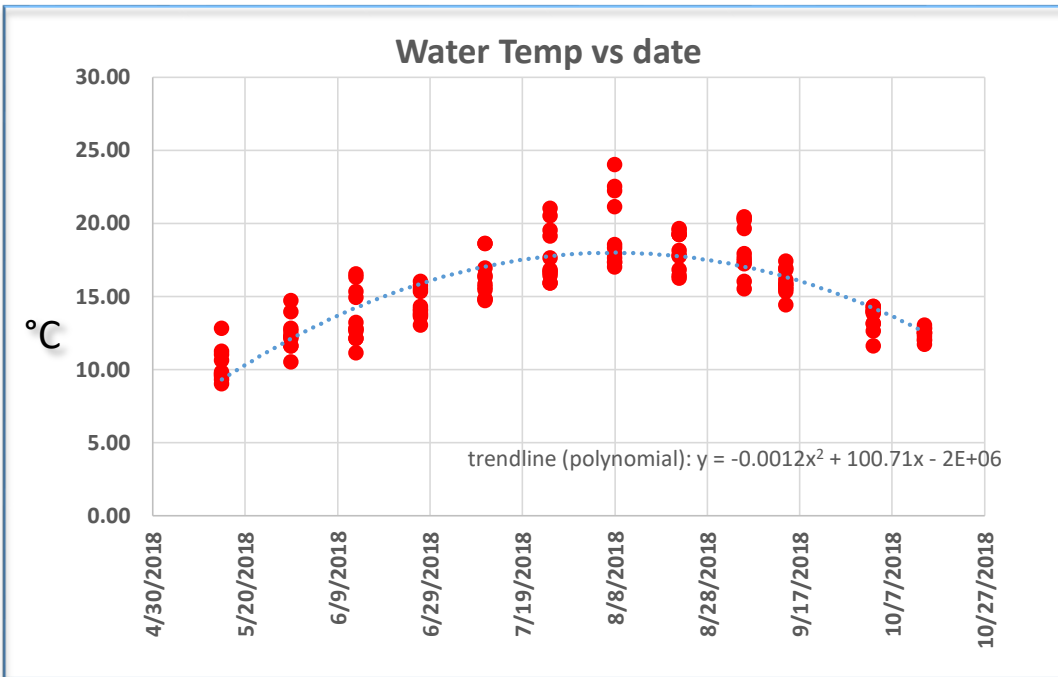
2018: salinity by site



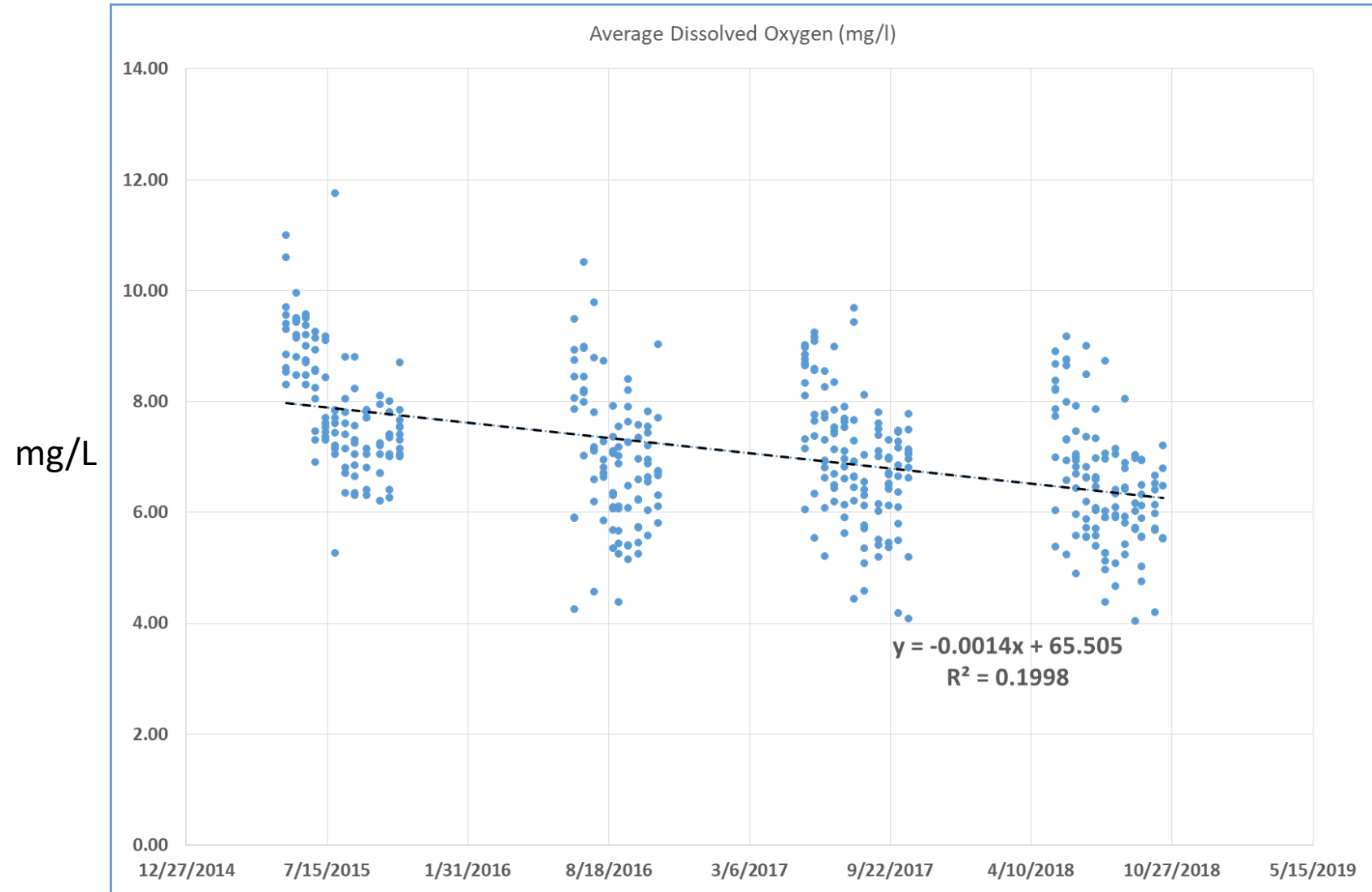
2018: DO by site

DO Values by Site

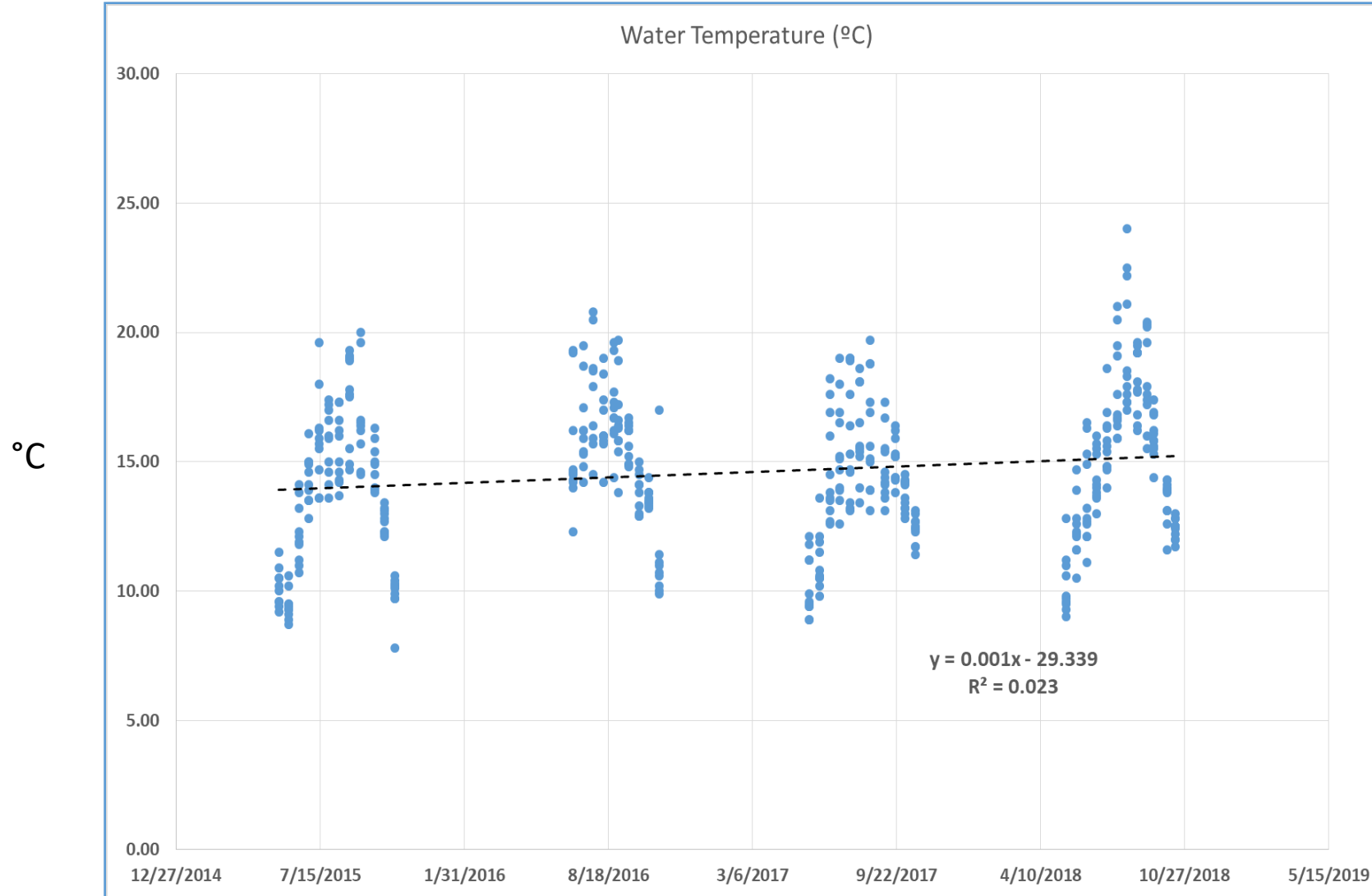




Key Variables 2015-2018



Key Variables 2015-2018



Key Variables 2015-2018

