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 /Harpswell 2018
- Boothbay data sent to UMaine for NOAA study

Things you should know about **ocean acidification**

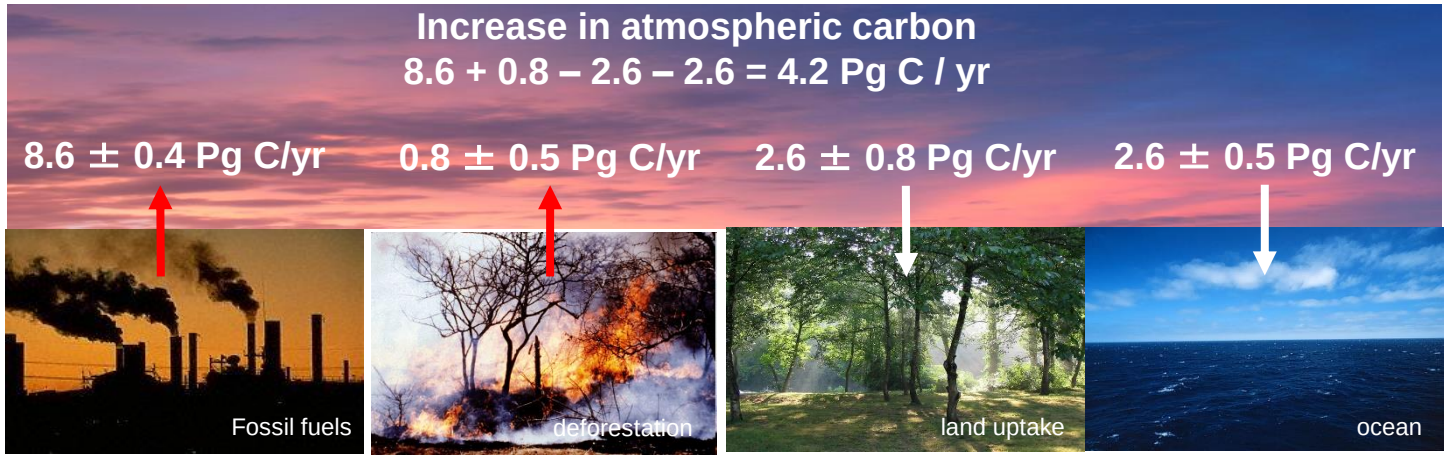
17 February 2014

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

Integrated Marine Biogeochemistry and Ecosystem Research

Ocean Acidification International Coordination Centre
OA-ICC

Ocean absorbs one-fourth of man-made CO_2 emissions



2002-2013 Carbon budget *Global Carbon Project (2013)*

Half of emitted CO_2 remains in atmosphere (causing global warming)

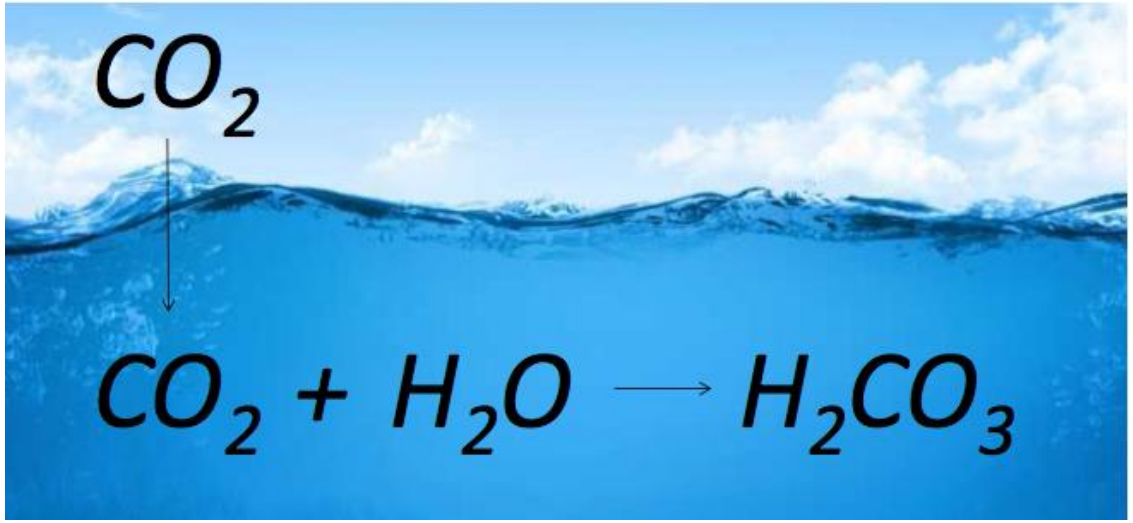
Half absorbed by ocean & land (trees, plants, and soils)

Ocean absorbs 24 million tons of CO_2 every day (4 kg per person, daily)

Le Quéré et al 2013; CDIAC data; Global Carbon Project 2013

GLOBAL CARBON PROJECT

More atmospheric CO_2 means increased ocean acidity



Schematic: Sam Dupont, University of Gothenburg

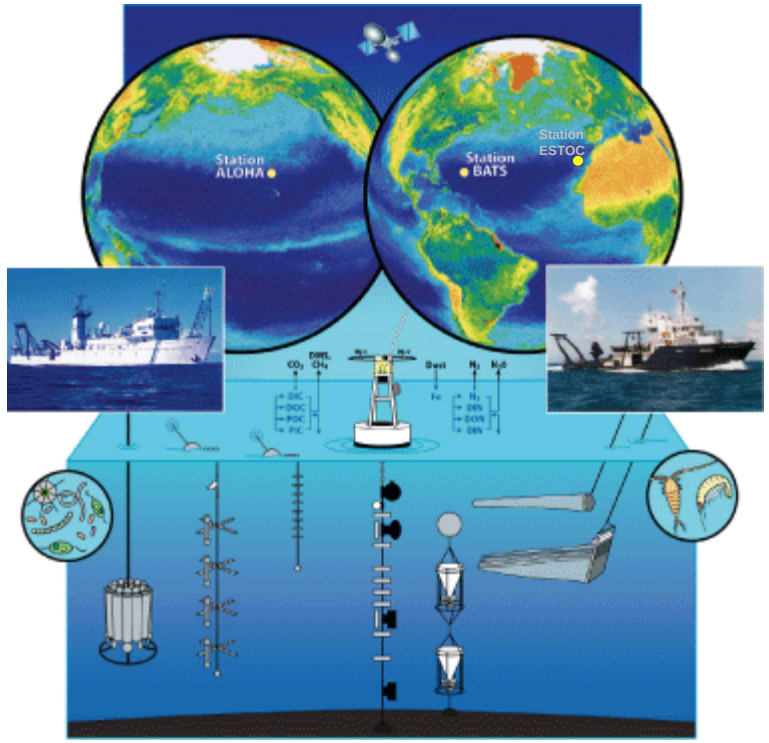
CO_2 is an acid gas (it produces acid when combined with water)

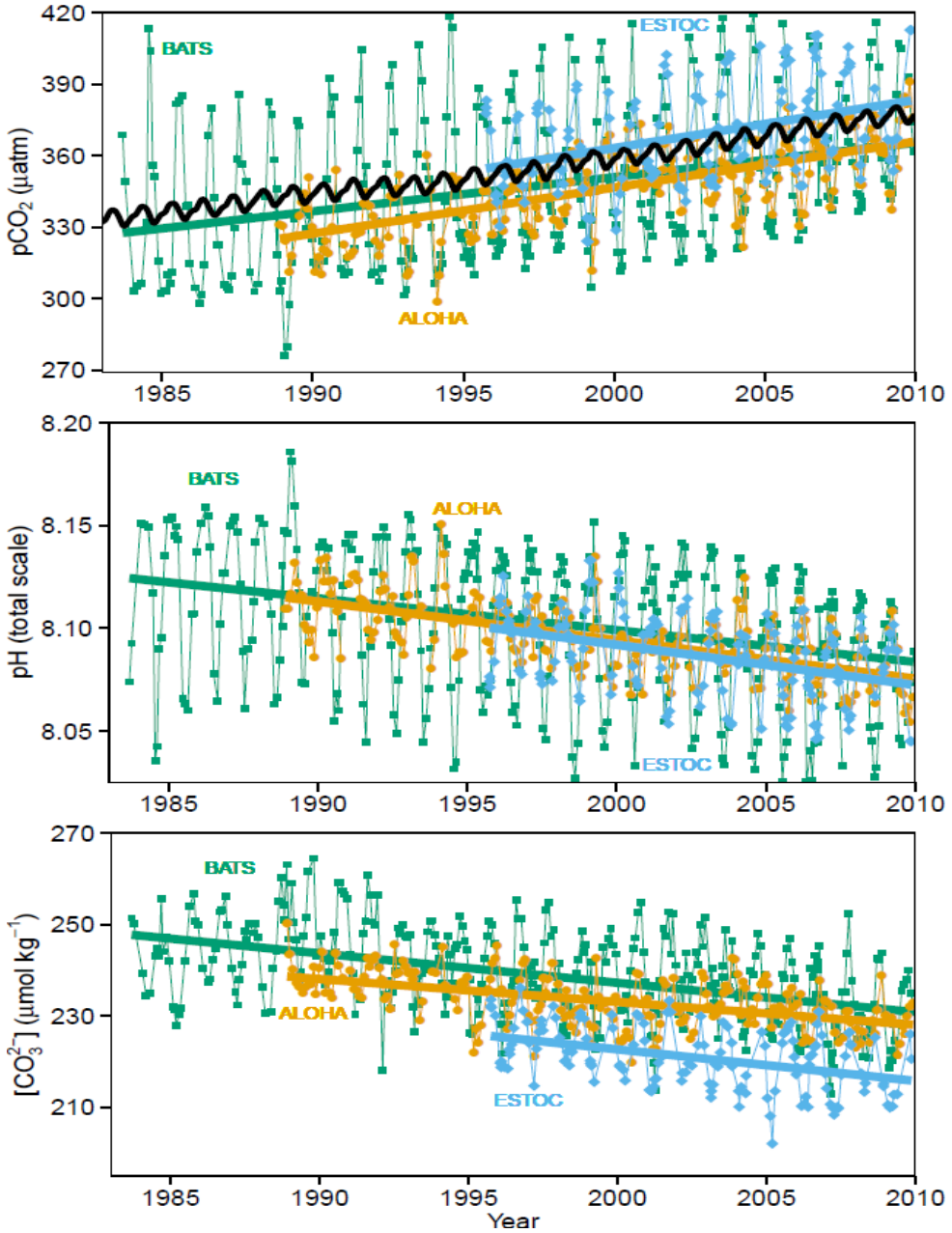
Each of us adds 4 kg CO_2 per day to the ocean (increasing acidity, reducing pH)

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

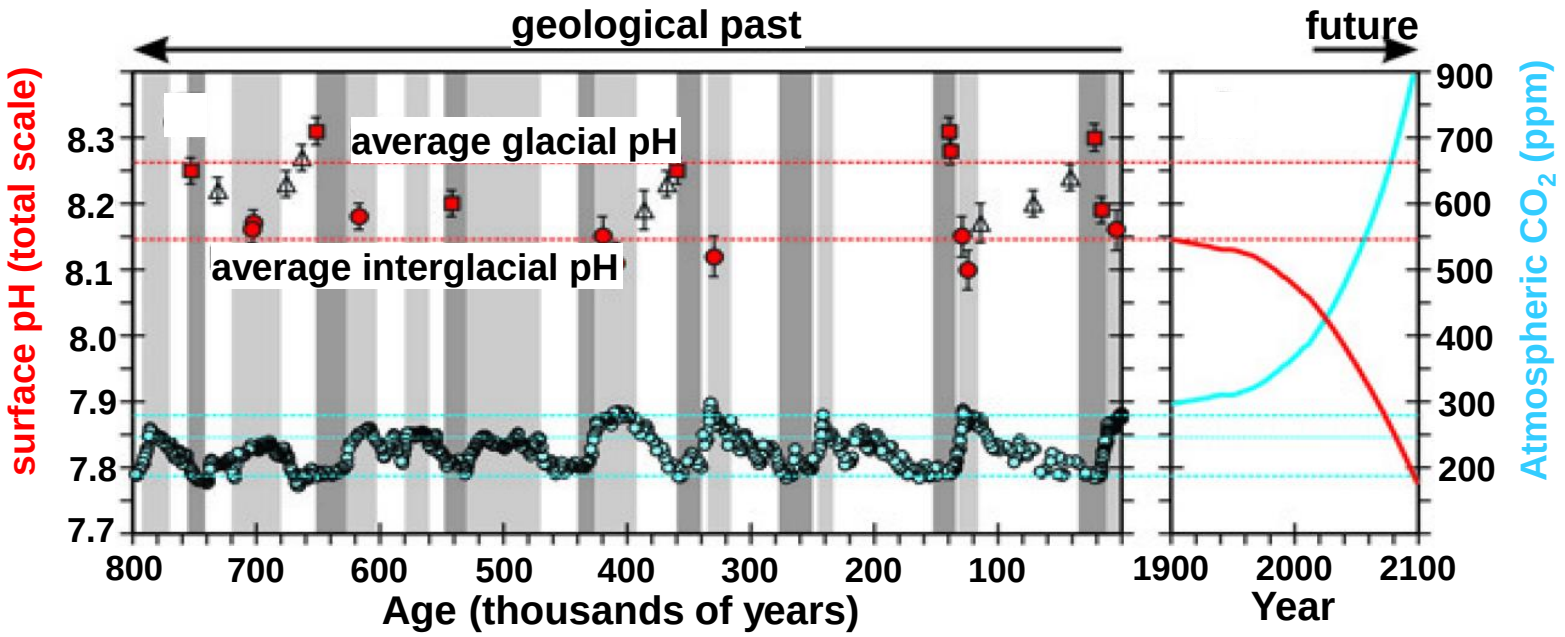




Data:
Bates (2007)
Dore et al. (2009)
Santana-Casiano et al. (2007)
Gonzàles-Dàvila et al. (2010)

IPCC AR5 WG1 Report, Chap. 3 (2013)

Today's rate of ocean acidfication may be unprecedented



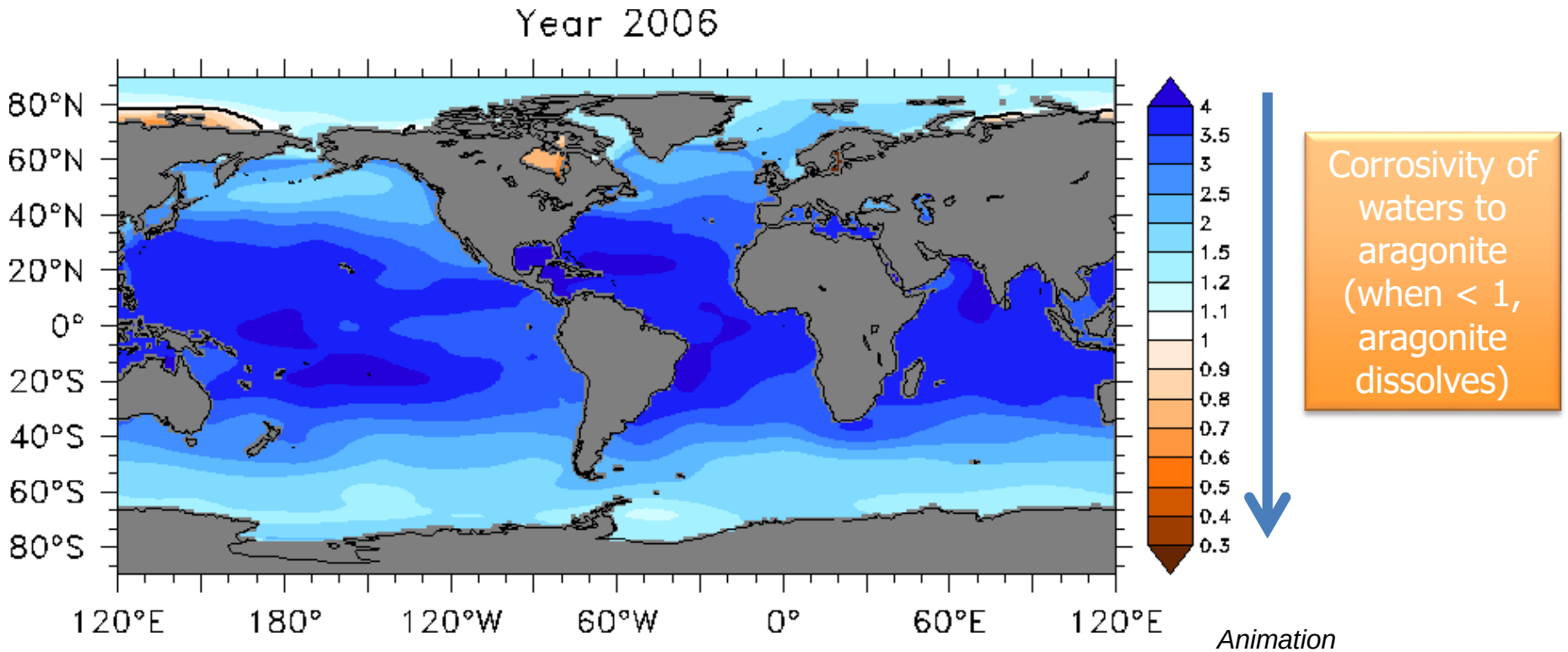
Barker and Ridgwell (2012)

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)

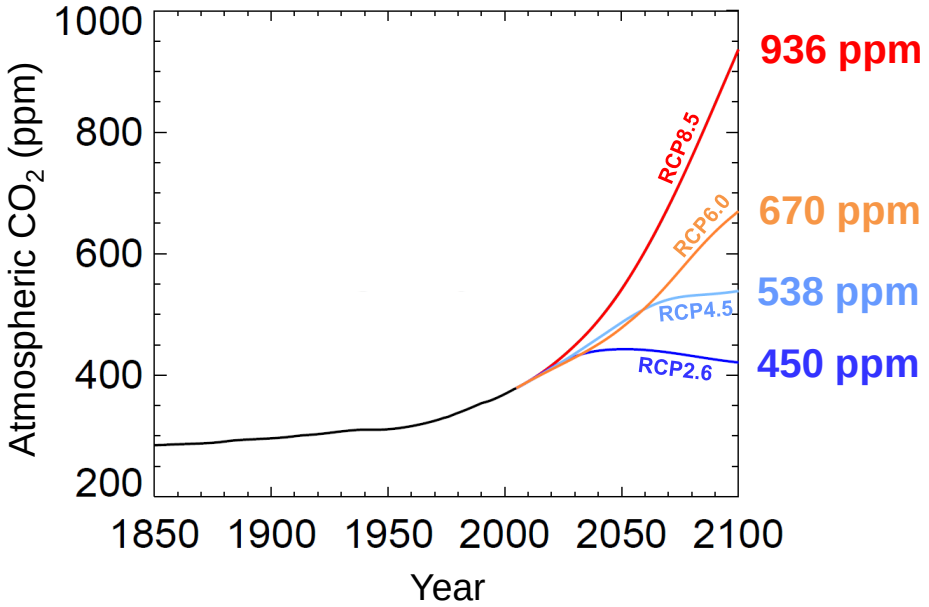
- Ocean acidification may generally affect aquaculture, fisheries, and human livelihoods

Photo: Rodolfo Quevenco, IAEA

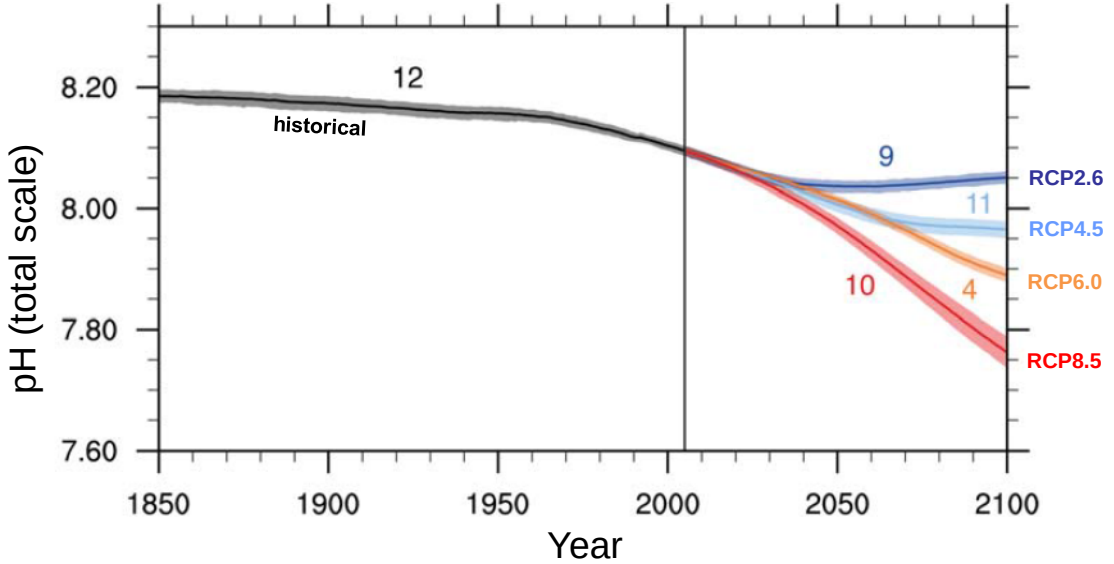
Photo: Jean-Louis Teyssié, IAEA

The intensity of ocean acidification depends on us

Future atmospheric CO_2 (latest IPCC scenarios)



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



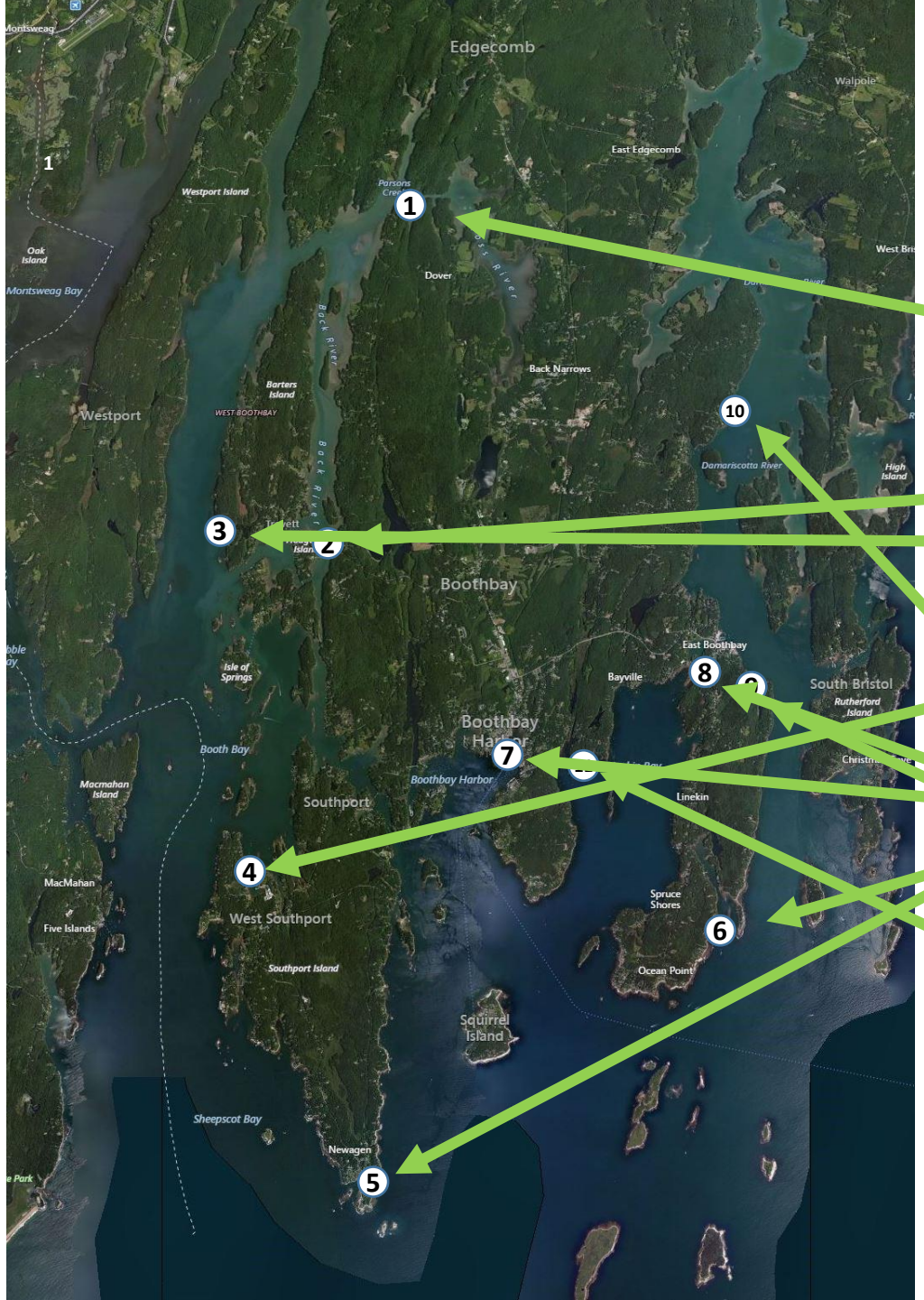
IPCC AR5 WG1, Technical Summary (2013)

see also Bopp et al. (2013)

Data Review

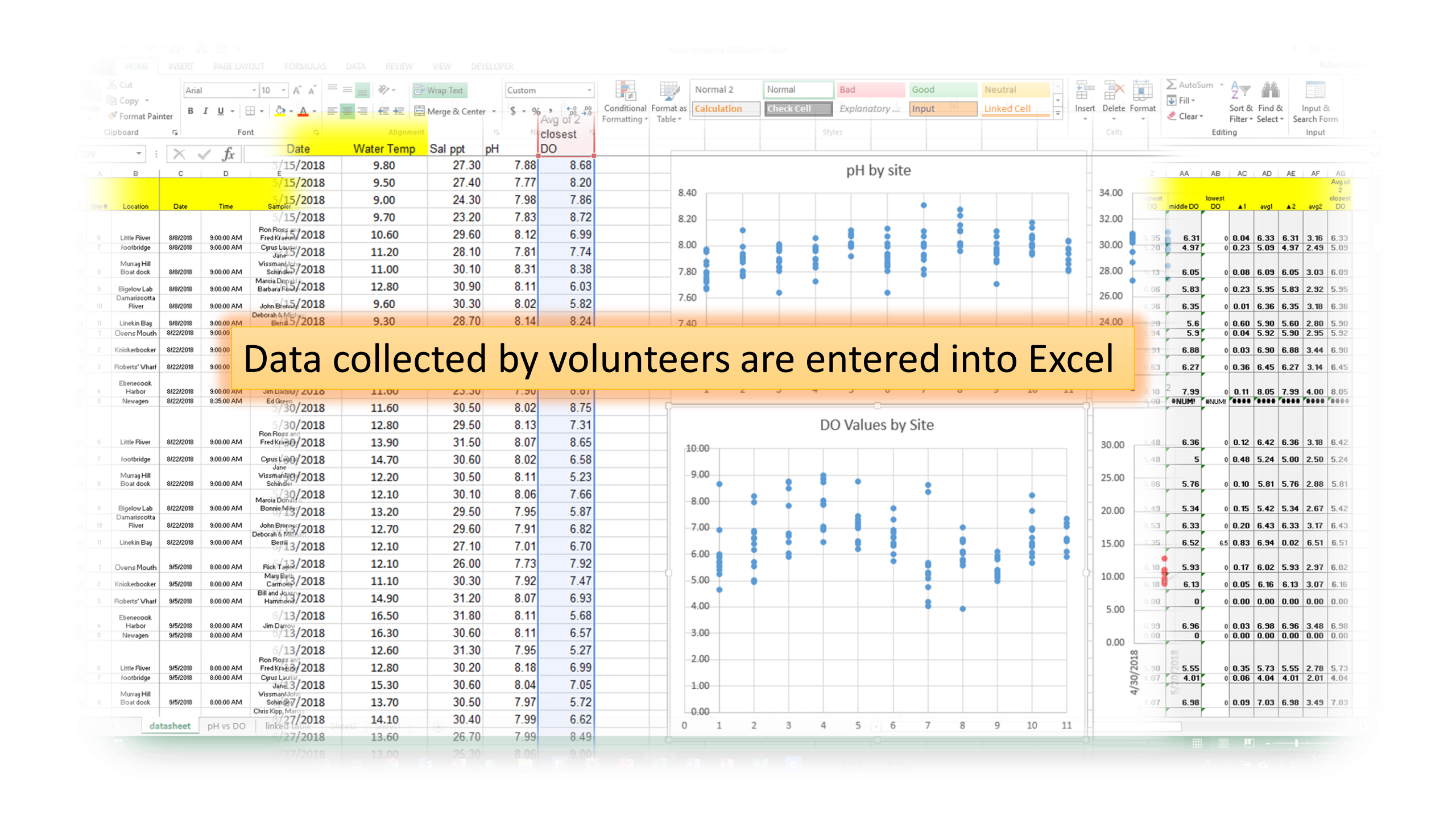
Measurements

- 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



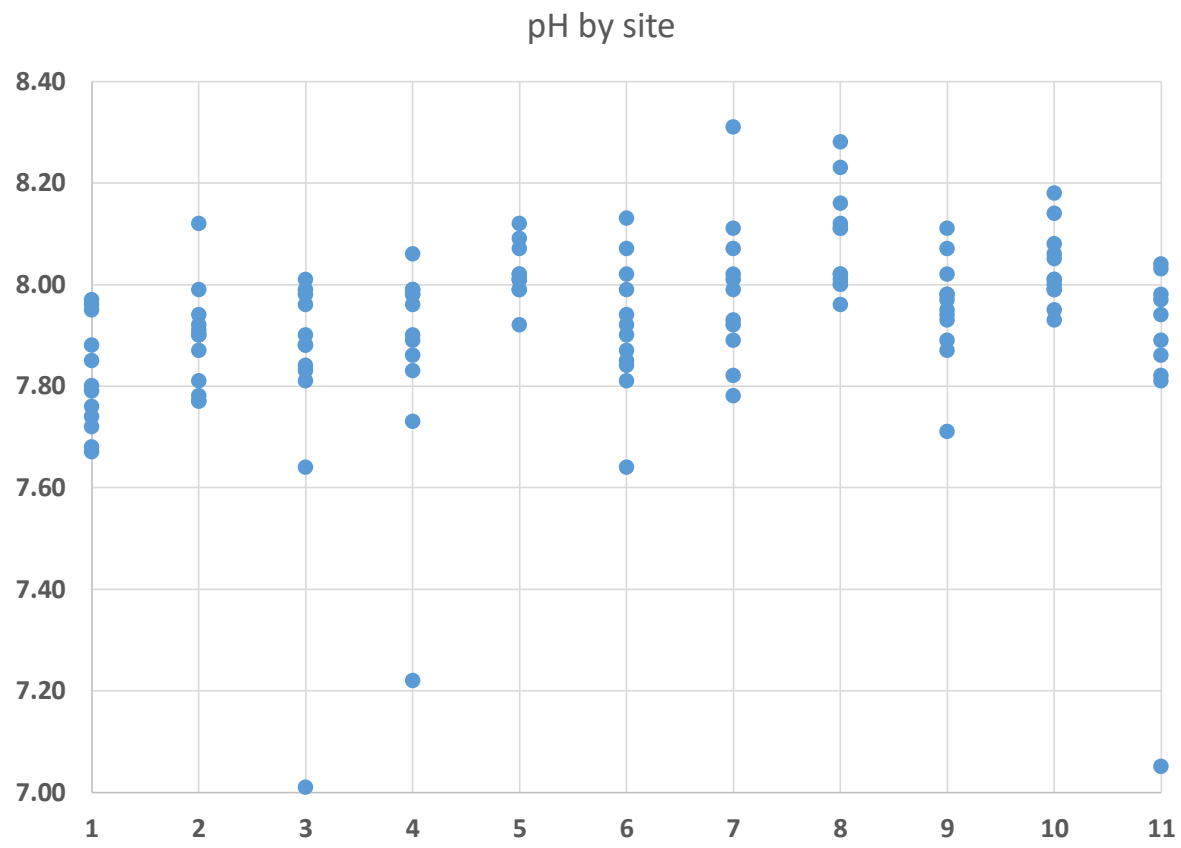
Where we measure

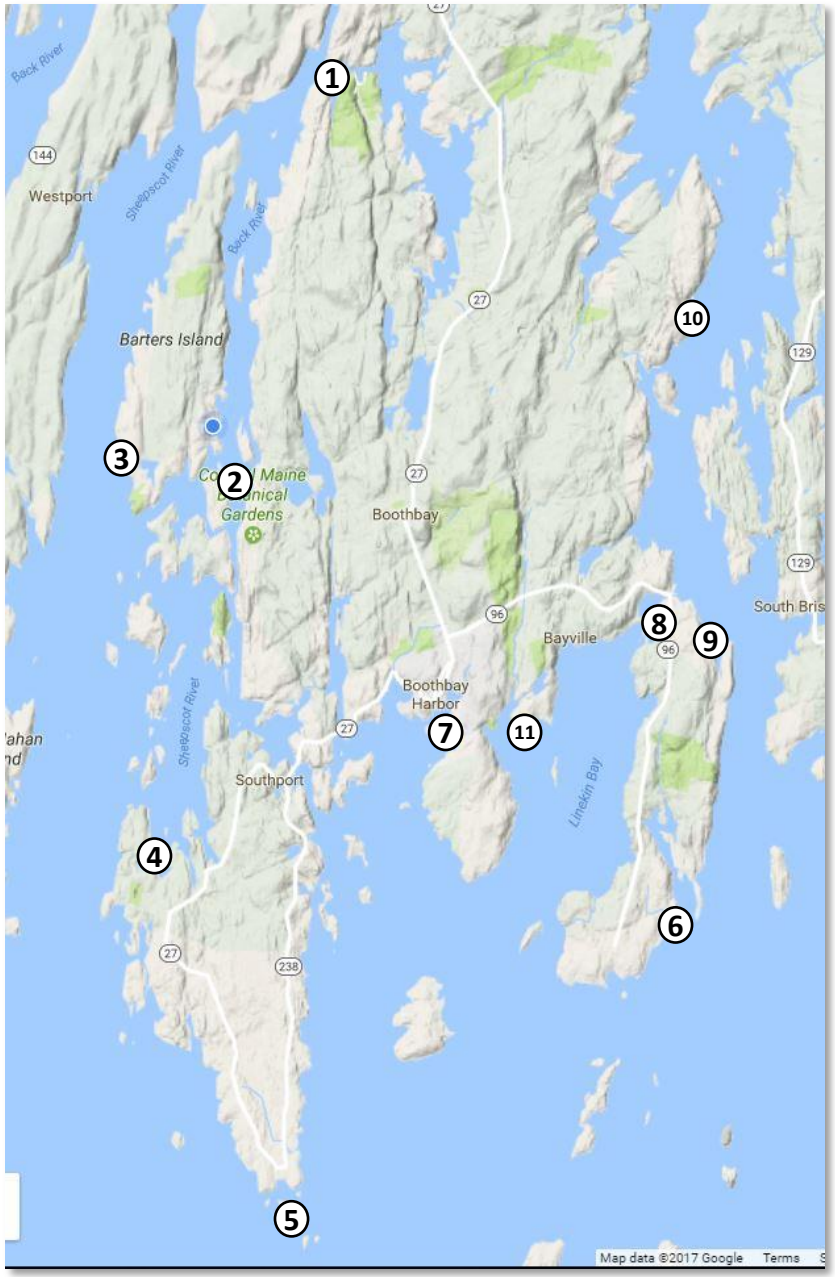
Site ID	Site Description
B 1	Oven's Mouth
B 2	Knickercane Landing
B 3	Robert's Wharf
B 4	Dogfish Head
B 5	Newagen Town Landing
B 6	Little River
B 7	Boothbay Harbor Footbridge
B 8	Linekin Bay
B 9	Bigelow Dock
B 10	Damariscotta River
B 11	Linekin Bay Resort


Data collected by volunteers are entered into Excel
pH by site
DO Values by Site
Date
Water Temp
Sal ppt
pH
Avg of 2 closest DO
datasheet
pH vs DO

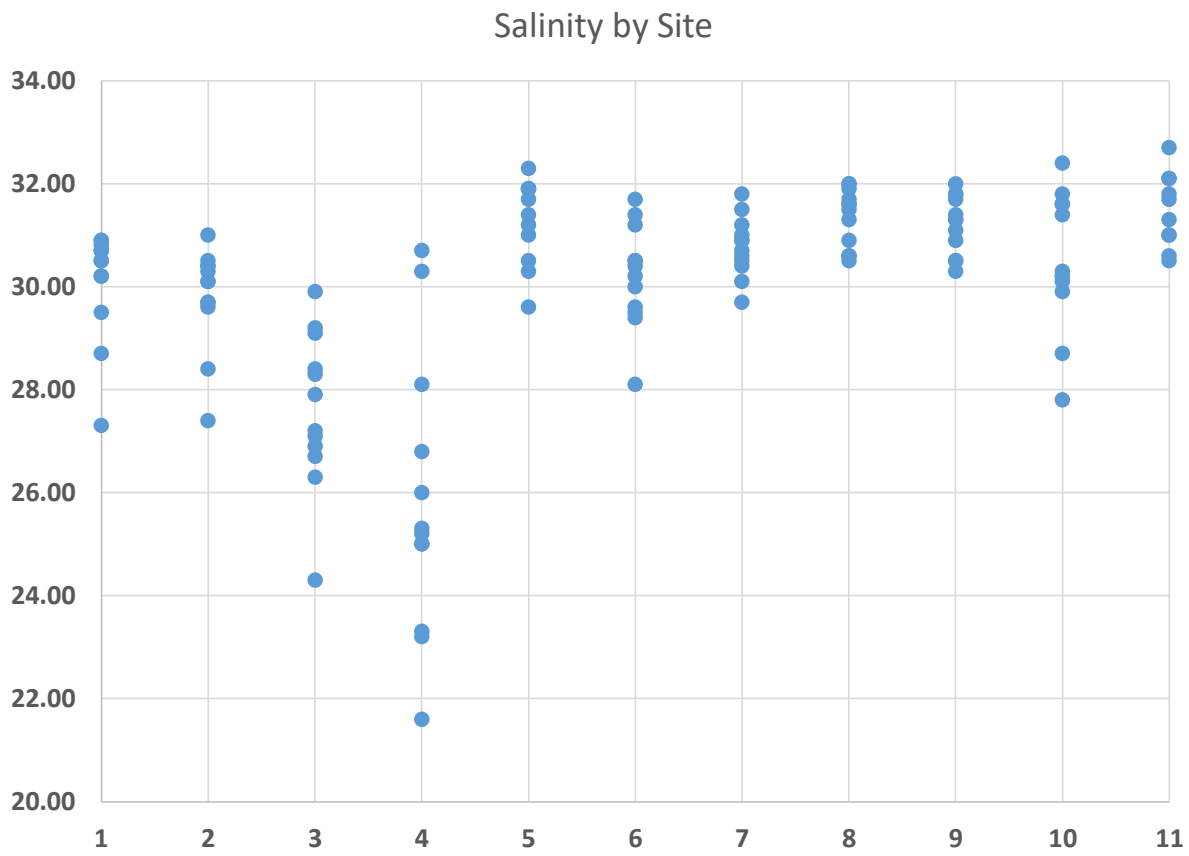
Summary of Key Parameters

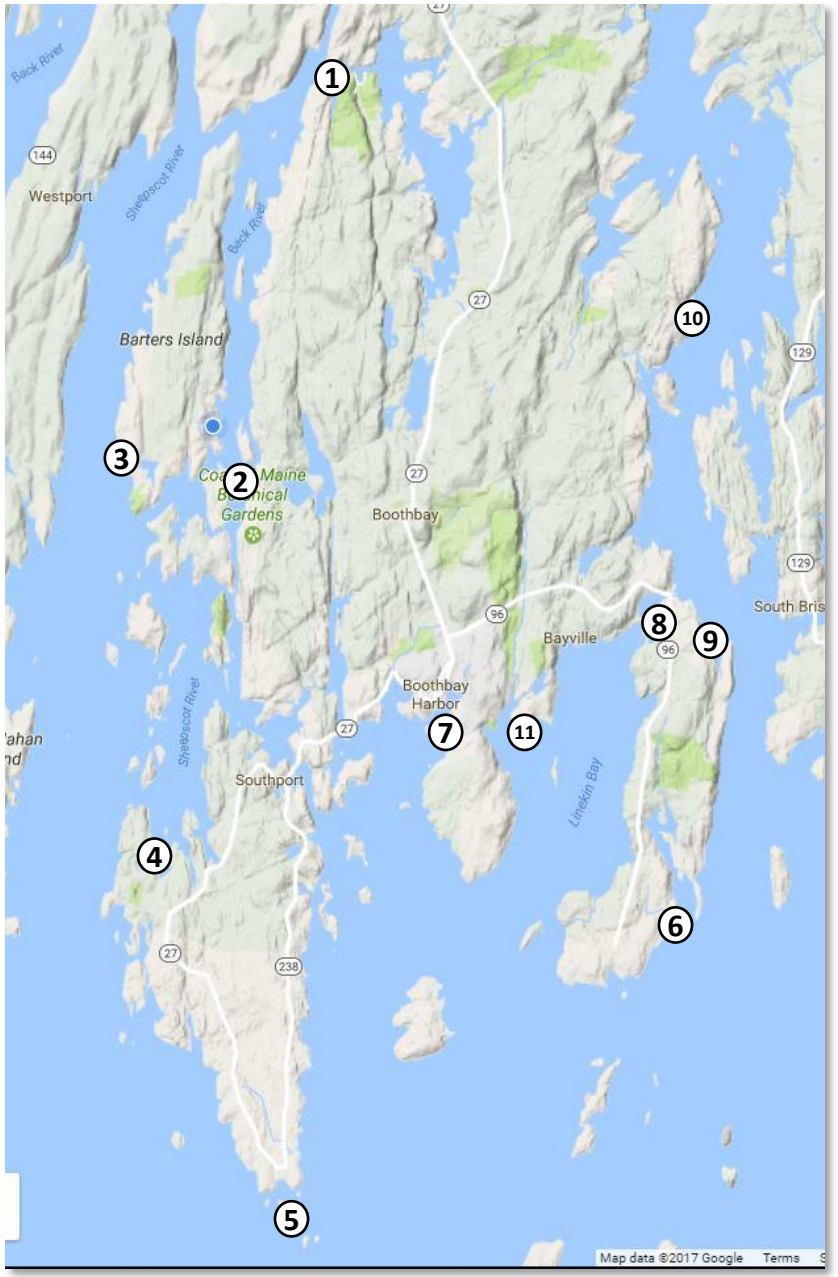
2018: pH by site



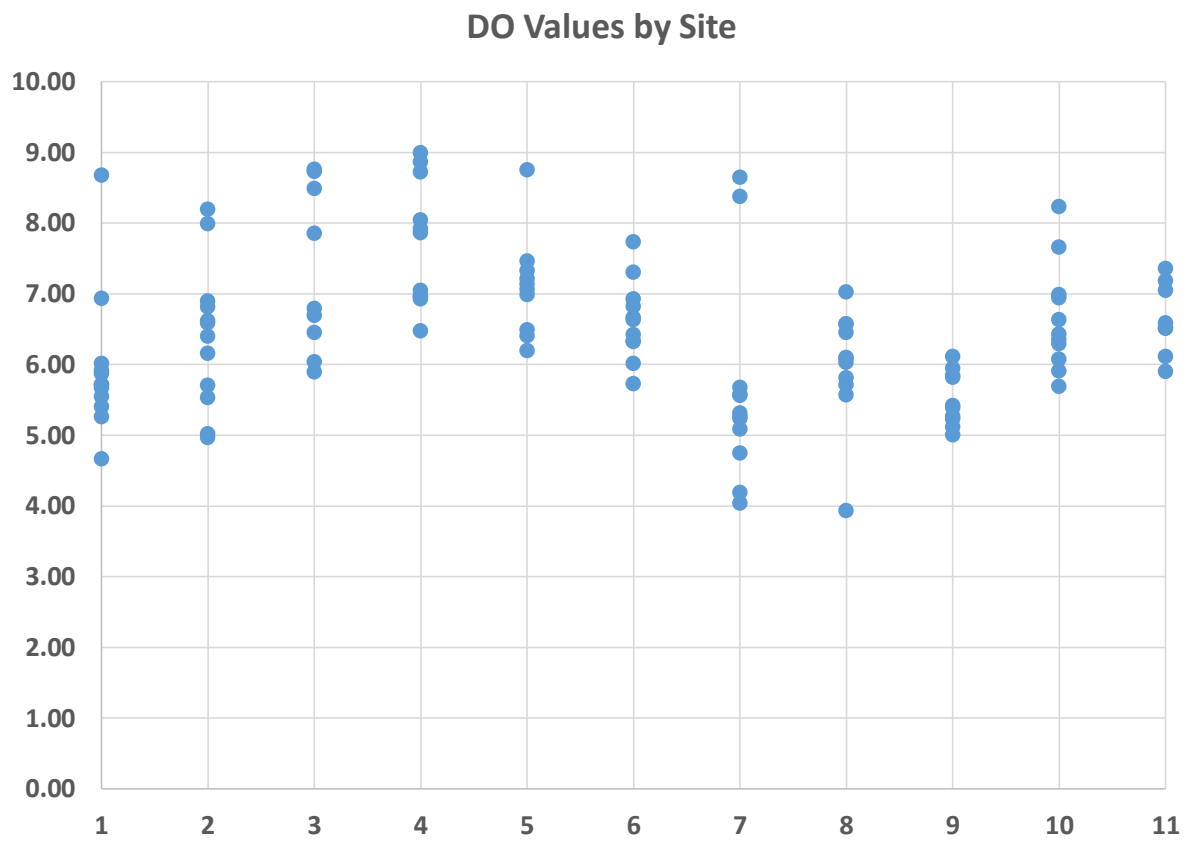


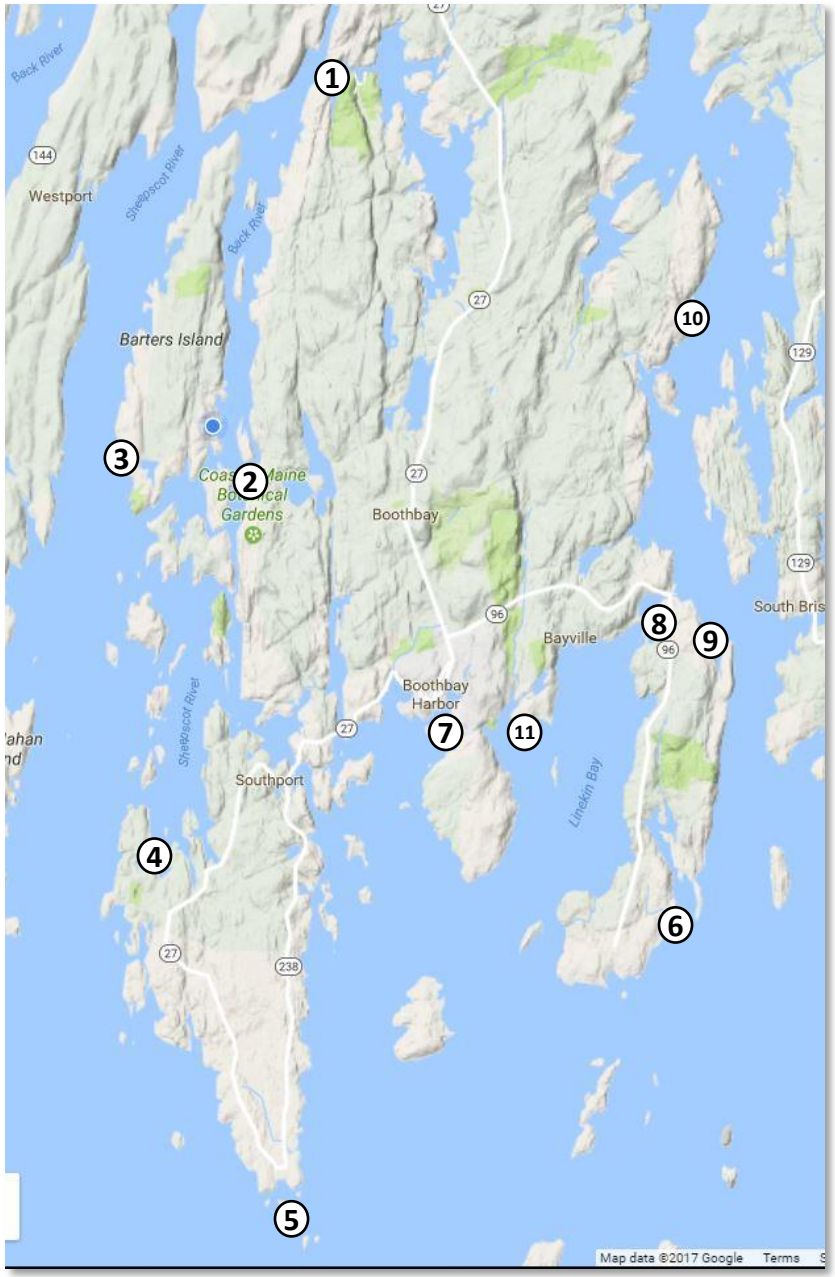
2018: salinity by site

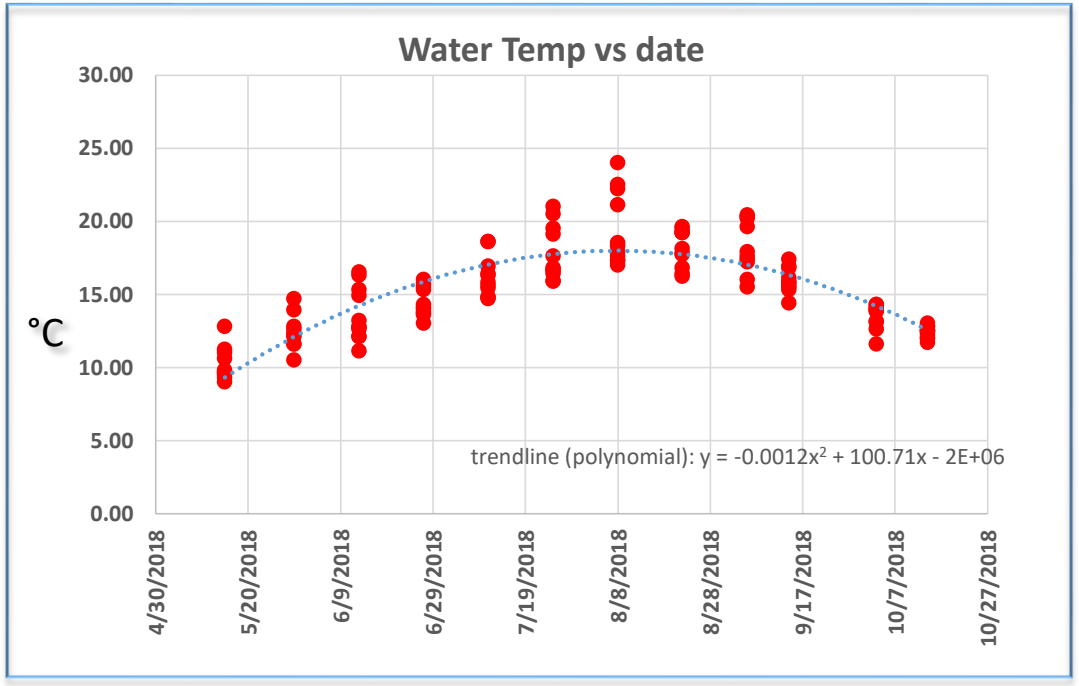


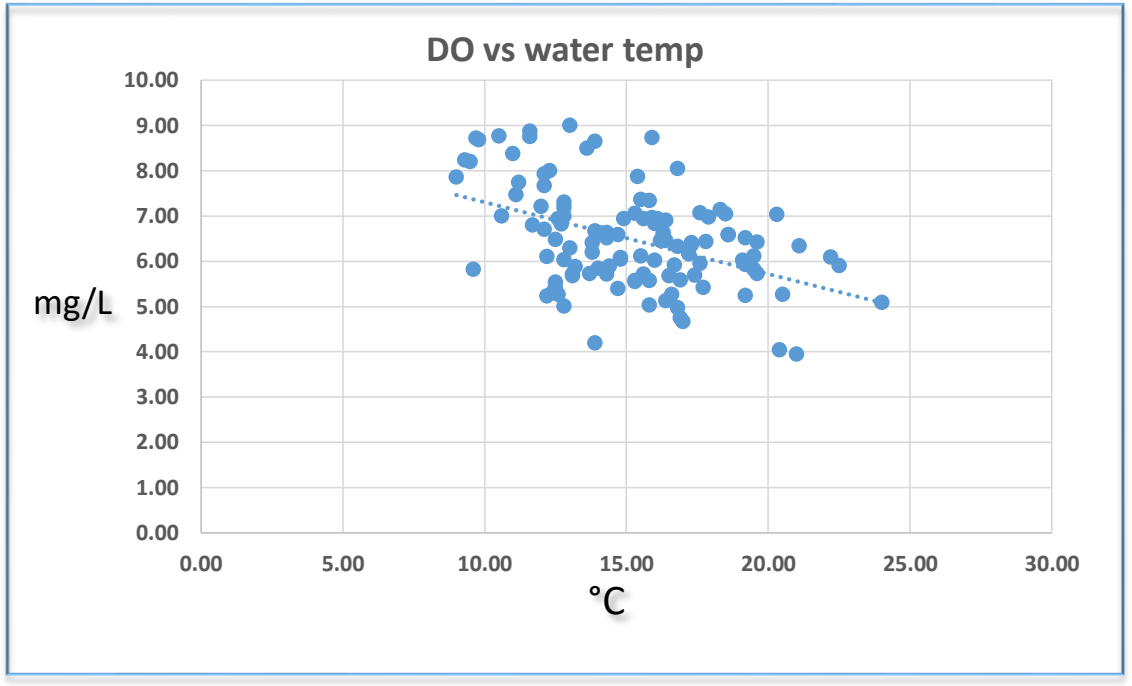


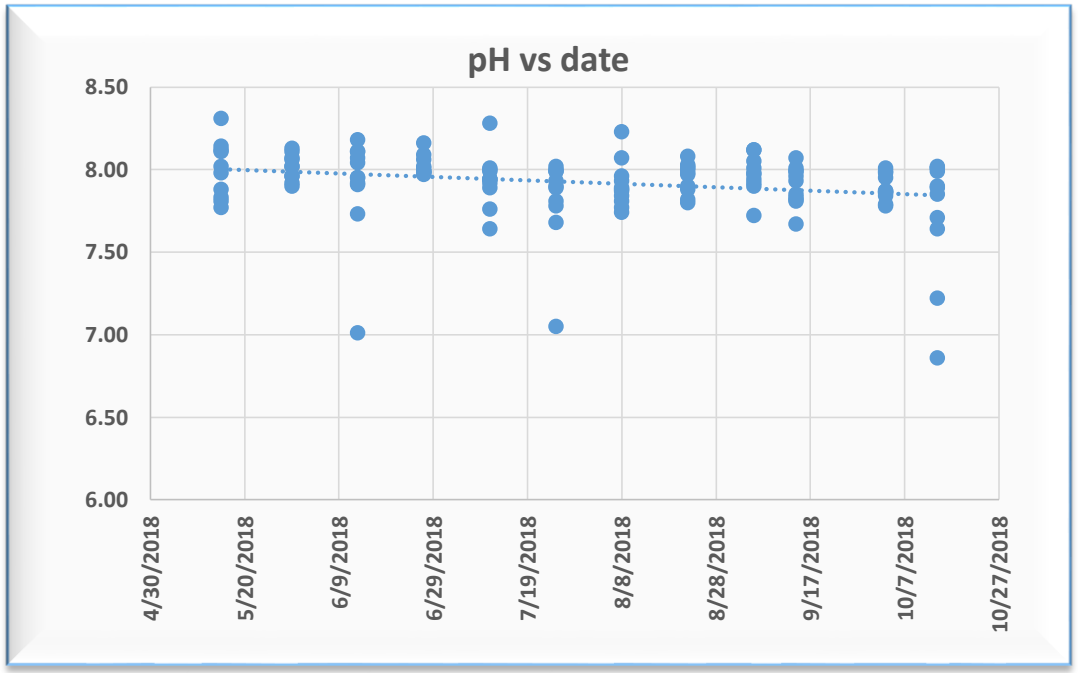
2018: DO by site

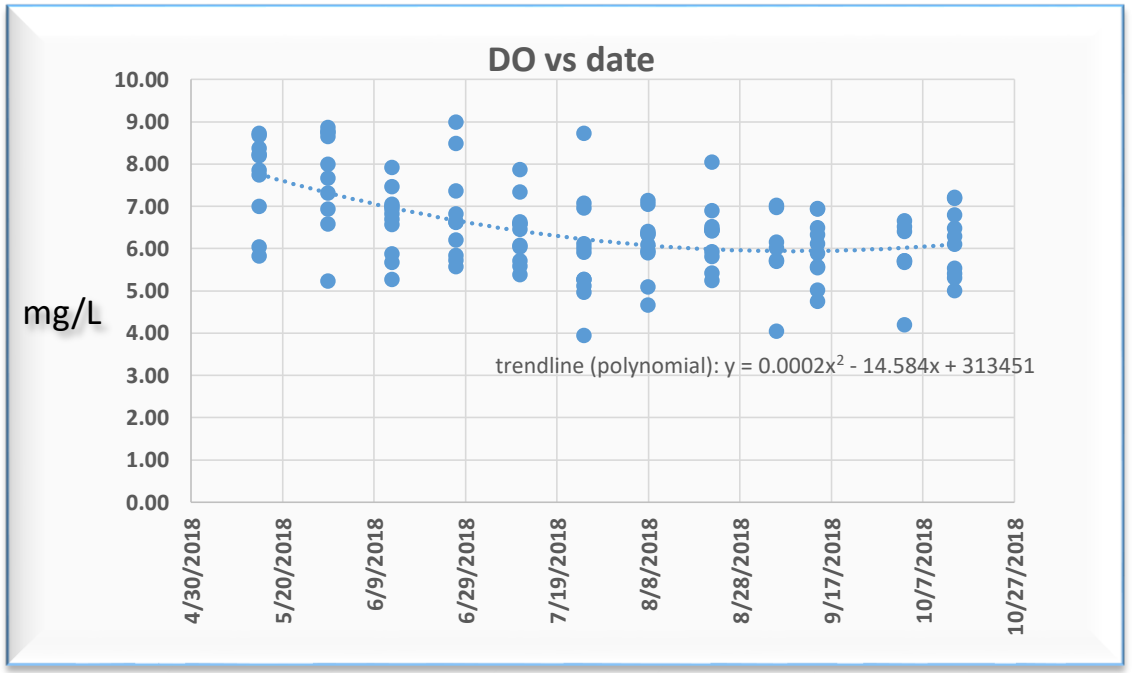





Water Temp vs date
°C
30.00
25.00
20.00
15.00
10.00
5.00
0.00
trendline (polynomial): y = -0.0012x² + 100.71x - 2E+06
4/30/2018
5/20/2018
6/9/2018
6/29/2018
7/19/2018
8/8/2018
8/28/2018
9/17/2018
10/7/2018
10/27/2018

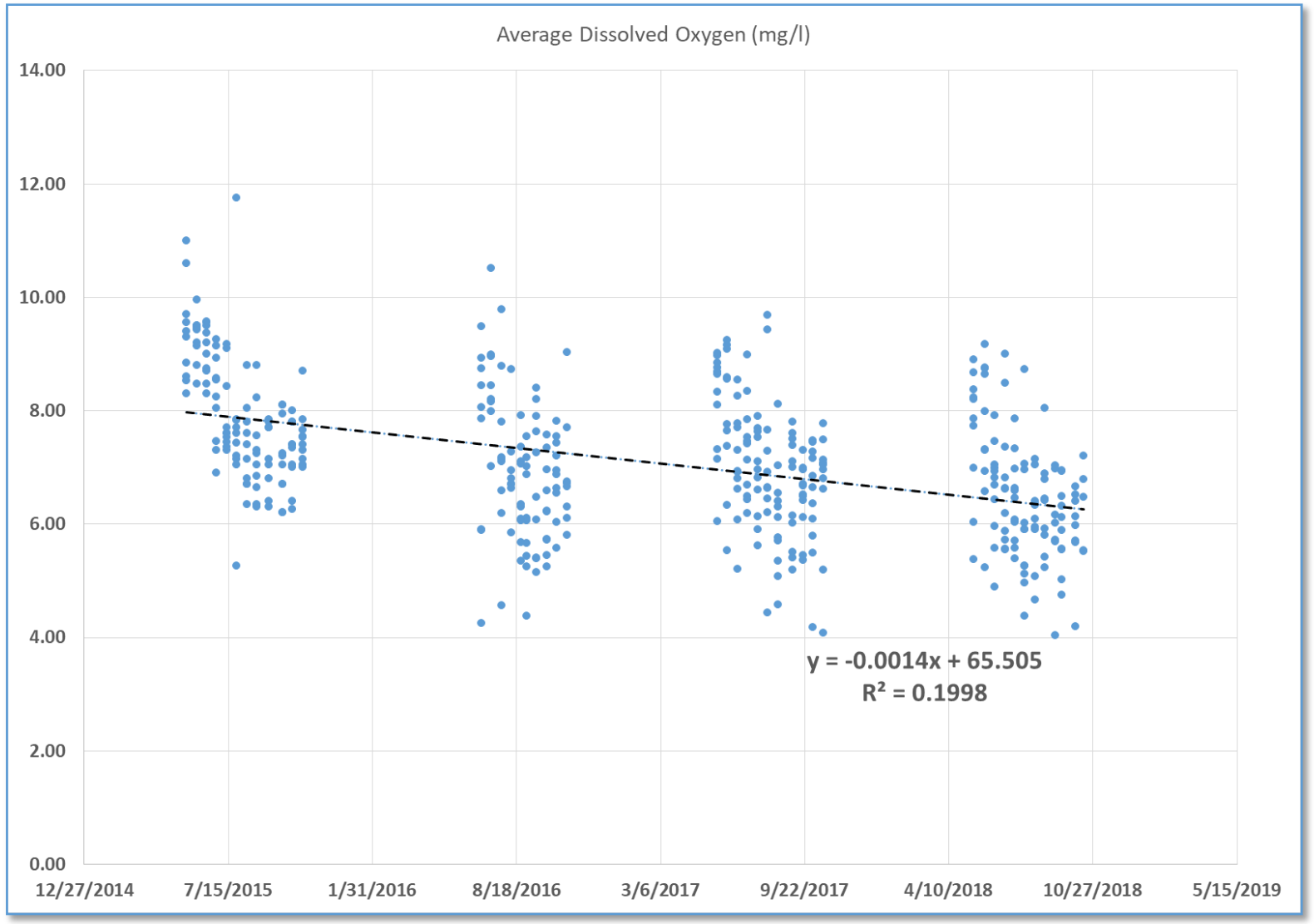

DO vs water temp
mg/L
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
°C


pH vs date
8.50
8.00
7.50
7.00
6.50
6.00
4/30/2018
5/20/2018
6/9/2018
6/29/2018
7/19/2018
8/8/2018
8/28/2018
9/17/2018
10/7/2018
10/27/2018


DO vs date
mg/L
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
trendline (polynomial): y = 0.0002x² - 14.584x + 313451
4/30/2018
5/20/2018
6/9/2018
6/29/2018
7/19/2018
8/8/2018
8/28/2018
9/17/2018
10/7/2018
10/27/2018

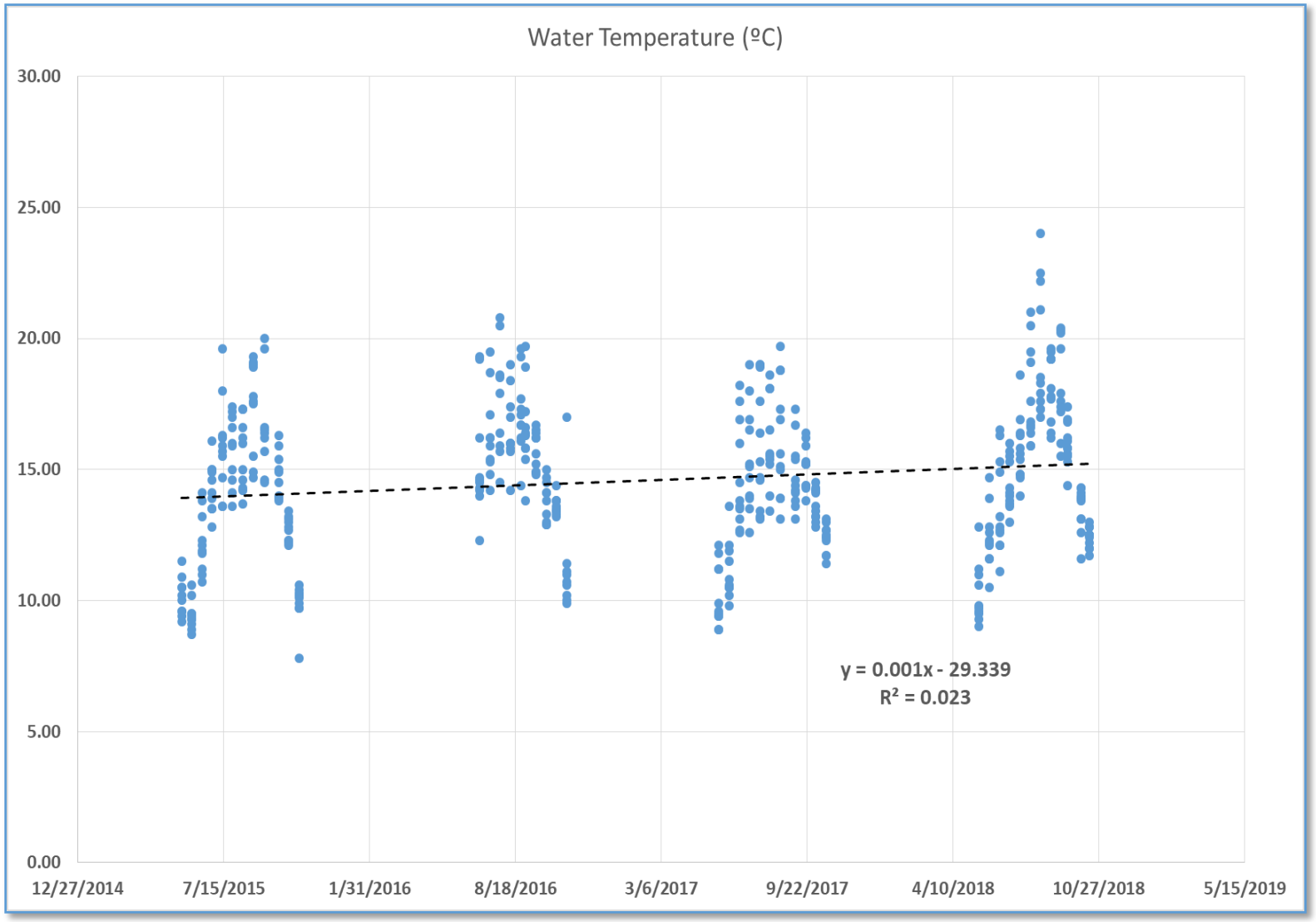
Key Variables 2015-2018

mg/L



Key Variables 2015-2018

°C



Key Variables 2015-2018