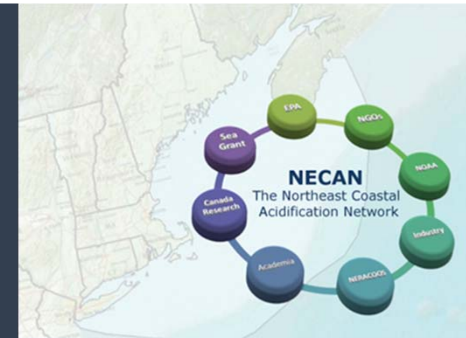
Shell Day 2019: Engaging citizen science groups to monitor coastal acidification

National Environmental Monitoring Conference
August 11, 2020

Matthew Liebman, EPA Region 1
For the Shell Day Science Advisory Team

Summary of presentation



- Background on ocean and coastal acidification
- Goals of Shell Day, a regional citizen science sampling blitz
- How we organized and conducted Shell Day
- Scientific results of Shell Day
- Lessons learned

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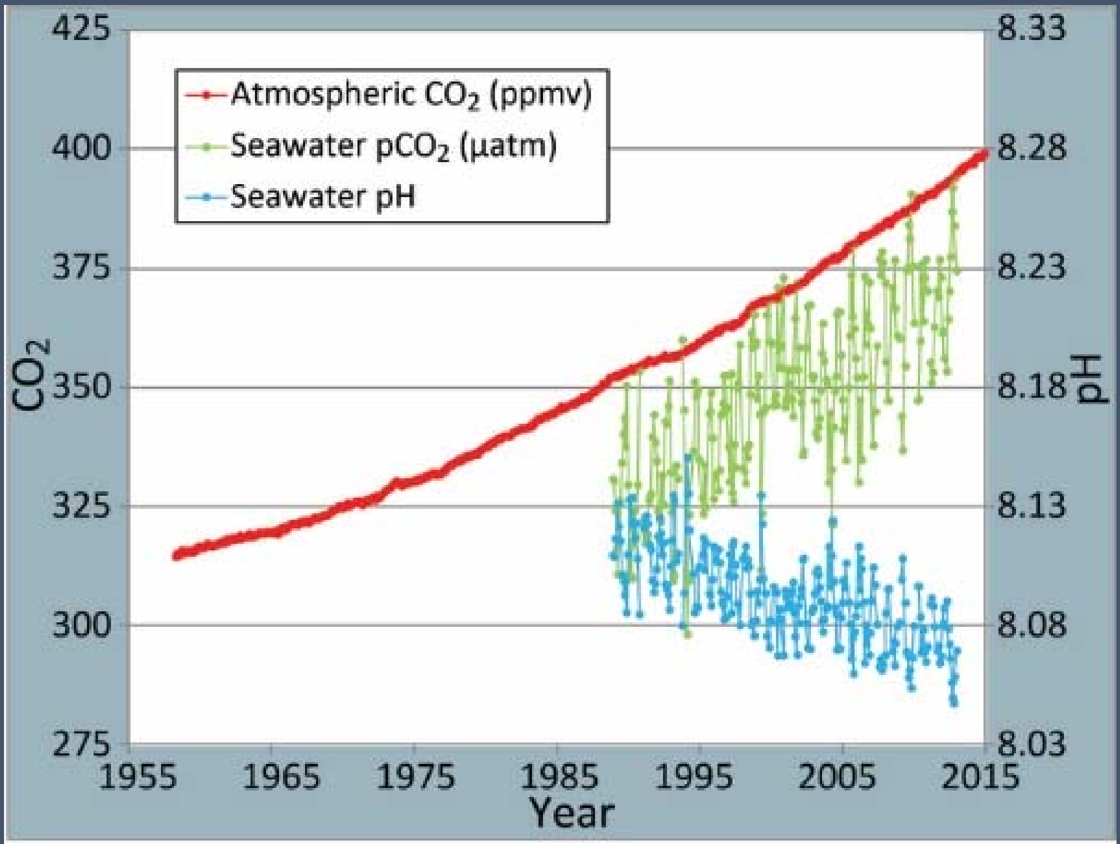
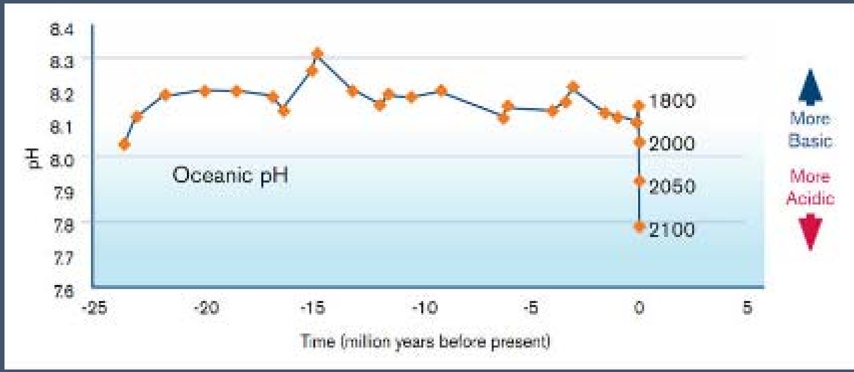


This graph shows the correlation between rising levels of carbon dioxide (CO_2) in the atmosphere at Mauna Loa with rising CO_2 levels in the nearby ocean at Station Aloha.
As more CO_2 accumulates in the ocean, the pH of the ocean decreases. (modified after R. A. Feely, Bulletin of the American Meteorological Society, July 2008).

Ocean Acidification is:

- **caused by increases in CO_2 emissions absorbed by the ocean;**
- **has declined by 0.1 pH units since 1850;**
- **is projected to decline by another 0.1 units in GOM by 2050; and**
- **is happening faster than at any time measured**



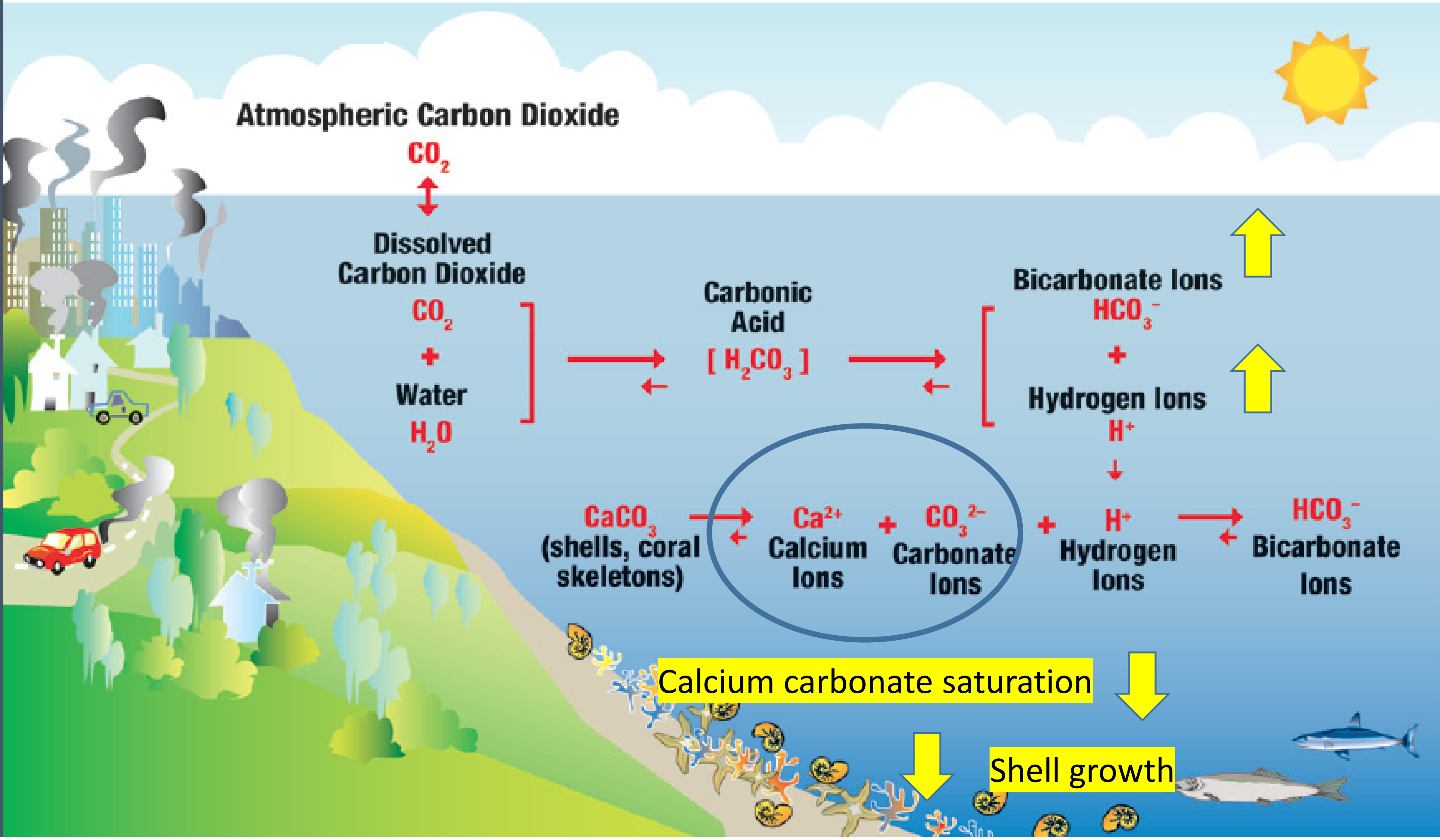
Since 1850, the ocean has absorbed about 35% of all fossil fuel emissions

(and about 28% of annual emissions)

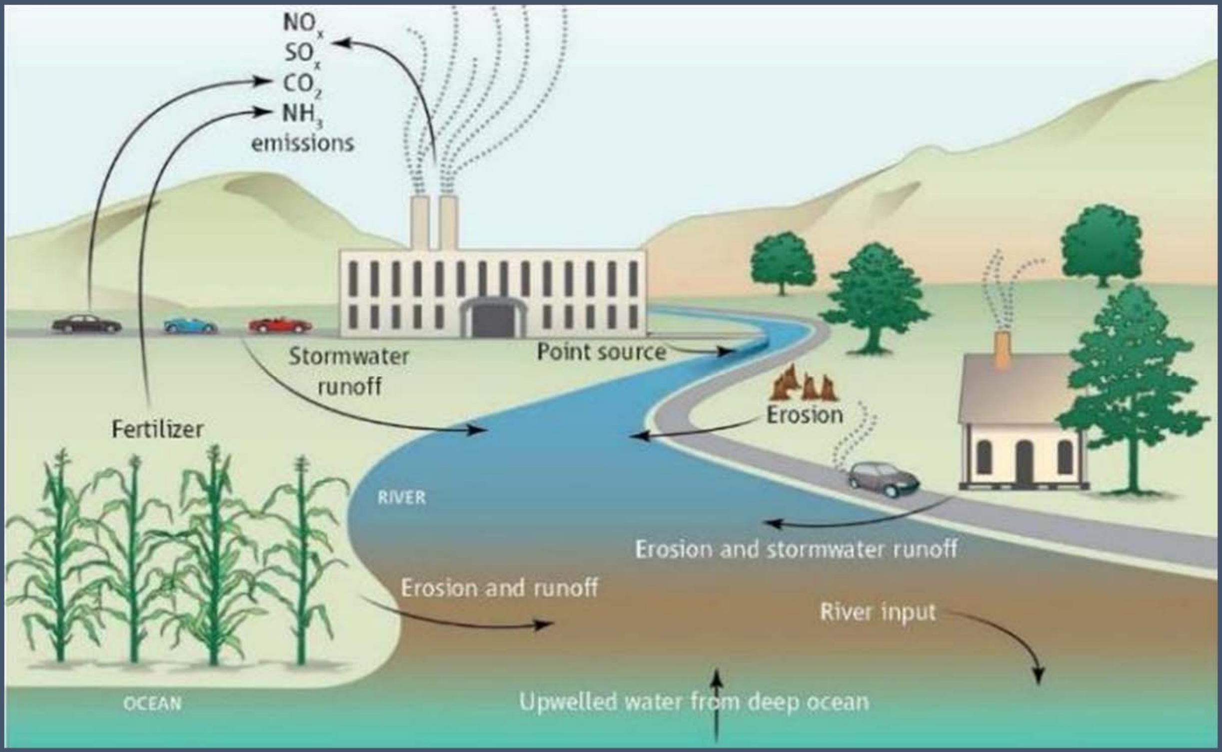
Hydrogen ions increase

Calcium carbonate ions decrease

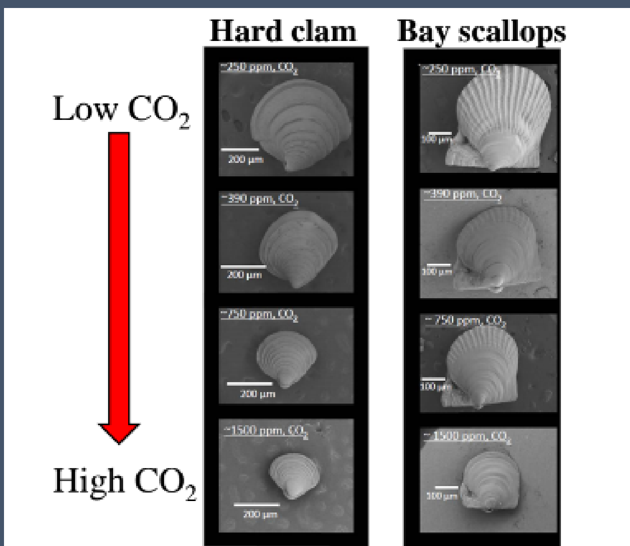
The Chemistry of Ocean Acidification



Coastal acidification is the process where coastal sources (e.g. nutrient runoff, rivers) modify and enhance ocean acidification



Laboratory experiments and field observations support projections of impacts to shellfisheries and ecologically important species



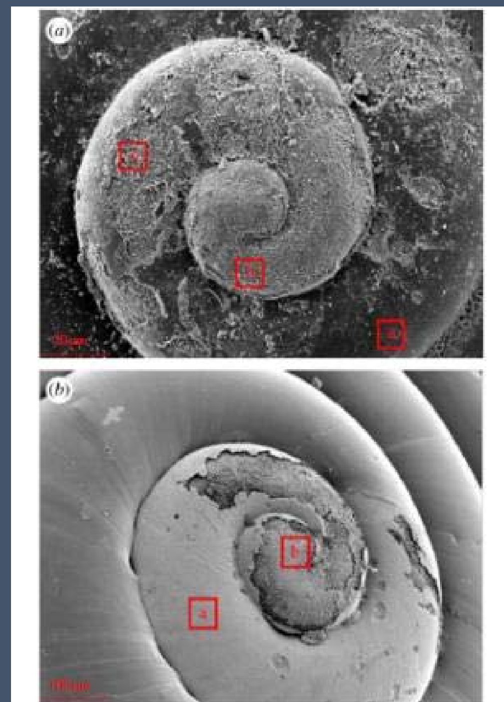
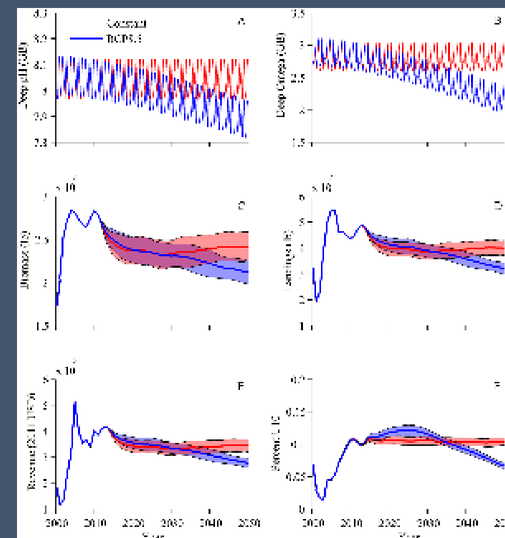
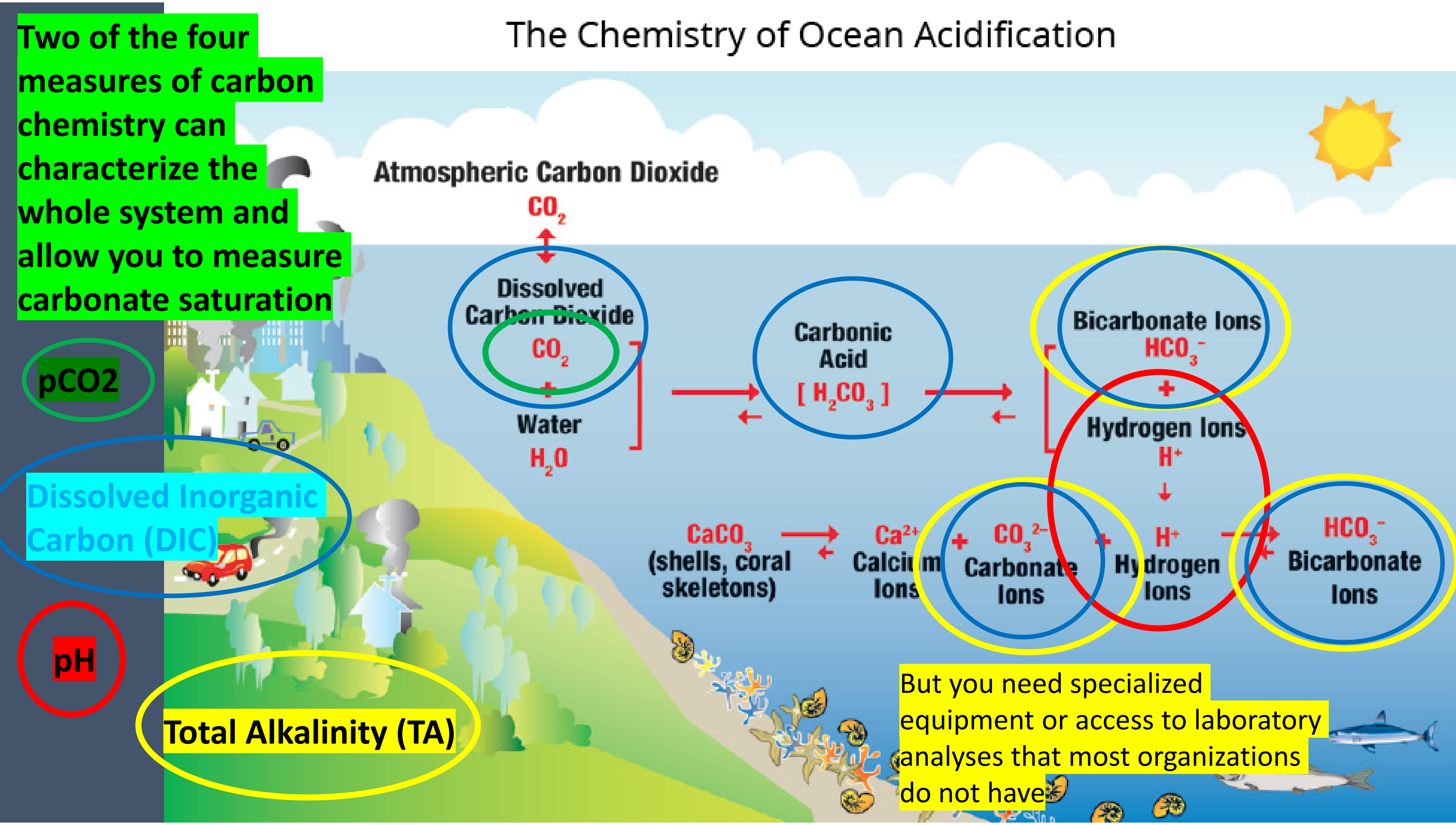


Figure 2. SEM images of shells of the pteropod *Limacina helicina helicina* f. *pacifica* sampled during the 2011 cruise showing signs of *in situ* dissolution from (*a*) an onshore station, with the entire shell affected by dissolution, and (*b*) from the offshore region, with only the protoconch (first whorl) affected. Indicated in the figure are: a, intact surface; b, Type I dissolution; and c, severe dissolution (Type II or Type III): see Material and methods for description of dissolution types. (Online version in colour.)



Will coastal acidification affect the New England coastal economy?

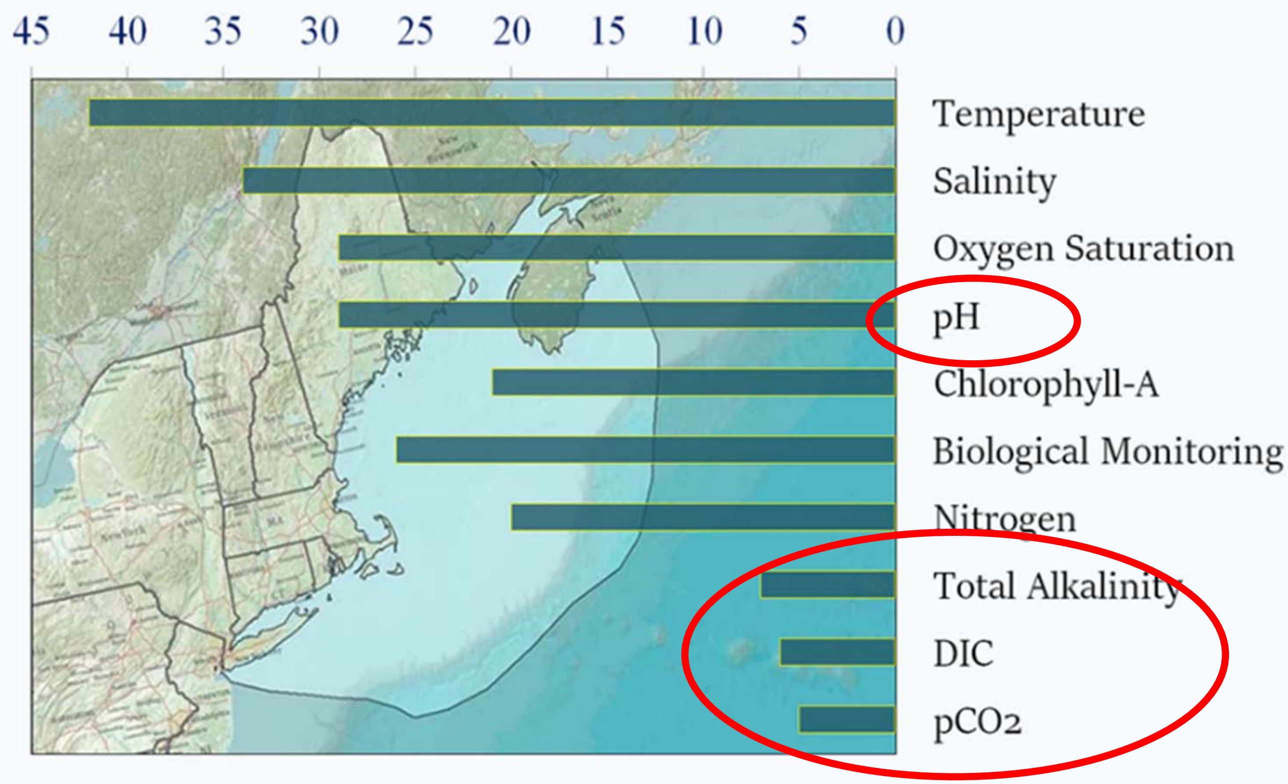
Answer : Monitor coastal waters for carbon chemistry parameters



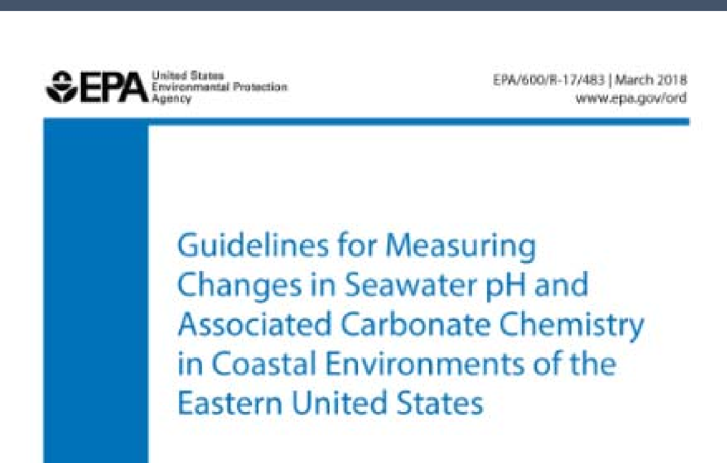
Two of the four measures of carbon chemistry can characterize the whole system and allow you to measure carbonate saturation
pCO2
Dissolved Inorganic Carbon (DIC)
pH
Total Alkalinity (TA)
The Chemistry of Ocean Acidification
Atmospheric Carbon Dioxide
CO_2
Dissolved Carbon Dioxide
CO_2
+
Water
H_2O
Carbonic Acid
[H_2CO_3]
Bicarbonate Ions
HCO_3^-
+
Hydrogen Ions
H^+
$CaCO_3$ (shells, coral skeletons)
Ca^{2+} Calcium Ions
+ CO_3^{2-} Carbonate Ions
+ H^+ Hydrogen Ions
HCO_3^- Bicarbonate Ions
But you need specialized equipment or access to laboratory analyses that most organizations do not have

NECAN (Parker Gassett and others) conducted an inventory of monitoring organizations and found that TA, DIC and pCO2 are not routinely monitored and pH measurements may not have the precision necessary to measure calcium carbonate (omega)

Organizations measuring each parameter

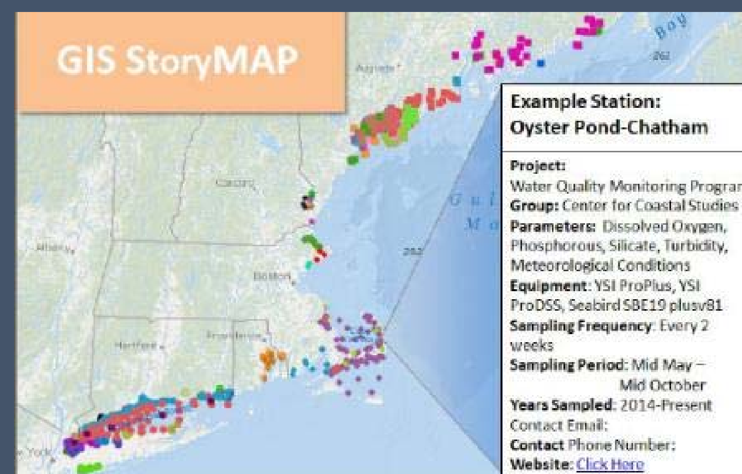


EPA developed and published in 2018 sampling guidelines targeted to state resource managers and citizen science monitoring organizations



Funded by the NOAA Ocean Acidification Program, NECAN set up training for coordinators and organizations

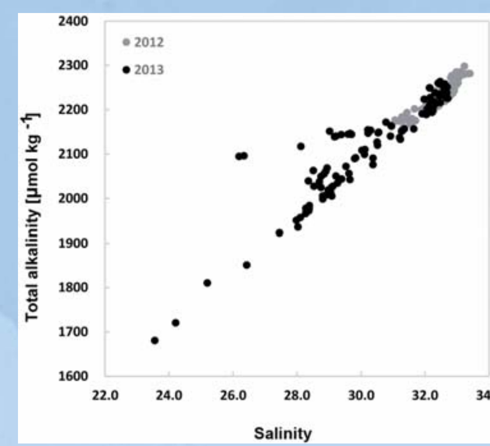
NECAN documented the universe of organizations collecting relevant water quality information and recruited these organizations for ……




SHELL DAY
AUGUST 22
2019
Ocean Acidification
Monitoring Blitz
NECAN
The Northeast Coastal
Acidification Network
EPA
NGOs
NOAA
Industry
NERACOOS
Academia
Canada
Research
Sea
Grant
NECAN.ORG/SHELLDAY

Shell Day Goals

- Assess regional variability of Total Alkalinity to evaluate whether coastal estuaries are vulnerable to OCA
- Determine if we can establish a relationship between TA and salinity (so that combined with pH, we can estimate calcium carbonate saturation)
- Improve capacity of monitoring organizations and laboratories to measure OCA parameters
- Educate public about OCA and create community leaders



Low Tide

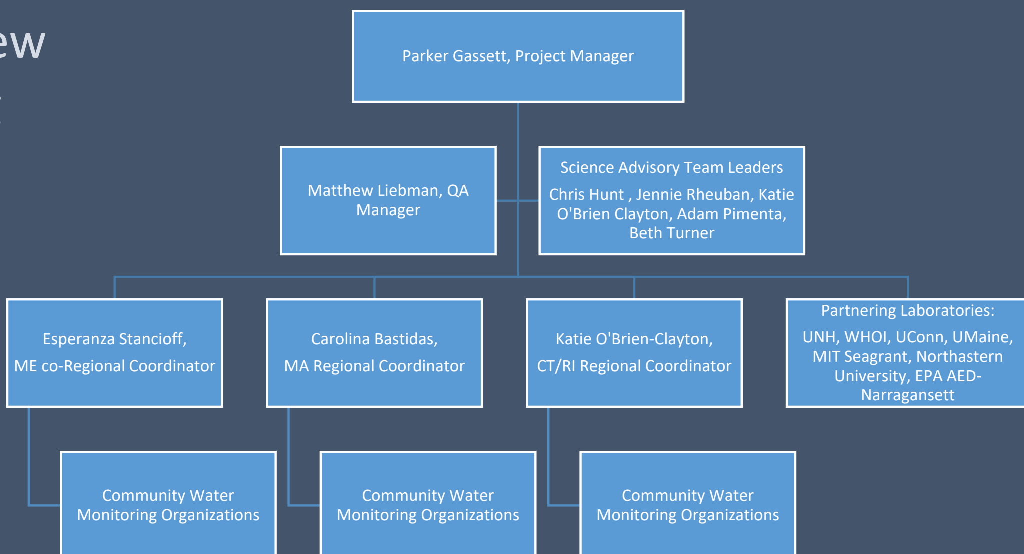
We incorporated tidal change into the study design.

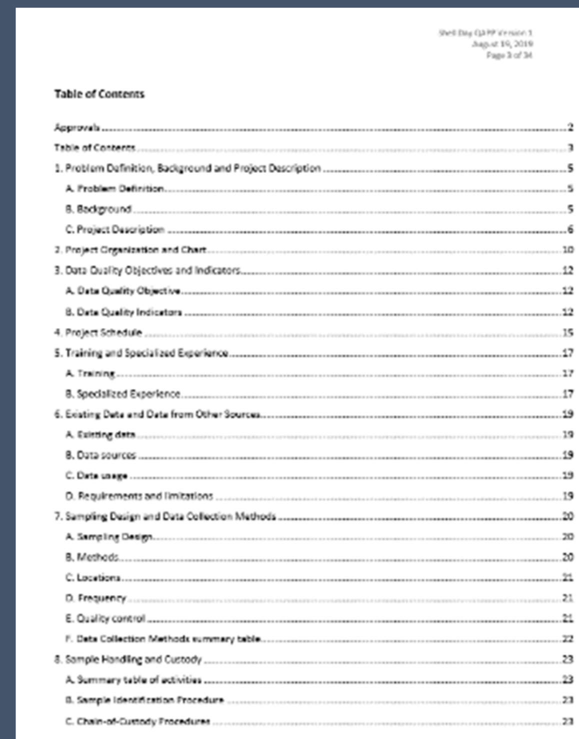
We sampled at low, mid and high tide over a 6 to 8 hour period.

High Tide

We wrote up a Quality Assurance Project Plan that included:

- Organizational structure
- Study design
- Sampling protocols and training
- Data Quality Objectives
- Data Quality indicators with Performance goals
- Data review
- Reporting





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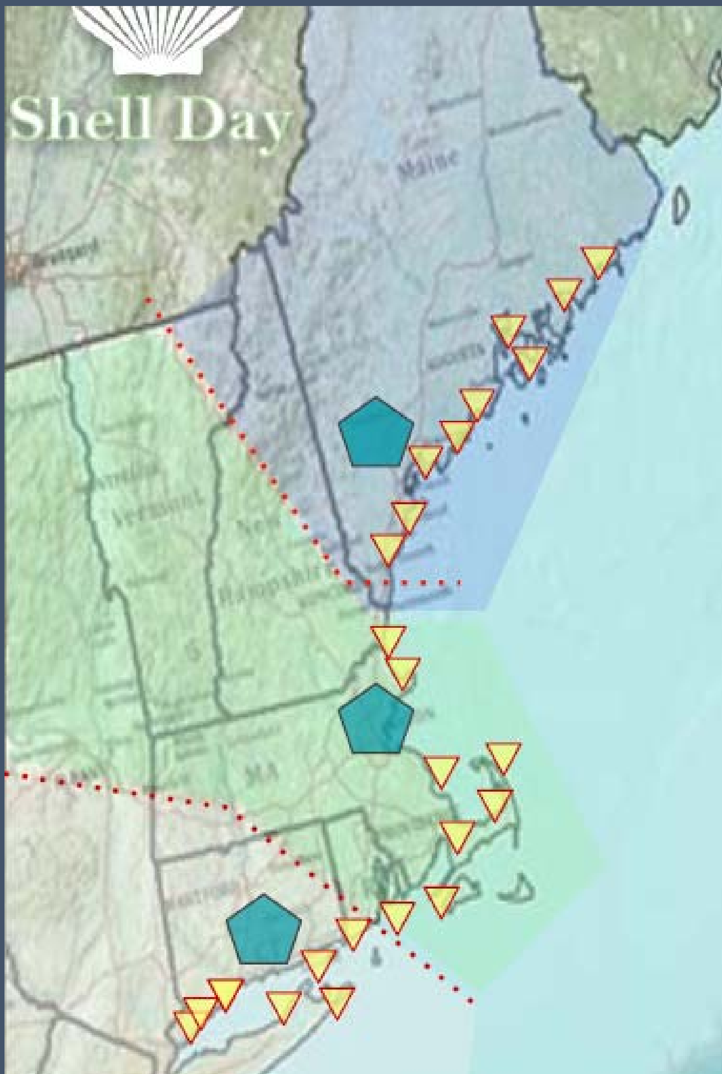

We recruited:

- volunteer monitoring organizations
- laboratories with capacity to measure total alkalinity

1. Cohasset Center for Student Coastal Research
2. North and South River Watershed Assoc
3. Neponset River Watershed Association
4. US EPA Region 1
5. National Park Service
6. New England Aquarium
7. Salem Sound Coastal Watch
8. Swampscott Conservancy
9. Clean Up Sound and Harbor
10. Harbor Watch
11. New England Science and Sailing
12. Setauket Harbor Task Force
13. Derecktor Shipyards
14. Interstate Environmental Commission
15. Save the Sound
16. Salt Ponds Coalition
17. Committee for the Great Salt Pond
18. URI Watershed Watch
19. Save the Bay
20. Salt Ponds Coalition
21. Maine Maritime Academy
22. UMaine Machias
23. Casco Bay Estuary Partnership
24. Maine DEP
25. Friends of Casco Bay
26. Shaw Institute
27. Belfast Bay Watershed Coalition
28. Bigelow
29. Boothbay Region Land Trust
30. Downeast Institute
31. Kennebec Estuary Land Trust
32. Maine Coastal Observing Alliance
33. Mook Sea Farm
34. Rockport Conservation Commission
35. Earthwatch / Schoodic Institute
36. Stormwater Management Research Team
37. UMaine Machias
38. University of New England
39. UNH Marine Docents
40. UNH
41. Cape Cod Cooperative Extension
42. Pleasant Bay Alliance
43. Aquacultural Research Corp
44. Nantucket Land Bank
45. Nantucket Natural Resources Dept.
46. Nantucket Land Council
47. Pond Watch
48. Woods Hole Sea Grant
49. Center for Coastal Studies
50. Plum Island LTER- Marine Biological Lab
51. MIT Sea Grant
52. Town of Mashpee DNR
53. Massachusetts Maritime Academy
54. Barnstable Clean Water Coalition
55. Island Creek Oysters
56. Martha's Vineyard Commission
57. Martha's Vineyard Shellfish Group
58. Wampanoag Tribe of Gay Head (Aquinnah)
59. Buzzards Bay Coalition
60. US EPA Atlantic Ecology Division Lab

Citizen Science and Research Organizations

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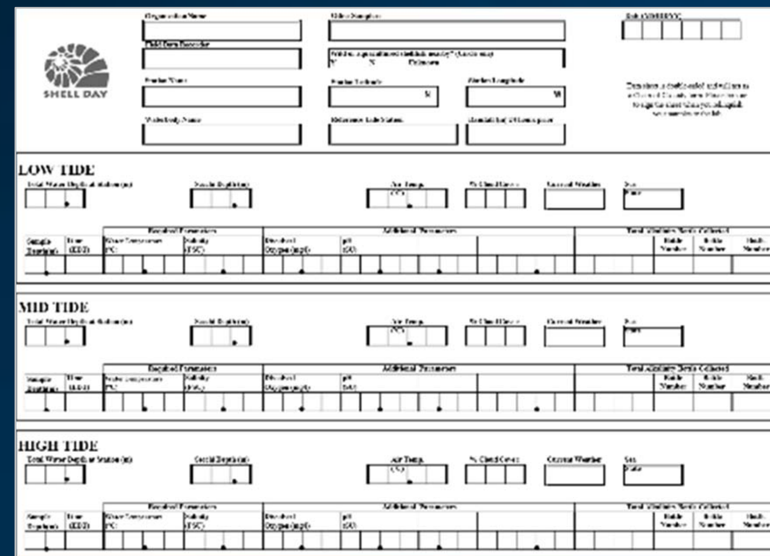
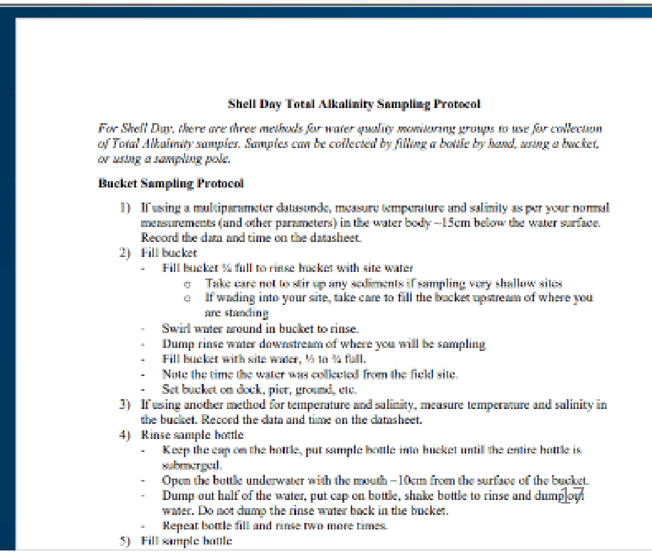
2019

We trained organizations with a video webinar

- Collection of water and measurements
- Data sheet information
- Written sampling protocol and QAPP

all available at NECAN.org



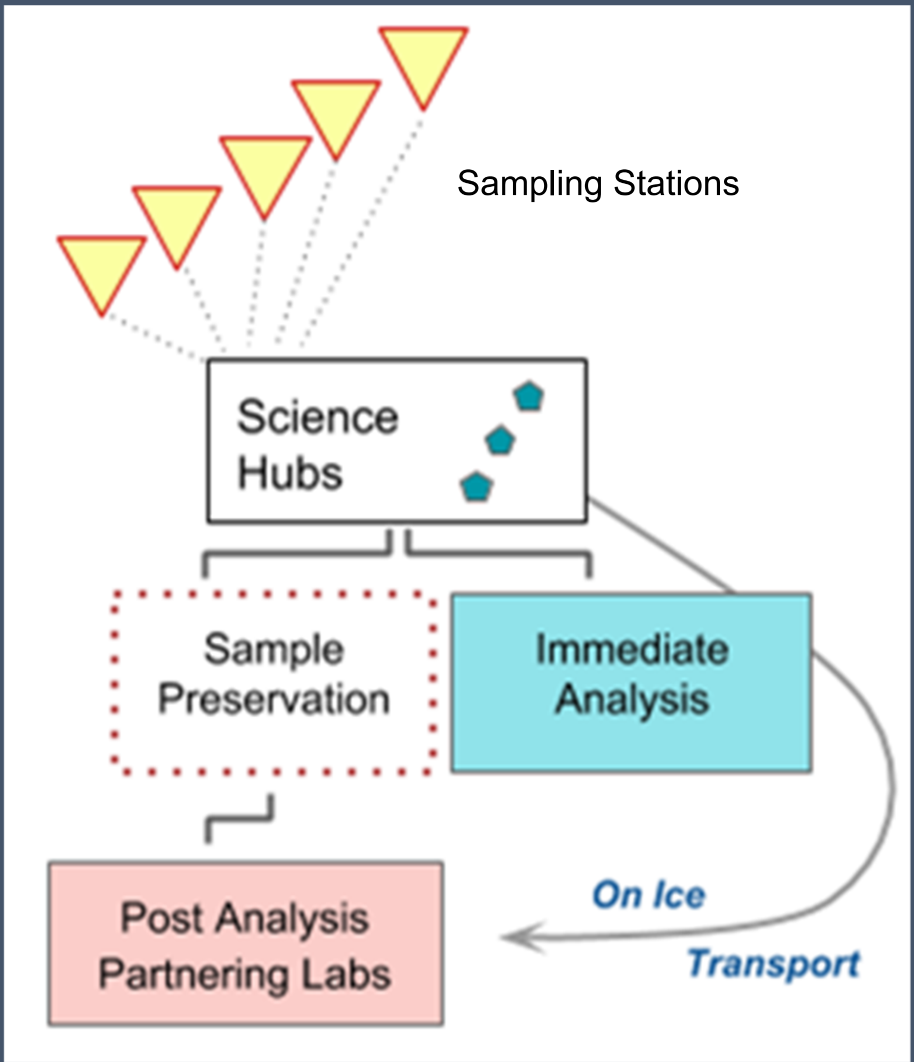


Shell Day Total Alkalinity Sampling Protocol

For Shell Day, there are three methods for water quality monitoring groups to use for collection of Total Alkalinity samples. Samples can be collected by filling a bottle by hand, using a bucket, or using a sampling pole.

Bucket Sampling Protocol

1) If using a multiparameter datasonde, measure temperature and salinity as per your normal measurements (and other parameters) in the water body ~15cm below the water surface. Record the data and time on the datasheet.
2) Fill bucket
   - Fill bucket ¼ full to rinse bucket with site water
     - Take care not to stir up any sediments if sampling very shallow sites
     - If wading into your site, take care to fill the bucket upstream of where you are standing
   - Swirl water around in bucket to rinse.
   - Dump rinse water downstream of where you will be sampling
   - Fill bucket with site water, ½ to ¾ full.
   - Note the time the water was collected from the field site.
   - Set bucket on dock, pier, ground, etc.
3) If using another method for temperature and salinity, measure temperature and salinity in the bucket. Record the data and time on the datasheet.
4) Rinse sample bottle
   - Keep the cap on the bottle, put sample bottle into bucket until the entire bottle is submerged.
   - Open the bottle underwater with the mouth ~10cm from the surface of the bucket.
   - Dump out half of the water, put cap on bottle, shake bottle to rinse and dump out water. Do not dump the rinse water back in the bucket.
   - Repeat bottle fill and rinse two more times.
5) Fill sample bottle



Our science team distributed labeled bottles and data sheets to organizations

We asked volunteers to take a surface sample and collect water from a bucket

Salinity was measured from the bucket using a refractometer or other device

Sometimes organizations measured salinity using a sonde (*in situ*) not in the bucket

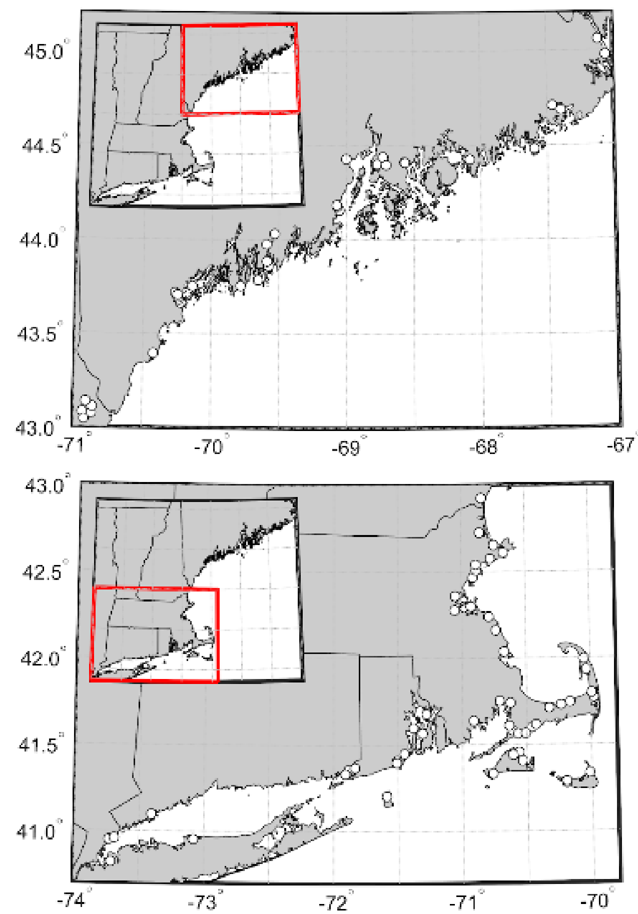
We hosted Open Houses at laboratories when organizations delivered samples

405 water samples collected

70 sampling stations

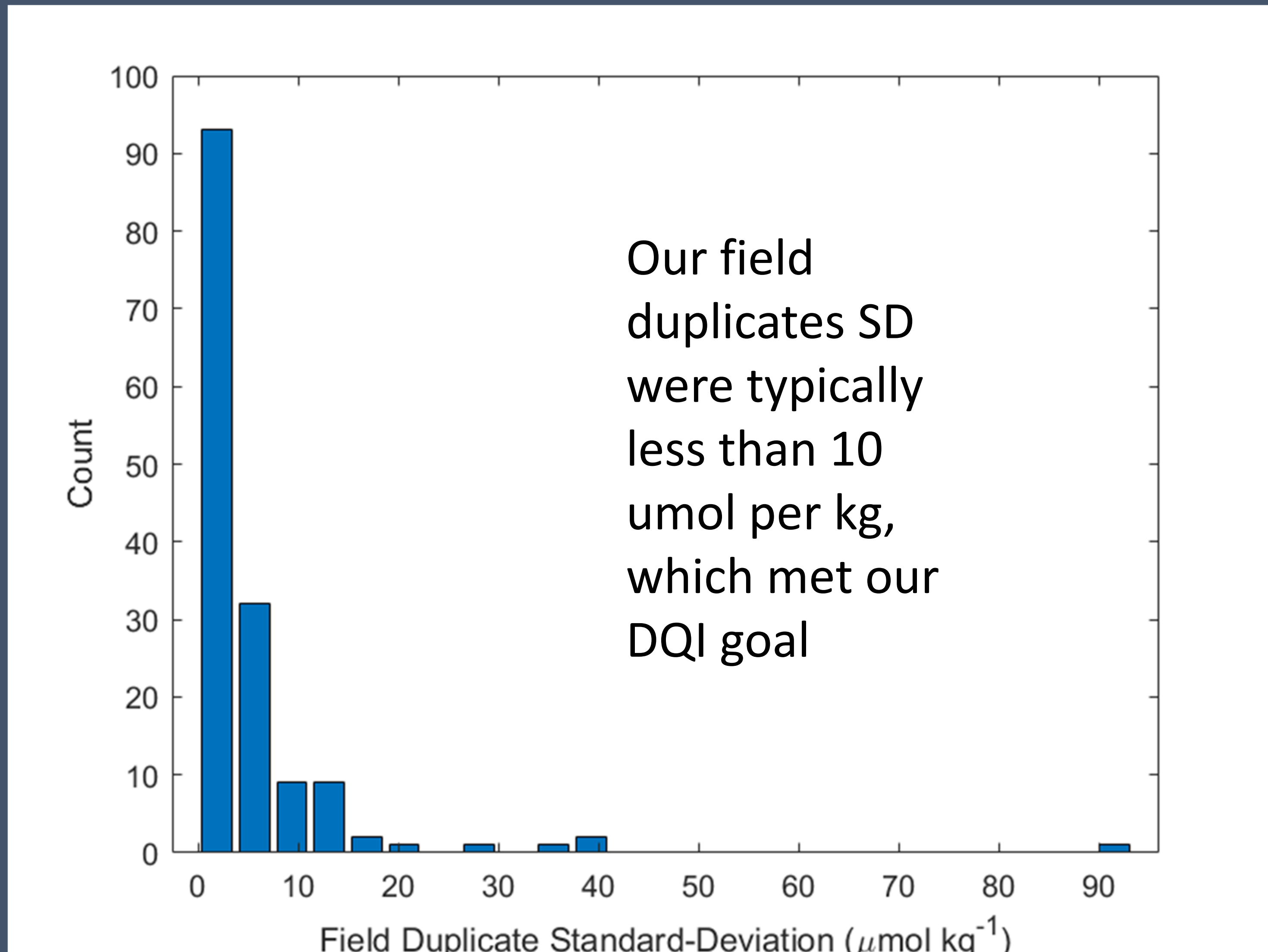
57 monitoring organizations

7 laboratories analyzed samples



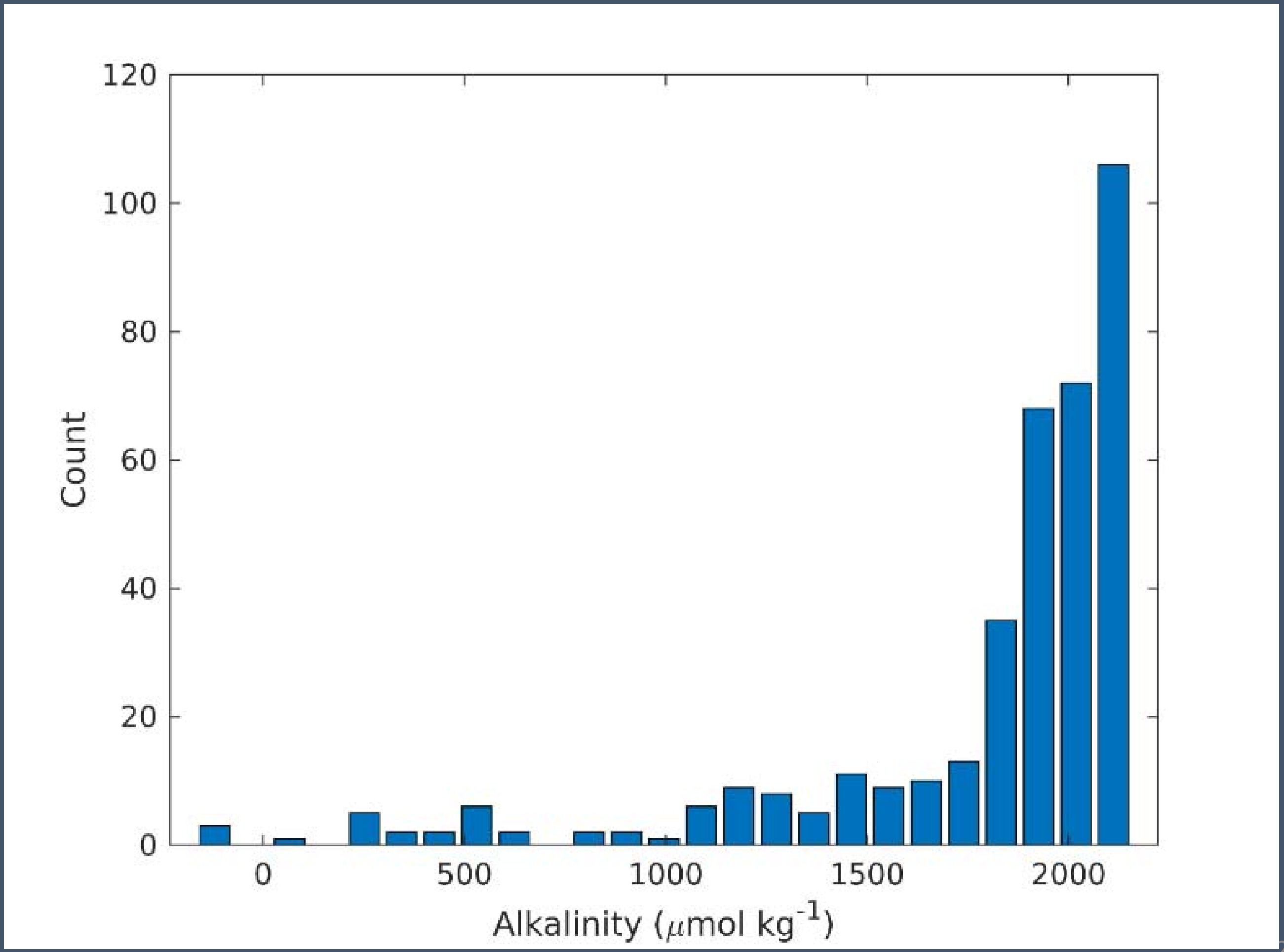
We flagged data if they did not meet DQI goals for:

- laboratory duplicates
- field duplicates
- expected range
- Certified Reference Materials



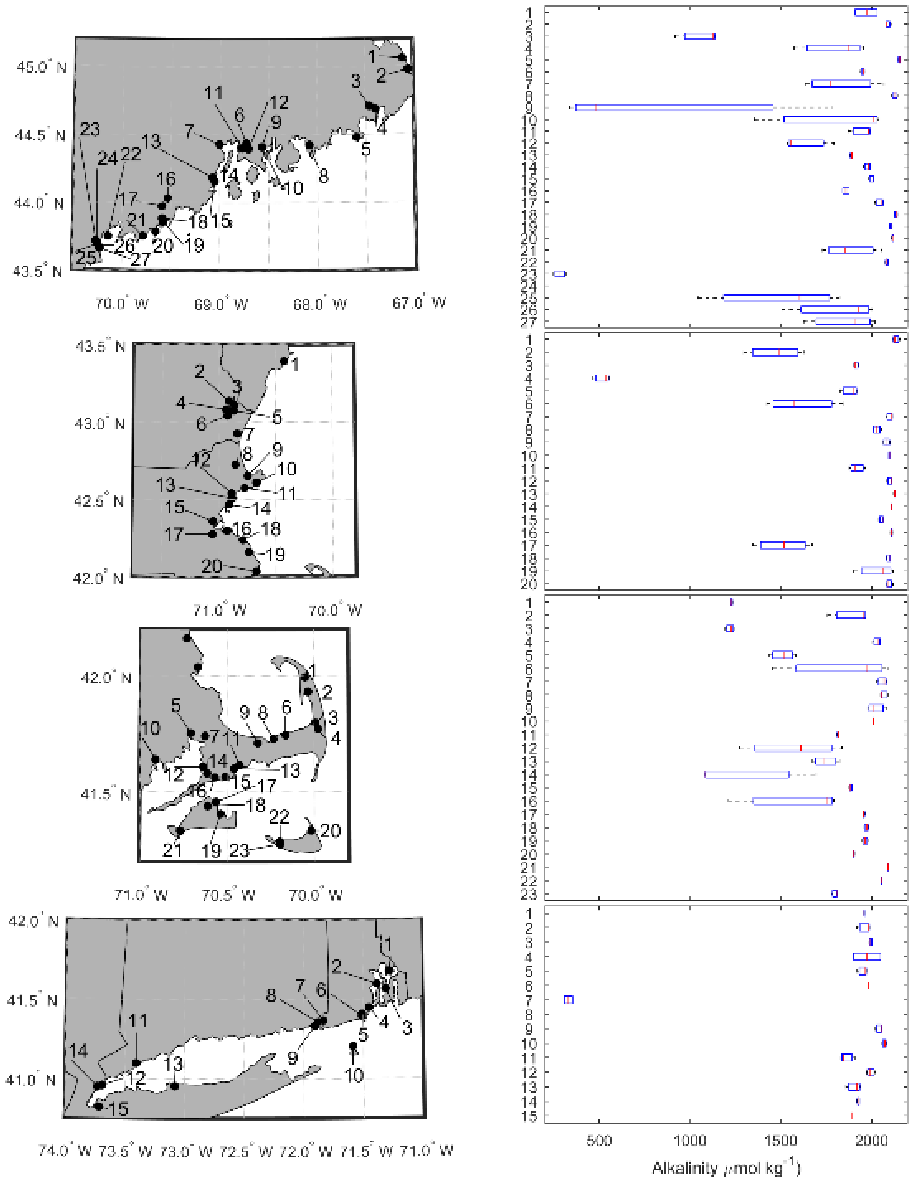
Here is what we found out!

TA ranged from less than 500 to over 2000 umol/kg



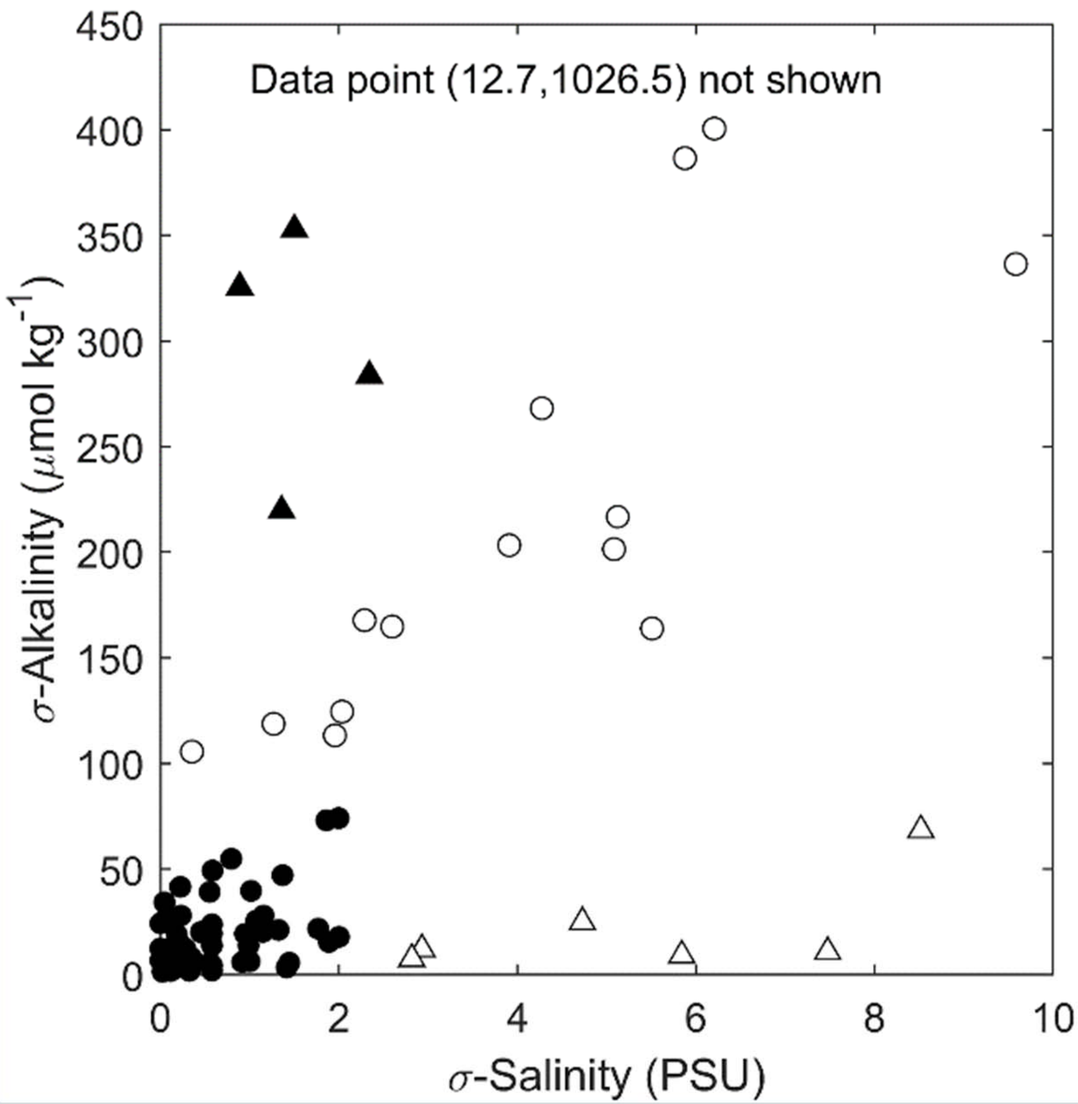
ME/NH: lower TA
(and more variation)

CT/NY: higher TA
(and less variation)

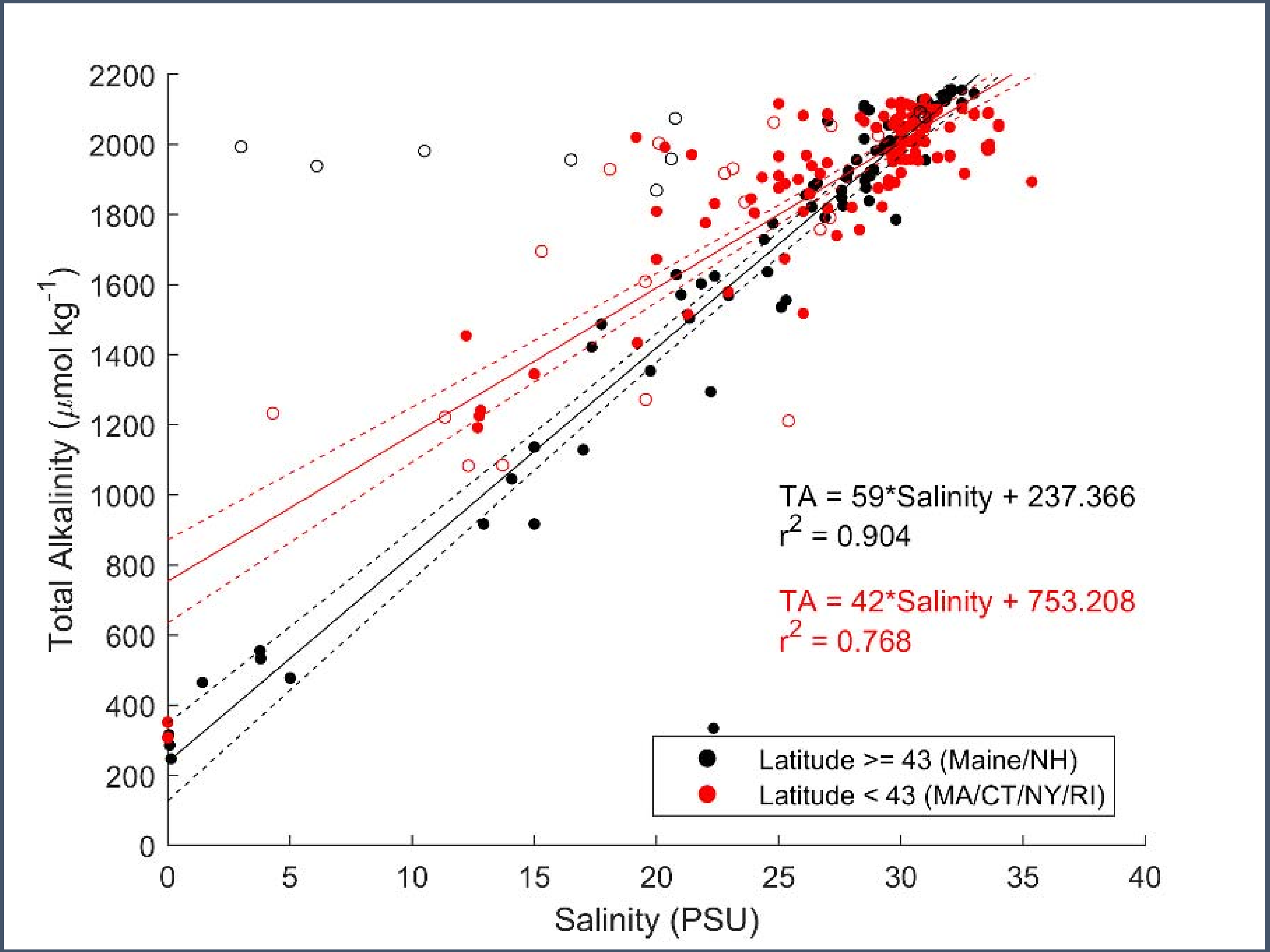


We observed four patterns of variation in total alkalinity and salinity

1. low variation in both total alkalinity and salinity (n=52)
2. low variation in salinity but high variation in alkalinity (n=4)
3. high variation in salinity but low variation in alkalinity (n=6)
4. proportional variation in both salinity and total alkalinity (n=18)



Total Alkalinity was <u>somewhat</u> related to salinity



Possible causes for lack of overall strong relationship

- Some of the salinity measurements were higher than expected range
- Some refractometer measurements were not well calibrated, as verified by comparison to laboratory measurements
- It is possible that some stations sampled salinity with a sonde that was not as representative as the well-mixed bucket sample
- Actual natural variability caused by local sources of TA or DIC (e.g. salt marshes or riverine sources)

Shell Day Conclusions and Lessons; It Worked!

- We were able to organize a large scale collaborative sampling event
- First regional picture (or Snapshot) of TA variability across New England along a tidal cycle
- Our QAPP helped guide us, and our QC was good
- Total Alkalinity varied widely across the region with some stations showing potentially low alkalinity and or high variability over a tidal cycle
- Couldn’t establish a strong relationship region wide for TA-salinity
- Found interesting patterns in tidal variability
- Hypothesized a few factors to explain variability
- Blitz sampling can be used to target further sampling
- Participating organizations contributed to the understanding of coastal acidification and of potential vulnerabilities in their local embayments

Special Thanks to our Partners

Laboratories:

Dan McCorkle/Jennie Rheuban - WHOI
Ryan Woosley - MIT
Penny Vlahos - UCONN
Chris Hunt/Joe Salisbury - UNH
Katherine Guay/Michelle Lavigne - Bowdoin
Adam Pimenta/Jason Grear - EPA Atlantic Environmental Sciences Division
Justin Ries - Northeastern Univ

And the many volunteer monitoring organizations

Maine, MIT, Woods Hole