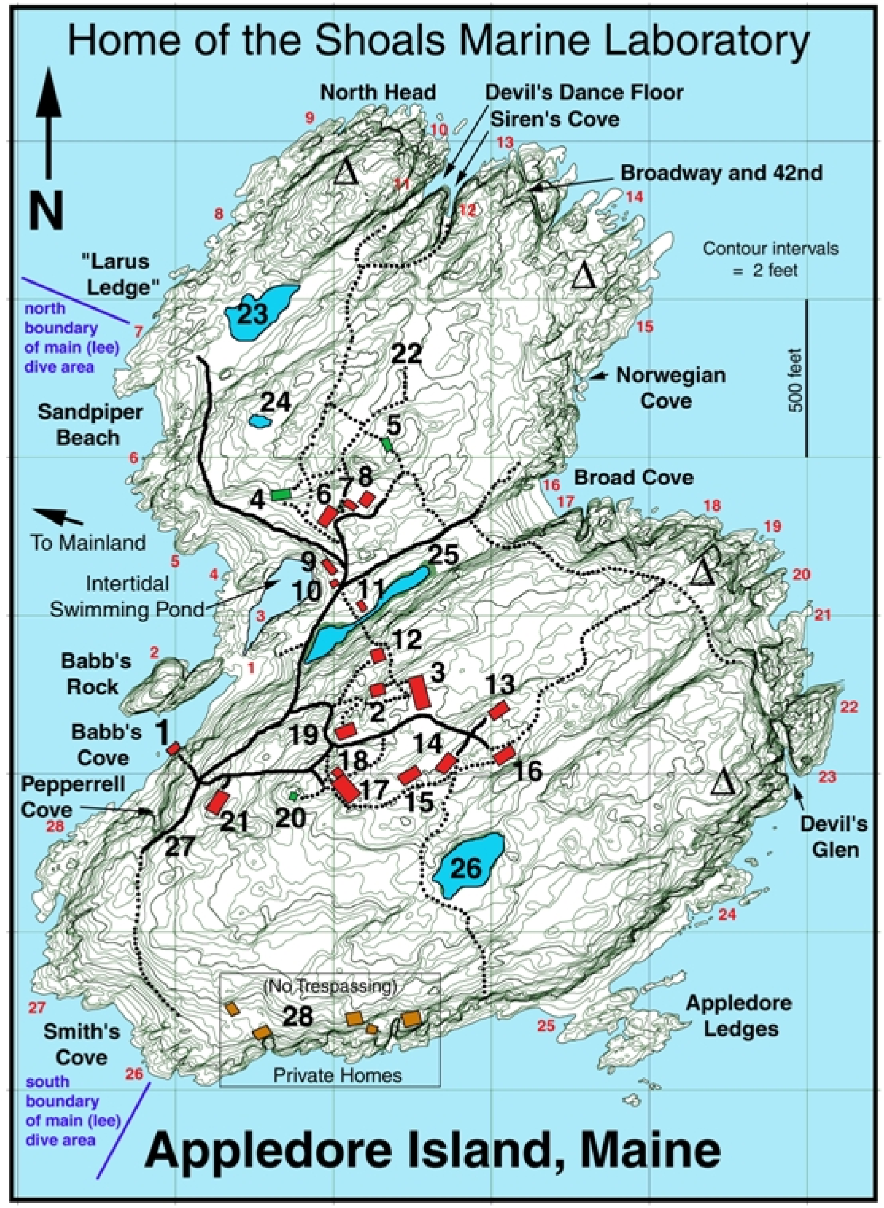
Appledore Field Trip
UNH Department of Earth Sciences
September 9, 2017



Itinerary

8:00 Meet at James and leave for New Castle

9:00 Board R/V Gulf Challenger at UNH Pier, New Castle, NH

9:45 Arrive Appledore Island

10-12 Walking tour/discussion of notable features on island (see numbers and labels on map)

- Shoals Marine Lab water supply well (22)
- Tidal pools
- Geologic features at "Broadway and 42nd"
- Broad Cove
- Crystal Lake (26)
- AIRMAP monitoring station (18)
- Glacial features and sea level change

12:30 Lunch provided at Sunset Pavillion (20)

1-2 Free time to explore

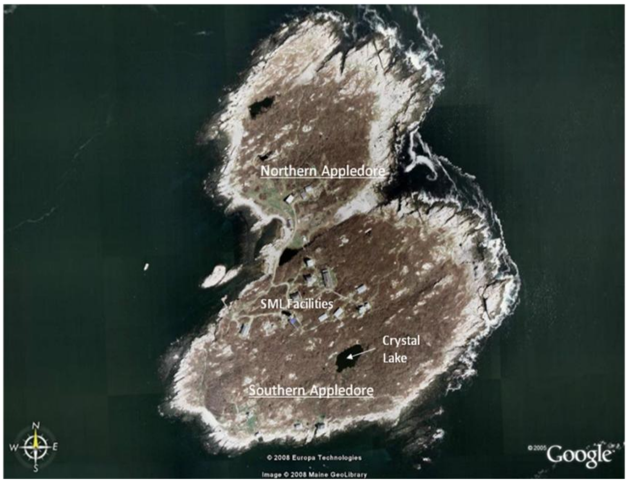
2:00 Board R/V Gulf Challenger, depart island

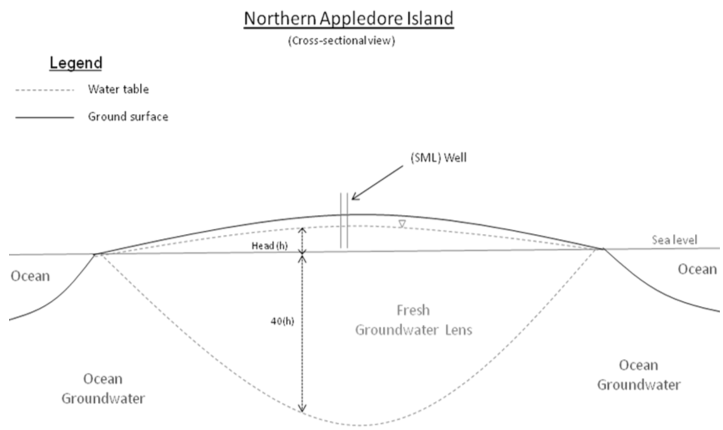
2:45 Arrive UNH Pier

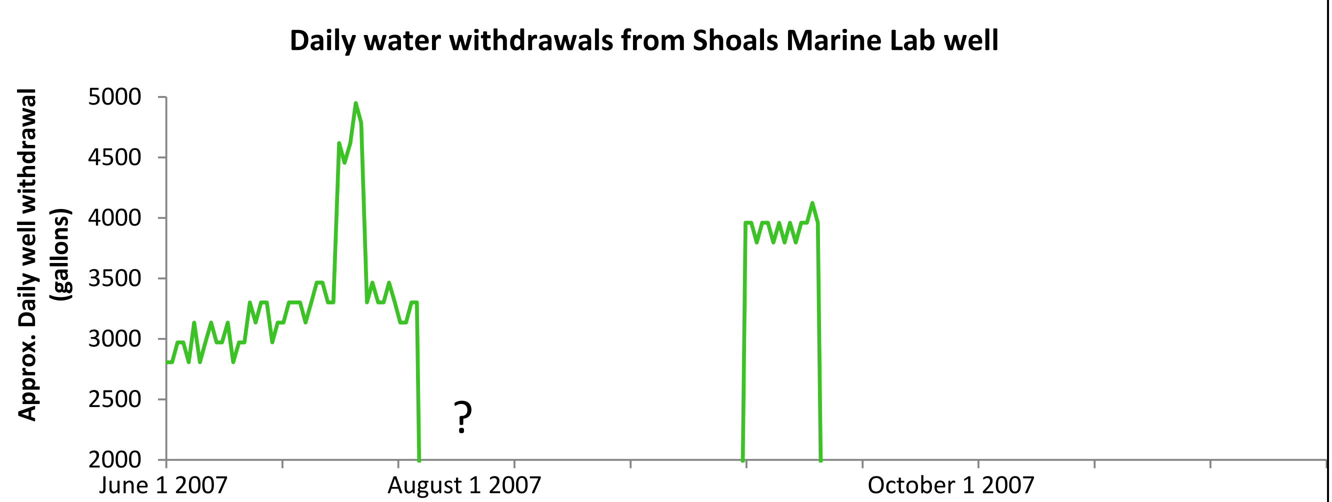
3:15 Arrive at James Hall

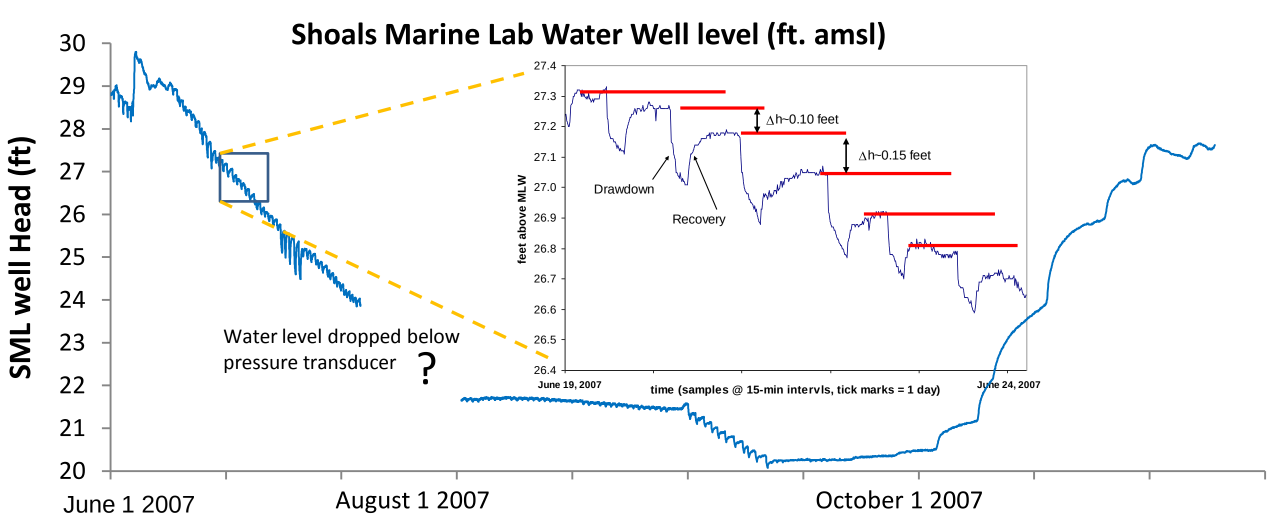
Hydrology & Groundwater Resources of Appledore Island, ME

Jonathon Felch (BS EnvSci '07) & Matt Davis









Rockpool Nutrient Dynamics

Reference: Loder, T.C, Ganning, B. and Love, J.A (1996). Ammonia nitrogen dynamics in coastal rockpools affected by gull guano, *Journal of Experimental Marine Biology and Ecology*, 196, 113-129.

Nutrient Sources to Rockpools Near Gull Rookeries

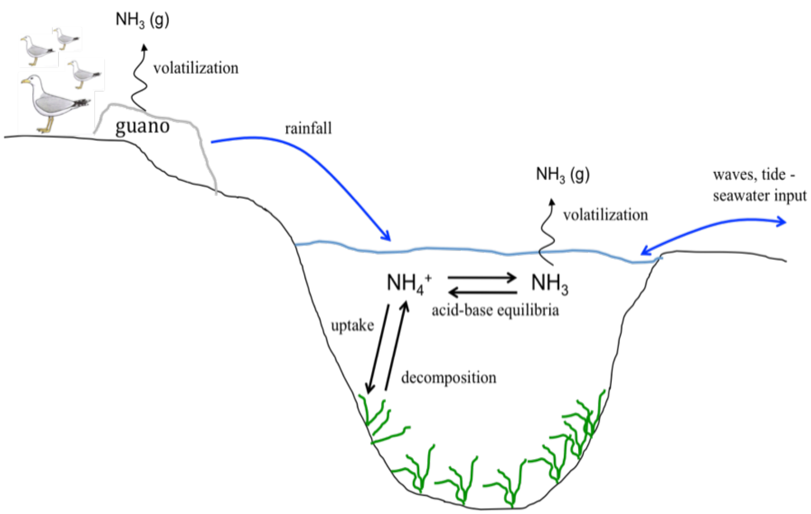


Figure 1. Illustration of ammonia dynamics and sources in rockpools.

Input of Nitrogen Due to Rainfall

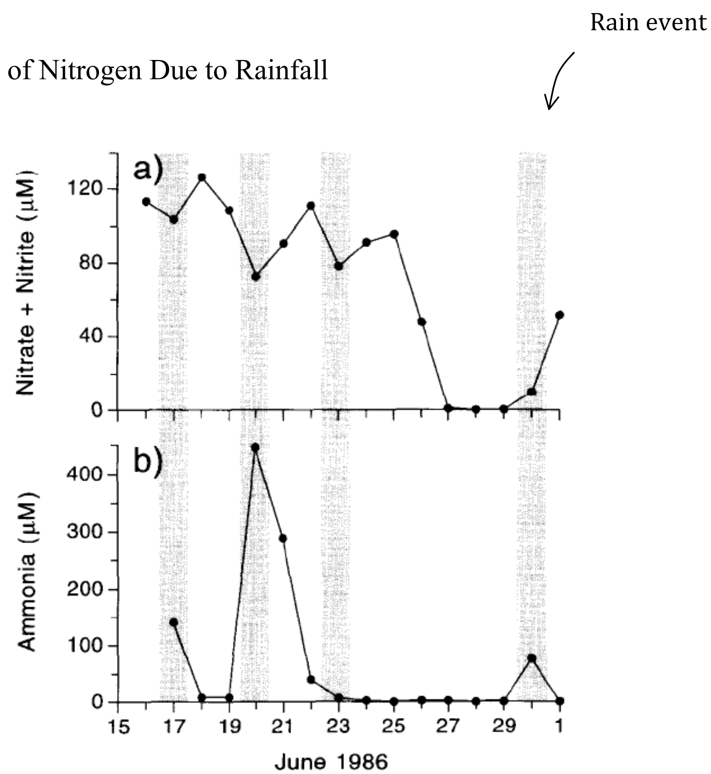


Figure 2. Daily changes of (a) nitrate + nitrite and (b) ammonia concentrations. Collected at 1 pm each day in Paradise Pool. Grey bands indicate when rainfall occurred (from Loder *et al*. (1996)).

Daily Changes in Total Ammonia Concentration in a Rockpool

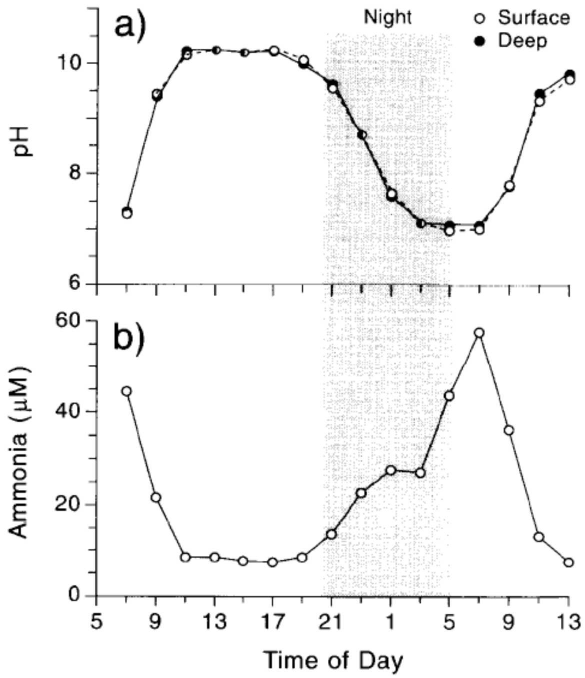


Figure 4. Changes of pH and ammonia concentration in Paradise Pool recorded every two hours in June (from Loder *et al.* (1996)).

Equations:

Total ammonia = $NH_4^+(aq) + NH_3\ (aq)$

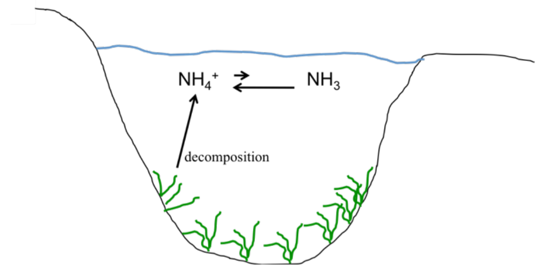
$$NH_4^+\ (aq) + H_2O \leftrightarrow NH_3\ (aq) + H_3O^+$$

ammonium — ammonia

$NH_3\ (g)$ ammonia gas

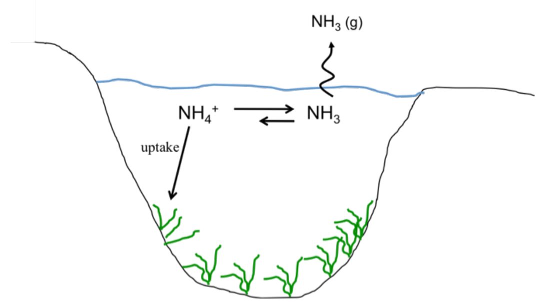
Night-time – high total ammonia concentrations

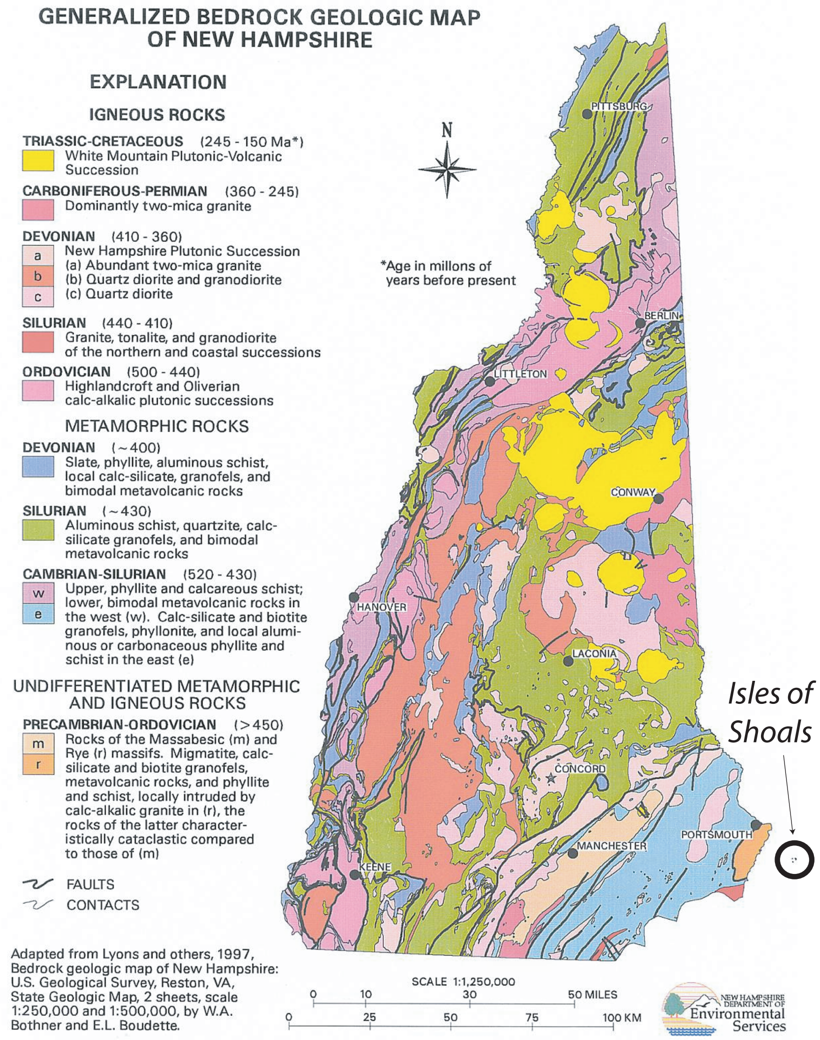
- Decomposition releases CO_2 and drives the pH down (pH ~ 7)
- Ammonium release from decomposing organic matter
- NH_4^+ dominates over NH_3 due to lower pH
- No ammonia exchange with the atmosphere



Day time – low total ammonia concentrations

- Photosynthesis consumes CO_2 and drives the pH upwards (pH >10)
- NH_3 concentration rises
- Ammonia volatilizes
- Loss of nitrogen from the rockpool
- Wind carries ammonia gas away

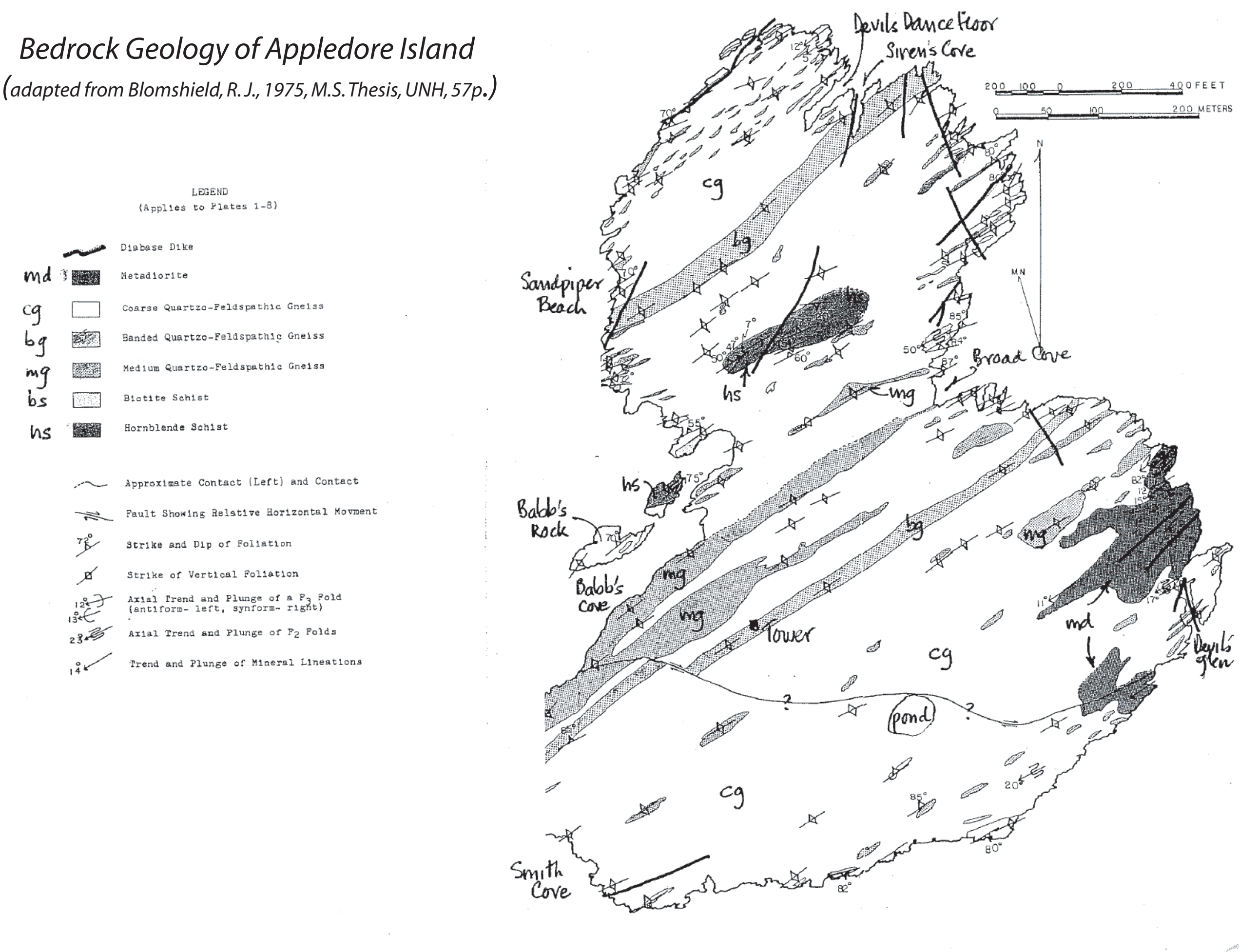




Map of Appledore Island (www.goshoals.org)

Bedrock Geology of Appledore Island

(adapted from Blomshield, R. J., 1975, M.S. Thesis, UNH, 57p.)



GSNH 2008 SUMMER FIELD TRIP

Appledore Island and the Isles of Shoals, Maine and New Hampshire

July 13, 2008

Comtemplating the Rye on Star Island in the 1950's, one of Brian Fowler's earliest geologic quandries

A walkabout Appledore Island, the largest of the Isles of Shoals, provides a fine introduction to the rocks characteristic of the 9-island archipelago 10 kilometers off the coast of New Hampshire and Maine. They and Boon Island to the northeast (hopefully visible today) are the only exposed bedrock highs between Cape Ann, MA and Portland, ME. Both island groups are underlain by metamorphic rocks of lower Paleozoic (or older?) age that have been multiply deformed and intruded in middle Paleozoic and again in Mesozoic time. The rocks have been correlated lithologically to those on the immediate New England coast, and confirmed by the careful scuba mapping and sampling in between by John Brooks (1986, 1990). All the islands have been shaped and scoured clean by glaciation and subsequent wave activity. They have occupied both larger and smaller physiographic "footprints" on and off the evolving New England coastline as sea level varied over the last 12,000 years or so (Fowler-Billings, 1959; Novak, 1971). There's much to see geologically, most of the evidence is clear, but there is much else to consider on these rocky outposts -- their geologic, biologic, and human history can fill many pleasant and challenging hours. We hope your visit will whet your appetite for more.

The rocks: Appledore and its nearest neighbors are underlain by variably deformed metsedimentary and metaigneous rocks correlated with the Rye Complex on the NH and ME coast (Fowler-Billings, 1959; Bloomshield, 1975). They are dominated by gray quartzofeldspathic (granitic) gneisses, coarse-grained biotite-rich, blastomylonitic quartzofeldspathic gneiss, and, only on Appledore and New Castle islands, metadiorite. Less common are pelitic schist and amphibolite, both commonly folded, that occur as enclaves in the gray gneisses and as map-scale bands across the island. These rocks preserve evidence of multiple stages of deformation (best seen in the folds), probable migmatization (partial melting), injection of dioritic and granitic magma, and the subsequent development of variable foliation, boudinage and shear fabrics.

The relative ages of rocks and relative timing of events can be easily worked out using the laws of cross-cutting relations and superposition, but the "absolute" ages remain equivocal. They are constrained by correlation with dated rocks on the mainland (Lyons and others, 1997; Bothner and Hussey, 1999; Hussey and others, in press). Like the Rye at New Castle and Gerrish Islands, the host rocks on Appledore were metamorphosed and deformed prior to the emplacement of mid-Devonian diorite and granite, deformed again during Permian shear, and intruded again during initial stages of the opening of the Atlantic Ocean. The abundant diabase dikes here and on the mainland attest to that stage of extension which was also accompanied by widespread plutonic/volcanic activity preserved at Mount Agamenticus, Cape Neddick, and the explosion breccias exposed on the shore of Gerrish Island (Hussey and others, in press).

Please watch your step...and it's also a good way to keep an eye on the rocks! The attached maps, airphoto, and groundwater profile should help with location and provide a basis for discussion. We'll decide the route (1 or 2) when we get there --- time, weather, and interest dependent. Enjoy the day!

References:

Bloomshield, R. J., 1975, Superposed deformations on the Isles of Shoals, ME-NH: Masters thesis, University of New Hampshire, 48 p.

Bothner, W. A. and Hussey, A. M., II, 1999, Norumbega connections: Casco Bay, Maine to Massachusetts?: in Ludman, A., and West, D. P., eds., Norumbega Fault System of the Northern Appalachians: Geological Society of America Special Paper 331, p. 59-72.

Brooks, J. A., 1986, Bedrock geology of New Hampshire's inner continental shelf: Masters thesis, University of New Hampshire, 127 p.

Brooks, J. A., 1990, The petrogenesis of the Agamenticus Complex and late Paleozoic and Mesozoic tectonics in New England; Ph.D. dissertation, University of New Hampshire, 315 p.

Fowler-Billlings, K., 1959, Geology of the Isles of Shoals: New Hampshire-Division of Economic Development Bulletin, 51 p.

Hussey, A. M., II, Bothner, W. A., and Thompson, P. J., in press, Geology of the Kittery 100,000 quadrangle, Maine and New Hampshire; Maine Geological Survey Open-File map 08-xxx.

Lyons, J. B., Bothner, W. A., Moench, R. H., and Thompson, J. B., Jr., 1997, Bedrock Geologic Map of New Hampshire: U. S. Geological Survey.

Novak, I. D., 1971, Origin and distribution of gravel on Broad Cove Beach, Appledore Island, Maine: NEIGC Guidebook for 1973, Concord, NH, 8 p.

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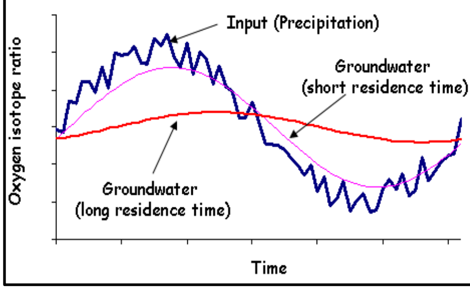
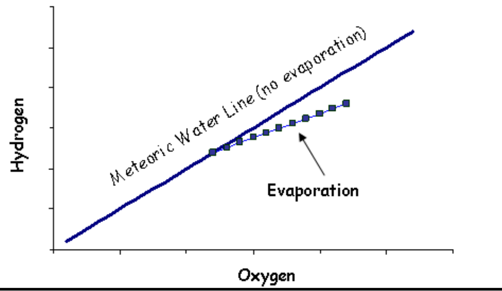
Appledore Island – Water Isotopes

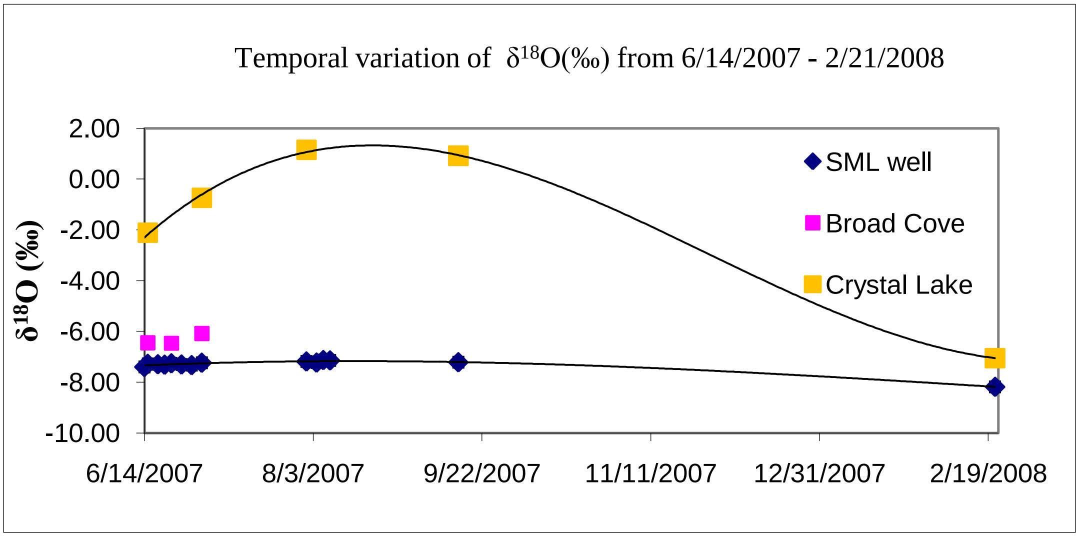
Isotopes of oxygen and hydrogen are helpful in understanding the hydrologic cycle on the island. The response to periodic forcing (precipitation) gives insight into residence times and the co-variation of $\delta^{18}O$ (‰) and δD (‰) gives insight into the magnitude of evaporation in the different parts of the island.

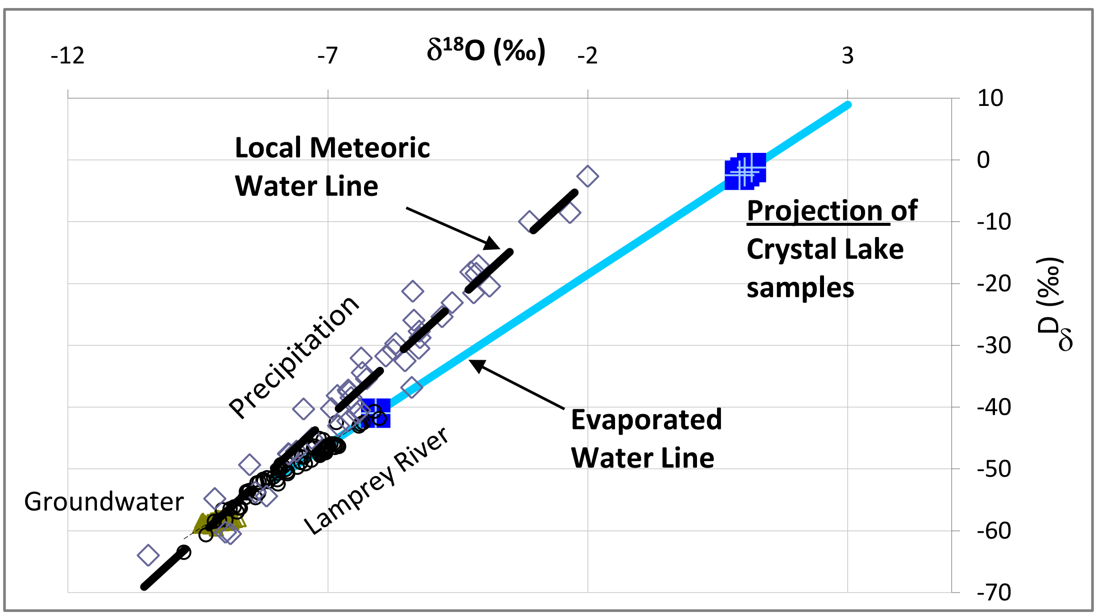
Schematic Illustration of Stable Isotope Ratios



Effect of Evaporation on Stable Isotope Ratios







UNH ATMOSPHERIC CHEMISTRY ON THE APPLEDORE TOWER

The **METEROLOGICAL STATION** is the first important group of instruments on top of the tower. It is located at the highest point sitting just above the 10' section of metal tower. The first part is the sonic anemometer. This instrument tells us the wind speed and direction so we can understand how fast and where air masses are traveling from. We also measure the atmospheric pressure, relative humidity, temperature, and precipitation.

An exciting area of study is **MERCURY** in our environment. Here we are measuring total gaseous mercury in the atmosphere but also characterizing reactive mercury and particulate bound mercury, two components that make up the total amount of mercury. These units trap the various forms and then carry them down to the instrumentation room where they are analyzed.

We also have a **WEBCAM** here so that along with our constant data transmission to UNH we can monitor the station, even when we are not on the island. You can find a link to this webcam and more project information at **www.airmap.unh.edu**

There are various types of **RAIN COLLECTORS** on the tower. One simply measures the amount of precipitation while the others we bring back to UNH for analysis. We are able to research what things, such as mercury, and what quantities are stripped from the atmosphere during a precipitation event. These units require someone on the island to collect the samples after each storm.

The large enclosure in the center houses a **MICRO-PULSE LIDAR**. The LiDAR, which stands for "Light Detection And Ranging", measures a vertical profile of aerosol and cloud structure in the atmosphere. This unit is one of only a few dozen in the world and along with other contributing universities and agencies sets up a network that provides information for studying a large range of issues including climate change, aerosol transport and validation of satellite measurements.

The **CEILOMETER** operates much like the LiDAR. It sends a laser pulse into the sky and measures the return time as the beam bounces back off of aerosols and clouds. The main difference between the two instruments is the height to which they measure. The ceilometer looks at aerosols and cloud heights below 1 kilometer (within the planetary boundary layer) while the LiDAR is powerful enough to measure to 30 kilometers.

The **SUN PHOTOMOTER** is another powerful tool which is linked to a worldwide network that collects data on aerosol optical depth and properties, as well as radiance both from the sun and off of the ocean surface. Like most of our instrumentation it is fully automated and programmed to run a series of measurements every 15 minutes on sunny days.

The **VISIBILITY SENSOR** is a tool commonly used at airports and in research to watch and record the weather. It can accurately make distinctions between dozens of conditions such as snow, fog, haze, ice, rain, dust as well as the rate of precipitation.

The **PYRANOMETER** and **PYRGEOMETER** sit closest to the tower on the pole that extends over the edge. The pyranometer measures the solar radiation spectrum between the wavelengths of 300 to 2,800 while the pyrgeometer measures the infra-red radiation spectrum between 4.5 µm to 100 µm.

The **J(NO2)-RADIOMETER** determines the rate of nitric dioxide photolysis in the atmosphere. In other words by looking at radiation in all directions we can measure how fast the nitric dioxide molecule breaks down due to photons hitting it. This reaction is a precursor for forming ozone.

INSIDE THE TOWER are two instrument racks. On the left we are measuring **MERCURY** (bottom) and **OZONE** (top). On the right side are **CARBON DIOXIDE** (top) and **CARBON MONOXIDE** (bottom) analyzers. For these units we rely on a manifold system (behind the racks) that pulls sample air from outside at a very high rate. We have two laptops that collect data from every instrument and send it back to UNH every 15 minutes for analysis.

Post glacial sea level changes & Bathymetric Map

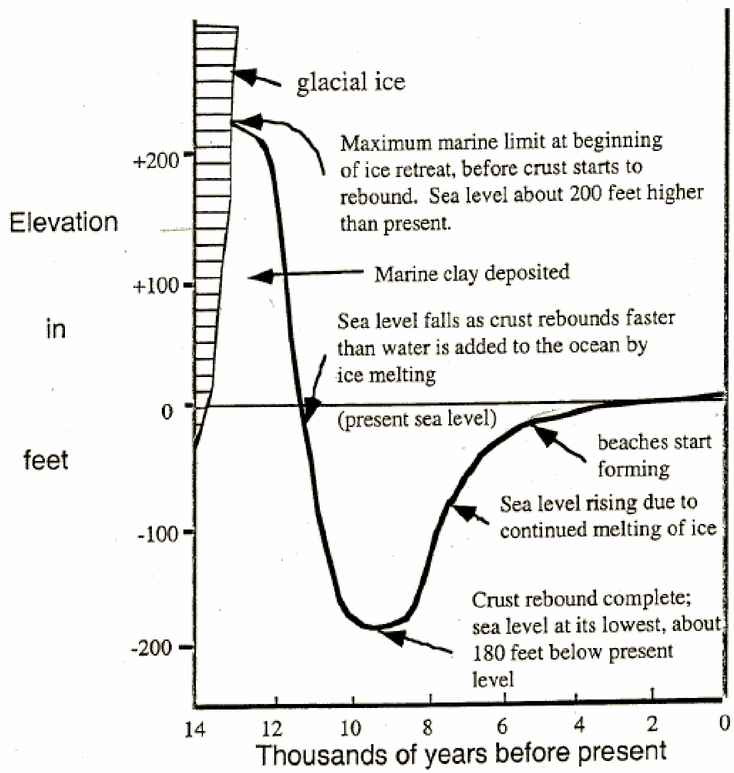
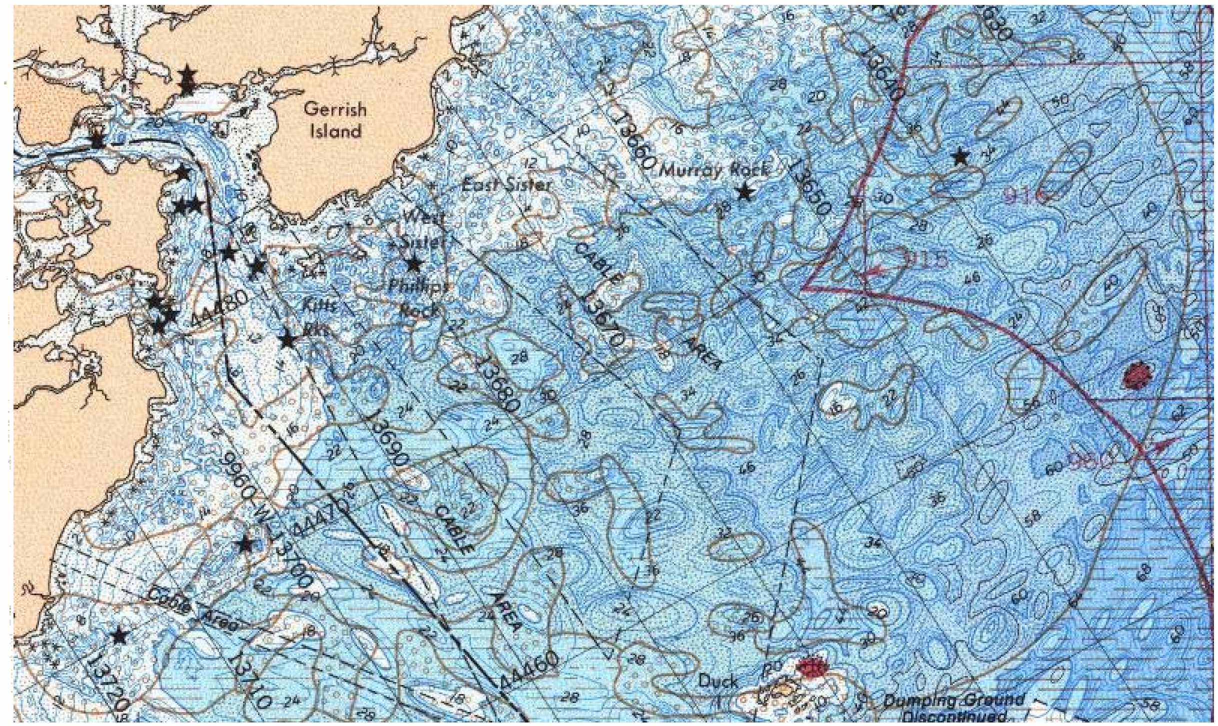


Figure 19. Sea level curve from the beginning of deglaciation to the present time (after Belknap, Anderson, Anderson, Anderson, Borns, Jacobson, Kelley, Shipp, Smith, Struckenrath, Thompson, and Tyler, 1986, Late Quaternary sea-level changes: in Maine: in Nummedal, Pilkey, and Howard, eds., Sea Level Rise and Coastal Evolution, SEPM Spec. Publ.



Source: NOAA NGDC Office of Coastal Survey Map F-73