““Goldie” the Great Pond Sentinel. Using an automated sampling buoy to monitor water quality of Great Pond.”

Whitney King, Kiana Kawamura, Rebecca Chmiel, Haiyang Tang

Department of Chemistry

Denise Bruesewitz

Environmental Studies

Colby College

Waterville, Maine

Supported by National Science Foundation award #EPS-0904155 to Maine EPSCoR at the University of Maine
Hydrology of the Belgrade Lakes Chain
Great Pond
Volume 2.130E+08 m³
Area 3.383E+07 m²
Area 8.360E+03 acres
Average Depth 6.297E+00 m

Volume Analysis

50%
20%
10%

Volume of Interval (m³)
Depth (m)
Great Pond Depth Profile and Nutrient Dynamics

North Wind

Surface water flow

Bloom

Upwelling

Epilimnion
- Warm
- Oxygen saturated
- Low phosphorus

Hypolimnion
- Cold
- Low oxygen
- High phosphorus

PO₄ flux

Distance from South to North on the Lake
Secchi Depths of East Pond

Volunteer Science
MB300 and SDL500
SDL500 Data Logger
**Parts List**

- NexSens MB-300 Data Buoy (1)
- NexSens MB-300 Aluminum Buoy Tower (1)
- Carmanah M502 1 Nautical Mile Solar Marine Light (1)
- NexSens SP5 5-Watt Solar Power Pack (3)
- NexSens SDL500C Cellular Data Logger (1)
- NexSens A49-SDL High Gain Cellular Antenna (1)
- NexSens MB-MAST Weather Sensor Tower Extension (1)
- LI-COR LI-190SZ PAR Sensor (1)
- LI-COR LI-192SA Underwater PAR Sensor (1)
- Zebra-Tech LI-COR LI-192 Hydro-Wiper (1)
- NexSens M-ARM-P Underwater PAR Sensor Mounting Arm (1)
- NexSens T-Node FR Water Temperature String (10)
- NexSens Underwater Cable Assemblies (10) NexSens UW-2W-A
- NexSens iChart 6 Software (1)
- PONSEL CALSENS Software (1)
- Dissolved Oxygen Sensor (2) Turner Designs Cyclops-7
- Chlorophyll Sensor (1) Turner Designs Plastic Cyclops-7 Shade

**Total Hardware Cost $25,000**

**Facilities List**

- Large Boat with trailer
- Verizon Cellular Service
- Land-based Server
- Tools and Test Equipment
- Support personnel

**Annual Support Cost $3,000**
Wind vectors show the direction that the wind is blowing. The angle of the arrow shows the direction of the wind, and the length shows the wind speed in MPH. North is straight up. Notice the prevalence of North and South winds on Great Pond.
Contour plot of Great Pond temperature. Notice the warm surface water, thermocline where all the contour lines are close together and the deep bottom water. Oxygen concentrations are included on the plot in units of percent saturation.
These plots show the temperature profile of the lake alongside the volume profile of the lake.

Great Pond has significant areas with shallow water with the lake volume profile similar to a margarita glass. Water deeper than 12 meters is cold, often depleted in oxygen, but also less than 10% of the volume of the lake. If the thermocline shallows significantly then considerably more of the lake water could become anoxic – an example of negative feedback.

Volume profile of the lake. The top 1 meter of the lake contains 35 million cubic meters of water, or about 9 billion gallons. Each layer contains less and less water with the deepest parts of the lake containing about 10% of the total volume. The lake doesn’t have negative volumes. The plot is reflected across zero to help illustrate the shape of the lake.
Great Pond, Belgrade Maine

S at 1 with gusts to 2 MPH

Surface flow

South End of Lake

North End of Lake

Unhappy Fish

Data Age (min): 20

06/24/13  11:10 PM

Go to Colby College

Open Weather Data in Web Browser

Go to Maine Lakes Research Center
Does Anyone Care?
The Schmidt Stability is a calculation of the lakes resistance to mixing.
Water Temperature

Depth (m)

May Jun Jul Aug Sep Oct Nov

0  5  10  15  20  25  30
Thermocline Depth 2013
Including top, middle, and bottom of thermocline

Depth (m)

5/1 5/31 7/1 8/1 8/31 10/1 11/1
Oxygen Concentrations at 2 and 16 meters (PPM)

Oxygen Loss 0.1 PPM/day

115 = 4/26/2013
181 = 7/1/2013
212 = 8/1/2013
\[
\text{ZOOM IN}
\]

\[
\text{\textbf{Equation}}
\]

\[
\text{\textbf{Text}}
\]

\[
\text{\textbf{Diagram}}
\]

\[
\text{\textbf{Legend}}
\]
30 days of Oxygen, Wind, and Sunlight

242 = 9/1/2013
Oxygen

Fluorescence

242 = 9/1/2013
Dynamic Graphs
Temperature (°C) in Great Pond 8/23/2006, Day 233

Distance south to north (km)

Depth (m)
“Goldie” the Great Pond Sentinel: Telling the Seasonal Story of Lake Dynamics to a Stakeholder Audience.

Kiana Kawamura, Rebecca Chmiel, Haiyang Tang, Denise Bruesewitz and D. Whitney King

Data Collection: Goldie is an automated sampling buoy deployed in the deepest point of Great Pond. Built by Nexsens Technology, the buoy is a highly capable platform for limnology research; equipped with a suite of sensors for measuring water temperature, light, dissolved oxygen concentration (surface and bottom), and fluorescence. The buoy is powered by 15-watt solar panels and communicates to our labs at Colby using a dedicated cell phone. Although Goldie provides extremely detailed data for the limnology professional, the information is not easily understood by the stakeholder community.

To promote communication, we are experimenting with a range of web-based display options:
- Real time weather
- Real time lake profiles
- Calculated fields
  - Secchi
  - lake physical properties
  - lake biological properties
  - lake “video games”

Analysis: Lake Analyzer is a GLEON supported analysis tool using water temperature, wind speed, and bathymetry to calculate stability variables such as Schmidt Stability, Wedderburn Number, the depth of the thermocline, and more.

During the summer, the less dense warm water floats on top of the cold deep water. It takes energy to mix the layers of water. The Schmidt Stability is a calculation of the lakes resistance to mixing.

Display: Our web-based display tools are designed to provide real-time data on observed and calculated parameters in a format that is easy to understand and promotes repeat visits.
- Lake Cartoon
- Full data in “ZOOMABLE” formats
- Narratives on the what the data means
- Follow with Google Analytics

Highcharts Graphs:
- Presents data clearly and accurately to a scientific audience.
- “Zoomable” to promote an understanding of lake dynamics on both a seasonal and daily level.
- Community members may find the graphic presentation difficult to understand, and may not use it on a day-to-day basis.

Cartoons:
- Present clear data to the community in a way that encourages day-to-day use and provides useful information to the stakeholder community.

Supported by National Science Foundation award #EPS-0904155 to Maine EPSCoR at the University of Maine