Cape Cod’s Freshwater Ponds:
The Basics

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Cape Cod Ponds

- 994 ponds and lakes
- 11,000 acres
- <1 acre to 735 acres;
- 21 biggest ponds have nearly half of 11,000 acres;
- 40% of ponds < 1 acre area;
Definitions: Lakes, Ponds, Vernal Pools

• Size doesn’t matter;

• Light penetration into the water column for photosynthesis is key; photic zone is 10 meters when water is clear;

• A body of water that is too deep to permit the growth of rooted plants all the way across is a LAKE.

• A body of water shallow enough to permit the growth of rooted plants all the way across is a POND.

• A pond that dries up occasionally, doesn’t have fish, and has vernal pool species is a VERNAL POOL.
Great Ponds (State-Owned)

- All standing natural bodies of water > 10 acres in area are Great Ponds (MGL Ch.91 S. 35)
- “Waters of the Commonwealth” means owned by the Commonwealth;
- Open to public use unless restricted by special acts of legislature;
- 164 Great Ponds on Cape Cod (1933 Legislature);
- 208 Great Ponds on Cape Cod (aerial mapping);
- One is used for public water supply (Long Pond in Falmouth);
Figure 14.

Great Pond in Wellfleet. This kettle pond marks the site of a large ice block left behind by the retreating South Channel lobe. The original kettle hole was far from round, but wave erosion and deposition along the shore have trimmed off headlands and closed off embayments in the shoreline much as they do along the ocean shore (photo by National Seashore Park Service).
# Great Ponds on Cape Cod

<table>
<thead>
<tr>
<th>Lens</th>
<th>Towns</th>
<th># of Great Ponds</th>
<th>Area (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagamore</td>
<td>Bourne, Sandwich, Falmouth, Mashpee, Barnstable, Yarmouth</td>
<td>111</td>
<td>6318</td>
</tr>
<tr>
<td>Monomoy</td>
<td>Dennis, Brewster, Harwich, Chatham, Orleans</td>
<td>74</td>
<td>3881</td>
</tr>
<tr>
<td>Nauset</td>
<td>Eastham, South Wellfleet</td>
<td>7</td>
<td>239</td>
</tr>
<tr>
<td>Chequesset</td>
<td>Wellfleet, South Truro</td>
<td>12</td>
<td>354</td>
</tr>
<tr>
<td>Pameet</td>
<td>Truro</td>
<td>1</td>
<td>351</td>
</tr>
<tr>
<td>Pilgrim</td>
<td>Provincetown</td>
<td>3</td>
<td>65</td>
</tr>
</tbody>
</table>

*Source: An Inventory of the Ponds, Lakes, and Reservoirs of Massachusetts, 1969*
Athabaska Glacier, Jasper National Park, Canada. Photo by J. Muramoto. The red arrow indicates the terminal moraine. The outwash plain is in front.
Origin of Pond Basins on Cape Cod

- Melting ice blocks left behind after glaciers retreated form kettleholes;
- Kettleholes fill with groundwater seeping in through sand;
- Groundwater-fed;
- 12,000 years old

Oldale, The Geologic Story of Cape Cod, USGS website
Groundwater-fed ponds

Note: there are some “perched” ponds and vernal pools lying above the water table; these are fed by runoff and are separated from groundwater by clay layers.
Groundwater – the lifeblood of Cape Cod

Upper diagram: Sagamore and Monomoy groundwater flow lenses.

Contour lines indicate the subsurface elevation of the water table, which is mounded higher in the Upper Cape and mid-Cape areas.

Lower diagram: cross-section of the groundwater lens, showing how the freshwater lens sits on top of saline groundwater which is in contact with sea water. As sea level rises, the lighter freshwater lens would be lifted up, which would raise the water table.

Figure 1. Top: the Sagamore (West Cape) and Monomoy (East Cape) groundwater flow lenses of Cape Cod, Massachusetts. Bottom: North-South cross-section, A-A', through Sagamore Inlet.
USGS Groundwater Monitoring Stations and Status

Map of the US with groundwater monitoring stations indicated by symbols. The legend explains the percentile classes based on most recent measurement. The map includes cities such as Brockton, Plymouth, New Bedford, and Falmouth. The sources for the map are Esri, HERE, DeLorme, USGS, and Intermap.
Water Column Structure

Layers in a Stratified Lake

- **Epilimnion**: warm, light, well mixed surface water
- **Metalimnion**: abundant oxygen and light; area of rapid temperature change
- **Hypolimnion**: cool dense water and sometimes anoxic in summer

MA Lakes and Ponds Guide, Ch. 2, Lake and Pond Basics
Thermal Stratification

Generalized Temperature Stratification

Example temperature data from Station 1 on August 15, 1997

Long Pond Water Quality Assessment
Cape Cod Commission, 1999
Trophic Status

• Oligotrophic (low nutrient levels)
• Mesotrophic (medium nutrient levels)
• Eutrophic (high nutrient levels)

Figure 2. Relative Phosphorus Mass at Lake Trophic Levels

Modified after McComas (1993)
Oligotrophic – Lake Tahoe.
Photo by J. Muramoto
Eutrophic – Mill Pond, Woods Hole. Photo by J. Muramoto
Uses (Human)

- Swimming
- Boating
- Fishing
- Scenic and aesthetic values
- Drinking water (1)
- Tourism
- Real estate
- Nutrient management?

Photos: Punchbowl (top); Crooked Pond (bottom). Photos by J. Muramoto
Ecological Values

- Fish and wildlife habitat
- Habitat for aquatic vegetation
- Rare species habitat
- Rare natural communities (e.g., coastal plain pondshores, Atlantic white cedar swamps, etc.)
- Nutrient cycling (sink, source)
- Supports food web
- Connected to estuarine and marine ecosystems via transfer of:
  - Water
  - Nutrients
  - Sediments
  - Fish, invertebrates, wildlife
  - Organic matter
Threats and Problems

- Water withdrawals that reduce water levels
- Pollution:
  - Atmospheric fallout (dust, N, Hg, organic, acids)
  - Fossil fuel–burning plants
  - Dust storms
  - Volcanic eruptions
  - Forest fires, wildfires
  - Polluted groundwater (N, other contaminants) – septic systems
  - Polluted stormwater runoff (P, N, bacteria, salt, fertilizers) from developed areas (lawns, golf courses, paved areas, roads, buildings, etc.)
  - Boat discharges (septic waste, oil, anti-fouling paints, power-washing wastewater, etc.)
  - Natural sources of bacteria such as waterfowl, wildlifes
  - Domestic animals (waste, sediment)
  - Agricultural runoff (sediment, fertilizers, pesticides, etc.)
Water quality

- 74 to 93% impacted by development;
- Dissolved oxygen: 45% of ponds and 89% of deepest ponds are impaired;
- Fish kills;
- Algal blooms;
- Poor water clarity;
- High temperatures;
- See 303(d) list: Cape has:
  - 19 TMDLs for nitrogen
  - 55 TMDLs for bacteria/pathogens
  - Many of these TMDLs affect ponds
Other Pollutants: Mercury

22 ponds on Cape Cod have fish consumption advisories.
Decline in Mercury in Northeast Lakes

Abstract

Mercury (Hg) concentrations were monitored from 1999 to 2011 in largemouth bass (LMB) and yellow perch (YP) in 23 lakes in Massachusetts USA during a period of significant local and national improvements in emissions from several ME coal and biomass power plants. As a result, Hg concentrations decreased.
Potential Effects of Sea-Level Rise on Hydrologic Systems
Climate Change Impacts?

- Warmer water?
- Deeper water is also warmer?
- Lower water levels due to drought?
- Higher water levels due to rising groundwater?
- Eutrophic conditions worsen?
- Flooding from the sea?
Useful Resources

• MA DEP Interactive Mapper of 303d Listed Waters, at http://www.mass.gov/eea/agencies/massdep/water/watersheds/integrated-list-of-waters.html
• Glacial Cape Cod: https://pubs.usgs.gov/gip/capecod/glacial.html

For more information, contact: Jo Ann Muramoto at (508) 362-4226.
Visit APCC’s webpage at: www.apcc.org
Nitrogen Attenuation in Ponds

Table IV-3. Nitrogen attenuation by Freshwater Ponds in the Namskaket Creek watershed based upon 2001 through 2005 sampling data collected by Brewster volunteers coordinated through the Cape Cod Commission. These data were collected to provide a site-specific check on nitrogen attenuation by these systems. The MEP Linked N Model for Namskaket Creek uses the listed attenuation rates.

<table>
<thead>
<tr>
<th>Pond</th>
<th>PALS ID</th>
<th>Area acres</th>
<th>Maximum Depth m</th>
<th>Overall turnover time yrs</th>
<th>TN samples for Attenuation calculation</th>
<th>N Load Attenuation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cliff</td>
<td>BR-1028</td>
<td>201.9</td>
<td>26.8</td>
<td>3.4</td>
<td>42</td>
<td>74%</td>
</tr>
<tr>
<td>Little Cliff</td>
<td>BR-192</td>
<td>34.5</td>
<td>13.8</td>
<td>0.6</td>
<td>26</td>
<td>82%</td>
</tr>
<tr>
<td>Ruth</td>
<td>BR-209</td>
<td>7.5</td>
<td>4.6</td>
<td>0.4</td>
<td>0</td>
<td>50%*</td>
</tr>
<tr>
<td>Flax</td>
<td>BR-168</td>
<td>51.2</td>
<td>21.8</td>
<td>4.8</td>
<td>41</td>
<td>72%</td>
</tr>
</tbody>
</table>

Mean | 76%
std dev | 5%

*standard MEP freshwater pond attenuation rate; Ruth Pond has no sampling data available, so standard rate was utilized in watershed nitrogen loading

Data sources: all areas from CCC GIS; Max Depth from MassDFW or Cape Cod PALS monitoring; Volume for turnover time calculations from MADFW bathymetric maps (www.mass.gov/dfwele/dfw/dfw_pond.htm); TN concentrations for attenuation calculation from volunteer monitoring including lab data from annual PALS Snapshot provided by SMAST lab and data from NPS lab

From: MA Estuaries Project report for Namskaket Marsh, Orleans, MA
Nitrogen Attenuation in Ponds: Caveats

Pluses:
• Promotes denitrification (loss of nitrogen to the atmosphere as nitrogen gas) and reduces the amount of nitrogen that reaches estuaries and which needs management.

Minuses:
• If nutrients are released into water from sediments during the growing season, algal blooms and eutrophication could occur.

• Accumulation of organic matter in sediments may promote anaerobic conditions in sediments or deep water, impacting fish, invertebrates and wildlife.

• Anaerobic conditions may stimulate methane bacteria to produce methane, a potent greenhouse gas, adding to climate change impacts.

Solution: Monitoring of the N cycle in ponds is needed, and a response threshold needs to be determined for any corrective actions if the pond doesn’t work.