

**Pond Water Quality Rating System and Sources of Nutrient Loading:
W. Wilcox, Water Resource Planner
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The quality of coastal pond systems described using a number of parameters measured in the field and at the lab. These parameters or similar ones have been utilized by the Buzzard's Bay project (Costa et al, 1996) and by NOAA (NOAA, 1996). These parameters are affected by the addition of nutrients to the system and include:

- Pigment (chlorophyll *a* + phaeopigment) content
- Oxygen saturation (the lowest third recorded)
- Transparency (Secchi depth)
- Dissolved inorganic nitrogen
- Total organic nitrogen

By convention the mean value of these parameters is determined for the period between June 1 and September 30, the period characterized as the "growing season".

In addition, more subjective indications of water quality can be made by evaluating:

- The percentage of potential area that is colonized by eelgrass beds.
- The quantity of epiphytic algae growing on hard surfaces.
- The viability of shellfish resources within the system as measured by yield.

Both the eelgrass and epiphytic categories could be made into measured parameters through extensive fieldwork and determination of the biomass and coverage. Shellfish yields could be converted to a more quantitative rating by converting total yield into yield per unit area of potential habitat within each system. Eelgrass mapping efforts by the Department of Environmental Protection may be utilized for this purpose. However, additional fieldwork will be necessary to determine the area of potential eelgrass beds (primarily depth but also sediment and water clarity) and the area of shellfish species habitat (primarily bottom sediment).

Ponds that have had enough fieldwork to be rated within this system include:

Edgartown Great Pond
Tisbury Great Pond
Chilmark Pond
Squibnocket Pond
Menemsha Pond
Tashmoo Pond
Lagoon Pond
Oak Bluffs Harbor
Farm Pond
Sengekontacket Pond

The 2003 data has not yet been added into the rating scheme. Ponds with only one year of data include Oyster Pond, James Pond, Cape Pogue and Poucha Pond. Ratings for

these ponds should be viewed with some skepticism. Systems with no or very limited data include: Katama Bay, Caleb's Pond and Trapp's Pond. Ratings for these systems are not made.

System water quality ratings used by the Buzzard's Bay Project are:

Buzzard's Bay Eutrophication Index

Parameter	Zero Score	Perfect Score
Oxygen Saturation (lowest 1/3 observed)	40% saturation or less	90% saturation or more
Transparency (Secchi disk)	0.6 meters or less	3 meters or more
Phytoplankton pigments	10 parts per billion or more	3 ppb or less
Dissolved inorganic nitrogen (DIN)	10 micromolar (0.14 ppm) or more	1 micromolar or less
Total organic nitrogen (TON)	0.6 ppm or more	0.28 ppm or less

To obtain scores for our ponds between the zero and perfect values, ranges were established by interpolation. These ratings are most suitable for describing the quality of tidal systems that are continuously circulated by the tides. They work for our south shore great ponds that are tidal periodically but the scores are typically lower reflecting the limitations caused by long periods of non-tidal conditions. It may be helpful to compare these ponds with each other rather than with a tidal pond like Sengekontacket and eventually to develop a separate rating system for them.

In the Table that follows, we use the Buzzard's Bay Program rating system for each of the coastal ponds where we have data. In addition, we have added ratings for eelgrass and for the slime coatings (epiphytes) typical of poorer water quality systems. The ratings for these two indicators are as follows:

* Eelgrass ratings

None or less than 10% coverage	0
Patchy beds scattered	25
Moderate beds	50
Extensive beds	75
Full coverage	100

* Epiphytes

Heavy fouling	0
Moderate fouling	50
Limited fouling	100

This spreadsheet is a work-in-progress and will be changed as more data becomes available. As with any rating system, only a limited number of parameters are used and have been characterized over a limited time frame. Therefore this document should be used for guidance until a large database has been formed and thoroughly evaluated.

POND SYSTEM RATINGS

DRAFT

For information: wilcox@mvcommission.org

Indicates less than optimum # of data points

PONDS	Stations	Secchi Reading meters	Secchi Rating	DO Sat. mg/l	DO Sat. Rating	Pigments ppb	Pigment ratings	DIN um/l	DIN Rating	TON mg/l	TON Rating	Sum rating no EG	Eelgrass Rating*	Epiphyte Rating*
Lagoon Pond 2003	4/5	2.38	74.2	42	4.0	4.152504	83.5	1.344596	96.2	0.364852	73.5	66.3	37.5	25
	8	4.1	100.0	77	74.0	3.97	86.1	2.0	88.4	0.44	50.0	79.7		
	10	1.88	53.3	81	82.0	3.74	89.4	1.82	90.9	0.48	37.5	70.6		
Lagoon Pond 2002	4/5	3.4	100.0	60	40.0	4.26	82.0	1.11	98.8	0.42	56.3	75.4	50	25
	8	3.18	100.0	90	100.0	3.557977	92.0	1.438431	95.1	0.370428	71.7	91.8		
	10	NA		88	96.0	7.843	30.8	1.181082	98.0	0.289	97.2	64.4		
Lagoon Pond 1995	4/5 (30)	3.5	100.0	57.7	35.4	3.01	99.9	0.862	100.0	0.3	93.8	85.8	50	50
	8 (29)	2.96	98.3	62	44.0			0.743	100.0	0.313	89.7	83.0		
	10 (28)			53	26.0	3.18	97.4	1.93	89.7	0.313	89.7	75.7		
Sengekontacket Pond 2003	2 (17)	2.07	61.3	66.2	52.4	4.13	83.9	4.1	65.6	0.46	43.8	61.4	25	37.5
	4 (19)			65.5	51.0	6.49	50.1	3.51	72.1	0.69	0.0	43.3		
	6					3.48	93.1	3.37	73.7	0.37	71.9	79.6		
	8 (21)	1.65	43.8	73	66.0	4.81	74.1	3.35	73.9	0.7	0.0	51.6		
Sengekontacket Pond 1995	2 (17)	1.71	46.3	57.6	35.2	3.39	94.4	1.032571	99.6	0.386	66.9	68.5	25	50
	4 (19)	1.91	54.6	63.7	47.4	5.22	68.3	0.97	100.0	0.42	56.3	65.3		
	6					4.783714	74.5	2.313558	85.4	0	187.5	101.7		
Cape Pogue 2003	2	4.48	100.0	93.2	100.0	2.95104	100.0	2.784599	80.2	0.360651	74.8	91.0		
	4	4.18	100.0	86.08	92.2	3.84	88.0		73.26688		41.40177	79.0	75	75
Poucha Pond 2003	1	2.35	72.9	84.9	89.8	2.601422	100.0	4.405357	62.2	0.459009	44.1	73.8		
	3	1.6	41.7	87.6	95.2	2.99	100.0		44.49452		2.405601	56.8	0	25
FRM1 2003	1			55	30.0	6.964135	43.4	3.709033	69.9	0.587984	3.8	36.8		
Farm Pond 2003	3	0.75	6.3	69.2	58.4	11.06457	0.0	3.636691	90.9	0.64479	0.0	31.1	75	37.5
Oak Bluffs Harbor 2003	3 (4)	2.07	61.3	77.95	75.9	6.563788	49.1	3.857152	87.8	0.327019	85.3	71.9		25
	1			66.45	52.9	5.568092	63.3	9.562454	6.3	0.486158	35.6	39.5		
Oak Bluffs Harbor 2001	3 (4)	2.37	73.8	77.33	74.7	5.86	59.1	2	100.0	0.352	77.5	77.0	0	25
	1			70.8	61.6	5.88	58.9	6.05	56.4	0.362	74.4	62.8		
CHP 2003	6	1.17	23.8	84.4	88.8	6.332458	52.4	2.10208	87.8	0.759263	0.0	50.5		25
Chilmark Pond 2003	3	1.62	42.5	88.8	97.6	4.55	77.9	1.507192	94.4	0.77	0.0	62.5	0	
Chilmark Pond 1999/2000	6	1.1	20.8	80.5	81.0	9.36	9.1	4.07	65.9	0.71	0.0	35.4		
Chilmark Pond 1999/2000	3	1.2	25.0	80.4	80.8	7.05	42.1	3.93	67.4	0.76	0.0	43.1	0	
Menemsha Pond 2003	1(49)					2.592804	100.0	2.362001	84.9	0.331231	84.0	89.6		
	3 (43)					2.73	100.0	2.750764	80.5	0.32	86.9	89.1	75	75
	7(47)					2.83	100.0	2.50122	83.3	0.51	28.8	70.7		
Menemsha Pond 2002	1(49)											0.0	75	75
	3 (43)											0.0		
	7(47)											0.0		
Menemsha Pond 1995	1(49)					2.9	100.0	1.03	99.7	0.259	100.0	99.9		
	3 (43)					3.13	98.1	0.91	100.0	0.365	73.4	90.5	75	75
	7(47)					3.06	99.1	1.02	99.8	0.361	74.7	91.2		
												0.0		
Squibnocket Pond 2003	3					4.710275	75.6	4.420175	62.0	1.119011	0.0	45.9		25
Squibnocket Pond 2002	3											0.0	0	25
Squibnocket Pond 1995	3	2.33	72.1			4.22	82.6	2.32	85.3	0.715	0.0	48.0	0	25
Tashmoo 2003 (one date)	2 (6)	2.7	87.5	79.3	78.6	3.211124	97.0	1.405022	95.5	0.329276	84.6	88.6	50	37.5
	3 (1)	2.7	87.5	71.1	62.2	5.347761	66.5	1.869944	90.3	0.408524	59.8	73.3		
Tashmoo 2001	2 (6)			85.3	90.6	3.85	87.9	1.05	99.4	0.418	56.9	83.7	50	37.5
	3 (1)	2.18	65.8	78.6	77.2	13.94	0.0	1.18	98.0	0.609	0.0	48.2		
Edgartown Great Pond '03	3	1.77	48.8	81.6	83.2	4.601693	77.1	3.3	74.1	0.53388	20.7	46.6		25
	4	1.67	44.6	87	94.0	4.143707	83.7	11.25188	0.0	0.642909	0.0	44.4		
	5	1.63	42.9	85	90.0	3.282362	96.0	4.445601	61.7	0.529304	22.1	62.5		
	6	1.75	47.9	85.3	90.6	2.929932	101.0	5.100956	54.4	0.498436	31.7	65.1		
	10	1.13	22.1	78.9	77.8	5.494896	64.4	6.384347	40.2	0.523314	24.0	45.7		
Edgartown Great Pond '02	3	2	58.3	88.7	97.4	5.27	67.6	1.31	96.6	0	187.5	101.5	0	25
	4	1.7	45.8	87.9	95.8	5.41	65.6	3.35	73.9	0	187.5	93.7		
	5	1.45	35.4	88	96.0	7.5	35.7	2.58	82.4	0	0.0	49.9		
	6	1.72	46.7	86.9	93.8	6.23	53.9	3.8	68.9	0	0.0	52.6		
	10	1.28	28.3	85	90.0	6.75	46.4	0.008	100.0	0.73	0.0	53.0		
Edgartown Great Pond '01	3	1.58	40.8	85.4	90.8	2.91	100.0	1.3	96.7	0	187.5	103.2	0	25
	4	1.56	40.0	83.8	87.6	3.71	89.9	7.21	31.0	0	187.5	87.2		
	5	1.5	37.5	92.2	100.0	3.15	97.9	3.17	75.9	0.46	43.8	71.0		
	6	1.6	41.7	90.2	100.0	2.68	100.0	3.76	69.3	0	187.5	99.7		

Nutrient Loading:

The growth of both microscopic and large, rooted plants in coastal ponds are determined by the amount of necessary nutrients available. The microscopic, chlorophyll-bearing, organisms called phytoplankton form the base of the food chain that extends through microscopic and very small grazers like copepods onward to small fishes like mummichogs and herring and culminating in the larger predatory fishes like bluefish and bass. Filter feeders like clams, oysters and scallops remove microscopic particles from the water column and excrete their waste into the sediment where they dwell. Stimulation of the phytoplankton by adding nutrients that they need to grow benefits the production in the entire food chain until a tipping point is reached. At the tipping point, the phytoplankton population becomes excessive, reducing light penetration into the water column and causing the dissolved oxygen saturation in the water column to dip down overnight to levels where fishes may be stressed and, in the more severe cases, killing out bottom dwelling organisms that cannot escape.

At the same time, the added nutrients may stimulate the growth of wrack algae like sea lettuce and the slime and fouling algae known as epiphytes. This organic matter may coat the leaves of eelgrass reducing light penetration to its leaves and causing the density of eelgrass shoots to decline and, in areas where the problem is most severe, the eelgrass beds may vanish altogether. The wrack algae may drift into shellfish flats or marsh areas and begin to decay causing very low oxygen levels and odors. The excess plant material gradually shifts the system away from filter feeders like scallops and toward grazers and detritus feeders like snails. It is not a desirable path to follow.

Nitrogen and Its Potential Impact: Nitrogen is an important component of all living organisms. It comprises about 78 percent of our atmosphere but is not very soluble as a gas in water. Only nitrogen fixing organisms such as blue green algae can convert atmospheric nitrogen gas into compounds usable in their systems. Nitrogen is most directly usable by phytoplankton and larger aquatic plants in the form of nitrate, nitrite or ammonium. These plants are therefore dependent on availability of these forms of nitrogen in order to grow. Sources of these forms of nitrogen include septic system leachate, sewage effluent, acid rain, fertilizers and release from pond bottom deposits following bacterial breakdown of organic matter. In the sandy soils present in the recharge area, most forms of nitrogen are oxidized to nitrate before they reach the ground water. Nitrate is highly soluble in water and generally not reduced or eliminated by any substantial process once it is in the ground water. For this reason, we can closely estimate the loading to the pond by making reasonable estimates of the quantity of nitrate reaching the ground water.

Other major nutrients required for growth of phytoplankton and algae include phosphorus, carbon, hydrogen and oxygen. Generally, the last three are sufficiently available in coastal waters so that they do not hinder growth of these aquatic plants. In phytoplankton, nitrogen and phosphorus are required in the approximate ratio of 16 to 1. While other less important nutrients may also affect growth rates, these two are of primary importance. In ocean waters, it is generally accepted that nitrogen is the deficient nutrient and phosphorus is usually present in sufficient quantities. Marine

waters are often spoken of as being nitrogen limited. This means if nitrogen is added to the water, phytoplankton can increase their reproduction to take advantage of the supply. Phytoplankton can grow and produce a new generation as often as several times each day under the right conditions. Explosive growth is called an algae bloom.

What are the sources of nitrogen?

Once nitrogen is converted to nitrate it is highly water-soluble and persistent under the conditions found in our aquifers. Nitrogen added to the groundwater in the far reaches of a watershed might well eventually reach the coastal pond where the groundwater discharges even after a 25-year travel time. The sources of nitrogen include:

Acid rain: Nitrogen is a major component in the stack emissions from power plants and in automobile exhaust. It is carried to the ground by precipitation and attached to dry particulate matter. Nitrogen content in acid rain has been measured at well over 0.5 parts per million and, in some cases more recently, at over 1.0 part per million (ppm). The vegetation largely absorbs the precipitation in the watershed but the direct fall on our ponds contributes immediately to the nitrogen budget.

Wastewater: Sewage effluent leaving the leaching areas of our on site septic systems carry nitrogen at about 35 ppm. Once it is beyond the root zone, it has been oxidized to the nitrate form that is very mobile and is not trapped by clay particles in the soil. The nitrate moves under the influence of gravity downward into the groundwater where it forms a “plume”, so-called because it is a limited area of higher concentration that flows with the groundwater down gradient. There is only limited vertical and horizontal diffusion and dilution of the nitrate in the plume.

Fertilizer: Because nitrogen is so important to the growth of plants, it is a major component of most fertilizer products. In a 10-10-10 fertilizer product, the first number is the percentage of the product that is nitrogen. When applied to excess or when heavy rainfall follows a fertilizer application, the soluble nitrogen may be able to by-pass the root zone and move downward into the groundwater. There are a number of ways to avoid having your lawn become a pollution source. Reduce the size of the area that you fertilize. Don't fertilize more often than spring and fall. Cool season grasses do not need it. Use slow-release nitrogen sources including organic fertilizers and coated fertilizers that provide the nitrogen at a measured pace.

Bottom sediment in each pond: bacteria and organisms that feed on dead material gradually break down the dead plant and animal material that falls to the bottom of a pond. The nitrogen in the tissues of these plant materials are gradually converted to more soluble molecules that can return to the water column to become a source of nutrition for growth of new generations of phytoplankton.

Stormwater: Stormwater discharges that bypass vegetated buffers and enter a pond directly carry not only the nitrogen in the acid rain but also the nitrogen that has been deposited on our streets as animal droppings, dead leaves and dry-deposits of microscopic atmospheric particles. If the runoff can be routed through a heavily

vegetated buffer strip and then into a fringing wetland, most of the nutrient load can be intercepted and its impact greatly reduced.

What are the sources of phosphorus?

Unlike nitrogen compounds, phosphorus compounds are strongly bonded to soil particles due to their electrical charge. As a result, although the sources of phosphorus are the same as the sources of nitrogen, they are usually trapped in the soil before they enter the groundwater and a pond. The exceptions include direct discharge of stormwater or eroded soil from agricultural lands and construction sites. The phosphorus content of acid rain that falls directly on a pond is also an addition to the pond's nutrient budget.

The phosphorus in wastewater can eventually overload the soil binding capacity and septic systems near a pond (300 feet plus or minus) may become phosphorus sources over time.

The role of wetlands:

Wetlands in the watershed of a coastal pond may intercept and trap the nitrogen in the groundwater from up-gradient when (and if) that groundwater enters a stream, freshwater pond or fresh wetland. Wetlands are nutrient sinks where the nutrients are deposited as wetland muck in the form of plant debris. Fringing saltwater wetlands may also trap nutrients entering with the groundwater although usually, where there are extensive fringing wetlands, the groundwater discharge is focused where there are sandy areas between the wetlands. Wetland systems are crucial to the health of coastal ponds whether they are in the watershed or around the perimeter of the coastal pond.

Preparing a nitrogen loading budget:

The Commission uses a population model to estimate the amount of wastewater flow within the watershed of a coastal pond. We assume that a certain percentage (varies by Town) of the dwellings are occupied only seasonally (75 days plus a 25-day shoulder season) and that the rest are occupied year-round at the US Census population figure for each Town. We assume that each person uses 60 gallons of water each day, producing an average of 48 gallons of septic effluent that enters the groundwater bearing nitrogen at a concentration of 35 parts per million.

We examine the houses in each watershed to estimate the average lawn area and the probable level of nitrogen fertilizer application. We then use a standard assumption that 25 percent of the applied nitrogen will bypass the root zone and add to the groundwater nitrogen concentration.

Next, we determine the acreage of each type of farmland in the watershed. We use standard agronomic fertilization rates to determine the amount of nitrogen applied to each crop type. We then assume that 25 percent of the nitrogen applied to pasture and hayland and 33 percent of the nitrogen applied to row crops will escape the plants root zone and reach the groundwater.

Stormwater discharges are estimated based on the amount of impervious surface that discharges directly to a pond. We use standard nitrogen content figures for runoff from residential areas to determine the amount of nitrogen added to each pond. Where there are no impervious areas that discharge stormwater as in the case of Edgartown Great Pond, we assume that any runoff in the watershed will flow into vegetated areas that will take up the nitrogen contained in the runoff.

When added together, these sources produce a present-day nitrogen load. We then project the loading based on at least two buildout scenarios. Under the high growth scenario, we assume that buildout will occur as permitted by current zoning. We then examine recent subdivisions to determine the average lot size. This figure is usually at a lower density than allowed under zoning. This becomes the basis for a lower growth buildout scenario and nitrogen load.

The present day and buildout nitrogen loads can then be compared to the pond's tolerance level for nitrogen (also called its nitrogen loading limit). The comparison tells us whether nitrogen reduction is needed in the watershed in order to avoid a water quality crisis in the pond system.

Summary of Nitrogen Loading and Loading Limits (in kilograms)

Pond	Load Limit	Current Load	Projected Low	Projected High
Lower Chilmark	3802*		5015	6551
Menemsha	31618		6700**	10608**
Squibnocket	3037*		2295	4059
Tisbury Great	15000	13443	15491	23204
Edgartown Great	15513	7923***	12475	17426
Tashmoo	9120	6327	7233	11561
Lagoon	17000	17240	20668	26806
OB Harbor	2800	12819	4269***	4773***

**Lowered water quality limit*

*** Includes load from Squibnocket*

**** Post upgrade of treatment plant loading*

NOTE: These numbers are more fully developed and the process described in MV Commission reports on these ponds.

Loading limit formulae are ideally suited for systems that are tidal. The loading limits shown here for the south shore great ponds that are only tidal for weeks or months each year should be viewed with caution. Those ponds already showing some water quality symptoms typically caused by excess nitrogen despite their current loads being less than their load limits include Lagoon Pond and Tashmoo Pond. Other ponds with periodic poor water quality include Oak Bluffs Harbor as well as the south shore great ponds. Clearly we need to revisit the nitrogen issue for these ponds with more refined tools that are available through the Massachusetts Estuaries Project. For more information on this program see: <http://www.mass.gov/dep/smerp/smerp.htm>

REFERENCES CITED

Costa, J., B. Howes and E. Gunn (1996) Report of the Citizen's Water Quality Monitoring Program, 1992-1995. Coalition for Buzzard's Bay and Buzzard's Bay Project

NOAA (1996) NOAA's Estuarine Eutrophication Survey. Office of Ocean Resources Conservation and Assessment, National Ocean Service, NOAA