

Accuracy of posting harbor beaches using previous day's *Enterococcus* results (or: How to Avoid Some Bad Days)

The tables below summarize water quality results from the 2011 monitoring season, evaluating the frequency that high *Enterococcus* counts occur on consecutive sampling days, at each individual location.

From an analytical perspective, 2011 was an excellent year because it had a high frequency and wide variety of storm conditions. 2011 provides a good example of a “worst case” year in terms of evaluating water quality conditions at harbor beaches and the impact of wet weather.

A brief summary of the analysis appears on page 4.

TABLE INFO:

- "Bad day" = day where sample(s) exceeded 104 colonies/100 mL *Enterococcus*
- Samples are limited to consecutive daily sampling only; first day of daily sampling and weekly samples are excluded from totals because there are no sampling results for the prior day.

Constitution Beach 2011

Location(s)	SUMS			FREQUENCY		
	Total number of consecutive daily sampling days in 2011	Total number of bad days in 2011	Number of bad days, when prior day was NOT bad	Frequency of bad days in 2011, of all sampling days	Percent of bad days, where prior day was NOT bad	Frequency of two or more bad days in a row, over the entire season
North Site	72	6	5	8%	83%	1%
Middle Site	72	6	5	8%	83%	1%
Rec. Center	72	6	5	8%	83%	1%
2 or more locations simultaneously bad	72	5	4	7%	80%	1%

Notes:

- **Consecutive bad days occur 1% of the time.**
- **Posting based on elevated bacteria from the previous day is accurate only 17% of the time, or incorrect 83% of the time – an 83% false posting rate for previous day's *Enterococcus*, if posting by individual location.**
- Constitution is the only beach where all **three** sites tend to be bad simultaneously.
- There is effectively no improvement in public health protection by posting locations separately, since error rates for individual posting or aggregating are similar (83% vs. 80%).
- This argues for aggregation to maximize public access with no increase in public health risk, with a slight reduction of the overall posting rate (7% vs. 8%), and a reduction in the false posting rate.

Recommendation: Aggregating results in no increased risk to swimmers compared to disaggregating. Posting if 2 out of 3 sites have *Enterococcus* > 104 does not increase false negatives and decreases false positives.

Carson Beach 2011

Location(s)	SUMS			FREQUENCY		
	Total number of consecutive daily sampling days in 2011	Total number of bad days in 2011	Number of bad days when prior day was NOT bad	Frequency of bad days in 2011, of all sampling days	Percent of bad days where prior day was NOT bad	Frequency of two or more bad days in a row, over the entire season
McCormack Bathhouse	73	1	1	1%	100%	0%
I Street	73	2	2	3%	100%	0%
M Street	72	1	1	1%	100%	0%
City Point	72	1	1	1%	100%	0%
2 or more locations simultaneously bad	73	1	1	1%	100%	0%
3 or more locations simultaneously bad	72	0	0	0%	100%	0%
Pleasure Bay	72	4	4	5%	100%	0%

Notes:

- **Consecutive bad days did not occur at Carson Beach in 2011. Sites were clean the day following a high count 100% of the time.**
- **Posting based on elevated bacteria from the previous day is inaccurate 100% of the time, if posting by individual location OR with aggregated locations. This corresponds to a 100% false posting rate.**
- Since the error rate is equally poor with aggregating or posting by individual location (100%), there is no increased risk to public health by aggregating, and public access is increased.

Recommendation: Aggregating results in no increased risk to swimmers compared to disaggregating. Posting if 3 out of 4 sites have *Enterococcus* > 104 does not increase false negatives and decreases false positives.

Wollaston Beach 2011

Location(s)	SUMS			FREQUENCY		
	Total number of consecutive daily sampling days in 2011	Total number of bad days in 2011	Number of bad days when prior day was NOT bad	Frequency of bad days in 2011, of all sampling days	Percent of bad days where prior day was NOT bad	Frequency of two or more bad days in a row, over the entire season
Milton Street	73	10	8	14%	80%	3%
Channing Street	73	10	8	14%	80%	3%
Sachem Street	73	11	9	15%	82%	3%
Rice Road	73	5	4	7%	80%	1%
Sachem & Channing simultaneously bad	73	5	5	7%	100%	0%
3 of 4 locations simultaneously bad	73	6	6	8%	100%	0%

Notes:

- **Posting based on elevated bacteria from the previous day is accurate 20% of the time if posting by individual location.** The accuracy rate is slightly worse if sites are aggregated (0%). Error rates are extremely high in either case (80 to 100%).
- Unlike Carson and Constitution, there is a slightly reduced reduction in public health risk by disaggregating (i.e. some consecutive days for multiple locations would be missed). **However**, most of these elevated counts occur during wet weather, when the beach would be posted due to rainfall anyway.
- High counts during dry weather are sporadic and do not occur on consecutive days, and conditions at one location have little to do with the conditions at another location.
- **Aggregating results in no increase in risk, as long as there is also precautionary posting at all locations due to rainfall, which will capture simultaneous high counts.** (Precautionary posting due to rain will close the entire beach, which is effectively aggregation--all sites are posted, so if one or multiple sites turn out to be elevated it is irrelevant).

Recommendation: Aggregating results in no increased swimmers risk compared to disaggregating, *as long as precautionary posting due to rainfall remains in place.*

Analysis Summary. The overall takeaway for this analysis is that previous day's *Enterococcus* >104 is a very weak predictive tool, with an accuracy rate in predicting high counts between 0 and 20%, depending on the beach. It is only useful in retrospect, at the end of the season, to calculate the percentage of days that failed to meet standards. At relatively clean beaches like Boston's where high counts are rare, previous day's *Enterococcus* >104 is nearly always wrong: only occasionally (1 to 3% of the time) predicting a high count the following day – at all beaches, clean or dirty, over the course of the season.

Because of this poor accuracy, closures due to previous day's *Enterococcus* at Boston beaches should be minimized to every extent possible, because they are nearly always a day too late and offer little public health protection. This was the original intent of developing rainfall protocols, to provide a real-time measure of risk and to reduce reliance on previous day's bacteria results.

Aggregation is the best way to minimize these unnecessary postings yet comply with DPH posting requirements, because multiple sites along a beach are simultaneously elevated less often than individual sites, thus the false posting rate is reduced with no increased risk to swimmers. Once again: for beaches with intermittent high counts, there is no increased risk to swimmers by aggregating because this predictor –previous day's *Enterococcus*>104—is by definition a day late, and is therefore no help in assessing current swimming risk. Its use in daily beach management at relatively clean beaches (in this analysis, frequency of intermittent high counts < 15%) should be reduced where possible. Daily *Enterococcus* measurement is, however, a very useful tool in sanitary surveys and to evaluate overall water quality at end-of-season. Other real-time prediction tools (like rainfall, or in the case of the Great Lakes beaches, turbidity) are much more accurate predictors of elevated bacteria in real-time and are therefore more protective of public health.