

ABSTRACT

Fecal pollution in Henderson Inlet generally declined from 2000 through 2009. Some claim remedial programs may have been responsible. However, others perceive that a decline in rainfall during the period may be a factor. Remedial action is difficult to accurately evaluate. The Washington State Department of Health (DOH) used three analytical approaches to study fecal pollution in inner Henderson Inlet and its relationship to rainfall characteristics. All analyses confirm fecal pollution declined. Two showed no evidence of rainfall reduction. The third showed slight evidence of reduction. Moreover, while rainfall statistics increased in 2009, rainfall is an important factor in reduced fecal pollution overall in

NSSP CRITERIA

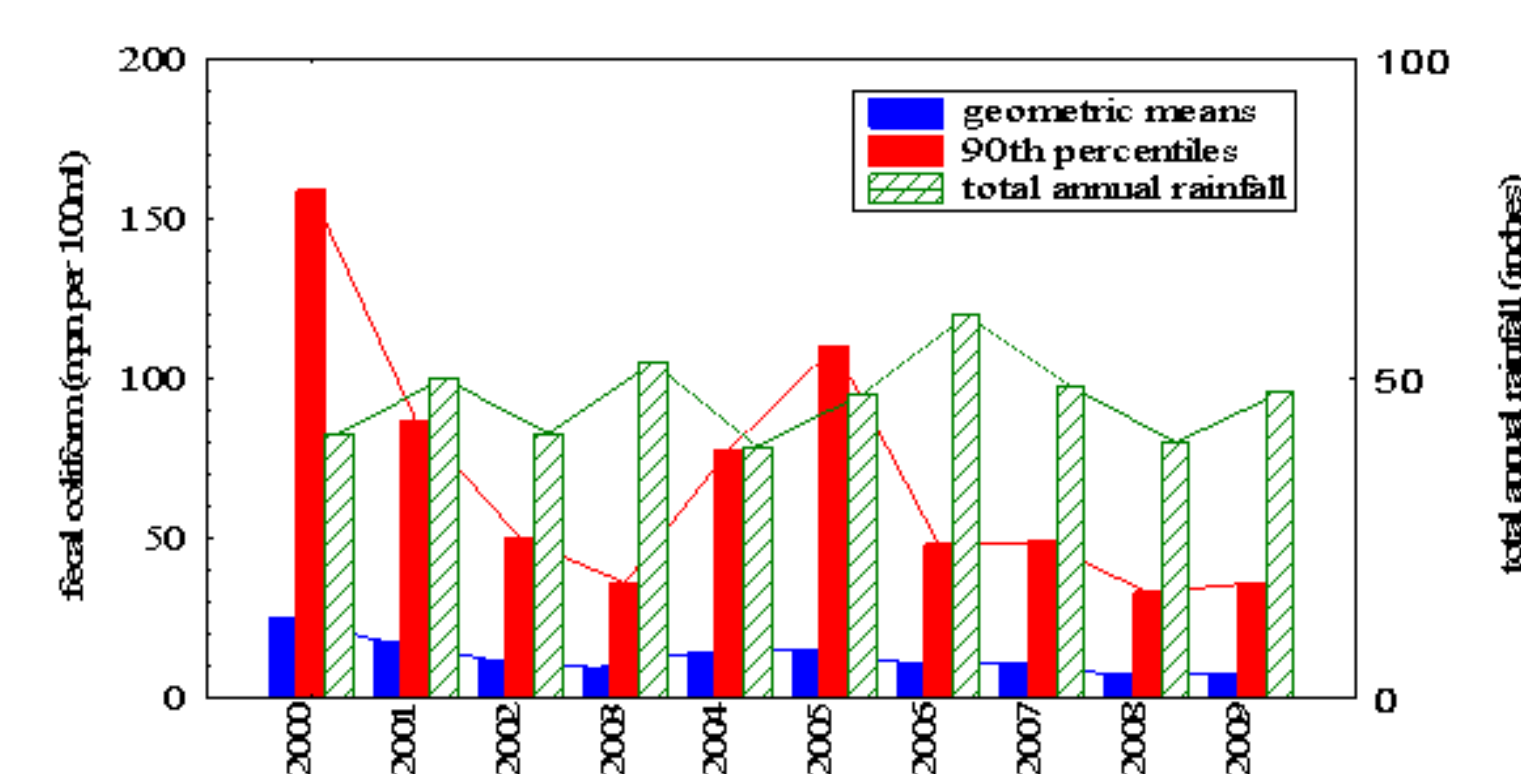
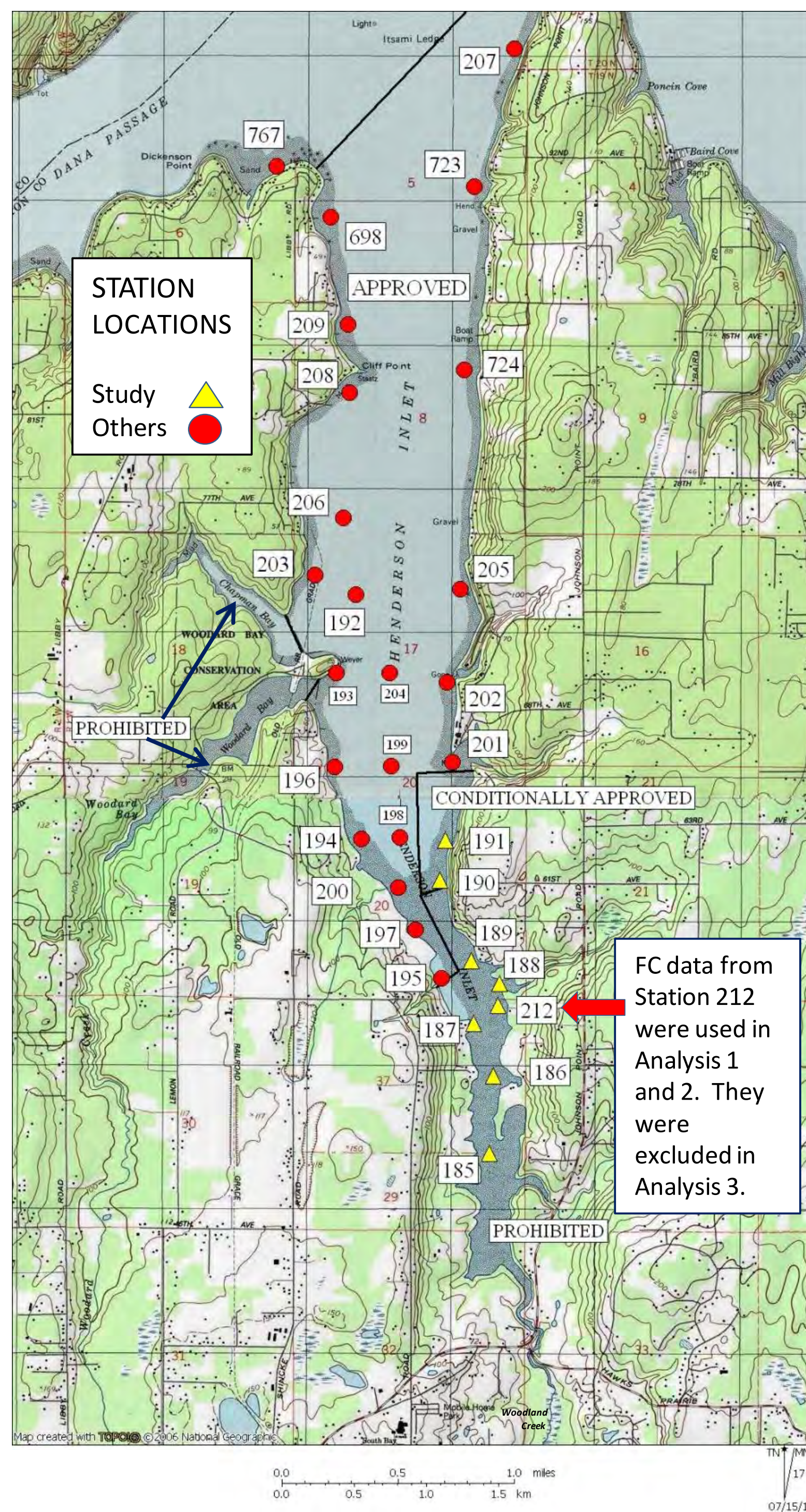
Criterion 1: Fecal coliform levels in water samples shall not exceed a geometric mean value of 14 organisms per 100ml.

Criterion 2: The estimated ninetieth percentile of fecal coliform shall not exceed 43 MPN per 100ml.

- A minimum of 30 previously collected results are needed to calculate the criteria
- Both criteria must be met

DOH cannot approve a harvest area if pollution sources may harm public health even if water quality is acceptable.

Analysis 1. Annualized Fecal Coliform Statistics and Total Annual Rainfall. Statistics (geometric means and 90th percentiles) were calculated from fecal coliform results from 8 study stations for each year from 2001 through 2009 (n ≈ 84; i.e., 7 stations sampled roughly 12 times each year). These statistics were examined for temporal trend and correlations using Spearman's Rho ($p = 0.05$).



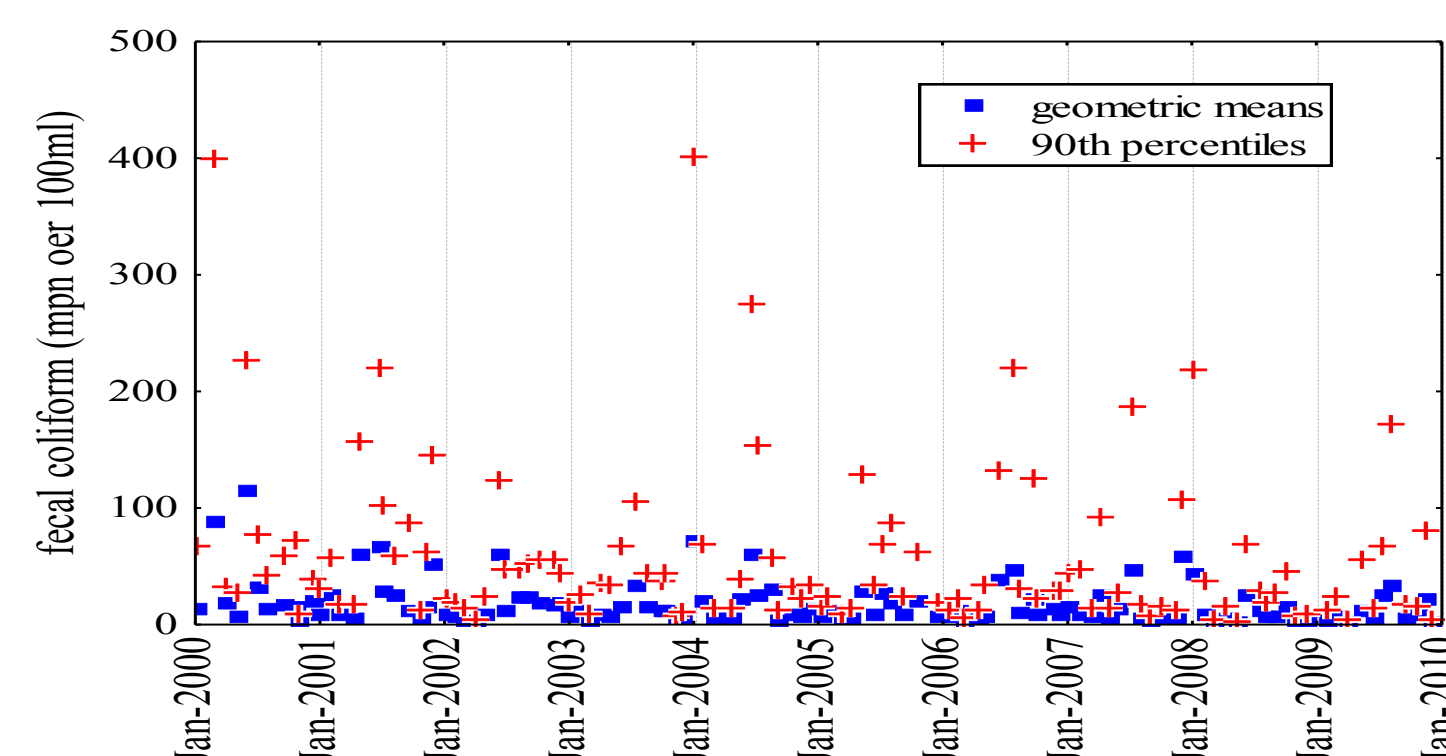
Results

- Annualized FC statistics (geometric means and 90th percentiles) declined significantly (GMs: Rho = -0.794, 90th percentiles: Rho = -0.699, n = 10).
- Total annual rainfall (Test 3) showed no significant temporal trend.

Analysis 2. Fecal Coliform Statistics by Sampling Date and "Recent" Rainfall Parameters. FC results from the 8 study stations were grouped by sampling date from 2000 through 2009. Geometric means and 90th percentiles were calculated from the pooled data. These statistics were aligned with "recent" rainfall parameters derived for each sampling date:

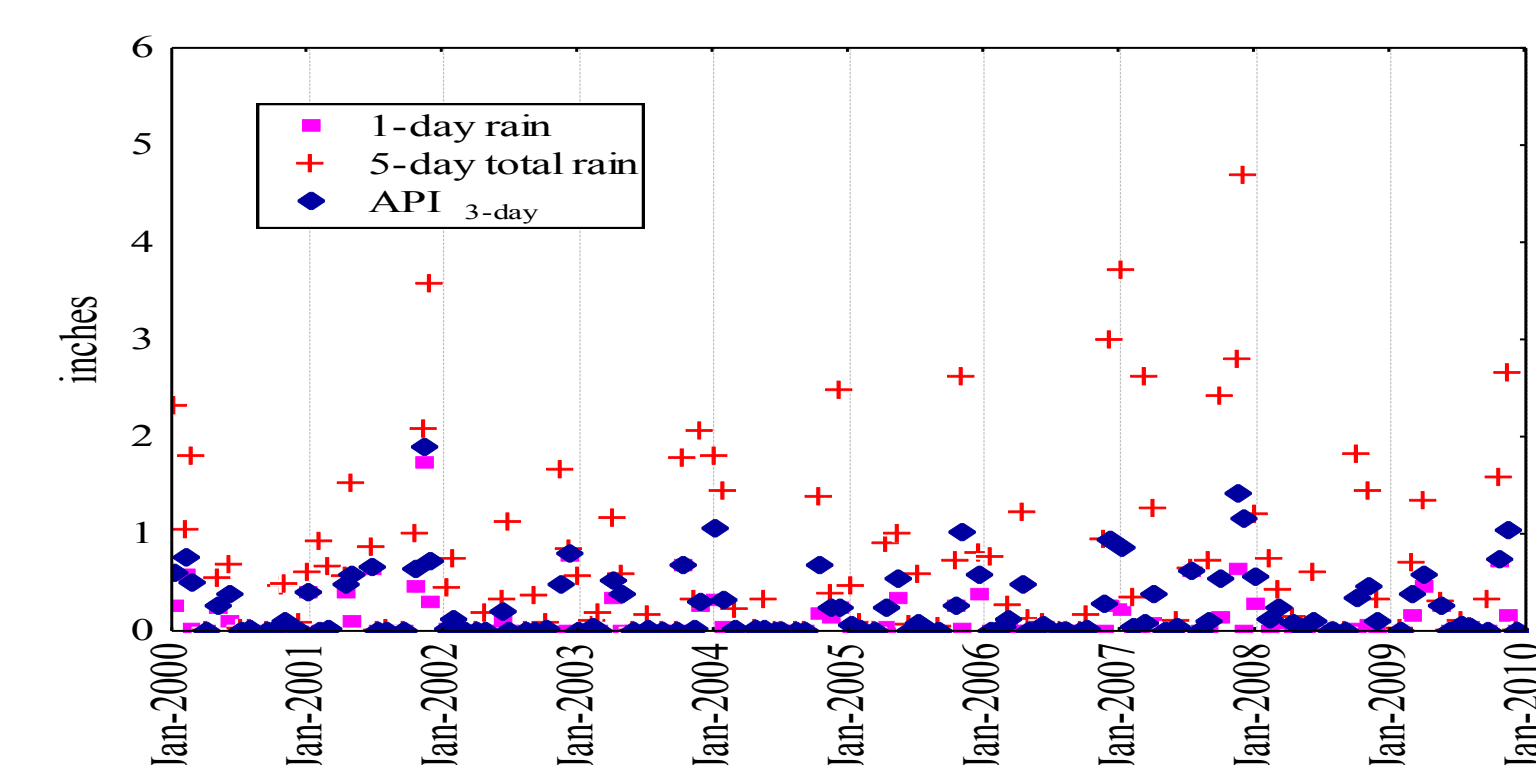
- 24-hour rainfall ("Rain_{1-day}"),
- total rainfall from the previous 5 days (Rain_{5-day}), and
- 3-day "Antecedent Precipitation Index" (API_{3-day}). (see Rao, et al 1978, Dunne and Leopold 1978.)

Trend in fecal pollution statistics.



- Geometric means and 90th percentiles of fecal coliform data show a slight, but significant decline over time (GMs: Rho = -0.275; 90th percentiles: Rho = -0.262, n = 119).

Trend in "Recent" Rainfall parameters (data from Olympia Airport).

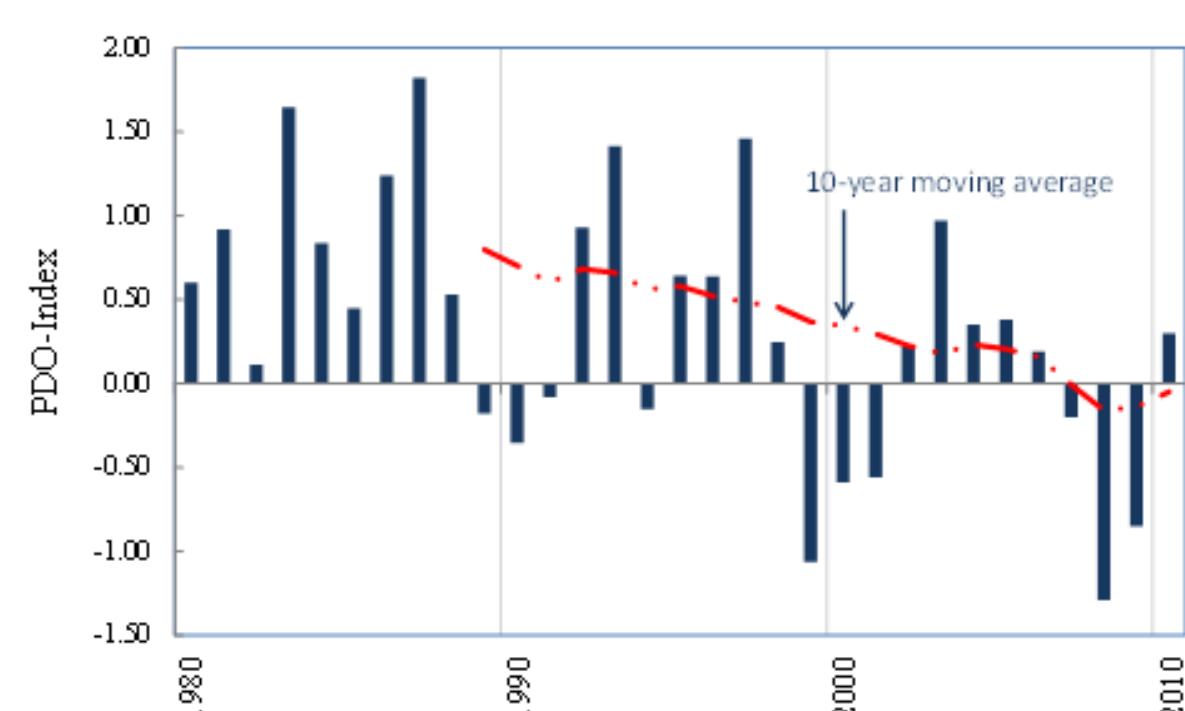


- "Recent" rainfall parameters show no temporal trend.

Analysis 3. "Moving" Statistics for Both Fecal Pollution and Daily Rainfall (Adapting NSSP Protocols). "Moving" statistics (geometric means, medians, and 90th percentiles) for both FC and daily rainfall were calculated for each sampling date. Fecal pollution statistics were calculated from a single geometric mean calculated from results pooled from seven inner Henderson Inlet stations. Calculations followed protocols set by the National Shellfish Sanitation Program (see NSSP 2009 and Appendix A, WDOH 2010.). NSSP requires moving statistics be calculated from 30 prior values by the requirement of a minimum. All parameters were examined for trends and correlations.

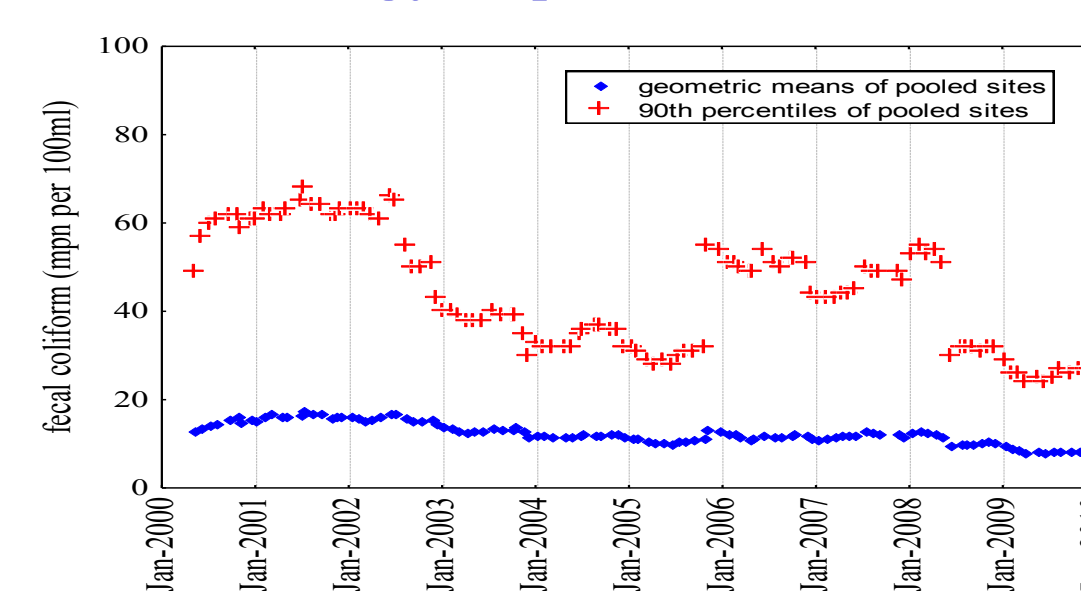
Future Challenges.

- A graph of annual average "Pacific Decadal Oscillation" (PDO) indices from 1980 through 2010 superimposed by a plot of the 10-year moving average. (concept suggested by Dr. Christopher Krembs, Senior Oceanographer, Washington State Department of Ecology) suggests a trend toward reduced indices (i.e., increased rainfall and storm runoff).



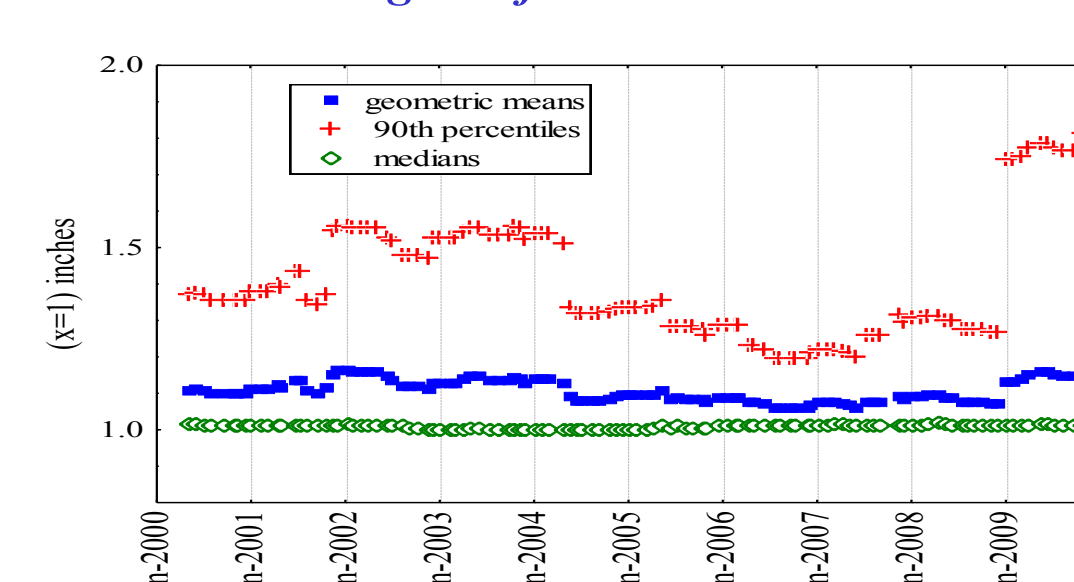
- Thurston County planning authorities predict increasing population growth and increasingly intensive land-use development in the Henderson Inlet watershed.

Trend in moving fecal pollution statistics



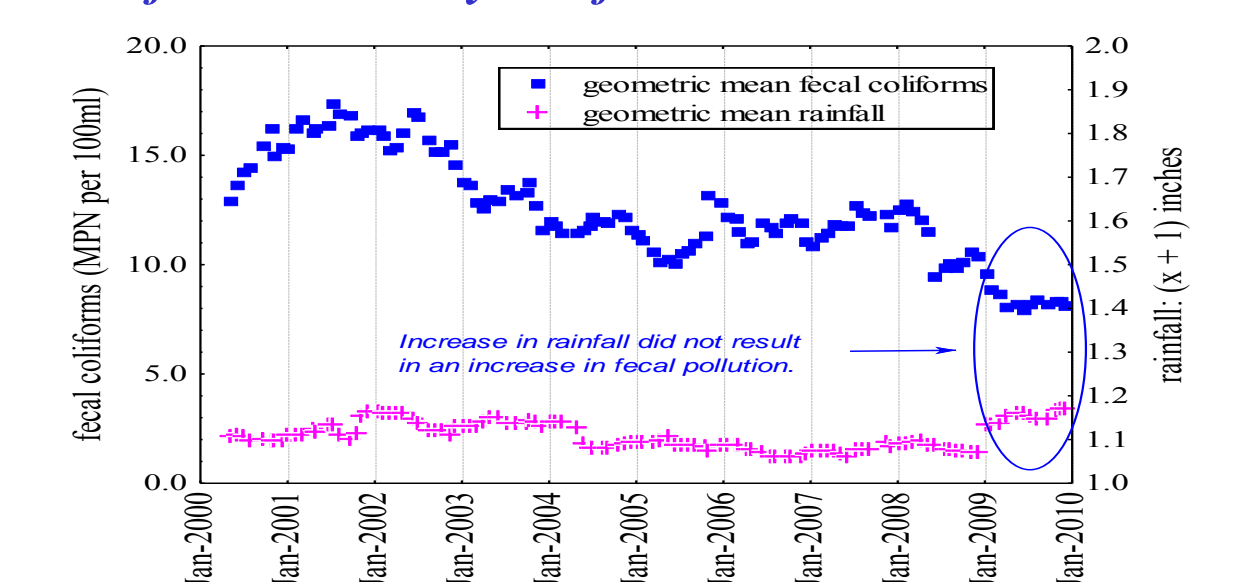
- Fecal pollution moving statistics significantly declined over time (GMs: Rho = -0.837; 90th percentiles: Rho = -0.632, n = 115).

Trend in moving rainfall statistics



- Moving daily rainfall statistics declined significantly, if only slightly, over time (GMs: Rho = -0.235; medians: -0.304; 90th percentiles: Rho = -0.257, n = 115).

Trend in moving geometric means of both fecal coliforms and daily rainfall.



- Rainfall statistics jumped markedly in 2009. Fecal pollution statistics did not seem to respond in kind. Control of fecal pollution may have reduced the potential for contamination of Henderson Inlet by runoff.

Correlations between moving statistics for fecal pollution and rainfall. Two of six combinations of moving statistics showed slight correlation (GM of FC Pollution vs. GM of Rainfall: Rho = +0.243; 90th percentile FC pollution vs. median rainfall: Rho = +0.327. The other four combinations were not significant. The evidence for a relationship between fecal pollution and rainfall is not compelling.

CONCLUSIONS

- All three analytical approaches used for this analysis show that fecal pollution has significantly decreased over the last decade in the innermost end of Henderson Inlet.
- The first two analytical approaches show no detectable change in rainfall over the past decade. However, the third NSSP-based approach suggested that rainfall may have declined, but the effect appears to be small.
- Despite evidence of increased rainfall in 2009 (Approach 3), fecal pollution has not increased. Thus remedial action to date may have been effective in controlling export of fecal pollution from the Henderson Inlet watershed.
- The first two approaches show no relationship between fecal pollution and rainfall. However, the third approach suggests a slight (relatively unconvincing) link between reduced fecal pollution and diminished rainfall.
- The third analytical approach appears to be the most powerful of the three tools when exploring temporal trend of rainfall and relationships between fecal pollution and rainfall.
- The climate may be drifting toward heavier, more frequent rainfall and increased runoff. Pressure on pollution control programs will likely intensify.

REFERENCES

- NSSP (2009). The National Shellfish Sanitation Program Guide to the Control of Molluscan Shellfish. <http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/Seafood/FederalStatePrograms/NationalShellfishSanitationProgram/ucm046353.htm>
- Thurston County GeoData Center Water and Waste Management (2007) Henderson Inlet Watershed Characterization Report. Water and Waste Management. Olympia, WA. 120 pages.
- Washington State Department of Health (2010). Status and Trends in Fecal Coliform Pollution in Shellfish Growing Areas of Puget Sound: Year 2009. Office of Food Safety and Shellfish Programs. Olympia WA 151 pp. <http://www.doh.wa.gov/ehp/sf/Pubs/fecalreport.pdf>.