Application of Bayesian Statistics to Study Determinants of Southern California's Coastal Water Quality (2008-03)

Samuel Choi[1], Sunny Jiang[1], Ivan Jeliazkov[2]

[1]Department of Civil and Environmental Engineering, [2]Department of Economics, University of California, Irvine, CA, USA

Abstract

Southern California's beaches are unique recreational and economic resource to the state of California. To protect this resource, California operates the most comprehensive water quality monitoring/regulatory program in the nation. This study investigates the occurrence of fecal indicator bacteria (FIB) along ~200 miles of southern California's coastline using 7 years of monitoring data from 148 stations to identify determinants that modulate the distribution of FIB. Several major hot spots of coastal water contamination were identified. These sites were associated with stream input into the beach. SUR analysis showed that rainfall is the single most important determinant for water quality. However, reanalysis of data from three summer months (June, July and August) by excluding 9 months of data with possible rain impact did not change the pattern of hot spot distribution map and relative trend of water quality among all 148 stations span three southern California Counties. Comparing year to year water quality variability over the seven-year period, the worst water quality was identified in 2004. Also interestingly, the level of contaminate using two different FIB showed opposite trend, yet the underline determinants for such observation is unclear. Monthly distribution of fecal bacteria showed lowest occurrence during the summer months as compared to winter months. Positive correlations were observed from all determinants for fecal coliform and enterococcus (excluding salinity) when 2001-2007 data were compiled. When data was binned to look at correlations during the summer; temperature, salinity and precipitation (48 hr prior to sampling) were significant determinants of fecal coliform variability, while temperature, salinity, and precipitation were significant determinants of enterococcus variability.

Introduction

Introduction:

- CA's Ocean
  - -Economy: $42 billion annual[1]
  - -150 to 400 million visitors annually[1]
- Public Health Concerns
  - -In 08-09, 55% of beaches received poor grades (C-F grade) [2]
  - -70-75% of postings and closures from unknown sources
  - -estimated ~689,000 to 4 million cases of GI illnesses in So Cal beaches per year [2]
- Response
  - -2000: BEACH Act affirmed development/application of statistical models to estimate and predict level of human fecal pollution
  - -Localized spatial temporal studies have been conducted at a few sites to identify determinants of recreational water quality[3,4,5], but So Cal need a comprehensive investigation of water quality and its determinants to mitigate coastal pollution.
- Objective of This Study
  - -Study determinants modulating occurrence/distribution of FIB on a large temporal and spatial scale

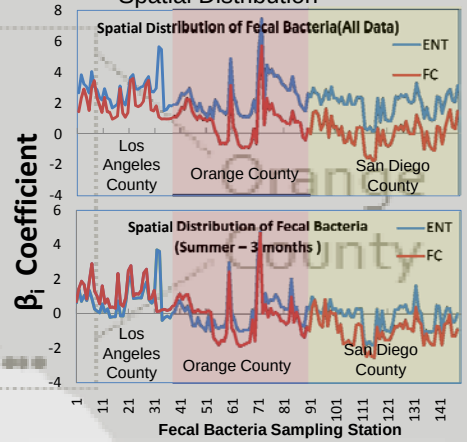
Material and Methods

Refer to Background for Map

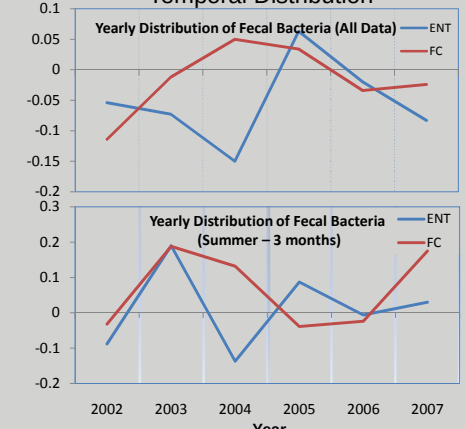
- Study Site
  - -3 counties (Los Angeles, Orange, San Diego)
  - -~220 miles of coastline
- Fecal Indicator Bacteria Data
  - -2001-2007, daily to weekly data for Enterococcus and Fecal coliform
  - -148 stations (LA:33 sites; OC:58; SDC:57) of over 200,000 data points
  - -Fecal Bacteria stations (indicated by ●)
- Environmental Determinants
  - -Precipitation (72 hours prior to sampling), salinity, temperature, distance from pollution sources
- Statistics/Modeling Bayesian Statistics
  - -Seemingly Unrelated Regression Model
  - -5000 runs
  - -Markov Chain Monte Carlo Output

Results

Spatial Distribution

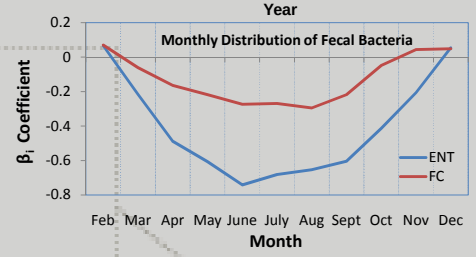


Temporal Distribution



Effects of Environmental Determinants on Fecal Bacteria

FIB	Determinant	Annual: Beta coefficient (β)	Annual: Standard Deviation	Summer: Beta coefficient (β)	Summer: Standard Deviation
Enterococcus	Temperature	0.036*	0.003	0.017*	0.005
	Salinity	-0.003	0.006	0.049*	0.008
	Precipitation (24 hours)	1.424*	0.031	2.319*	0.708
	Precipitation (Post 1 day)	1.547*	0.027	0.01	0.68
	Precipitation (Post 2 days)	0.827*	0.03	-0.575	1.325
	Precipitation (Post 3 days)	0.535*	0.028	2.135*	0.675
Fecal coliform	Temperature	0.01*	0.003	-0.014*	0.005
	Salinity	0.062*	0.006	0.092*	0.008
	Precipitation (24 hours)	1.232*	0.03	0.738	0.722
	Precipitation (Post 1 day)	1.166*	0.026	3.228*	0.682
	Precipitation (Post 2 days)	0.701*	0.029	5.683*	1.353
	Precipitation (Post 3 days)	0.37*	0.028	0.533	0.69



Discussion and Conclusion

- In spite of the strong influence of rainfall on coastal water quality, the hot spots of water contamination are independent of rainfall. The relative water quality index seems to be site specific (The "bad sites" are always bad regardless of rainfall).
  - -On the contrary to the spatial distribution of water quality hot spots, precipitation significantly impacts the seasonal level of coastal contamination. Water quality is the best during the summer months, while the worst water quality is found during winter wet seasons.
- Yearly water quality variability is inconclusive for the seven-year study period. Although high levels of contamination were observed for both FIB in 2005, level of contamination showed appositive trend in 2004. The ecology of the indicator bacteria may be an important factor that has not been included in the model.
- High level of contamination identified at mouths of Queen Bay (LAC), Alamito Bay (OC), Aliso Creek (OC), and San Juan Creek (OC) suggesting natural source of fecal contamination may be an important contributor for the coastal water quality.

Acknowledgements

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