Headwaters to Ocean Conference
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Blame the Moon:

A Critical Analysis of "Environmental Sources" of Enterococcus in Southern California Coastal Waters

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Environmental Sources of Enterococcus

*The hypothesis is that natural components of coastal ecosystems **(tides, sand, kelp, plants, groundwater, birds, and wetlands)** generate enterococcus bacteria and falsely cause beaches to appear contaminated by human sewage.*

Hypothetical uncertainty of false positives in monitoring data allows researchers to argue that enterococcus is an unreliable measure of water quality.

*In peer reviewed scientific publications, **researchers directly warn regulators** to account for great uncertainty when developing enterococcus standards.*

A critical analysis exposes major faults in the hypothesis

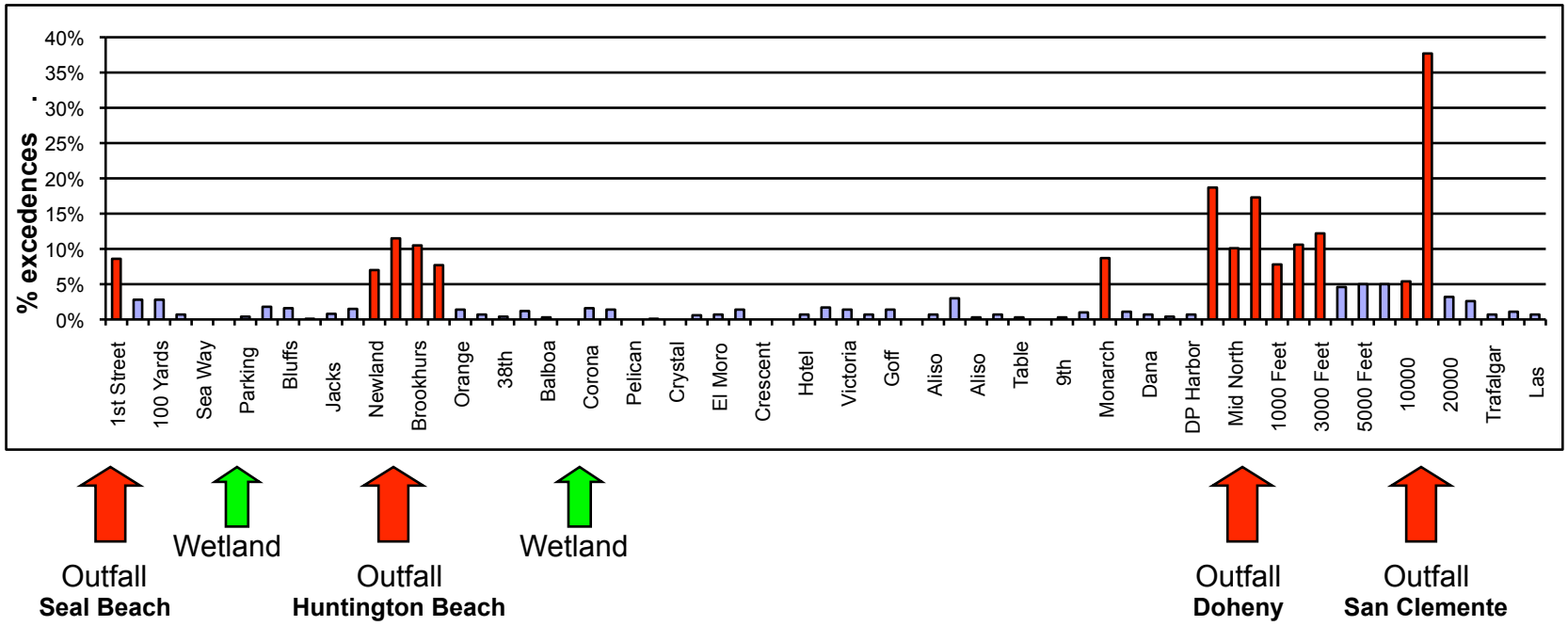
Several basic principals of scientific investigation are violated.

- Conclusions are not supported by the results; Studies do not satisfy criteria for causation because they lack appropriate control sites, lack specificity, consistency, coherency and strength of association, and are not biologically plausible. Site selection bias and lack of critical analysis was also prevalent.

- Most of the studies discussed were conducted in **south Huntington Beach (SHB)** near one of the largest sewage outfalls in the country: 240 m/g/d of effluent is discharged less than 5 miles directly offshore.

Sewage Discharges into Southern California's Coastal Waters

Orange County California: AB 411 Period - Dry Weather Single Sample Standard Exceedance Rate for Enterococcus (2005 – 2009) - Data provided by: County of Orange Health Care Agency - Environmental Health



Sand

Sand has been alleged to be a source or reservoir of enterococcus in several **SHB** studies (Grant, 2001; Boehm, 2002; Boehm, 2005; Sanders, 2005; Ferguson, 2005). One reported enterococcus persisting in sand ***"may cause beach water quality failures and calls into question the specificity of this indicator for determining recent faecal contamination."*** (Ferguson, 2005).

- The conclusion is not supported by results as control sites were lacking or tested clean *"… low or nondetectable levels [of enterococcus] in offshore and control site sediments."* (Ferguson, 2005)
- Not biologically plausible as sand is a filtrate for a range of substances including microorganisms and chemicals.
    - Sand is used in the tertiary treatment process of human waste water (Bauer, 2010).
- No consistency or coherency as most beaches have sand, and most beaches have clean coastal waters.
- Not biological plausible for a line of sand at the high tide mark to culture sufficient concentrations of bacteria needed to contaminate millions of gallons of open ocean beach water.
- No physical transport mechanism for high tide sand to influence water bacteria concentrations during low tides.

- Studies show that known point sources (sewage outfalls and spills) do contaminate coastal waters and beach sand (Elmanama, 2005; Ghinsberg, 1994).
    - Polluted waters contaminate sand - not visa versa.

Groundwater

Another **SHB** study investigated the daily exchange of sea and groundwater along the coastal fringe, and concluded that groundwater can negatively impact coastal water quality if it were contaminated (Boehm, 2004), and groundwater could be a source of nutrients contributing to the growth of enterococcus in coastal waters. **"*This work … presents evidence that supports an association between groundwater discharge and fecal indicator bacteria*."**

- The conclusion is not supported by results as groundwater samples tested clean.
- There are no underground sources of enterococcus
- Groundwater has low nutrient availability, so unable to promote growth of bacteria in coastal waters.
- No consistency or coherency as most beaches experience varying degrees of ocean-groundwater exchange.

Plants and Dirt

A study at **SHB** reported 8-13% of enterococcus isolates from coastal waters were from species *"associated with plants and soil and rarely associated with human infection."* (Ferguson, 2005).

- Not biologically plausible as plants and soil (lacking digestive systems) can not culture enteric bacteria in sufficient concentrations to contaminate open ocean beaches.
- The conclusion is not supported by results as control sites tested clean.
- No consistency or coherency as beach waters near undeveloped watersheds (more plants and soil) have better water quality than beaches near urbanized watersheds.
- No physical transport mechanism for plant bacteria to reach coastal waters as creek flow is rain dependant.
- No critical analysis of the 87%-92% of bacteria isolates that were opportunistic pathogens (Willey, 1999).

Kelp

A study at **SHB** reported kelp fragments washed up on the high tide line are a source of enterococcus bacteria which are released into coastal waters during high tide events (Boehm, 2005).

- Not biological plausible as kelp is a photosynthetic marine alga; No association with enteric bacteria.
- Kelp is an indicator species of clean healthy ocean water.
- No consistency or coherency as beaches with high kelp density have excellent water quality (Monterey for example).
- Southern California kelp forests have been in dramatic decline the past 50 years primarily due to high nutrient loads.

Birds

Birds observed at **SHB** studies (Grant, 2001; Kim, 2004; Boehm, 2005) lead researchers to conclude, ***"Bird feces are a significant source of enterococcus…"*** (Grant, 2001).

Birds observed at **Doheny Beach** lead researchers to conduct an epidemiology study that defines Doheny as a bird-impacted beach (Critical Path Science Plan, EPA, 2007).

Doheny is one of the most contaminated beaches in California, and a small bird colony is the alleged problem!?!? Rarely mentioned, a large sewage outfall discharges millions of gallons every day less than two miles off the beach.

Bird guano can impact water quality under highly qualified conditions (small water body with restricted flow: ponds & bays).

However:

- Not biologically plausible for a bird colony to generate enough guano to contaminate open ocean water at high levels (several hundreds of enterococcus cfu/100 ml seawater).
    - At the beach, bird feces are literally a drop in the ocean.
- No consistency or coherency as most beaches have birds, and most beaches have clean coastal waters.
- No concentration/response effect as beaches with high bird densities (sanctuaries) have good water quality.
- No significant human health risk posed by bird droppings due to the limited presence of pathogens (Soller, 2010).
- **Doheny epidemiology study found elevated health risk associated with swimming. This conflicts with the bird-impacted beach claim as bird guano does not generate high risk outcomes.**

Moon and Tides

Two studies at **SHB** observed enterococcus concentrations tended to be higher when samples were collected at high tide (Boehm, 2002; Boehm, 2005). Enterococcus from bird feces are alleged to be growing on the sand and kelp and are suspended by the incoming tide, resulting in erroneous false-positives in monitoring data. ***"…tide should be considered in the design and interpretation of beach monitoring program data."*** (Boehm, 2005).

- Not supported by results as high bacteria levels were observed during other tidal phases, including low tide.
- No consistency or coherency as all beaches experience tidal influence, and most have clean coastal waters.

These studies observed a "concentration distribution" and concluded the things with the highest concentration were the source of the bacteria. However, high tide lines accumulate higher concentrations (residue) of all things floating in the ocean including kelp, driftwood, garbage, seashells, and bacteria.

Wetlands

A study at **SHB** observed high enterococcus concentrations at the mouth of a small tidal wetland, and concluded the wetland was a source of bacteria causing false-positives in monitoring data (Grant, 2001). ***"This … calls into question the use of ocean bathing water standards based on enterococci at locations near coastal wetlands."***

- No consistency, coherency or concentration/response effect as wetlands contain all alleged environmental sources of enterococcus (many are bird sanctuaries), yet nearby beaches have clean coastal waters.
- It is well established that wetlands are a pollution sink and not a source.
    - Municipalities use (and construct) wetlands to treat and remediate municipal wastewater.
    - Wetlands can reduce inputs of fecal indicator bacteria by 97% (Kay, 2005).
- A subsequent, more comprehensive study of the same wetland reported opposite results.
    - Enterococcus concentrations were highest at the source of urban runoff, and incrementally decreased through the wetland, with the lowest concentrations observed at the ocean mouth (Reeves, 2004).

SUMMARY

The hypothesis that natural components of coastal ecosystems are responsible for enterococcus contamination of beaches lacks adequate evidence. The supporting studies violate basic principals of scientific investigation because they lack established methods for hypothesis testing, and do not satisfy the criteria for causation.

Lack of falsifiability. Most of the studies lacked appropriate control sites and the conclusions are based on inadequately tested hypotheses.
Lack of specificity, consistency and coherency. Most beaches have sand, birds, tides, etc., yet are characterized by low bacteria concentrations.
Lack of a concentration/response effect. Wetlands with high concentrations of all alleged sources have consistently low water bacteria levels.
Lack of strength of association. Epidemiology studies report health risk is associated with elevated enterococcus concentrations in recreational marine waters (positive-positives). The epidemiological and microbiological evidence does not support the claim of false-positives.
Lack of biologically plausibility. For the hypothesis to hold true, unrelated components in nature must align to selectively culture the one enteric bacterium used to test marine water quality. Further, the alleged sources selectively culture enterococcus at only certain beaches, yet not for the majority. Systematic species specific differential mis-classification bias is biologically improbable.
Lack of biological plausibility. The alleged sources (tides, sand, kelp, etc.) can not physically mass culture the single isolate in sufficient concentrations to consistently contaminate millions of gallons of open ocean beach water.
Selection bias. Most supporting studies were conducted at south Huntington Beach (**SHB**) near a large sewage outfall.
Lack of critical analysis. The studies failed to consider other plausible explanations for elevated enterococcus concentrations, such as sewage outfalls.

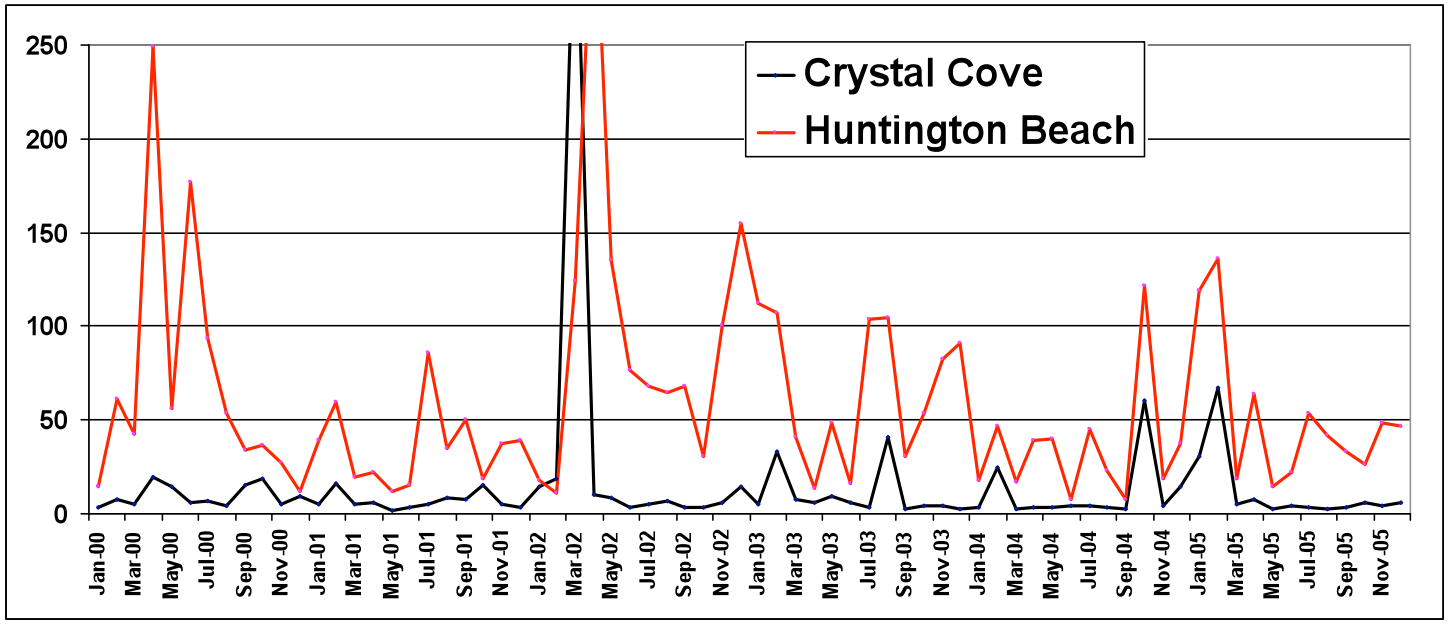
Do natural components of coastal ecosystems (sand, kelp, birds, wetlands, etc.) generate the particular enteric bacteria that we happen to use for testing water quality? And does this phenomena occur only at certain beaches?

Two widely established scientific observations refute the environmental sources hypothesis.

- **Most southern California beaches have sand, birds, tides, etc, and most beaches have clean coastal waters**.
    - References: *Figure 2; Noble, 2000; Surfrider, 2010; NRDC, 2010*
    - Water quality for southern California beaches is good: 91% of beaches with A or B grades (HTB, 2010).
    - Only some beaches frequently exceed the health standard.

- **Decades of epidemiology studies confirm increasing enterococcus concentrations in recreational marine waters are associated with health risk.**
    - References: *Saliba, 1990; Pruss, 1998; Wade, 2003*
    - The statistically significant dose-response relationship is in direct conflict with the claims of false-positives.
    - All epidemiology studies were conducted with alleged environmental sources present.
        - Any background "noise" due to natural sources was present and accounted for in the elucidation of the dose/response relationships.
    - **The current single sample standard** (104 cfu) is calculated from a generous 75% confidence interval (34 cfu = "acceptable" 1.9% HCGI), which **allows a wide range of variability in bacteria concentrations before the standard is exceeded**.
    - Enterococcus is the only indicator bacterium accepted by the U.S. EPA and W.H.O. for monitoring recreational marine waters for fecal contamination.
    - Recent studies confirm enterococcus is a stronger predictor of risk than other indicators (Colford; Wade; Fleming; Kay; 2009 EPA Beach Conference).

2000 – 2005: Mean Monthly Enterococcus Concentrations (cfu)



- Both beaches have sand, birds, groundwater, tides, kelp and plants
- Huntington Beach has a large sewage outfall

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