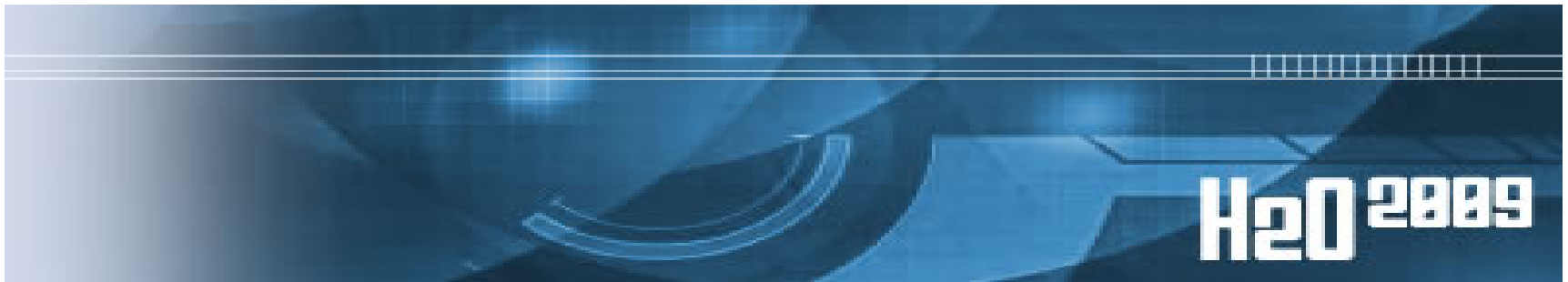


Restoration of San Dieguito Lagoon: Impact on Bacteria Levels



Presented to

2009 Headwaters to Ocean (H2O) Conference, 28 October 2009

Presented by

Robert Grove
Southern California Edison

Hany Elwany, Ph.D.
Coastal Environments

11/30/2009

Slide 1

Restoration of San Dieguito Lagoon: Impact on Bacteria Levels

Outline:

1. **Primer on bacteria monitoring**
2. **San Dieguito Project – the setting**
3. **Bacteria study results, 2002-2008**
 - Comparisons:**
 - Inlet open vs. closed**
 - Winter vs. summer**
 - Bird nesting season vs. the non-nesting season**
 - Before vs. after restoration**
 - Beach-inlet vs. lagoon**
4. **Conclusions**

Why Monitor Bacteria?

- Bacteria in ocean waters may present health risks to swimmers and surfers.
- Bacteria in lagoon waters may signal degraded environmental conditions and it may effect the quality of water in ocean.
- Bacteria in lagoon waters may indicate pollution originating from runoff or spills from sewers or from other human sources.



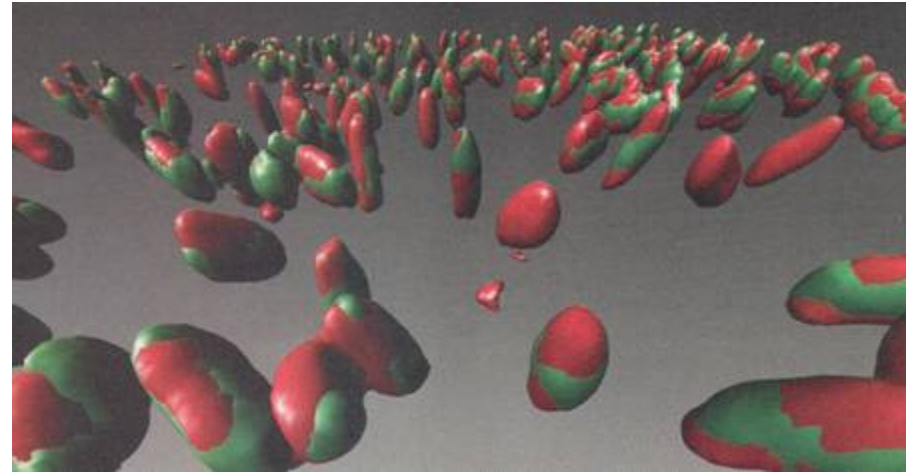
PHOTO BY NINA DEPTON / INDEPENDENT
A sign at the south end of Huntington State Beach warns swimmers of high bacteria levels in the water. Several beaches have been closed because of bacteria problems.

Findings without answer

Los Angeles Times, 2002

What Bacteria Do We Monitor?

- **Fecal Indicator Bacteria (FIB)** are bacteria that live in the intestines of animals and are deposited in the environment in feces.
- While most are harmless, their presence indicates fecal contamination, which may mean that other disease-causing bacteria also found in feces may be present.
- **Coliform Bacteria** such as *Escherichia coli* (*E. coli*) have been heavily studied, and there are well-established methods to detect and measure them in water samples.
- **Pathogenic bacteria** are often more difficult to measure and may require specific tests.



Immobilized *E. coli* cells expressing cytosolic chaperone and its cognate signal sequence.

Fluorescence and deconvolution.
Magnification: 100x.

Dr. Colin Rickman, University of Edinburgh.
“Image of distinction” award – 2008 Nikon Small World Competition.

Am. Biotechnology Laboratory, Vol. 27, No. 10,
October 2009

11/30/2009

Slide 4

FIBs Measured to Monitor Water Quality

Coliform presence is recognized as a reliable indicator of fecal pollution in freshwater.

- **Total Coliforms** - are coliform bacteria that live in the intestines of animals.
- **Fecal Coliforms** - are a specific subgroup of coliform bacteria that live in the intestines of warm-blooded animals and humans.
- ***Enterococcus*** - is another fecal bacteria that lives in the intestines of warm-blooded animals, and is a more reliable indicator in marine waters than coliforms.

Bacterial Water Standards

- The California Health and Safety Code sets standards for bacterial concentrations on public beaches.
- Bacterial levels above these limits are considered unsafe for human health:
 - Total coliforms: 10,000 MPN/100 ml
 - Fecal coliforms: 400 MPN/100 ml
 - *Enterococcus*: 104 MPN/100 ml



Not Strictly for the Birds

Undaunted by brown pelicans and caution tape, a surfer heads for the waves Wednesday morning near a stretch of shoreline in Huntington Beach that has been closed for two weeks because of pollution. Investigators are still seeking the source of the bacteria. B3

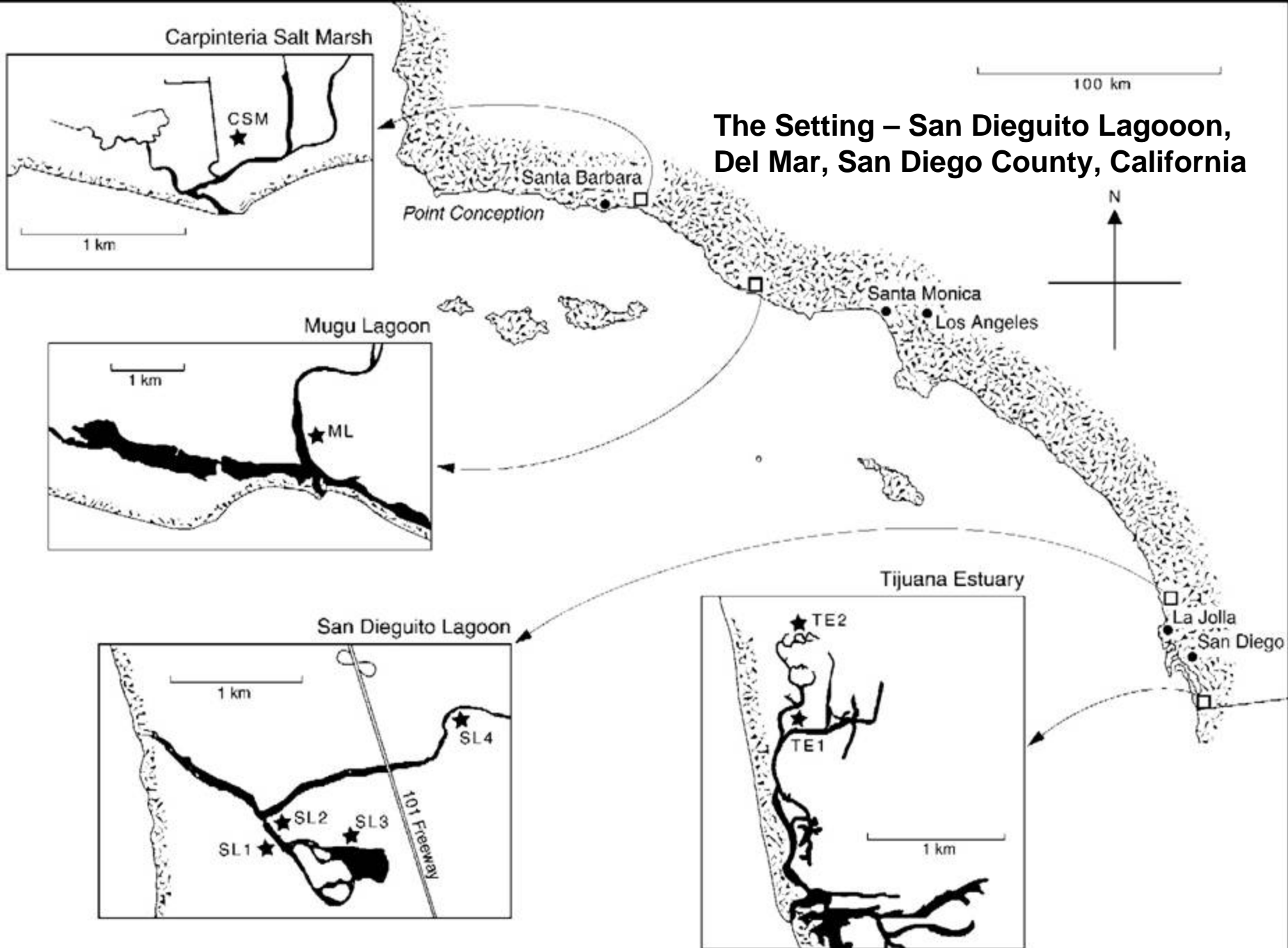
DON KUSLERSKI / Los Angeles Times

Los Angeles Times, May 2, 2002

Sources of FIB in the Environment

- **Bacteria are normally present in the intestines of native fauna that use the lagoon area.**
- **Naturally-occurring bacteria levels may fluctuate seasonally as a result of animal activity, for example, increases are observed when birds are nesting.**
- **Bacteria may also be due to human activity such as runoff from agricultural areas.**
- **Rainstorms, particularly at the beginning of the rainy season, wash fecal bacteria from the surrounding area into the lagoon and ocean.**
- **The lagoon may act as an incubator for bacteria when it is closed off from tidal flushing.**

The Setting – San Dieguito Lagoon, Del Mar, San Diego County, California



Bacteria Sources Specific to San Dieguito Lagoon

- San Dieguito Lagoon has a history of agricultural use (east of I-5 Freeway).
- The Horse Stables, which are located next to the lagoon, are a source of runoff fecal material.
- Increased use of the lagoon by native fauna, such as the nesting activities of birds.



11/30/2009

Slide 9

Factors Reducing Bacteria in the Environment

- Fecal bacteria are unable to grow in marine waters and will die off after a short period of time.
- Bacteria can be killed by solar radiation, high salinity, and predation by microorganisms.
- Flushing of the lagoon dilutes any bacteria present and exposes them to marine conditions.



Oct. 4, 2002 21:25 GMT
0m 125 250 375 500
© 2002 by Ocean Imaging
This image may not be reproduced
without written permission

San Dieguito Lagoon Prior to Restoration



11/30/2009

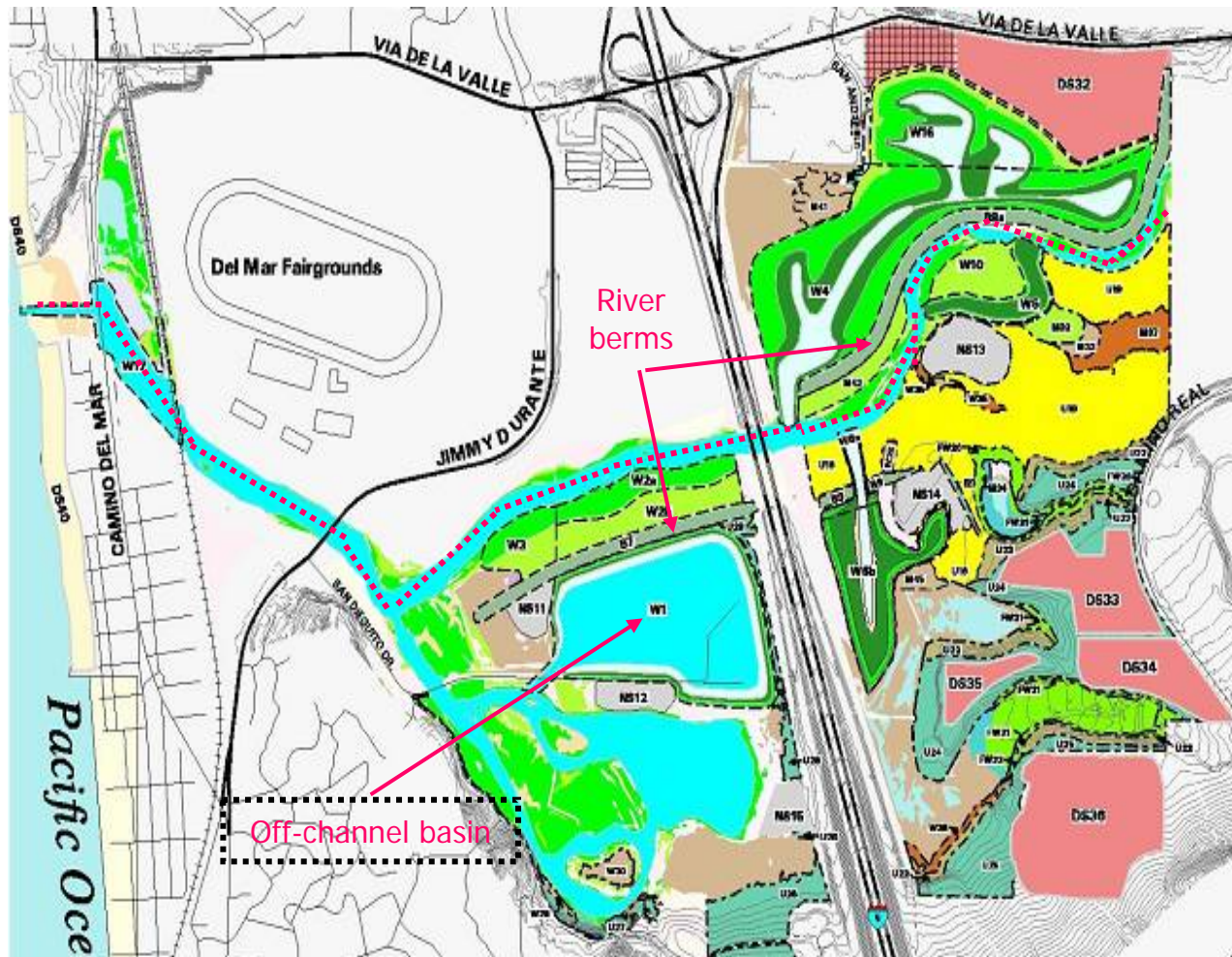
Slide 11

Construction of basins east of I-5

Letting the tide in



San Dieguito Lagoon Restoration Project



- Basins
- Channels
- Four Nesting Sites

SCE obtained the following credits:

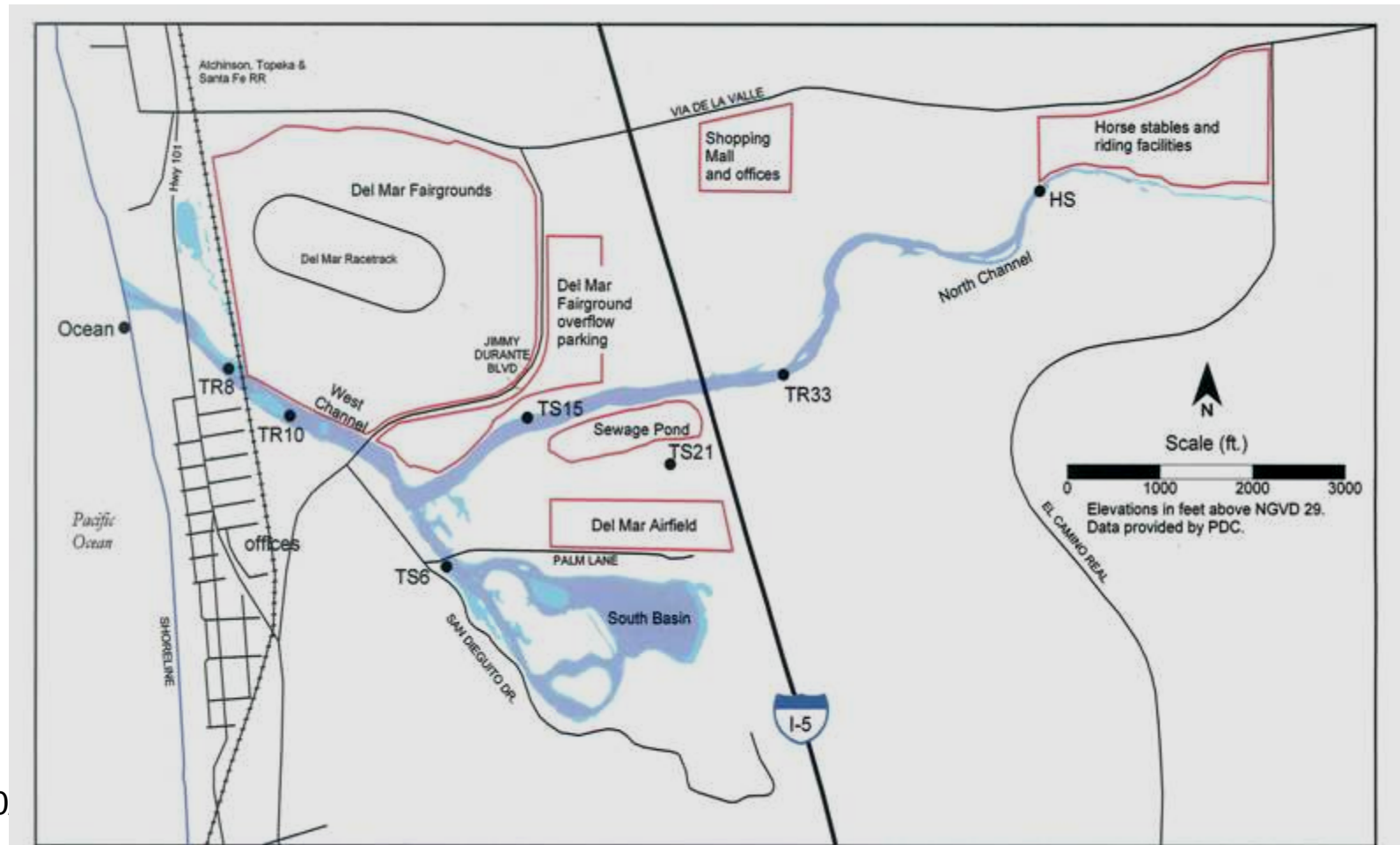
- 135 acres for restoration, and
- 15 acres for keeping the inlet open.

11/30/2009

Slide 13

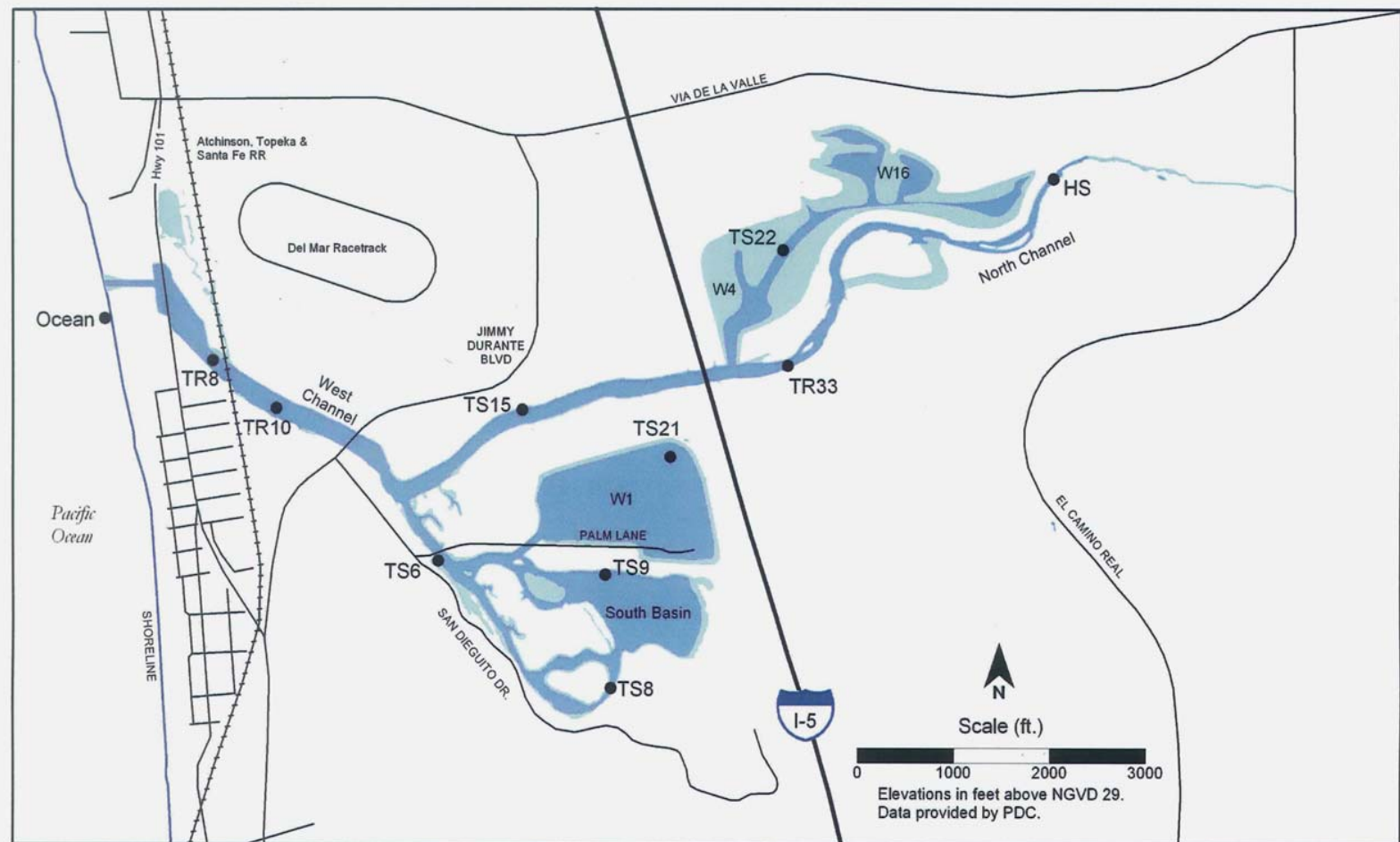
Bacterial Monitoring Stations Before the Restoration

- Measurements were made at 7 Stations
- Measurement were made twice a month.



Bacterial Monitoring Stations Following Restoration (map after restoration)

- Measurements made at 10 Stations.
- Measurements made twice a month.



11/30

5



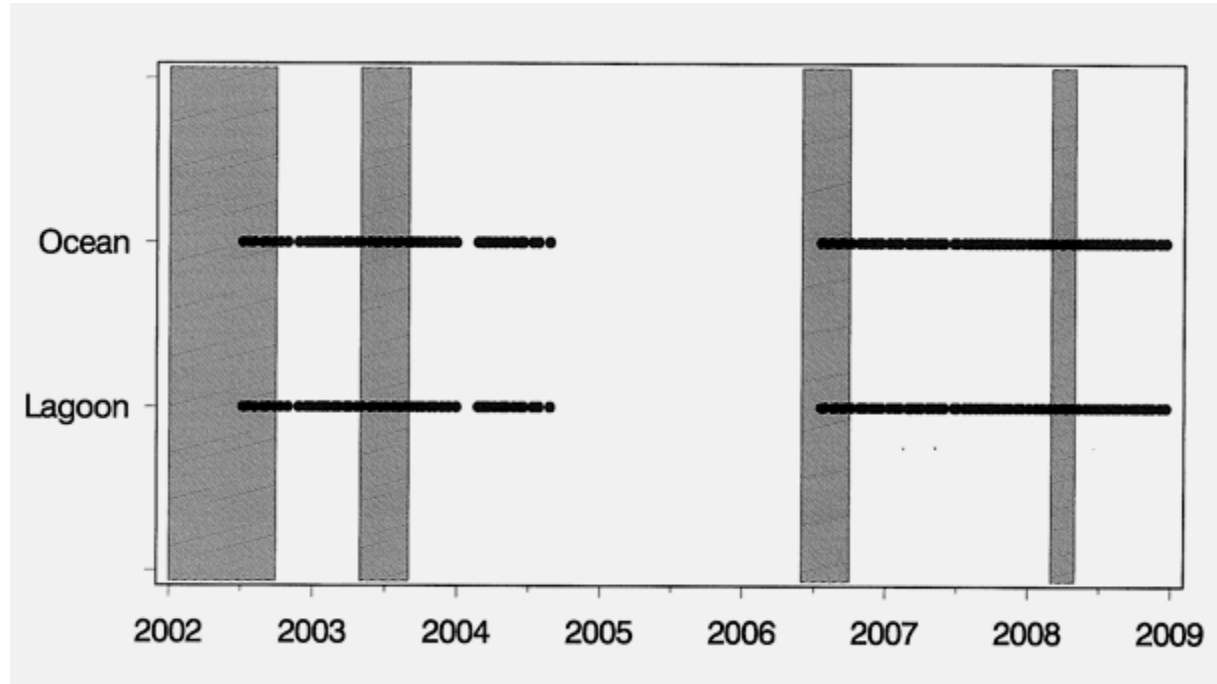
Bacteria Measurements during "closed" and "open" periods

"Before Restoration":

- From 1 July 2002 – 25 August 2004

"After Restoration":

- From 21 July 2006 – 31 December 2008

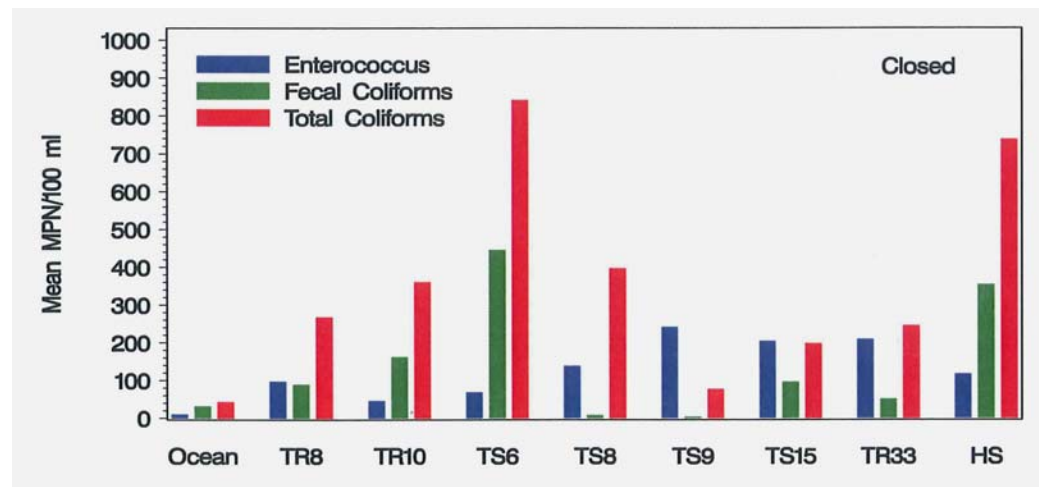
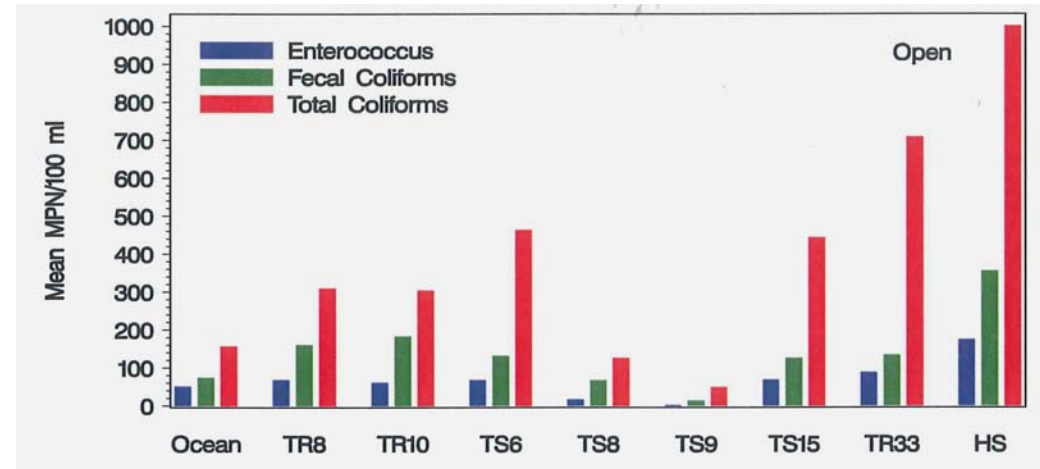


Shaded: inlet closed
Clear: inlet open



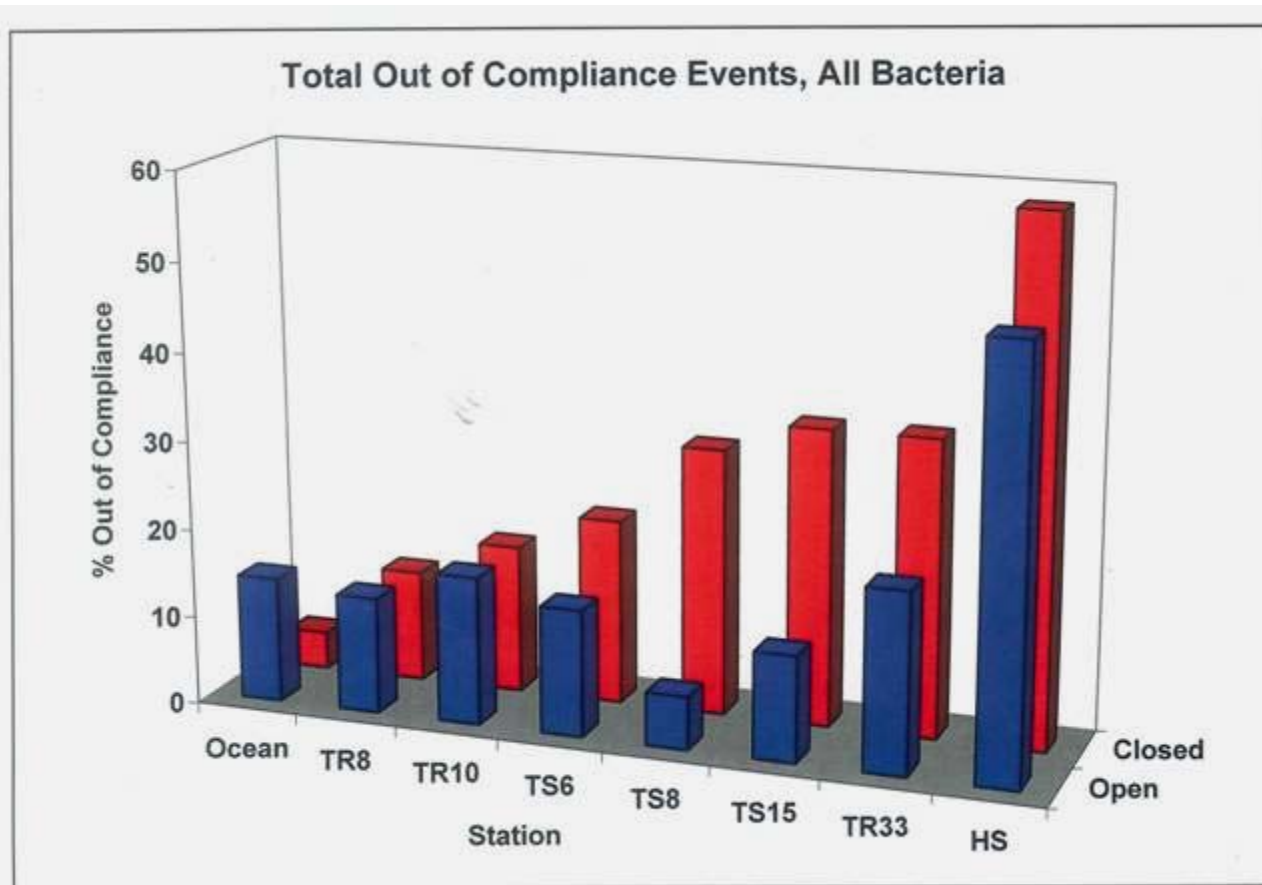
Bacteria Measurements (2002-2008), by Station With Lagoon - Open, and - Closed

- Lagoon is Open approximately 80% of time.
- No statistical difference between mean measurements while lagoon open or closed (t-test).



11/30/2009

Percent of Out of Compliance, by Station Inlet/Lagoon Open vs. Closed

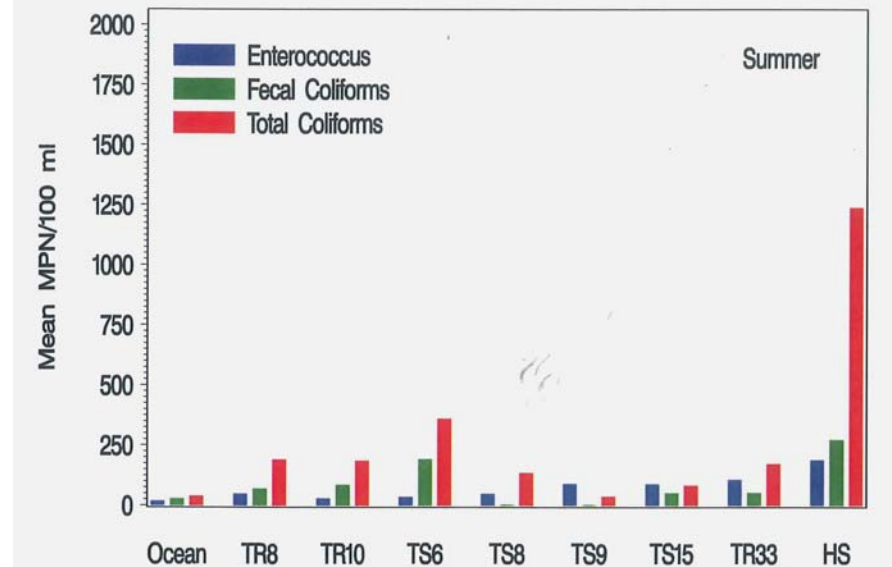
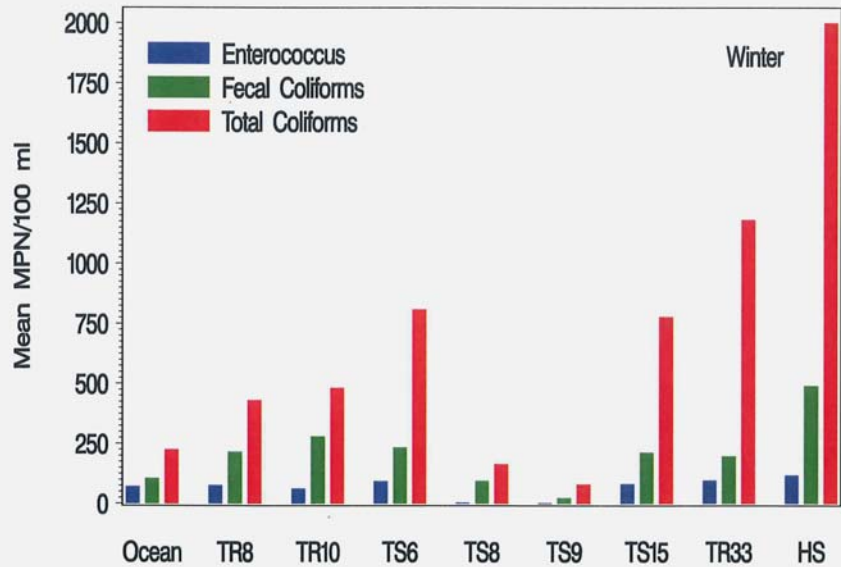


- **Percentage of Out-of-Compliance is higher when the lagoon is closed.**

11/30/2009

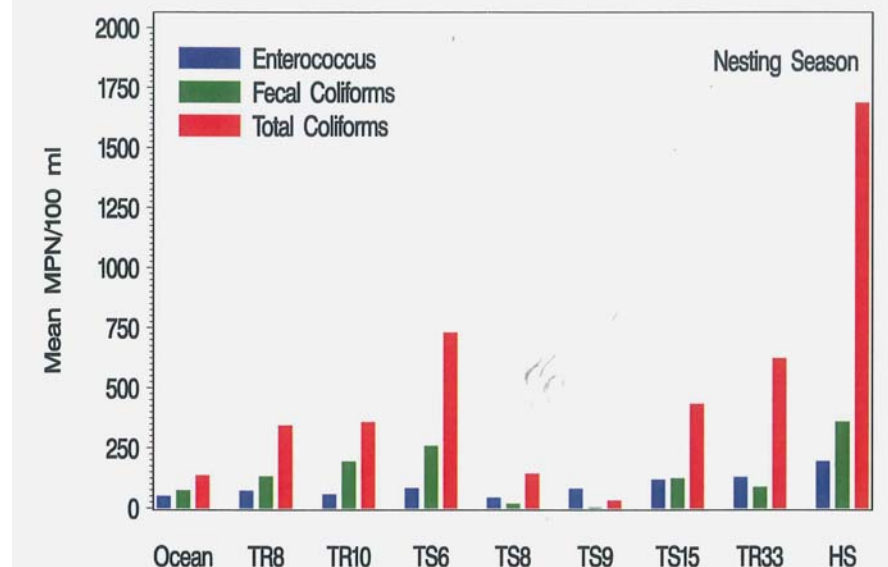
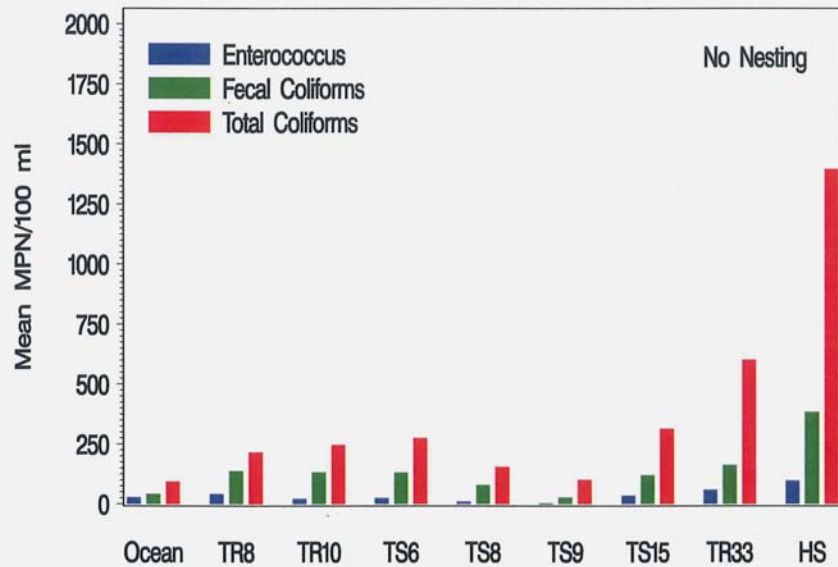
Slide 19

Bacteria Measurements, by Station Winter vs. Summer Seasons



- Mean bacteria concentrations is lower in Summer than Winter.

Bacteria Measurements, by Station Non-Nesting vs. Nesting Seasons

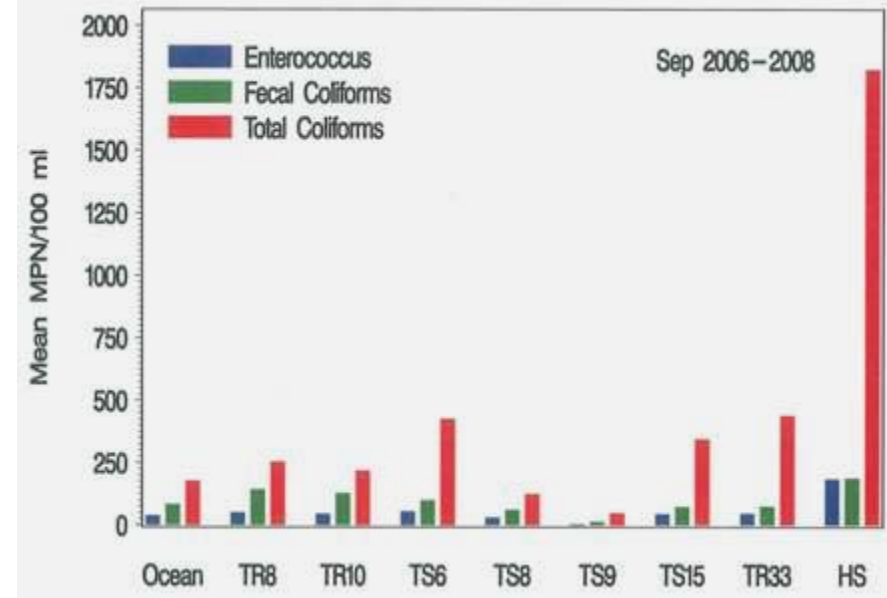
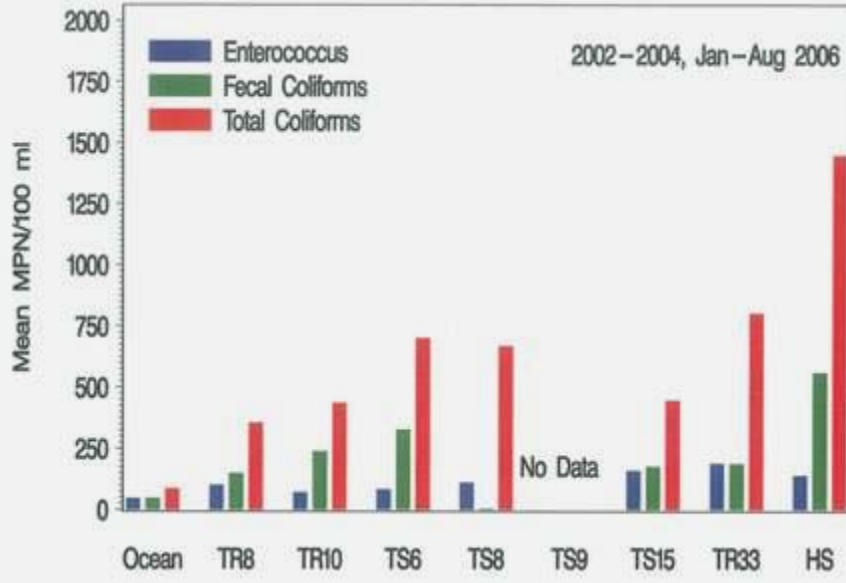


- **Nesting Season: 15 February to 15 August.**
- **No large differences in the mean of bacteria concentrations during nesting season and the remainder of the year.**

11/30/2009

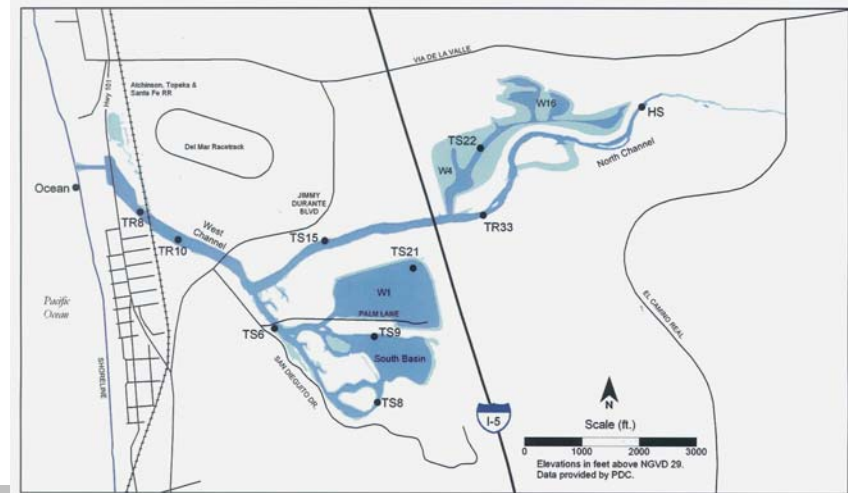
Slide 21

Bacterial Measurements, by Station Before vs. After Restoration

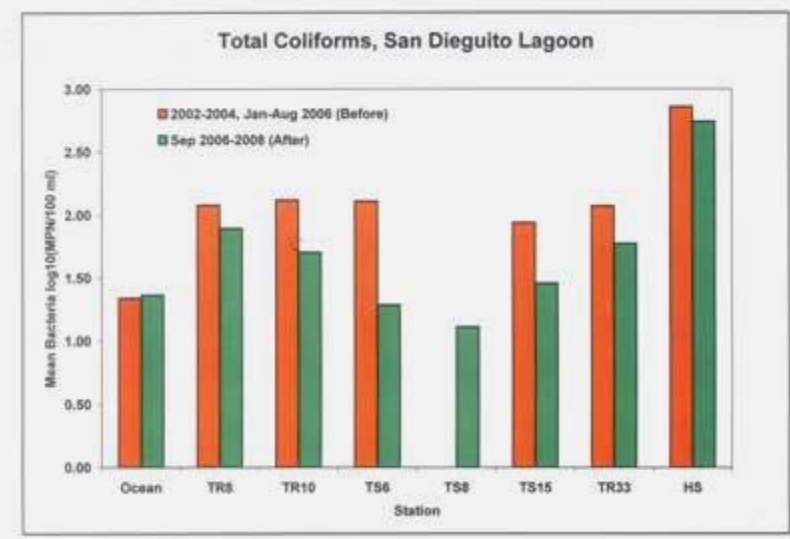
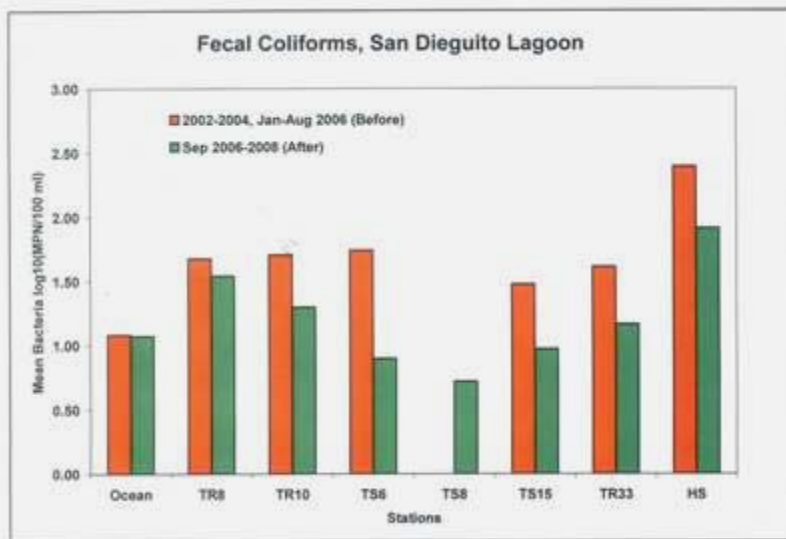


- Mean “after” bacteria concentrations were statistically significantly lower for the three indicator bacteria (Total Coliforms, Fecal Coliforms, and *Enterococcus*) for most stations.

11/30/2009

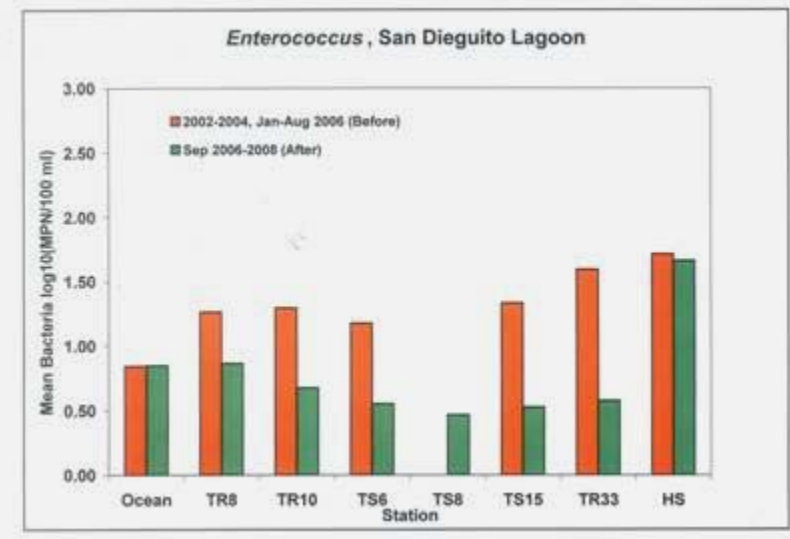


Bacterial Measurements, by Station Before vs. After Restoration

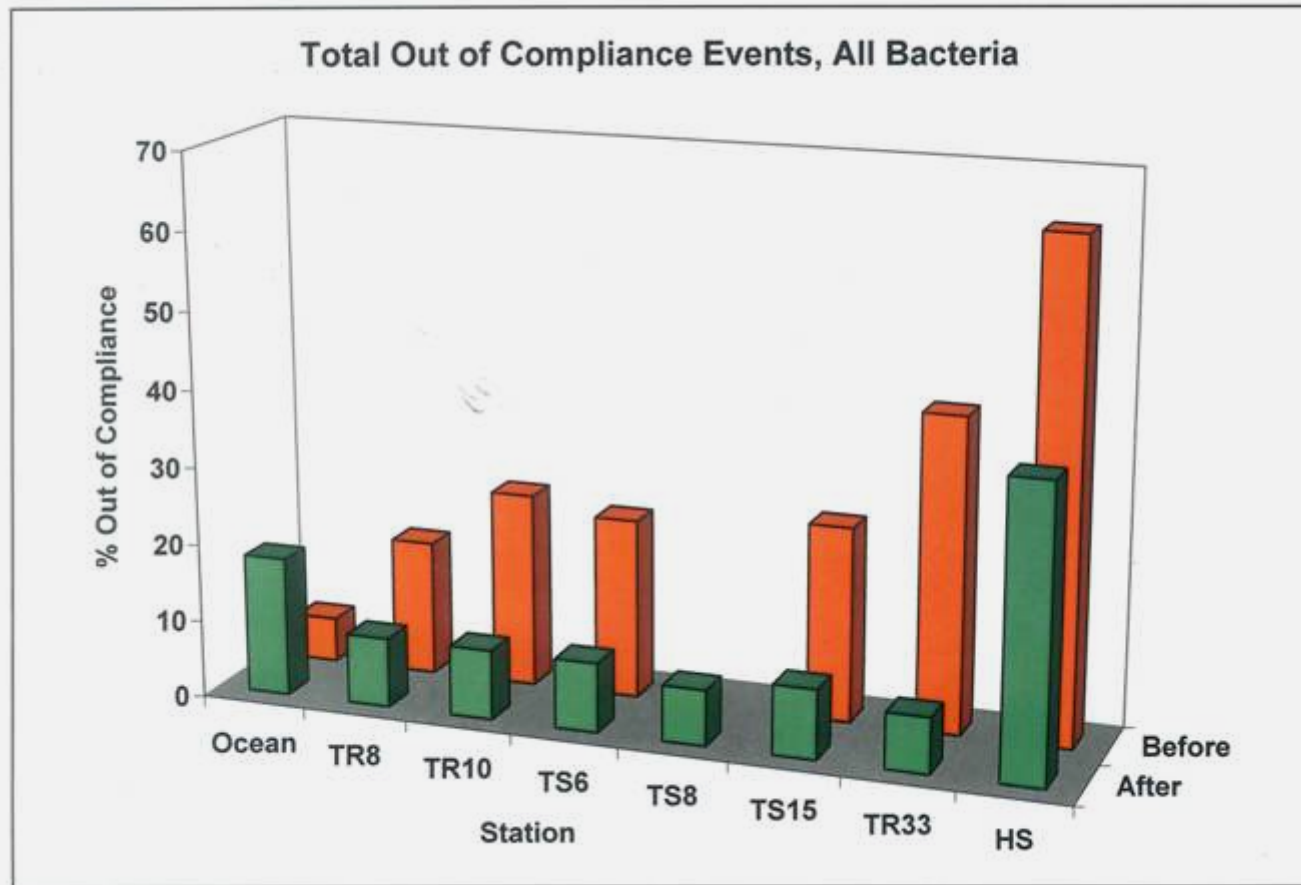


- **Before: 2002-2004, Jan.-Aug. 2006 (Orange)**
- **After: Sep 2006-2008 (Green)**

11/30/2009



Percent of Out of Compliance Before vs. After Lagoon Restoration

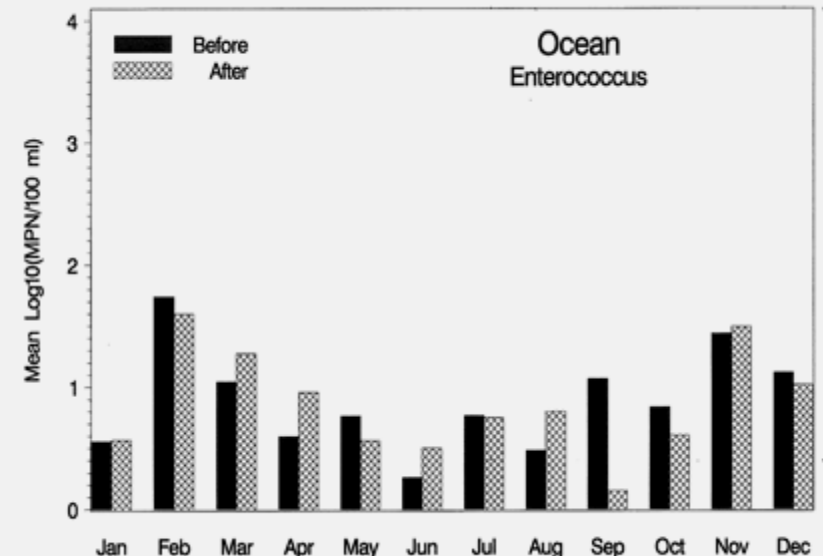
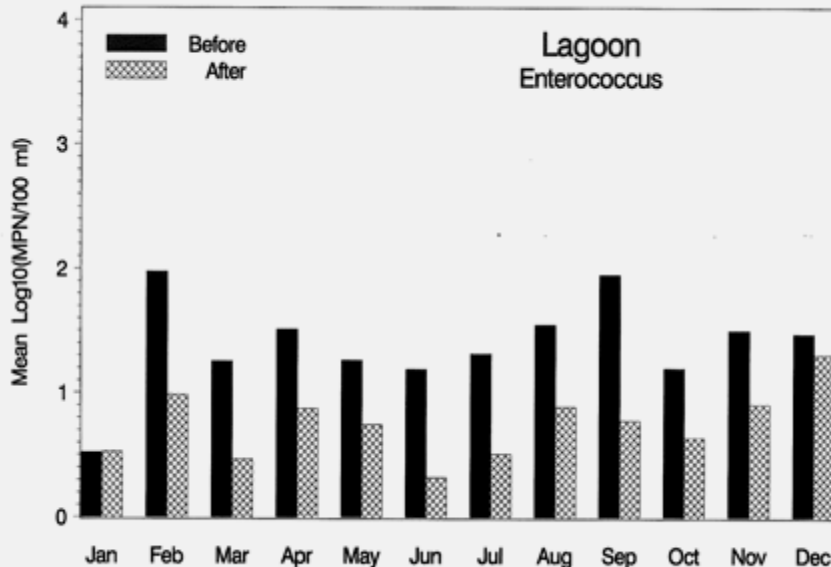


- **Percent Out-of-Compliance at all Lagoon Stations was much lower after restoration than before restoration.**

11/30/2009

Slide 24

Monthly Comparison of *Enterococcus* Lagoon vs. Ocean, Before & After Lagoon Restoration



- Large differences in *Enterococcus* concentrations in the lagoon between before and after restoration.
- No significant differences for *Enterococcus* concentrations in the ocean for the same periods.

11/30/2009

Slide 25

Percent of Out of Compliance Lagoon vs. Ocean

Period	Lagoon		Ocean	
	N1	Percent	N2	Percent
Before	316	32.6	53	5.7
After	392	12.5	56	17.9

N1 = Number of Lagoon water samples. Samples are taken from several stations.

N2 = Number of ocean water samples.

CONCLUSIONS

- **Bacterial levels in San Dieguito Lagoon are impacted by human use of the lagoon area.**
- **Percent of out of compliance is higher when the lagoon is closed than when it is open.**
- **Percent of out of compliance is higher in summer than winter; while the mean values of bacteria concentrations are lower in summer than winter.**
- **No significant difference of bacteria concentrations during the nesting seasons and the other time period of the year.**
- **Lagoon bacterial levels have been statistically significantly reduced following restoration.**
- **Bacteria levels in the ocean are more or less similar before and after the restoration project, and the lagoon does not act as a source of contamination to the ocean.**
- **Sources of bacteria in the ocean in front of the lagoon are not known.**

Site features

- Surf zone sites
- Lagoon sites



4sz: Storm drain



0sz: Dog beach

6sz: Storm drain



-4sz: Storm drain

Possible bacteria sources, Del Mar beach and San Dieguito Lagoon



RR: PVC p



RR: Stagnant water ditch just next to RR



EE: Natural Preserve (dry bird feces)

Questions?

From: Stanley Grant, et al., 2002

11/30/2009

Slide 29