Water Quality Investigations in the Tijuana River/Estuary and Near-Coastal Ocean

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San Diego
United States of America
Estados Unidos Mexicanos
Tecate
Tijuana
Rosarito
Océano
Pacifico


DANGER
CONTAMINATED WATER
AVOID WATER CONTACT
FROM THIS POINT SOUTH
TO THE
INTERNATIONAL BORDER
PELIGRO
AGUA CONTAMINADA
/ ALEJESE
EVITE CONTACTO
CON EL AGUA HASTA
LA LINEA INTERNACIONAL

Water Pollution and the Tijuana River

- Stormwater contamination from wet weather runoff events
- Sewage collection system: Not all of the population of Tijuana is connected to sewers (perhaps as much as 10-15% of the population)
- Discharge from a variety of maquiladoras and other industrial and commercial land use activities.
- Point source discharges into the Tijuana River watershed (e.g. Tecate brewery and Tecate wastewater treatment plant).

T
Tijuana Population

Source: UN World Urbanization Prospects

year	population	Growth rate	
2010	1,754,403	2.54%	
2015	1,938,597	2.02%	
2020	2,140,398	2.00%	
2025	2,333,215	1.74%	
2030	2,490,861	1.32%	
2035	2,626,333	1.06%	


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Tijuana River Mouth

- Watershed drains 1,735 square miles.
(70% of which is in Mexico)
- Estimated 200,000-300,000 persons are not connected to sewer.

Source: http://www.coastalconservancy.ca.gov/scwrp/SitePics/01-12_tj_mouth.jpg

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Quantitative Detection of Hepatitis A Virus and Enteroviruses Near the United States-Mexico Border and Correlation with Levels of Fecal Indicator Bacteria[▽]

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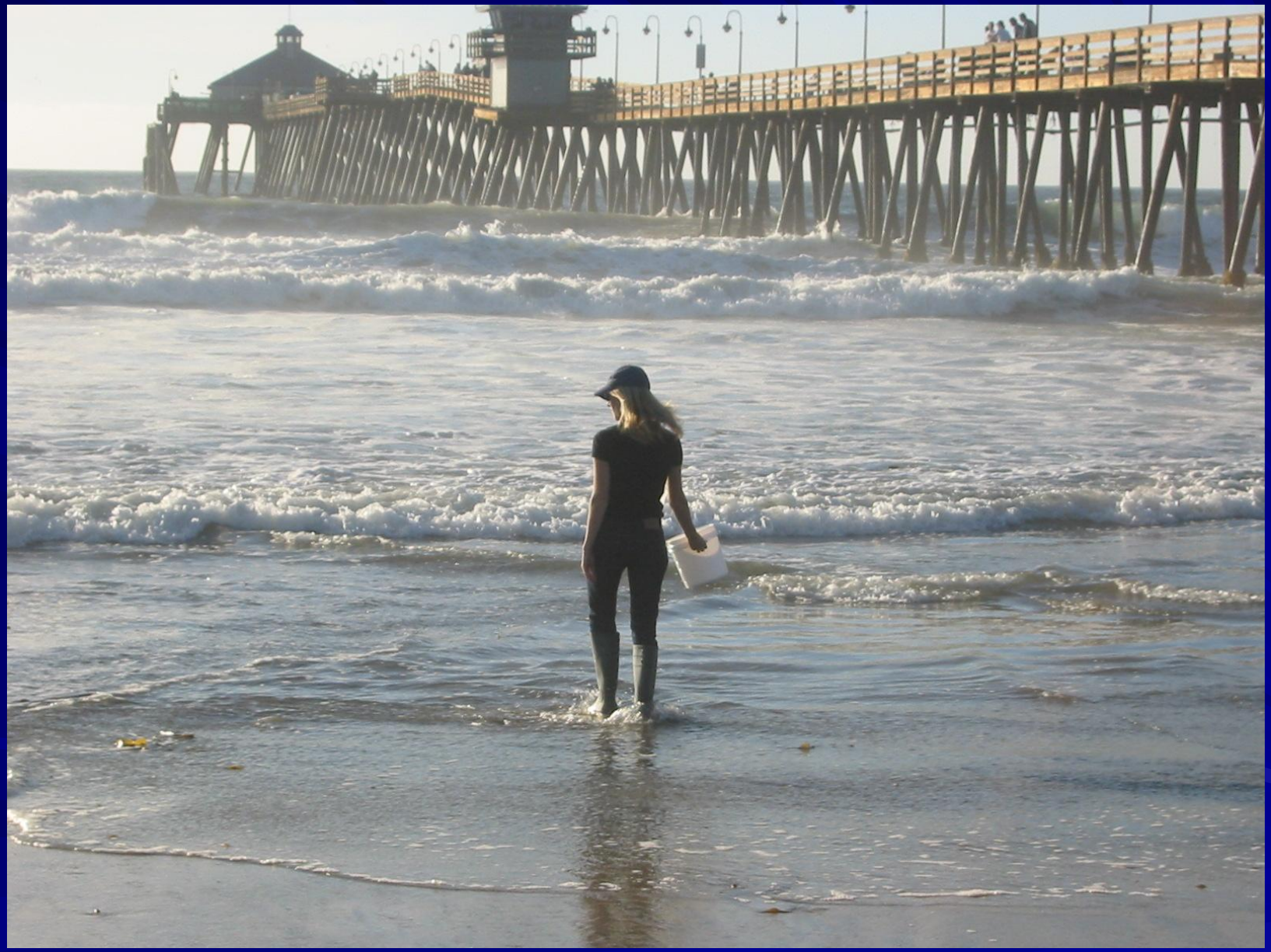
For decades, untreated sewage flowing northward from Tijuana, Mexico, via the Tijuana River has adversely affected the water quality of the recreational beaches of San Diego, California. We used quantitative reverse transcription-PCR to measure the levels of hepatitis A virus (HAV) and enteroviruses in coastal waters near the United States-Mexico border and compared these levels to those of the conventional fecal indicators, *Escherichia coli* and enterococci. Over a 2-year period from 2003 to 2005, a total of 20 samples were assayed at two sites during both wet and dry weather: the surfzone at the mouth of the Tijuana River and the surfzone near the pier at Imperial Beach (IB), California (about 2 km north of the mouth of the Tijuana River). HAV and enterovirus were detected in 79 and 93% of the wet-weather samples, respectively. HAV concentrations in these samples ranged from 105 to 30,771 viral particles/liter, and enterovirus levels ranged from 7 to 4,417 viral particles/liter. The concentrations of HAV and enterovirus were below the limit of detection for all dry weather samples collected at IB. Regression analyses showed a significant correlation between the densities of both fecal bacterial indicators and the levels of HAV ($R^2 > 0.61$, $P < 0.0001$) and enterovirus ($R^2 > 0.70$, $P < 0.0001$), a finding that supports the use of conventional bacterial indicators to predict the levels of these viruses in recreational marine waters.

Sampling Sites

Sampling Overview

- 4 rain events sampled.
- 2 samples each rain event; 200yd. N of the Tijuana River mouth & Imperial Beach pier.
- After ≥0.2 inches of rain.
- Taken about 12 hours after river peaks.
- 1500 yards apart.



qPCR

QUANTITATIVE ANALYSIS OF GENE EXPRESSION

VALIDATING DNA MICROARRAY RESULTS

QUANTIFYING:

FUNGUS

VIRUS

BACTERIA

PCR + QUANTITATIVE PCR

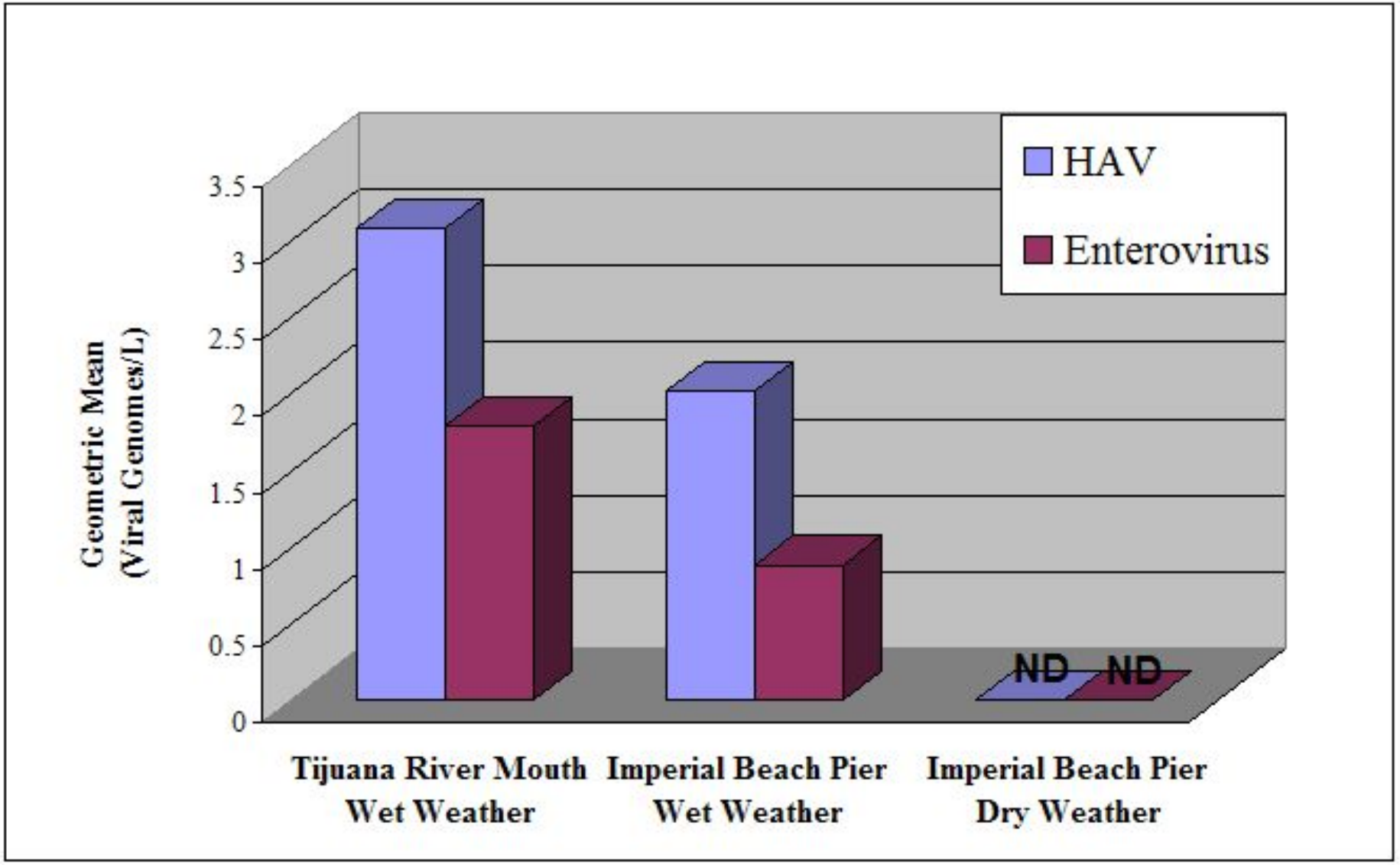


Figure 5. Average viral loads of HAV and enterovirus at the Tijuana River mouth and Imperial Beach pier during wet and dry weather determined using real-time RT-PCR

Human Health Risk Assessment Using the Beta-Poisson Infectivity Model

- Under conditions where the distribution of microorganisms in the administered dose is regarded as Poisson, then this infectivity model takes the form of an exponential model, where the parameters α and β characterize the dose response curve:
- $P_i = 1-(1+\frac{\mu V}{\beta})^{-\alpha}$

Risk Assessment for Swimming at Imperial Beach, CA During Wet Weather

$$Pi = 1-(1+\frac{\mu V}{\beta})^{-\alpha}$$

α = 0.409
B = 0.788

194 copies/L/ 55 (# of infectious particles per copy number)
= 3.53 infectious particles per L
=0.353 particles per 100 mL or

$$Pi = 1-(1+\frac{0.00132}{0.788})^{-\alpha}$$

Pi= 1-(0.8595)
Pi= 1.4 x 10^{-1}

Risk (Pi) of Infection is 1.4 per ten swimmers. Risk of disease is lower , perhaps on order of 1 in 100

Risk Assessment for Swimming at Imperial Beach, Ca During Dry weather

$$Pi = 1-(1+\frac{\mu V}{\beta})^{-\alpha}$$

α = 0.409
B = 0.788

<2 copies/L/ 55 (# of infectious particles per copy number)
= < 0.036 infectious particles per L
=<0.0036 particles per 100 mL

$$Pi = 1-(1+\frac{0.0036}{0.788})^{-\alpha}$$

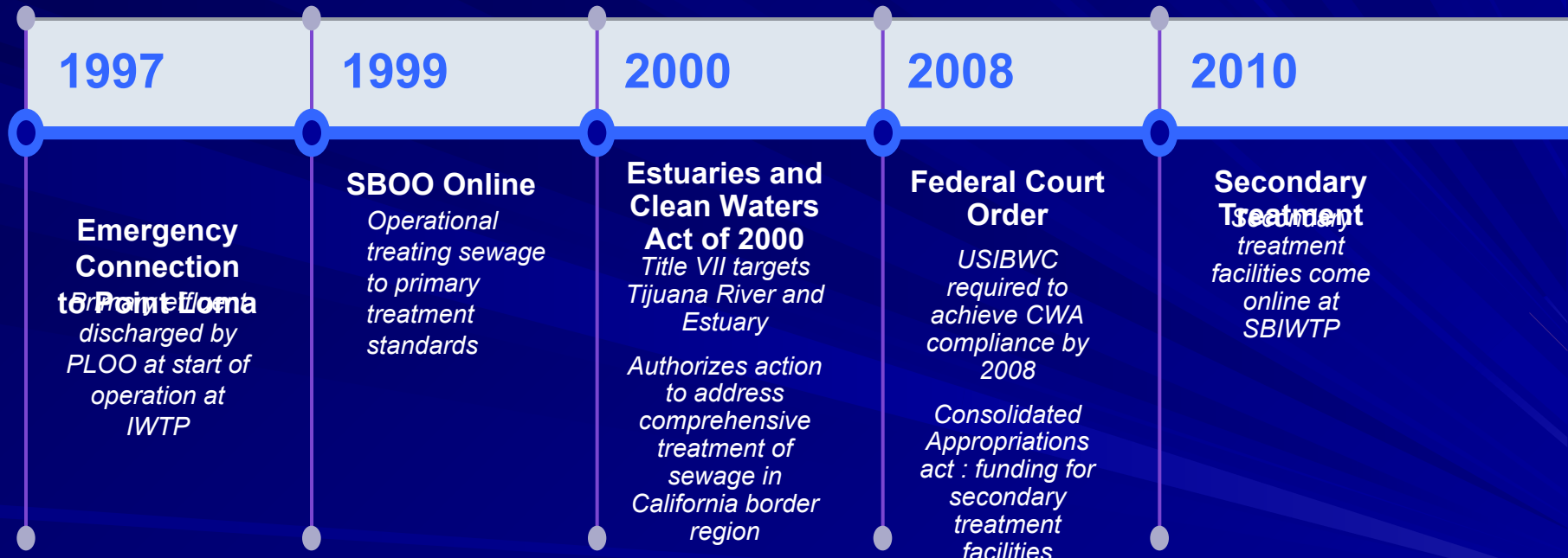
Pi+ 1-(0.9981)
Pi= 1.86 x 10^{-3}

Risk (Pi) of Infection is slightly less than 2 in one thousand
Risk of disease is lower, perhaps on the order of less than 2 in 10, 000

Conclusions

- High levels of hepatitis a during wet weather attributed to inadequate sewage collection infrastructure in Tijuana
  - 86% of samples taken from the surfzone were positive for hepatitis a virus and enteroviruses
- The risk of infection for swimming in the ocean during wet weather at Imperial Beach is relatively high at 14%, although the risk of disease in health swimmers/surfers may be significantly lower.

A Very Brief History of the Sewage Situation at the Tijuana River/Estuary and the operation of the South Bay International Wastewater Treatment Plant (SBIWTP)



Effect of the South Bay Ocean Outfall (SBOO) on ocean beach water quality near the USA–Mexico border

Richard Gersberg ,Jürgen Tiedge,Jürgen Tiedge,Dana Gottstein,Jürgen Tiedge,Dana Gottstein,Sophie Altmann,Jürgen Tiedge,Dana Gottstein,Sophie Altmann,Kayo Watanabe,Jürgen Tiedge,Dana Gottstein,Sophie Altmann,Kayo Watanabe &Volker Lüderitz

International Journal of Environmental Health Research (2008)

- The frequency of exceedence of bacterial indicator thresholds was statistically analyzed for 11 shore (surfzone) stations throughout US and Mexico using the Fisher's exact test, for the years before (1995–1998) as compared to after the SBOO discharge began (1999–2003).
- Results showed that when the water quality for the shore stations was statistically compared for the years before (1995- 1998) and after (1999- 2003) the operation of the SBOO, only two of the beach stations in the US (station S11 the beach at the end of Monument Rd. and S12, the beach at end of Carnation Street) showed significant reductions in the exceedence frequency for both the mean FC and TC thresholds after the outfall discharge began.
- **Moreover, using this exceedence of the enterococcus mean threshold which is now considered by both the State of California and the U.S. EPA to be the indicator of choice for marine waters, we found that not a single beach station in the USA, showed significant improvement in water quality after the start of discharge to the SBOO**.
-

Effect of Secondary Treatment at the South Bay Ocean Outfall on Water Quality near the US-Mexico Border

Katie Shephard and Richard Gersberg
School of Public Health
San Diego State University

1. Determine the effect of secondary treatment of the SBIWTP on densities of fecal indicator (enterococci, total and fecal coliforms) bacteria at ocean and shore stations in the region of the ocean outfall.
2. Determine the effect of secondary treatment of the SBIWTP on the frequency of exceedances of the Ocean Plan water quality standards at ocean and shore stations in the region of the ocean outfall.
3. Evaluate the effect of secondary treatment to the SBIWTP on the levels of dissolved oxygen and chlorophyll a at offshore ocean stations.

City of San Diego ocean Monitoring program

- Monthly reports of water quality and ocean conditions from Playa Blanco, Mexico to Coronado, USA are generated by the City of San Diego
  - NPDES Permit compliance
- 11 Shore Stations
  - Samples collected at the surf zone weekly
- 33 Off Shore Monitoring Stations
  - Dissolved oxygen, chlorophyll a – data collected quarterly
- 7 Kelp Stations
  - Collection on monthly basis at discrete depths

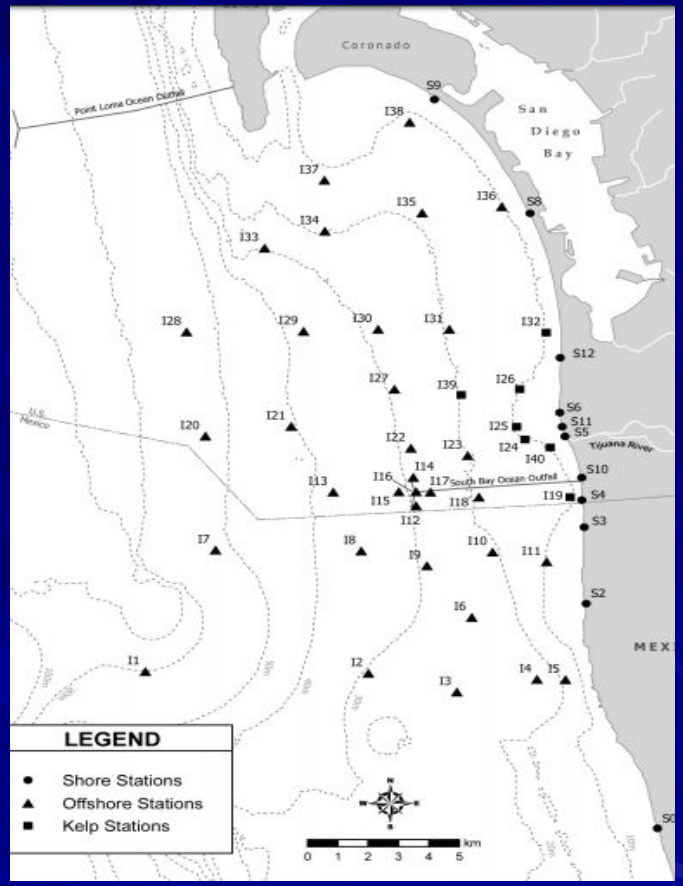


Figure 1. Monitoring stations of the City of San Diego. (2018). Source: City of San Diego. (2018). Retrieved from (https://www.sandiego.gov/sites/default/files/sbwrp_mwqr_august_2018.pdf)

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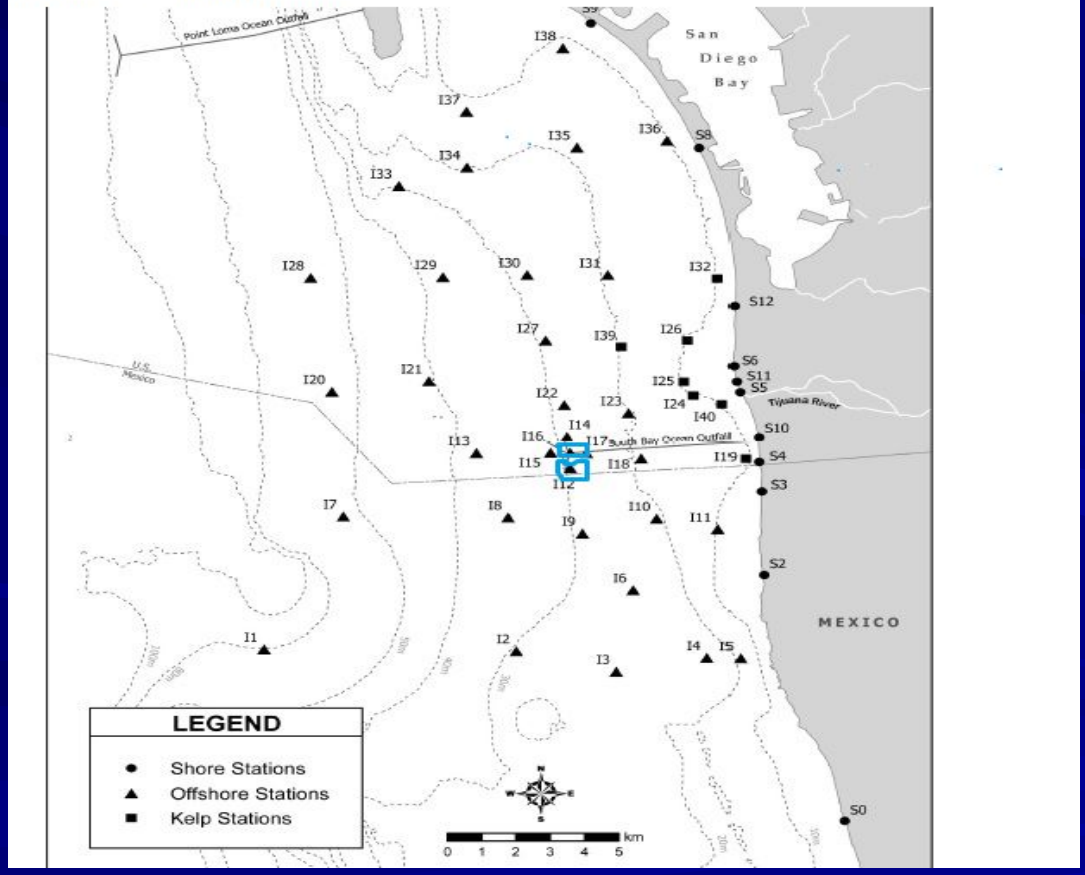
-

Winter Period Water Quality After Secondary Treatment Upgrade - Ocean Stations

Of the 21 ocean stations only two (Stations I12 and I16) showed a decrease in bacterial densities (enterococci, fecal coliform and total coliform) and these only at the 18-meter depth contour. for all three fecal indicator bacteria analyzed (enterococci, fecal and total coliforms) after the upgrade to secondary treatment



Winter Period Water Quality After Secondary Treatment Upgrade- Kelp Stations

Only three of the kelp stations (I25, I26, I32) evidenced a significant decrease in bacterial density after the addition of secondary treatment

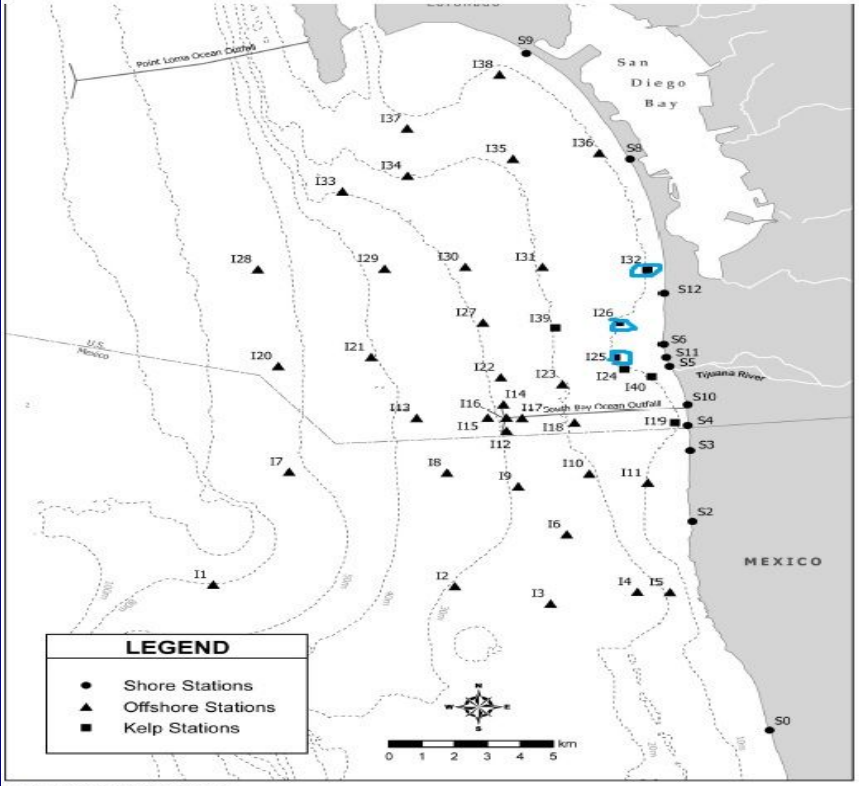


Figure 1.1 Station Map

Winter Period Water Quality After Secondary Treatment Upgrade - Shore Stations

Wilcoxon rank sum test indicated that seven of the shore stations showed a decrease in total bacterial density post-treatment upgrade for all three indicators (enterococci, fecal coliforms and total coliforms)

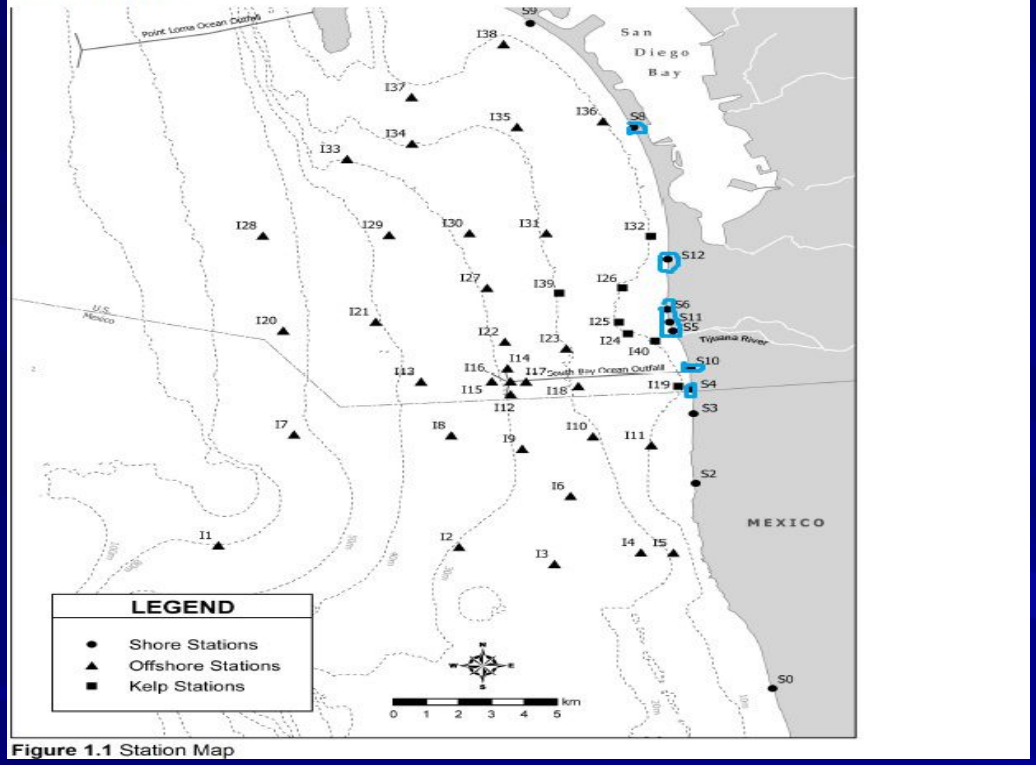


Figure 1.1 Station Map

Summer Period Water Quality After Secondary Treatment Upgrade- Ocean Stations

Similar to the results of the chlorination analysis, only ocean stations I12 and I16 evidenced an improvement following the secondary treatment upgrade for all three indicator bacteria, but only at the 18-meter sampling depth

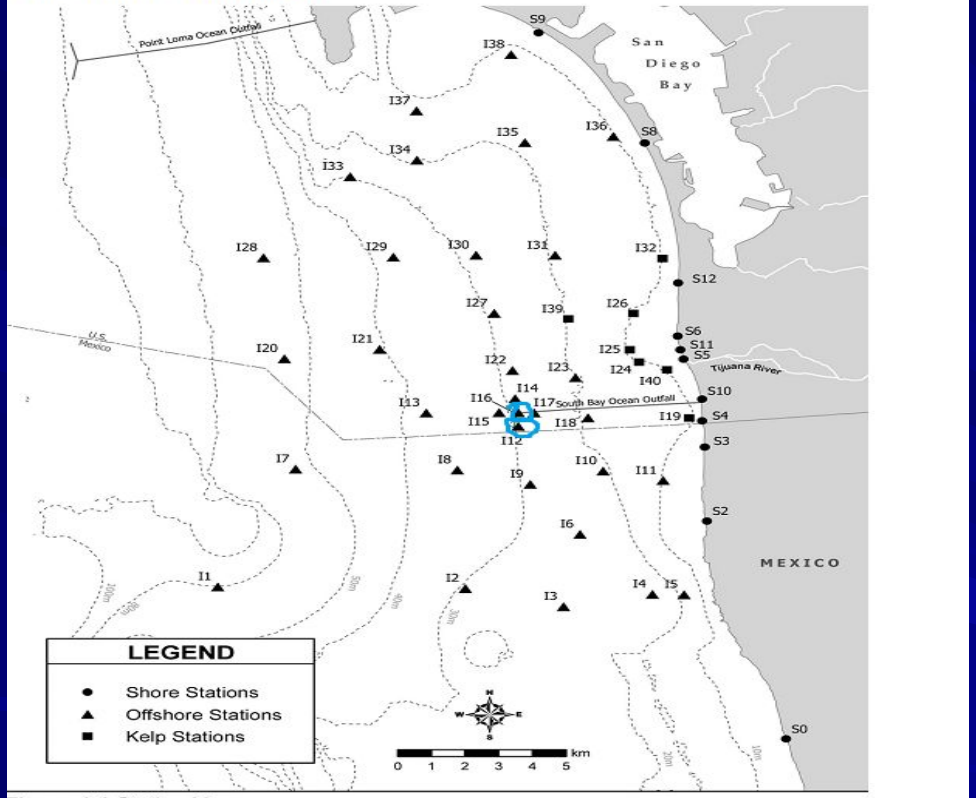


Figure 1.1 Station Map

Summer Period Water Quality After Secondary Treatment Upgrade- Kelp Stations

There were no kelp bed stations that had an improvement in water quality following the addition of secondary treatment during non-chlorination. In fact two stations (I24 and I25) evidenced a significant increase increase in bacterial densities for enterococci

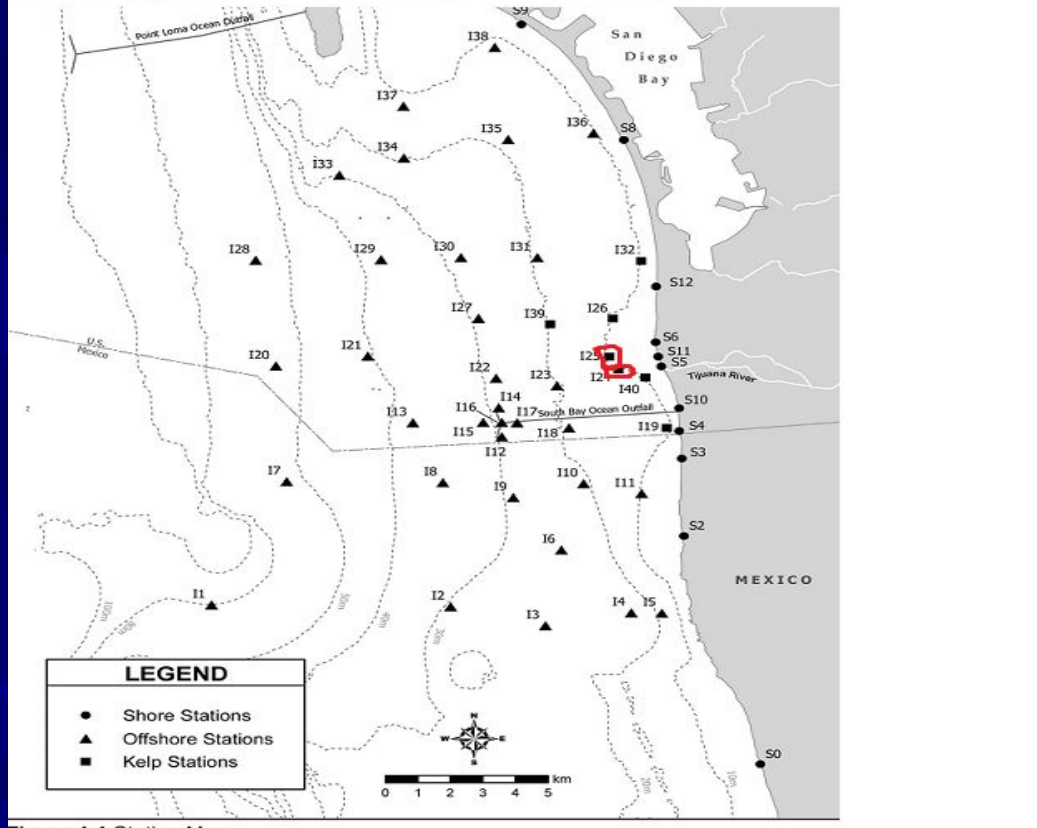


Figure 1.1 Station Map

Summer Period Water Quality After Secondary Treatment Upgrade- Shore stations

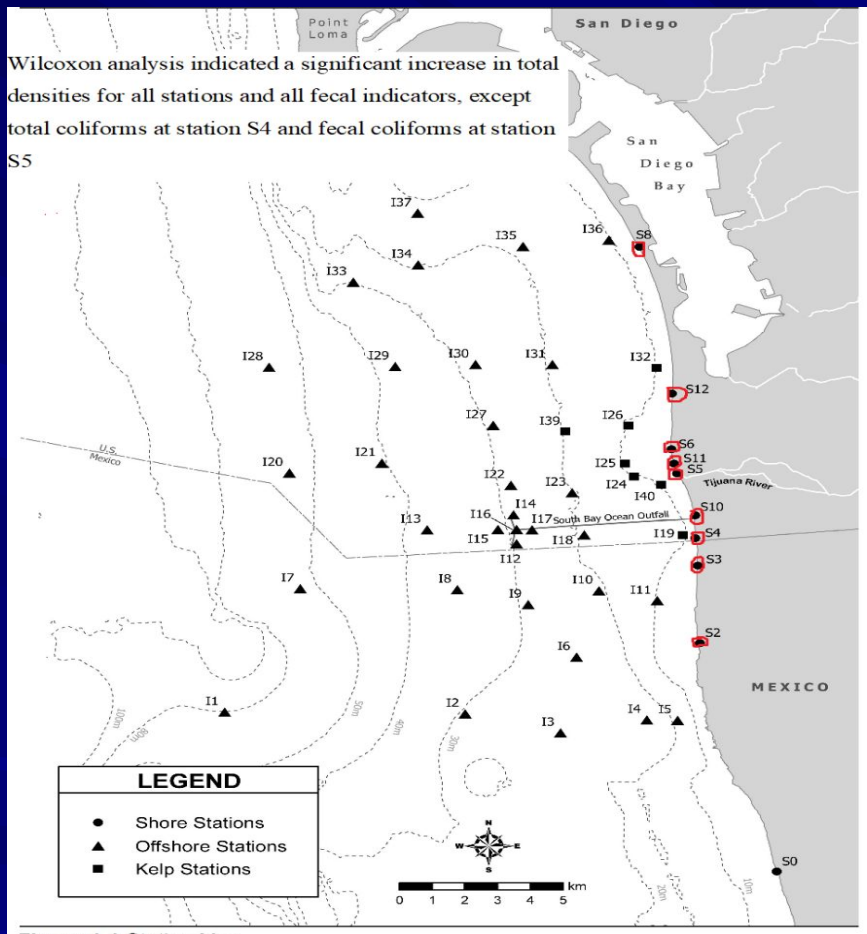


Figure 1.1 Station Map

Conclusions

- The improvements to water quality in the ocean in the region of the South Bay Ocean Outfall were quite modest after the upgrade of the South Bay International Wastewater Treatment Plant to secondary treatment in 2010.
- In the winter period (during chlorination) there was a significant improvement at most of shore stations, but this positive effect on microbial water quality during the winter period may well have ended when chlorination was discontinued in 2014.
- On the contrary, there was **no significant improvement** in microbial water quality at any shore station in the summer (**when and where people actually swim and surf**). Indeed there was actually a significant increase in bacterial densities at all shore stations after the upgrade to secondary treatment
- Overall, this study shows that the positive effect on microbial water quality engendered by the upgrade to secondary treatment at the South Bay International Wastewater Treatment Plant, which cost 92.7 million (GAO, 2008), was quite limited, especially in the summer in surface ocean waters of both shore (or kelp) stations where people swim and surf.

$300 Million Secured to Help Combat Tijuana Sewage Spills

Recommendations for Programs

- **My presentation shows that sometimes large investments in infrastructure do not yield equivalent large gains in water quality.**
- **The condition of critical wastewater collection and conveyance infrastructure in Tijuana is poor and has resulted in frequent pump failures and line breaks causing raw sewage to flow into the Tijuana River and adjacent canyons.**
- **Continued investment in Tijuana's wastewater infrastructure and O&M is critical to address the aged and deteriorated infrastructure vulnerable to pipe and pump failures, and inadequate wastewater treatment. Solving pollution close to the source (in Mexico)) would make the most sense and be more cost-effective than a larger capacity treatment plant on U.S. side**
- **Expanding the capacity of the International Wastewater Treatment Plant (IWTP) might well be preferred, but better than investing money in bricks, mortar and steel that would remain idle for most of the year (except for cross-border spills/flows), would be to construct a large wetlands area to intercept and treat such sewage flows before discharge to the estuary/ocean.**