Runoff in a Warming World

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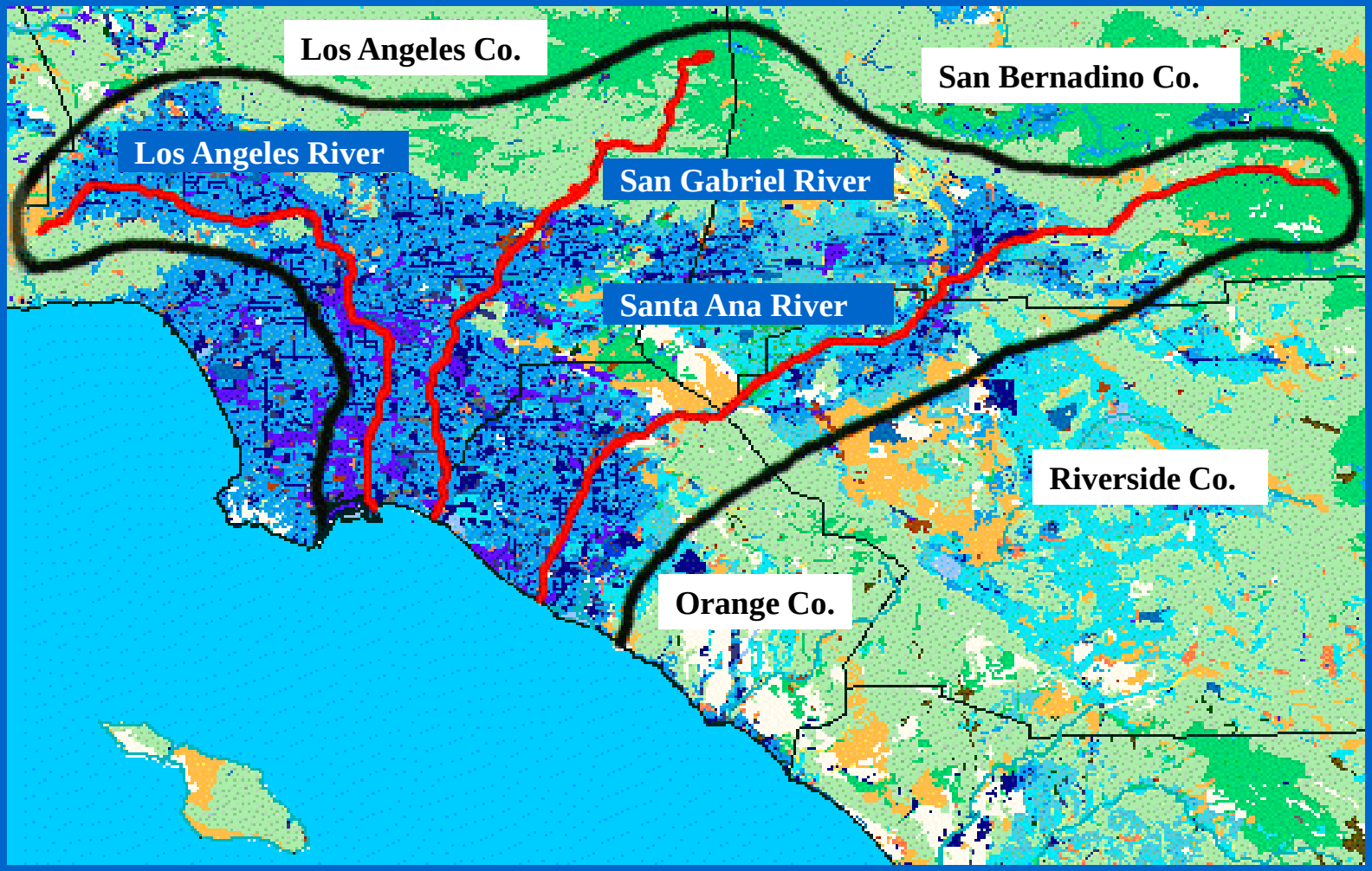
- ***Multidisciplinary Analysis of North Orange County's Coastal Water Quality***
  - **Environmental Analysis (Urban runoff)**
  - **Epidemiology Investigation (Health effects)**
  - **Economic Valuation (Cost of illness)**
- Relation to climate change and local adaptation

Combined Watershed Areas for the Los Angeles, San Gabriel and Santa Ana Rivers



Urban Runoff from the L.A. Basin

- **Non-point source pollution: Tragedy of the Commons**
  - **Residents, Businesses, Industry, Military, Agriculture**
  - **Watershed characteristics influence pollutant load**
  - **Wide range of possible pollutants**
- **Storm drains direct runoff to three rivers**
- **Untreated runoff discharged onto beaches**
- **Urban runoff vs. Urban flush**

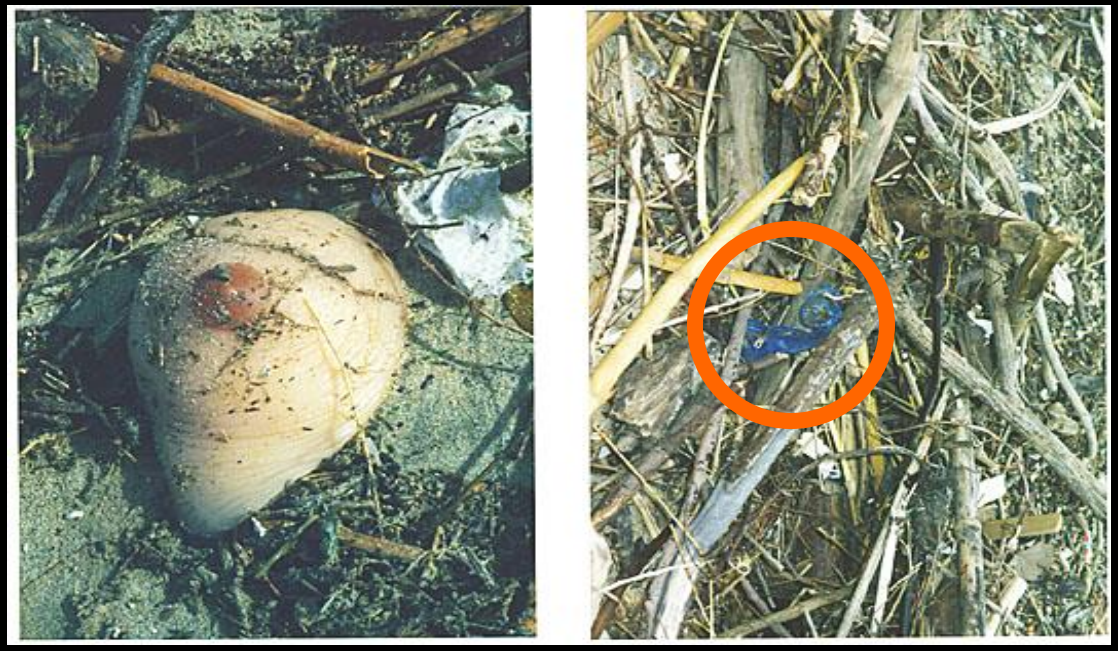
Santa Ana River

Urban Runoff

Urban Flush


Santa Ana River
X
Newport Beach

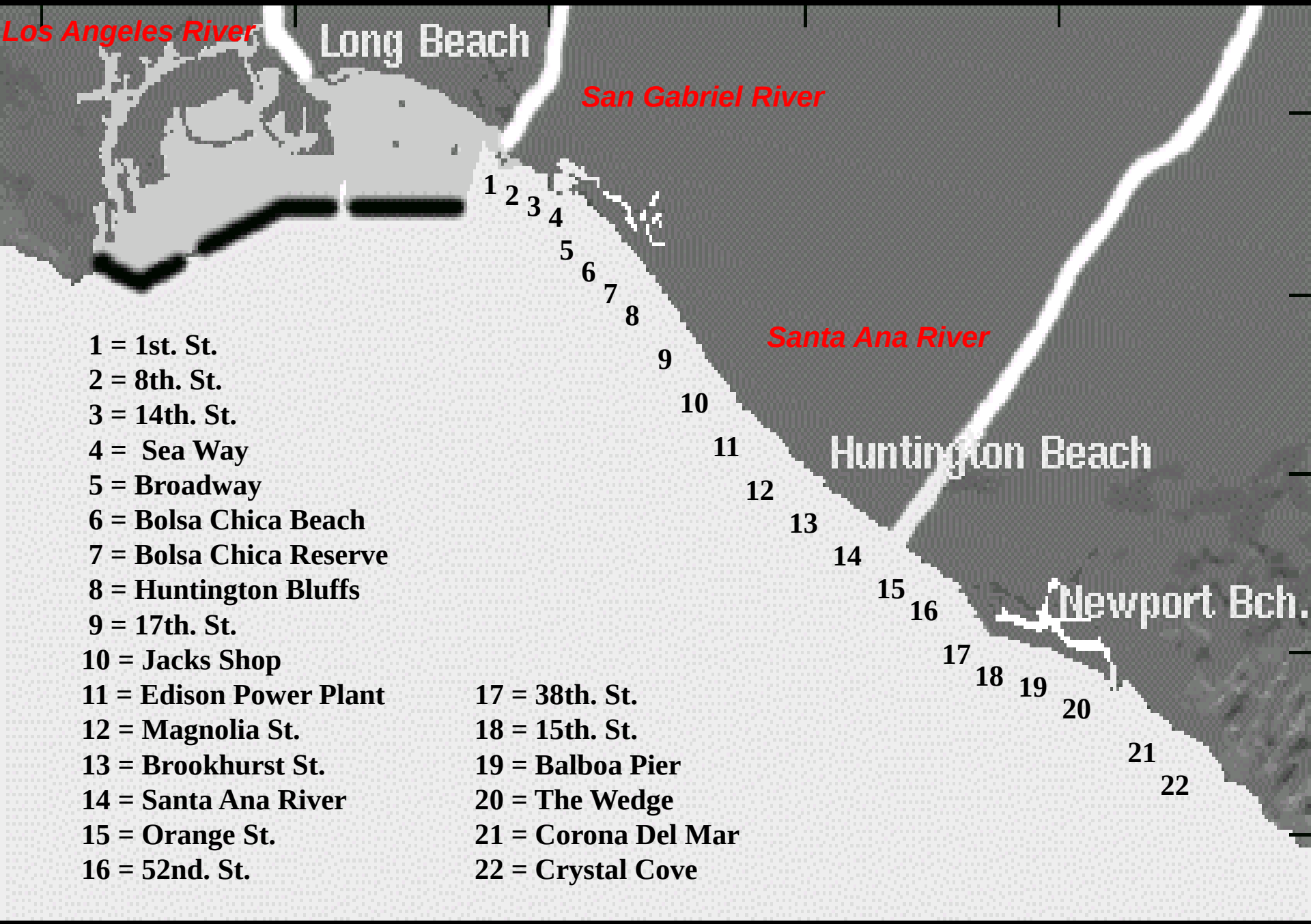

Santa Ana River



El Niño's Effect on Urban Runoff and Coastal Water Quality in Orange County, California

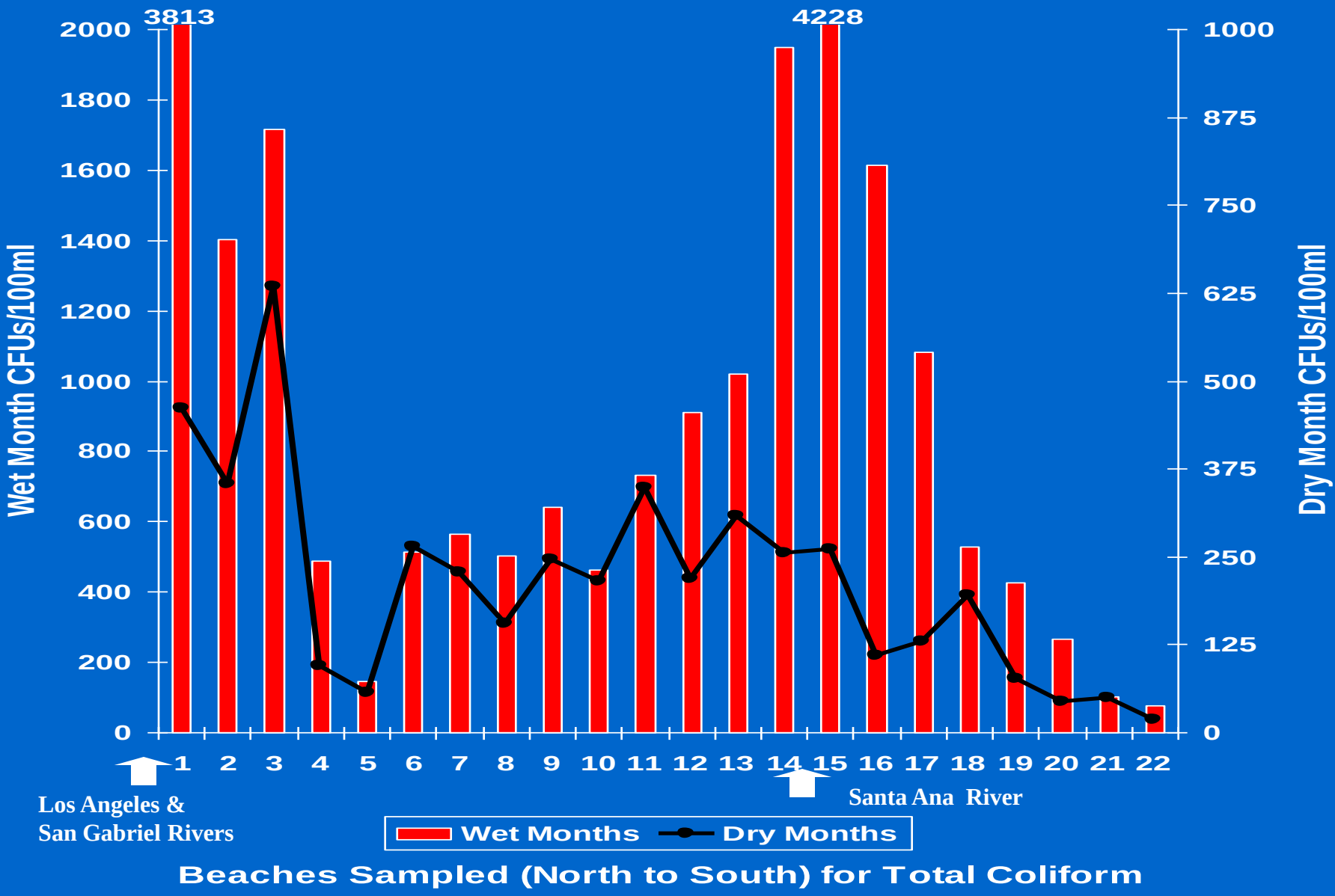
- **Objective: Determine if precipitation & river discharge are associated with coastal pollution**

- **Methods: Spatial and temporal analysis**
  - **January 1st 1997 - July 31st 1999 (El Niño and La Niña)**
  - ***Precipitation data*** ***(Western Regional Climate Center)***
  - ***River discharge data*** ***(U.S. Geological Survey)***
  - ***Water quality data*** ***(Orange County Healthcare Agency)***
    - ***Total coliform was bacterial indicator of water quality***

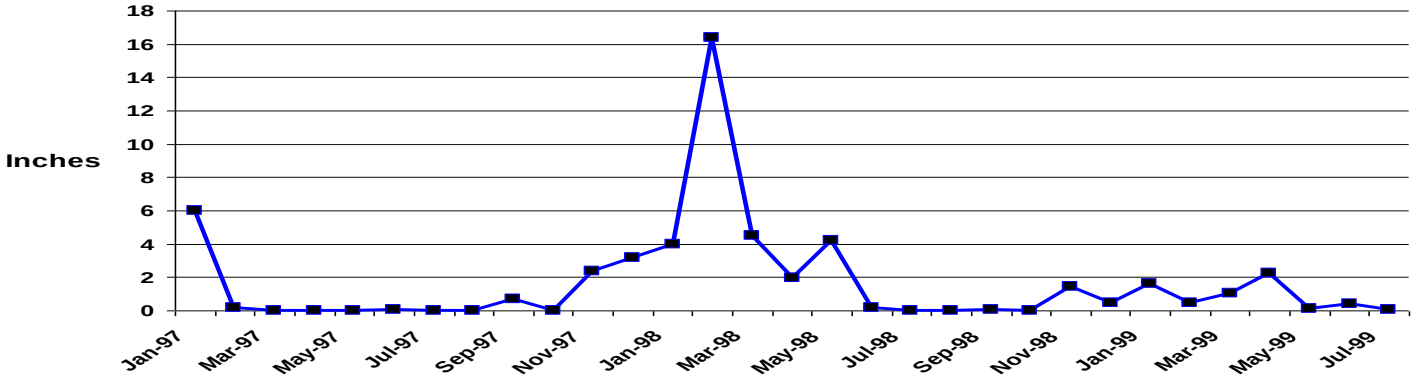


1 = 1st. St.
2 = 8th. St.
3 = 14th. St.
4 = Sea Way
5 = Broadway
6 = Bolsa Chica Beach
7 = Bolsa Chica Reserve
8 = Huntington Bluffs
9 = 17th. St.
10 = Jacks Shop
11 = Edison Power Plant
12 = Magnolia St.
13 = Brookhurst St.
14 = Santa Ana River
15 = Orange St.
16 = 52nd. St.
17 = 38th. St.
18 = 15th. St.
19 = Balboa Pier
20 = The Wedge
21 = Corona Del Mar
22 = Crystal Cove

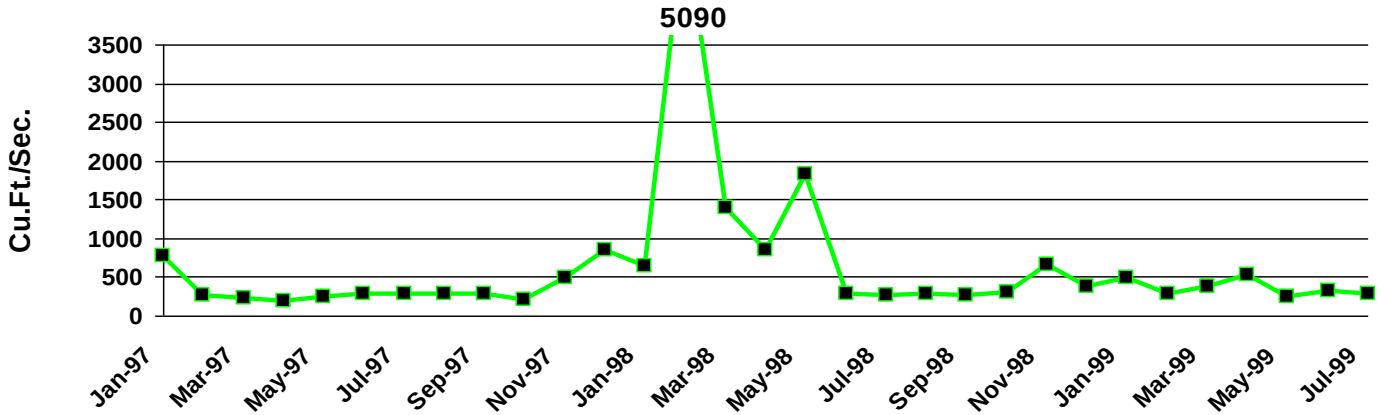
Mean Total Coliform Levels for 22 Orange County Beaches



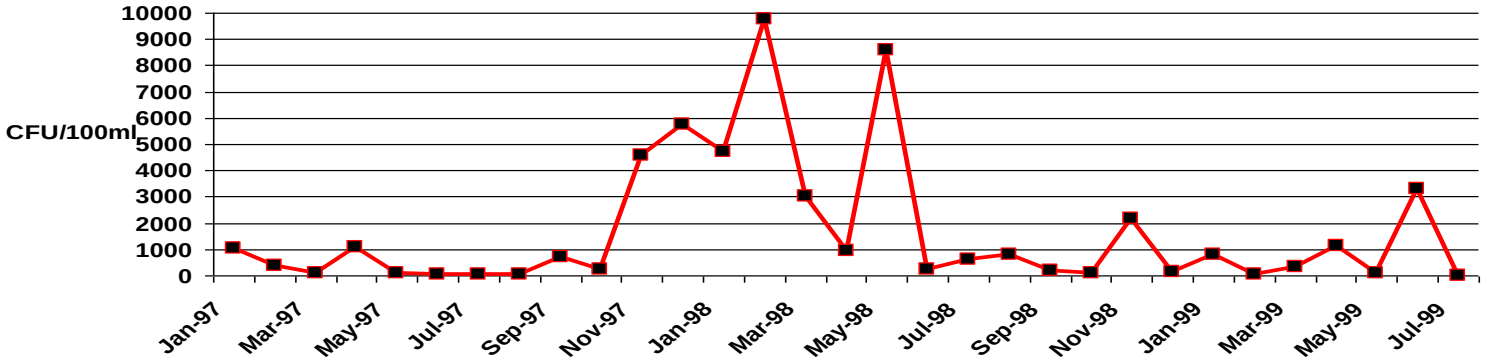
Mean Precipitation Per Month for Combined San Gabriel and Los Angeles Rivers' Watersheds



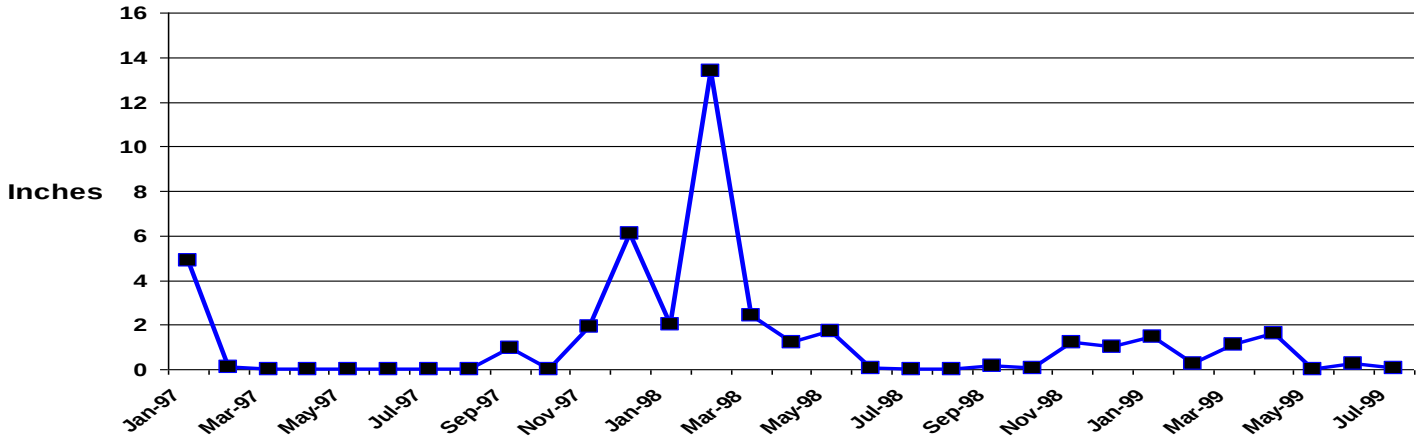
Mean Discharge per Month for Combined San Gabriel and Los Angeles Rivers



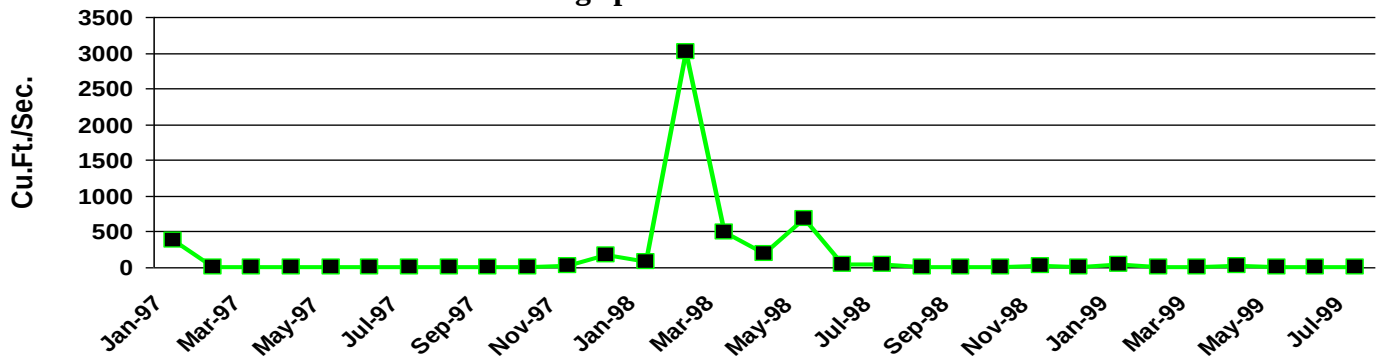
Mean Total Coliform per Month at Beach Next to Rivers: #1 (First St.)



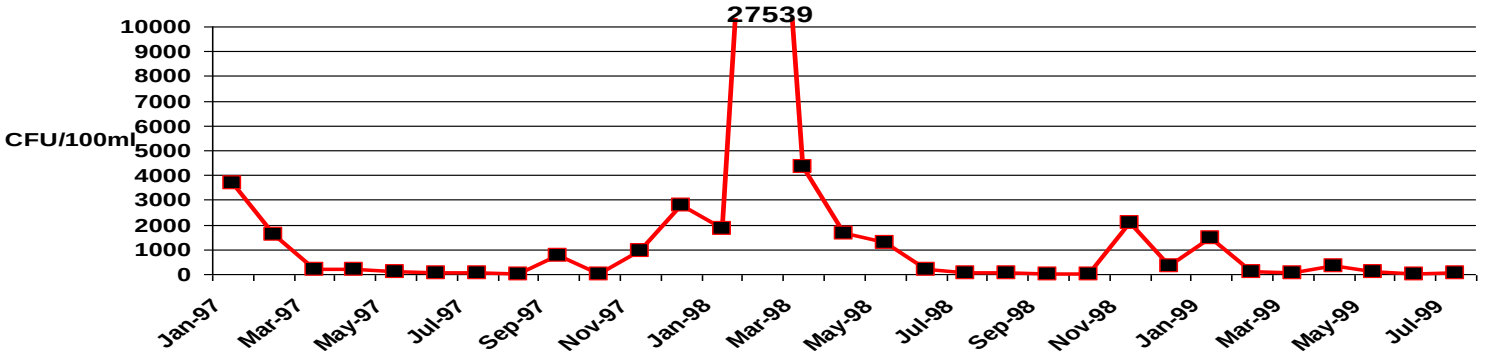
Mean Precipitation Per Month for Santa Ana River Watershed



Mean Discharge per Month for Santa Ana River



Mean Total Coliform per Month at Beach Next to River: #15 (Orange St.)



Spearman Rank Correlations (r)

	r
Los Angeles & San Gabriel Rivers	
Rain X Flow	**0.89****
Flow X Water quality	**0.64****
Santa Ana River	
Rain X Flow	**0.80****
Flow X Water quality	**0.67****

- ***** = Significant at 0.01 level***

Results and Conclusions

- ***Beaches next to rivers consistently had the highest bacteria levels***
  - ***Urban runoff from rivers is major source of NOC's coastal water pollution***
  - ***These beaches may pose the greatest health risk***
- ***Bacteria levels were highest during winter precipitation events (1998 El Niño winter)***
  - ***Majority of urban runoff from rain events (Urban Flush)***

So What?

- Runoff carries pathogens
- Pathogens cause illnesses
  - Epidemiology studies show cause and effect
- Wide range of possible illnesses
  - GI, sinus, respiratory, ear, eye & skin
  - Rare: hepatitis, cholera & typhoid

Health Effects Associated with Recreational Coastal Water Use in Urban vs. Rural California

- **Objective:**
  - **Determine if North Orange County's coastal waters are a public health risk**
- **Methods: Cross sectional epidemiology study**
  - **Compare illness rates: North Orange County (NOC) vs. Santa Cruz County (SCC)**
- **Surfers as subjects because of high exposure**
- **Team of interviewers at NOC & SCC beaches**

  n= 853 in 1998 n= 1,020 in 1999

Interviews in North Orange County

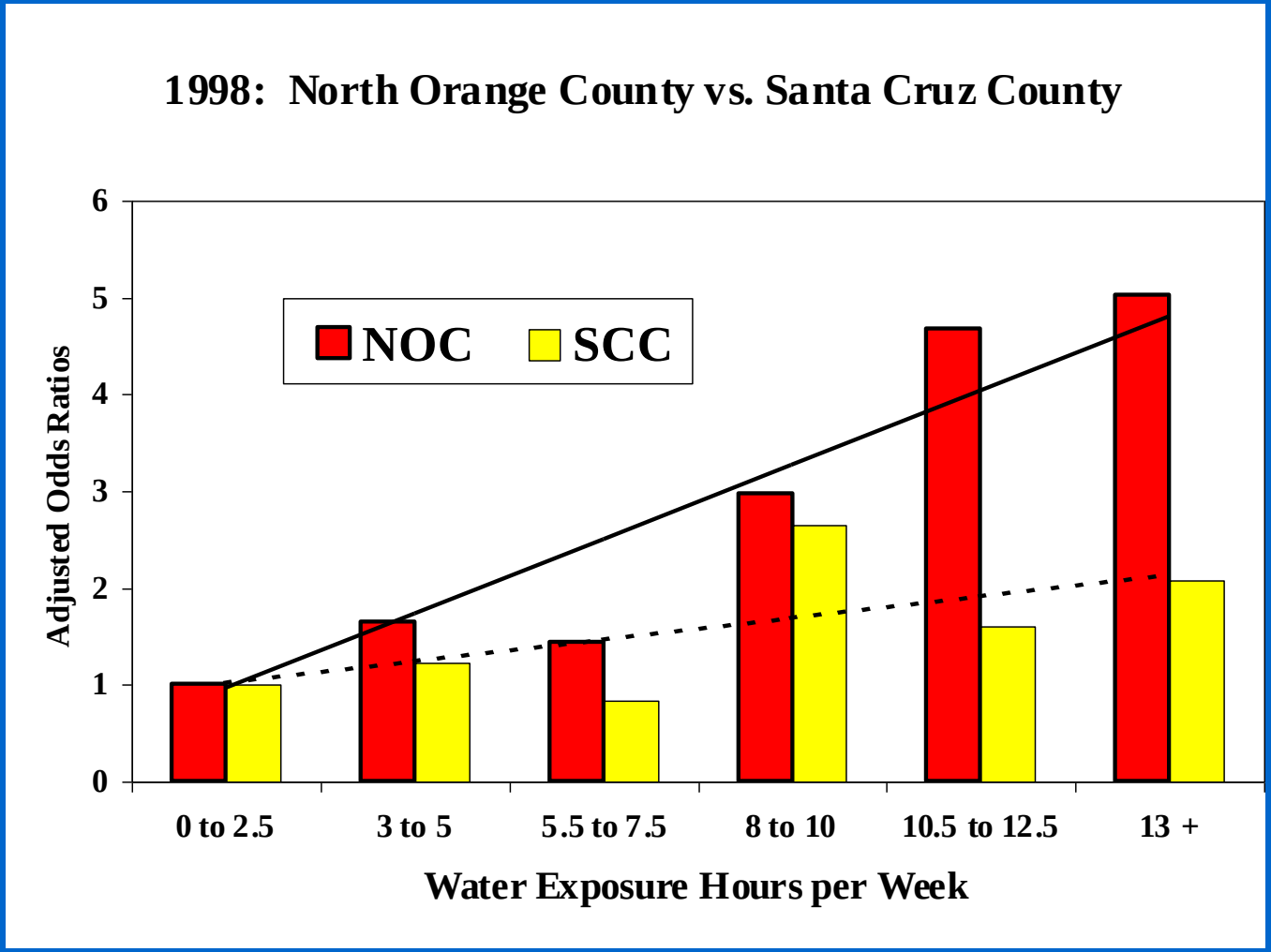
Interviews in Santa Cruz County

Odds Ratios: North Orange County vs Santa Cruz County (Water-Attributed Symptoms)

	1998 - El Niño Winter			1999 - La Niña Winter		
	%NOC	%SCC	OR	%NOC	%SCC	OR
Any Symptom	39	19	2.77*	28	13	2.34*
Fever	10	4	2.90*	8	3	2.54*
Chills	4	1.5	2.81*	3	1	2.97
Stomach Pain	7	2	3.19*	5	3	1.60
Vomit	3	0.5	9.43*	3	1.5	1.70
Diarrhea	7	2	3.78*	5	3	1.27
Sinus	20	11	2.05*	19	6	4.02*
Cough	13	4	3.09*	13	4	2.78*
Phlegm	10	4	2.29*	6	4	1.43
Sore Throat	17	8	2.64*	14	3	4.18*
Eye Infection	4	2	2.91*	3	1	3.38
Ear Infection	13	7	1.86*	9	3	2.86*
Skin Infection	10	3	3.16*	5	3	1.11

* = adjusted odds ratio is significant at P <0.05 level

Effect Modification of Exposure/ Response Relationship



Again…. So What?

- **The Public is exposed**
  - **5.5 million exposures/year in Newport and Huntington Beaches alone**
  - **48% of summer beach-swimmers are children who are more susceptible to pathogens in water**

Estimated Health Costs for Illnesses Associated with Recreational Contact with Marine Waters Contaminated by Urban Runoff

- **Objective:**
  - **Quantify the cost of illnesses associated with polluted coastal waters**
- **Method: Cost of Illness (Cost to individual)**
  - **Survey data: illness type, length, medical treatment, yearly income**
- **601 illnesses cost the subjects $108,571.00**
- **Scale of Estimated Public Health Costs**
  - **Variables from survey data and referenced**

Scale of Estimated Health Costs

Rate of Illness	Illnesses / 100,000	Lost Work-Days	Lost Wages @ $20K/yr	Lost Wages @ $40K/yr	Doctor Costs	Antibiotic Costs	Total Health Costs Low	Total Health Costs High
1%	1,000	570	$126,107	$252,215	$3,920	$1,020	$131,047	$257,155
2%	2,000	1,140	$252,214	$504,430	$7,840	$2,040	$262,094	$514,310
3%	3,000	1,710	$378,322	$756,645	$11,760	$3,060	$393,142	$771,465
4%	4,000	2,280	$504,430	$1,008,860	$15,680	$4,080	$524,190	$1,028,620
5%	5,000	2,850	$630,537	$1,261,075	$19,600	$5,100	$655,237	$1,285,775

- EPA standard for recreational marine waters
  - **Allowable illness rate = 1.9%**
- 5.5 million exposures/year **(Newport & Huntington Beaches)**
- **1.9% = 104,500 illnesses = $13-$26 million** /year

Climate Change & Local Adaptation

- ***Prediction:*** ***Global increase in precipitation and extreme weather events***
- ***Rain - Runoff - Pollution - Illnesses - Money***
  - ***Extreme weather affects public health & economics***
    - ***2001 Tropical storm Allison = 22 deaths and $1 Billion in damage***
- ***Consequences will vary per region***
  - ***Influenced by rainfall and watershed characteristics***
- ***Public health adaptations should be watershed specific***

- *How should urban Southern California adapt?*
  - *Predicted less Sierra snowpack, but more rain*
    - *Knowles N., (2001) Scripps Institution of Oceanography*
  - *Capture, filter and reuse*
- *Public health research related to climate change should include waterborne pathogens*
  - *enteric protozoa, viruses and bacteria*
  - *GI is the worlds leading cause of child mortality*
- *Ecosystems also suffer (Sedimentation & Pollution)*
  - *Enclosed water bodies most vulnerable*
  - *Most sea life along coastal fringes*
- *Climate change and population growth both will affect urban runoff and water pollution*