Beach Water Quality:
New Testing Methods & Surfer Health Study Update

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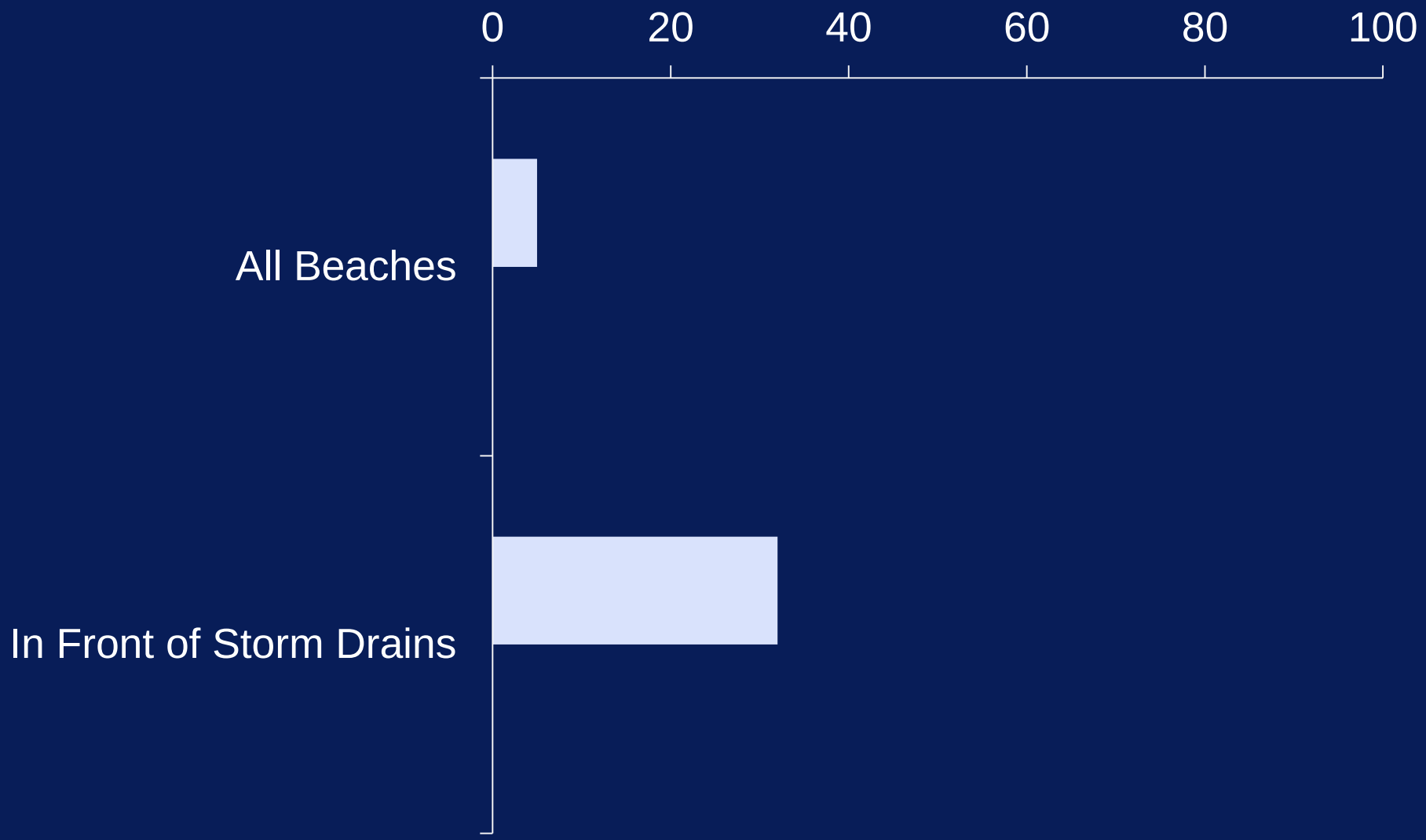
www.SCCWRP.org

So Cal Beach Water Quality Facts

- 175 million beach-goers every year
  - An estimated $41B in beach tourism
- Over 90,000 analyses per year for beach monitoring to protect public health
  - Approximately $5M
- Beach water quality isn’t as bad as you might think in dry weather
  - Wet weather may be a different story

Water Quality Standard Exceedences

(All Southern California)



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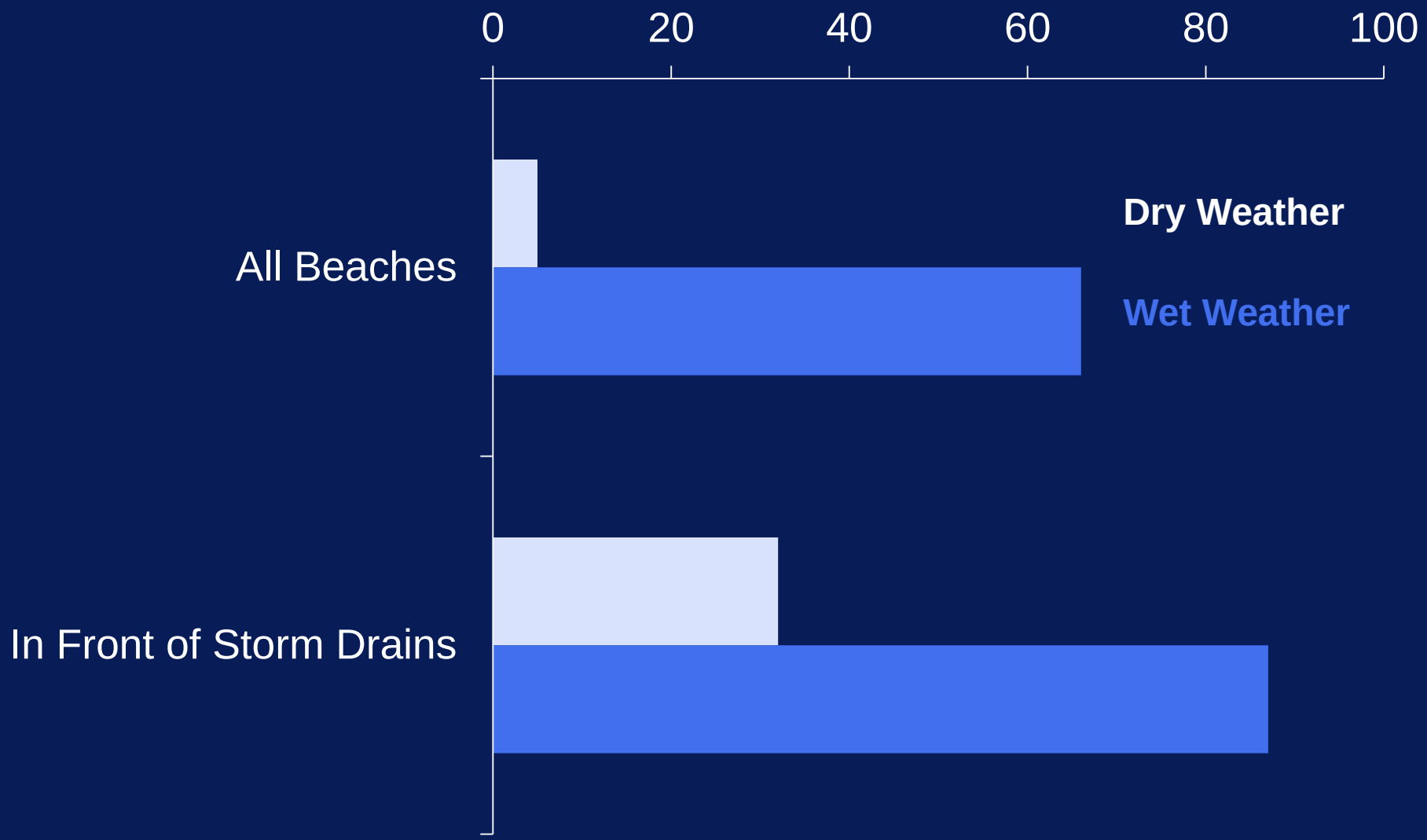


Current Beach Water Quality Monitoring Basics

- **Agencies monitor for Fecal Indicator Bacteria**
  - ***Enterococcus*, Fecal and Total Coliforms**
- **Fecal Indicator Bacteria do not make you sick**
  - **Covary in sewage with the pathogens that do**
- **Cheap and easy to conduct**
  - **Incubate bacteria with selective media**

Current Beach Water Quality Monitoring Problems

- **Methods are over 50 years old**
  - Growing bacteria is slow, one day minimum
- **Fecal Indicator Bacteria are not just from sewage**
  - Any warm-blooded animal
  - Survive and regrow in the environment
- **Non-human sources of Fecal Indicator Bacteria assumed to carry less risk**

BEACH WATER QUALITY MONITORING

Beachgoers feel protected

Reality

Culture Methods

Results in 24-96 hours

Genetic Methods (qPCR)

Results in <2hrs

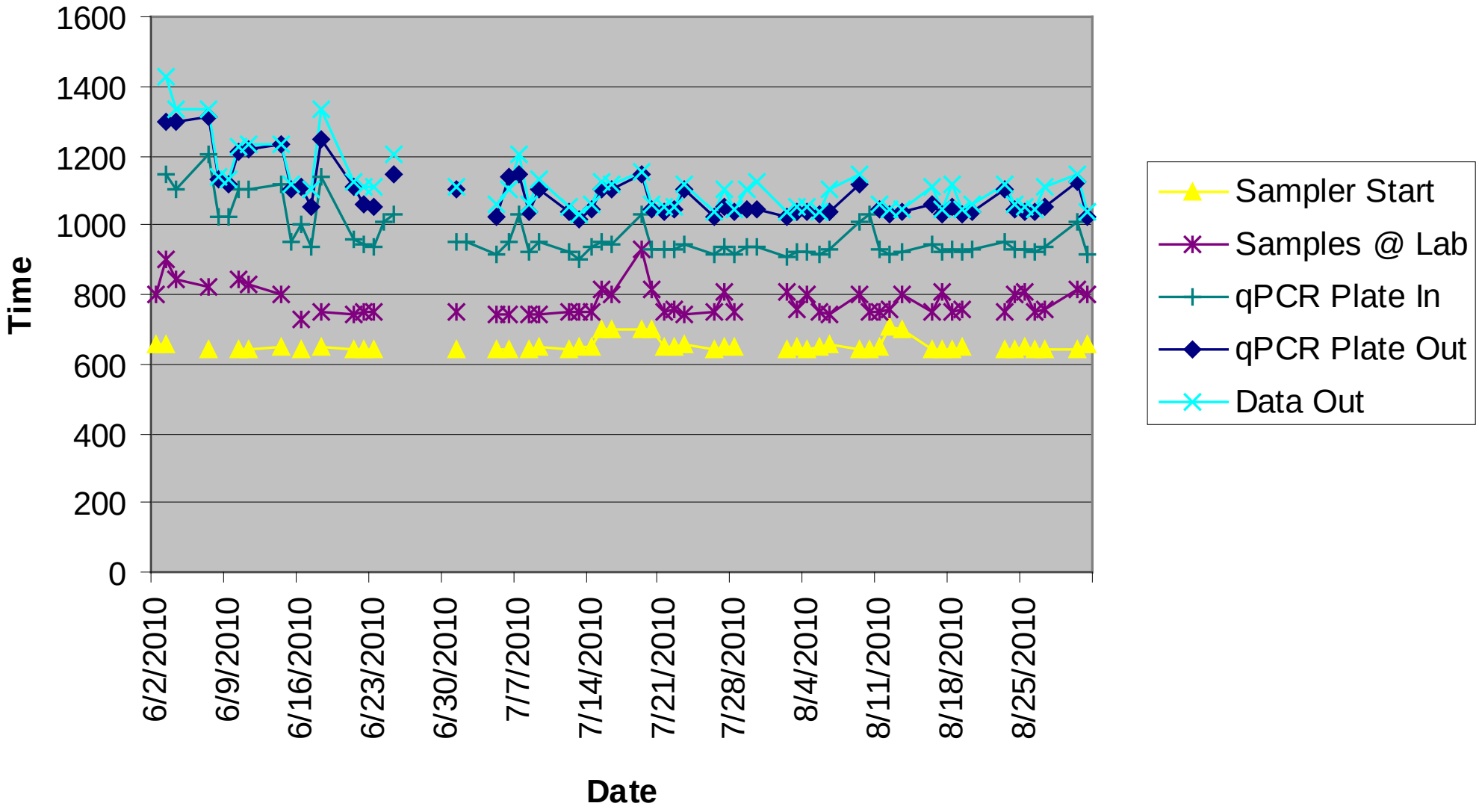
Integrating Genetic Testing Into Beach Monitoring

- Side-by-side testing between qPCR and culture methods
  - accuracy, precision, bias, inhibition
- Moving from research to mainstream laboratories
  - Capital equipment staff training
- Implement into monitoring programs

Rapid Method Demonstration Project

- Summer of 2010 at three beaches and three labs
  - South Orange County
- Samples run by both culture and qPCR methods
- Goal was to take samples in the morning and have signage decisions by noon
  - Laboratory analysis was not the primary impediment

Beach Decisions By Lunch?




Doheny State Beach
THE FOLLOWING PICNIC AREAS ARE RESERVED TODAY
3 7 10
11 12
ALL OTHER PICNIC AREAS AND TABLES REQUIRE 2 ADULTS PER TABLE TO RESERVE
CAMPGROUND FULL
STOP
PARK WATCH
No re-entry into park if lot fills up.
VISIT DOHENY GIFT SHOP OPEN EVERY DAY 10:00-4:00 THANKS FOR KEEPING THE BEACH CLEAN
STOP

today's water quality

miocean

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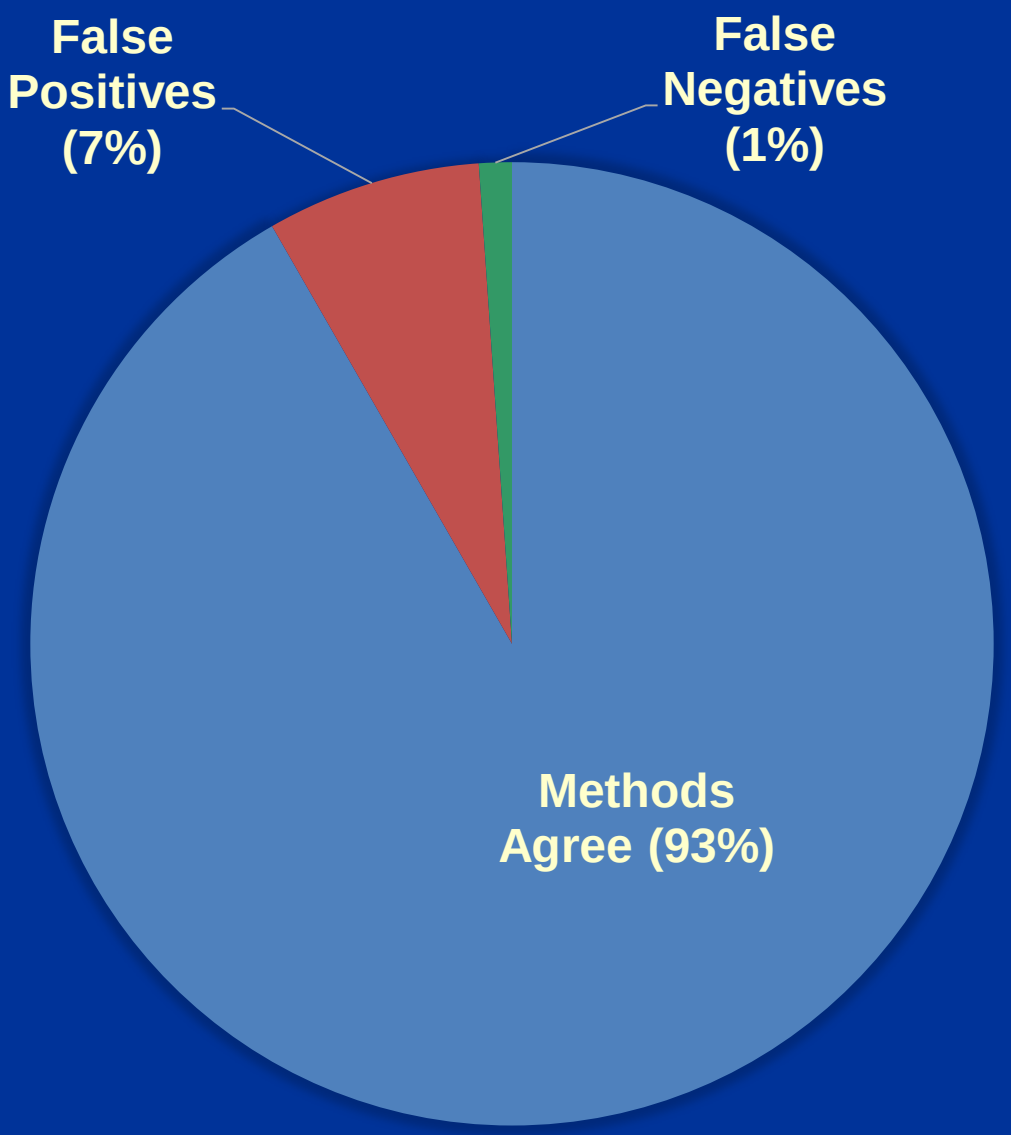
Friday
July 2, 2010

last updated 11:30am

Doheny State Beach

miocean.org

Demonstration Project: Beach Decisions Using Culture *vs*. qPCR Methods



Next Steps for Genetic Testing

- Training for routine labs
  - Bight'13 Regional Monitoring
- Next generation qPCR; Droplet Digital PCR (ddPCR)
- Portability

Droplet Digital PCR (ddPCR)

Old qPCR

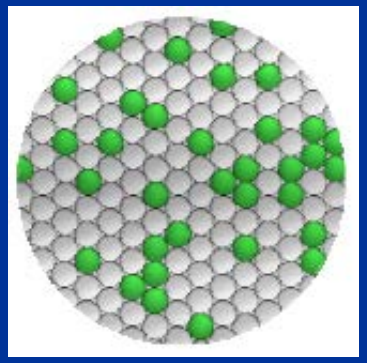
20µl PCR
(tube/well)

96 wells

Compare to
Standard Curve

New ddPCR

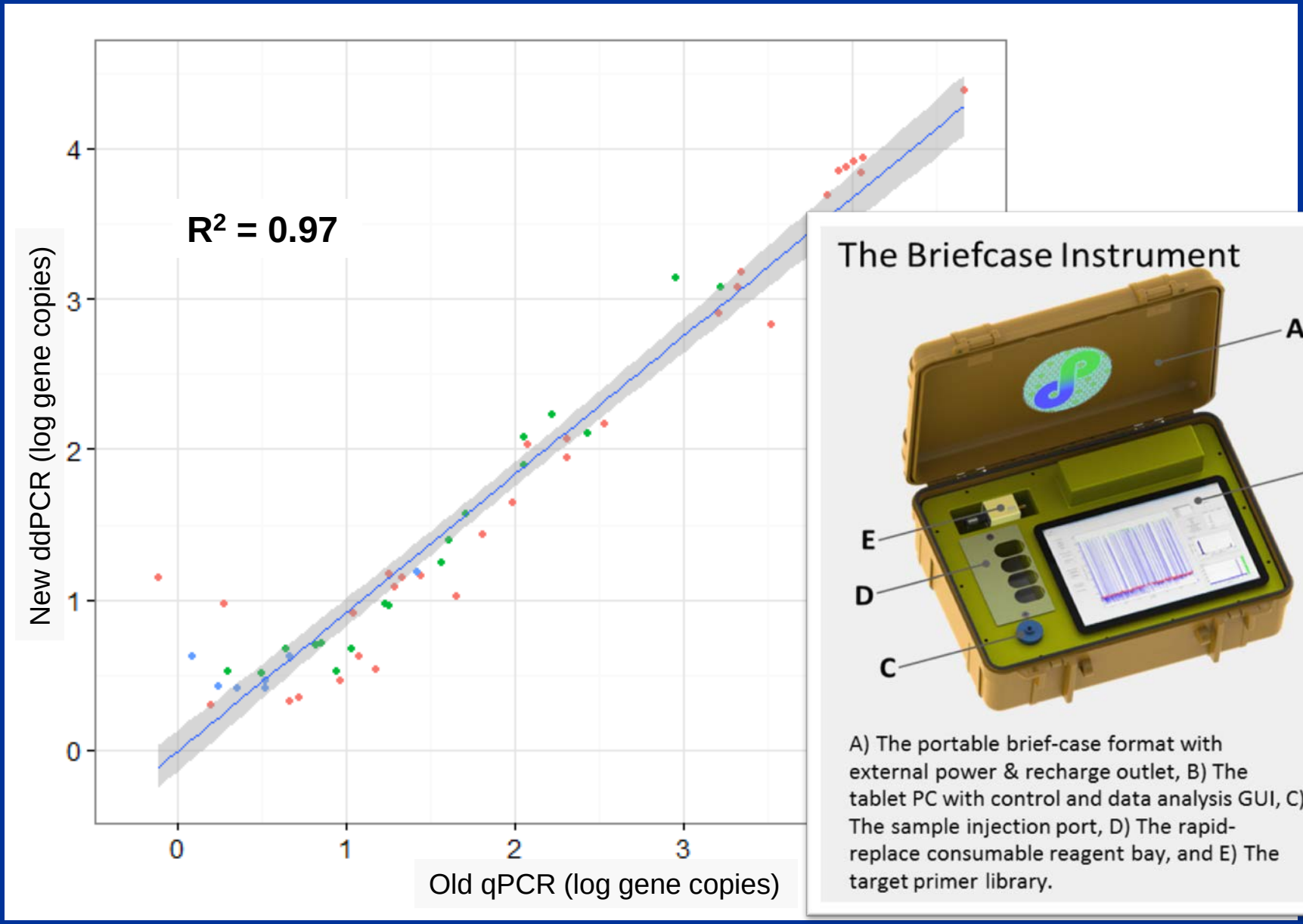
20µl PCR
(tube/well)



10000 - 20000
droplets or chambers

Direct quantification
using statistics

Enterococcus Highly Correlated Between qPCR and ddPCR Methods



The Briefcase Instrument

A) The portable brief-case format with external power & recharge outlet, B) The tablet PC with control and data analysis GUI, C) The sample injection port, D) The rapid-replace consumable reagent bay, and E) The target primer library.

ddPCR Is Resistant To Inhibition (false negatives)

Humic acid concentration (ng/ul)	Old qPCR Method (gene copies)	New ddPCR Method (gene copies)
0	1810	1810
1	1165	1680
2.5	184	1700
5	0	1870

Why Stop Genetic Testing at Just Indicator Bacteria?

- Once you're genetic testing for *Enterococcus*, you can substitute any genetic sequence
- Genetic markers of sources (hosts)
- Pathogens themselves
  - viruses, protists, eukaryotes

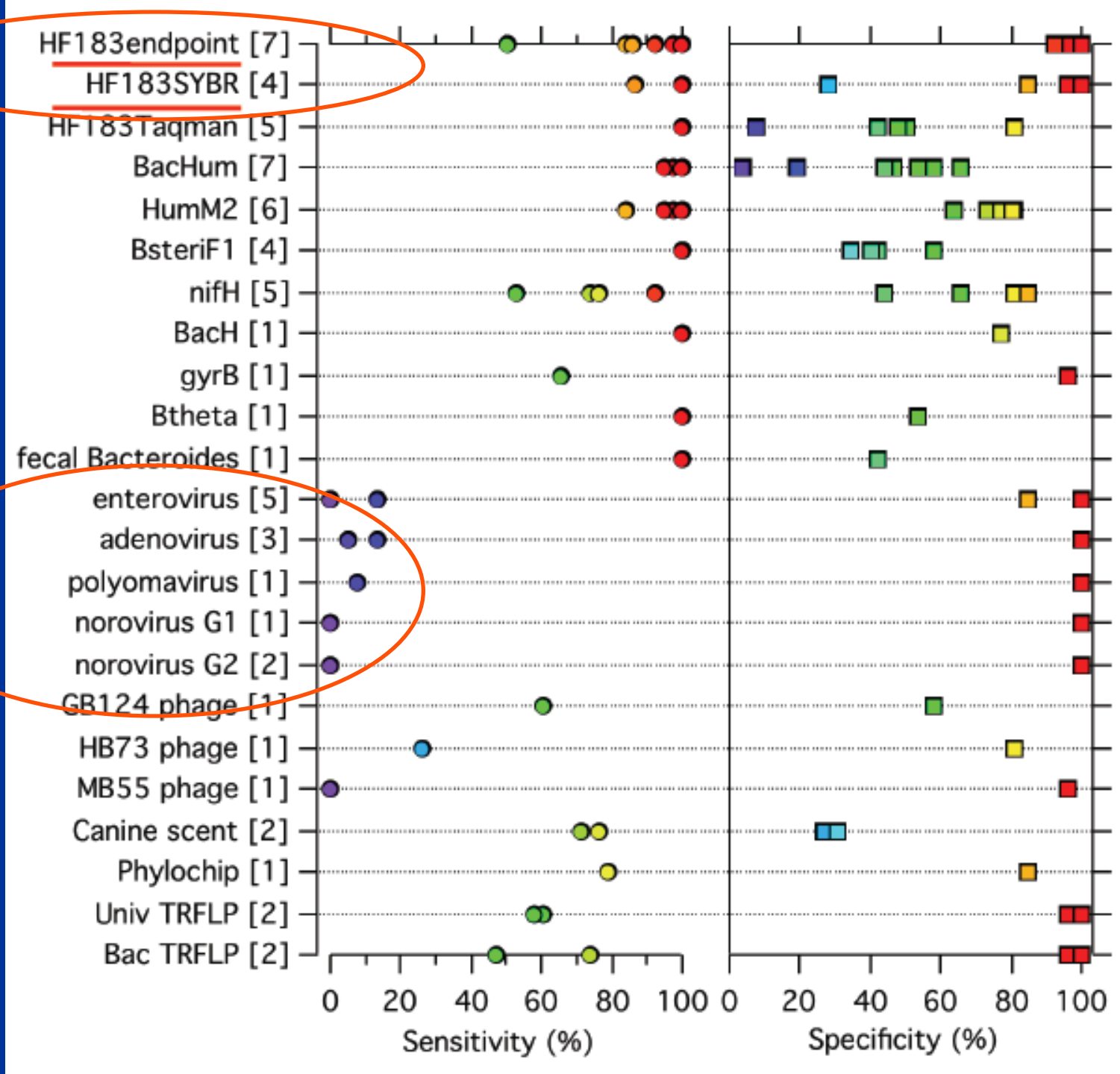
Developing a Source Identification Toolbox

- State has invested >$100M cleaning up beaches
  - Many challenging beaches remain
- Need reliable source tracking methods
  - sensitive, specific, reproducible
- SCCWRP led the evaluation study that changed the landscape
  - Produced the SWRCB's Source Identification Manual

Method Evaluation Study Design

- 50 source tracking methods evaluated
  - 26 top labs around the globe
- Challenge each method with 64 blind samples
  - 12 different sources
  - Varying mixtures and concentrations
  - Duplicates and blanks
- Some methods run by multiple labs

Human Source Marker Evaluation



New Methods Need To Be Tested Against Human Health

- Epidemiology studies are the Gold Standard for evaluating beachgoer risk
  - Cornerstone of US EPA's new beach criteria
- SCCWRP and UC Berkeley have been conducting epidemiology studies since 2003
- Highly comparable study designs, but different foci
  - Treated wastewater vs. non-point discharges

Synopsis of Four California Summer Epidemiology Studies

- **Avalon Bay: risk of gastrointestinal illness (GI) significant**
  - **Correlation with *Enterococcus* at low tide**
- **Doheny State Beach: risk of GI significant**
  - **Correlation with *Enterococcus* when beach berm is open**
- **Malibu Surfrider Beach: risk of GI significant**
  - **No correlation with *Enterococcus***
- **Mission Bay: risk of GI measureable, but not significant**
  - **no correlation with *Enterococcus***

Prospective Cohort Epidemiology: Traditional Approach

- **Recruit swimmers (and non-swimmers) on crowded summer weekends and holidays**
  - **Collect same day water quality samples to assess exposure**
- **Call beachgoers 10 to 14 days later**
  - **Ask about their health status since their day at the beach**
- **Compare health outcomes between swimmers and non-swimmers**
  - **Look for relationships to water quality results**

Wet Weather Changes Everything

- Wet weather fecal indicator bacteria contamination levels always seem high
- Likelihood that some sources are not human
  - Assumption that non-human sources carry less risk
- Remediation strategies are expensive
  - Regulatory compliance deadlines are on the horizon

Photo: Paul Fisher / Surfline.com

Surfer Health Study Questions

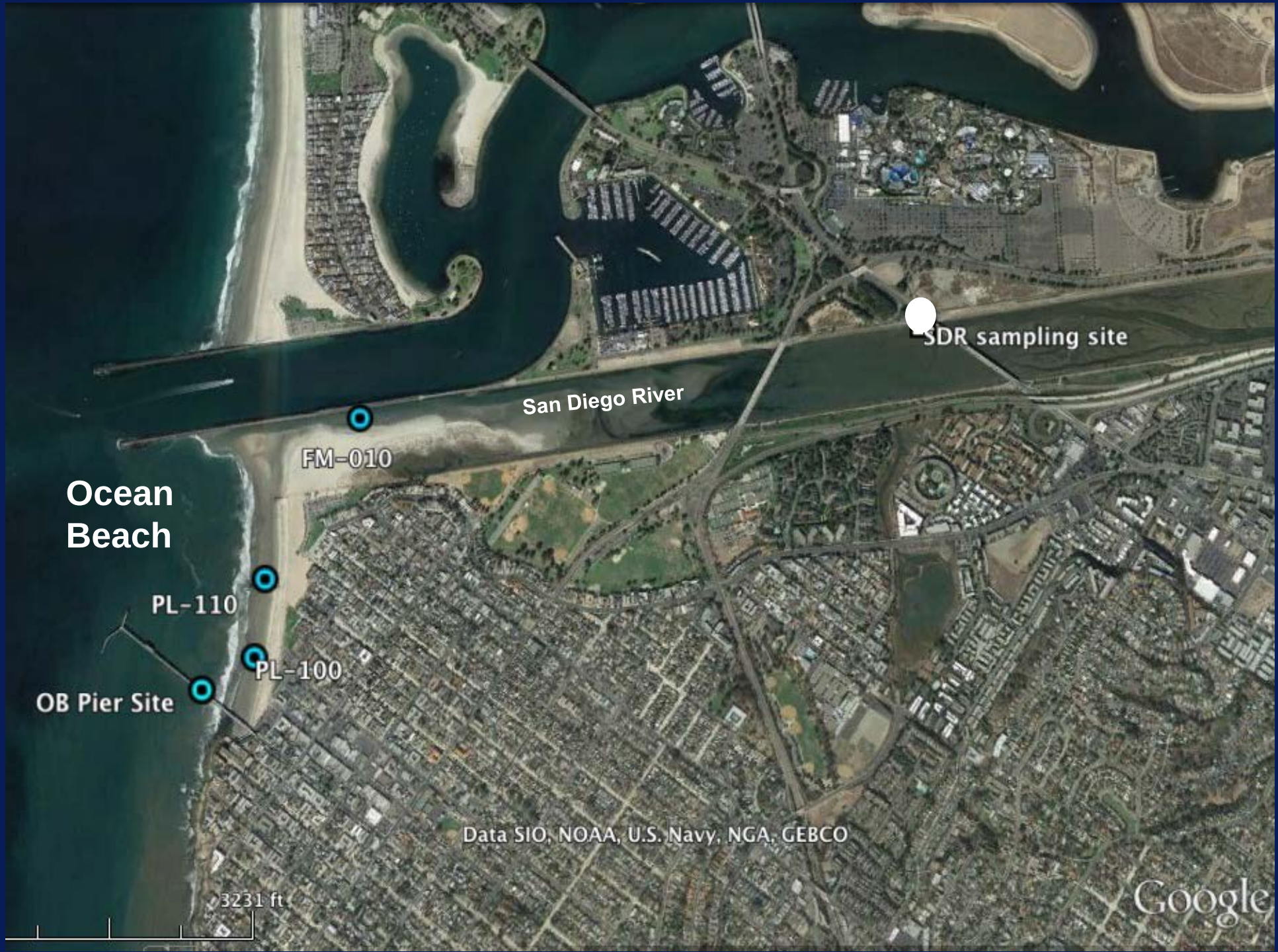
- Is surfing associated with an increased risk of illness?
- Is illness risk greater when surfing following wet weather compared to dry weather?
- What is the association between water quality and illness following wet weather events?
- What level of water quality corresponds to the same risk of illness as current water quality objectives?

Longitudinal Cohort Epidemiology Study Approach

- Recruit ≥250-300 surfers across any San Diego County beach
- Two sentinel beaches
  - Ocean Beach and Tourmaline Surfing Park
- Daily water quality at sentinel beaches
  - Discharge during storm events

- Follow daily surfing activity and health status each week for three months using web or cell phone app
  - Compare illness rates when surfing vs. not surfing
  - Compare illness rates surfing in dry vs. wet weather


Tourmaline N Drain
FM-030
Tourmaline Surfing Park
Tourmaline Creek
Tourmaline South


SDR sampling site
San Diego River
FM-010
Ocean Beach
PL-110
PL-100
OB Pier Site
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
3231 ft
Google

nrollment Strategy

●●●○○ Verizon 8:27 PM

Did you enter the ocean on any days in the past week?

- ☐ Today
- ☐ Thursday
- ☐ Wednesday
- ☐ Tuesday
- ☐ Monday
- ☐ Sunday
- ☐ Saturday
- ☐ Did not Enter

Back | Save | Next

Section (%):

Total (%):

You have completed 4 follow-up surveys when you reach 8 you will receive a $20 gift card

Available on the App Store | GET IT ON Google play | Complete Weekly Survey

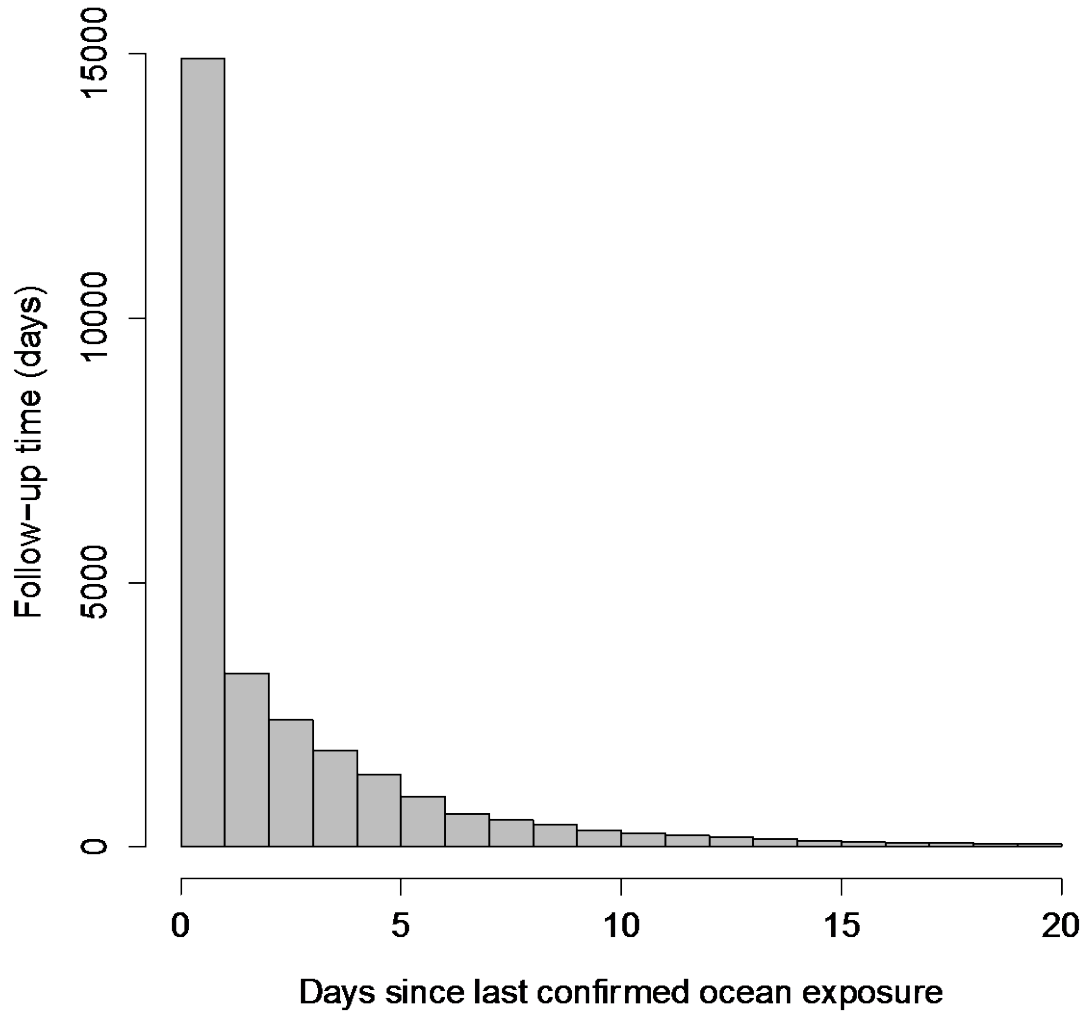
F.A.Q. View Consent Form Contact Brochure

Enrollment in Other Beach Epi Studies

	No. People Enrolled	No. Days of Follow-up	No. Exposure Events
Boqueron, PR	15,726	172,986	12,111
Surfer Health Study	**654**	**33,377**	**10,081**
Surfside, SC	11,159	122,749	8,073
Silver, MI	10,921	120,131	5,651
Mission Bay, CA	12,469	137,159	4,524
Doheny, CA	9,525	104,775	4,335
Avalon, CA	6,165	67,815	3,891
Malibu, CA	5,674	62,414	2,559
Washington Park, IN	4,377	48,147	2,360
West, IN	2,877	31,647	1,668
Goddard, RI	2,977	32,747	1,080
Fairhope, MS	2,022	22,242	823
Huntington, OH	2,840	31,240	757
Edgewater, AL	1,351	14,861	741

80% of Surfers enter the ocean ≤ every three days

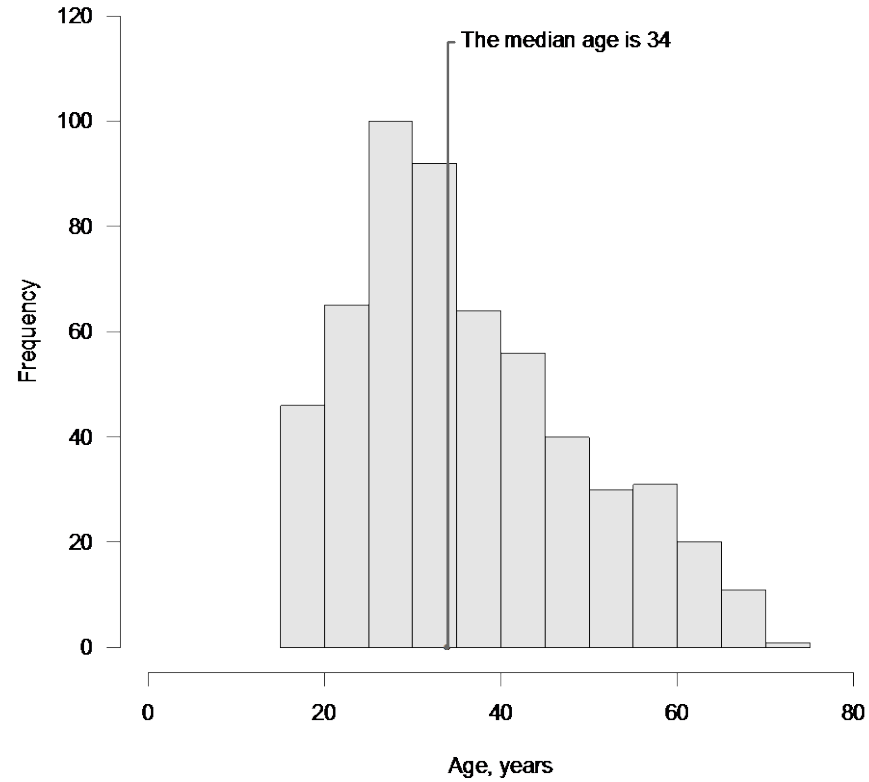
Distribution of days since last confirmed ocean exposure



Population characteristics

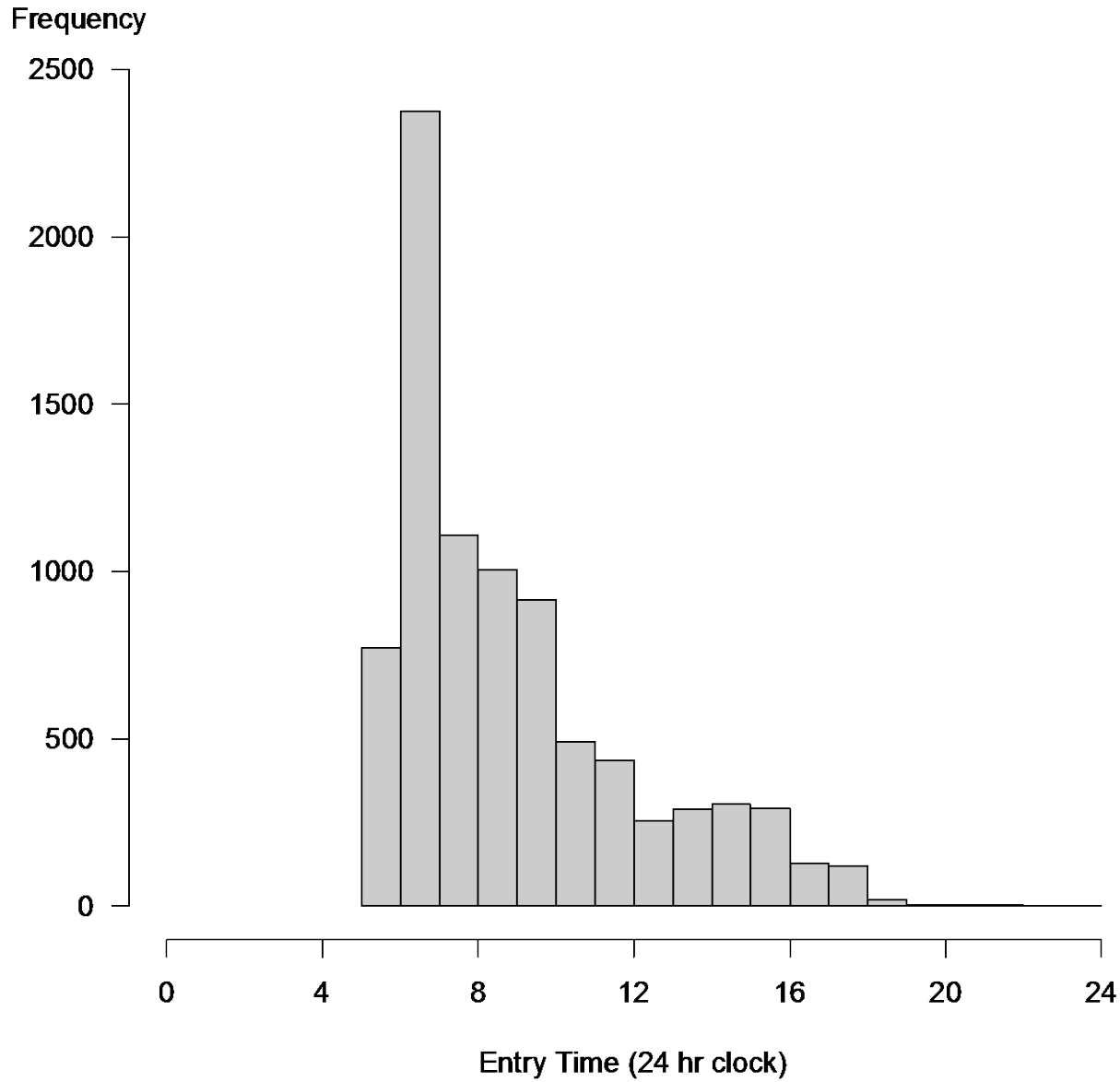
- **79%** male
- **76%** employed
- **63%** college educated
- Median age (IQR):

  34 (27, 45)



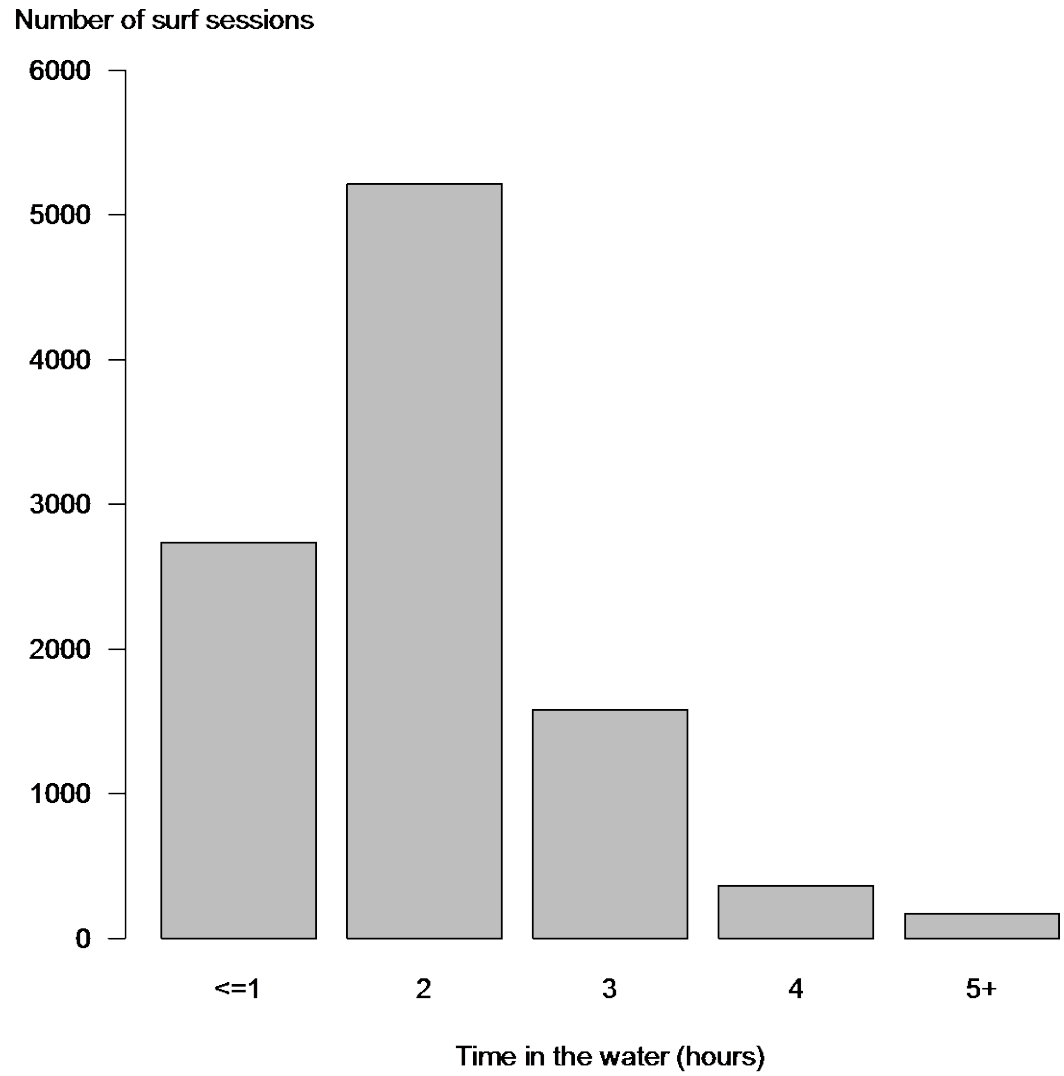
Majority of surf sessions were in the morning

Distribution of entry times

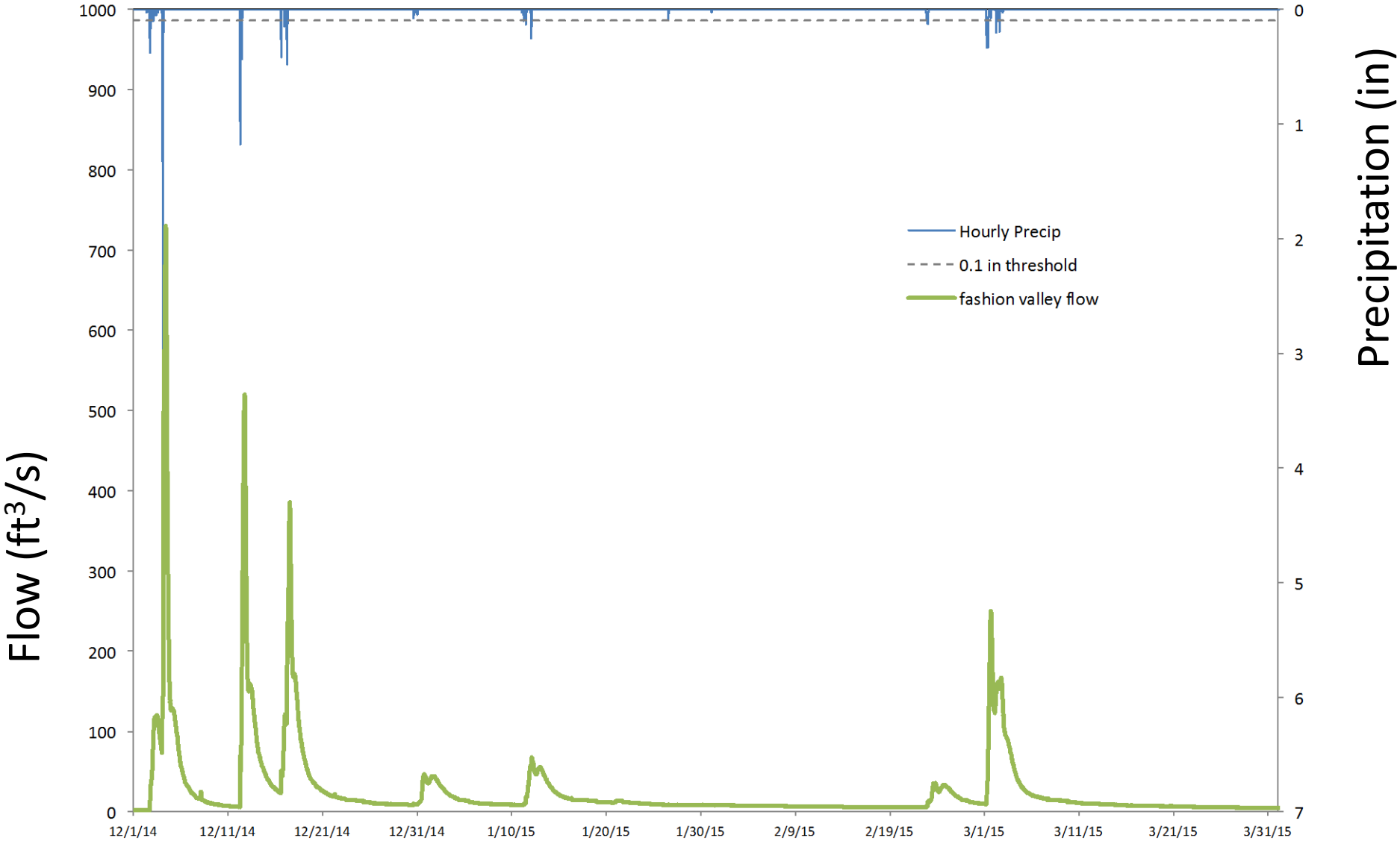


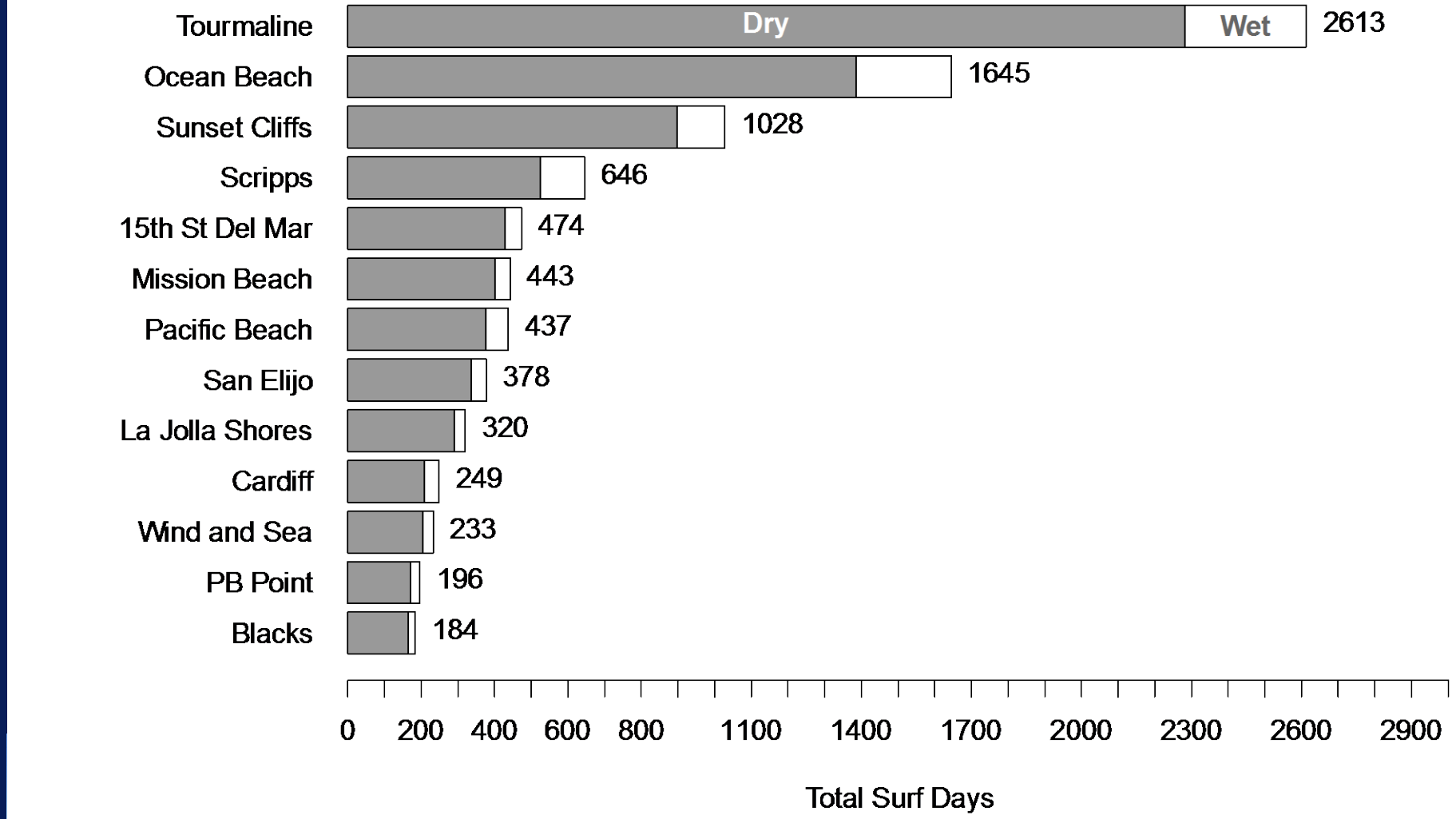
Surfers typically spent 1-2 hours in the water

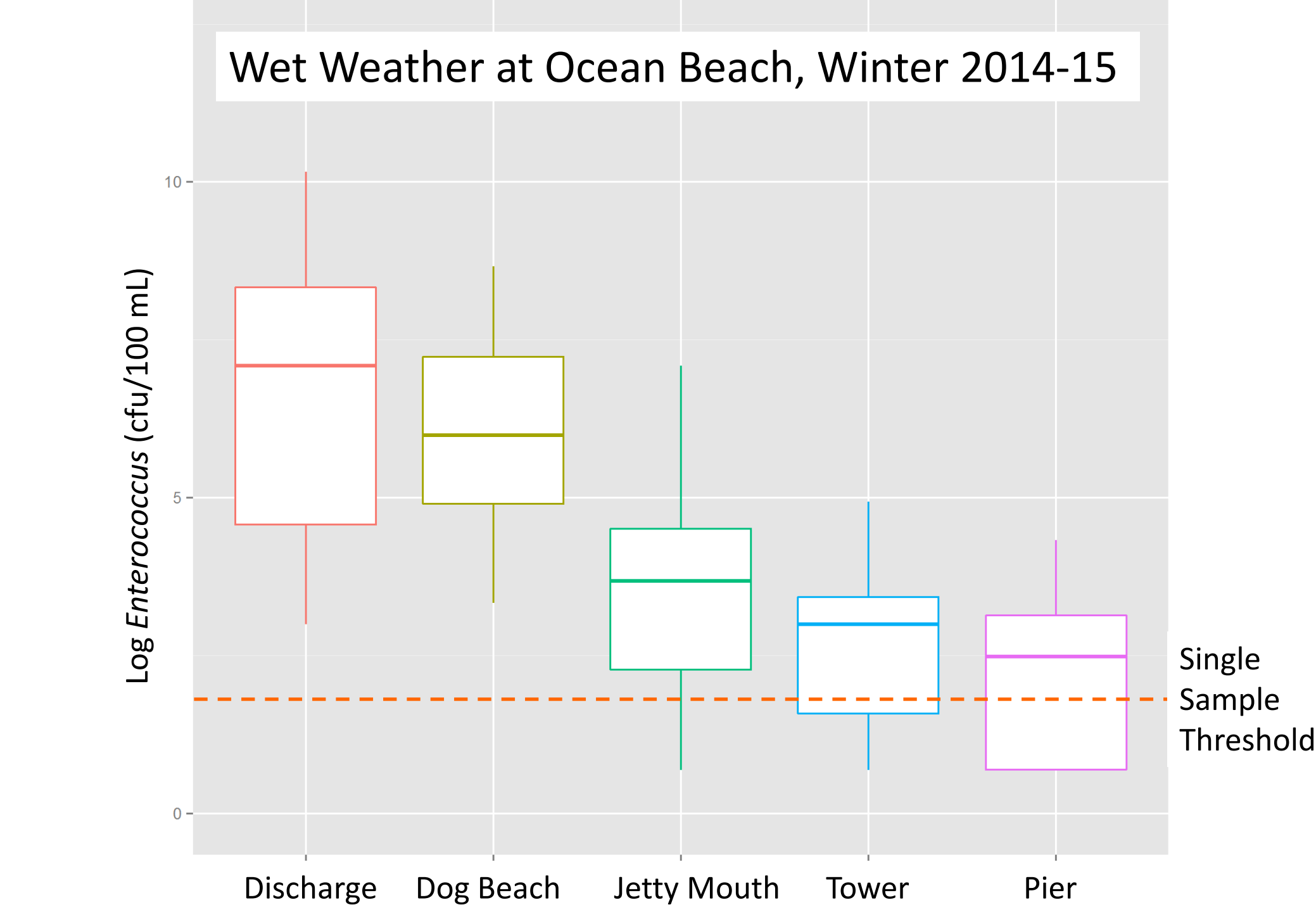
Distribution of hours spent in the water



San Diego River, Winter 2014-15




Tourmaline
Ocean Beach
Sunset Cliffs
Scripps
15th St Del Mar
Mission Beach
Pacific Beach
San Elijo
La Jolla Shores
Cardiff
Wind and Sea
PB Point
Blacks
Dry
Wet
2613
1645
1028
646
474
443
437
378
320
249
233
196
184
0
200
400
600
800
1100
1400
1700
2000
2300
2600
2900
Total Surf Days


Wet Weather at Ocean Beach, Winter 2014-15
Log Enterococcus (cfu/100 mL)
10
5
0
Discharge
Dog Beach
Jetty Mouth
Tower
Pier
Single
Sample
Threshold

Wet Weather Discharges: Detection Frequency for Pathogens and Human Markers

	Noro-virus	Adeno-virus	Entero-virus	*Campylo-bacter*	*Salmo-nella*	HF183
San Diego River	96%	22%	0%	100%	25%	86%
Tourmaline Creek	72%	9%	0%	45%	9.5%	95%

Our Next Steps

- **Complete data analysis**
  - **Health effects**
  - **Relationships to water quality**
- **Quantitative Microbial Risk Assessment**
  - **US EPA's newest tool for site-specific thresholds**
- **Full report by spring 2016**

QMRA Background

- This type of risk modeling is not new
  - Commonly used for other EPA criteria
- QMRA for recreational water contact following wet weather is new
  - No other coastal QMRA in the US
- Other attempts at new thresholds for beaches have not succeeded

QMRA Requires Four Steps to Estimate Probability of Illness

- Pathogen concentration at exposure point
- Volume of water ingested
- Relationship between number of pathogens ingested and adverse health effect
  - dose-response curve
- Proportion of infections that result in illness

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REGULATIONS
The Surfer Health Study
Winter 2014 - 2015
For more information and to enroll visit our study website:
www.sccwrp.org/shs
or scan the QR code:
What is the study about?
This will be the first research study to measure the health risks (if any) associated with surfing on the California coast during the winter months.
How can you help?
We are enrolling hundreds of surfers in the San Diego area to parcipate in 5-10 minute online surveys over the 2014-2015 winter. For every 4 weekly surveys you complete, we will give you a $20 gift card to Swell.com.
You can help us by enrolling and by getting the word out!
School of Public Health
UNIVERSITY OF CALIFORNIA, BERKELEY
SCCWRP
SURFRIDER FOUNDATION
This study is funded by the City and County of San Diego


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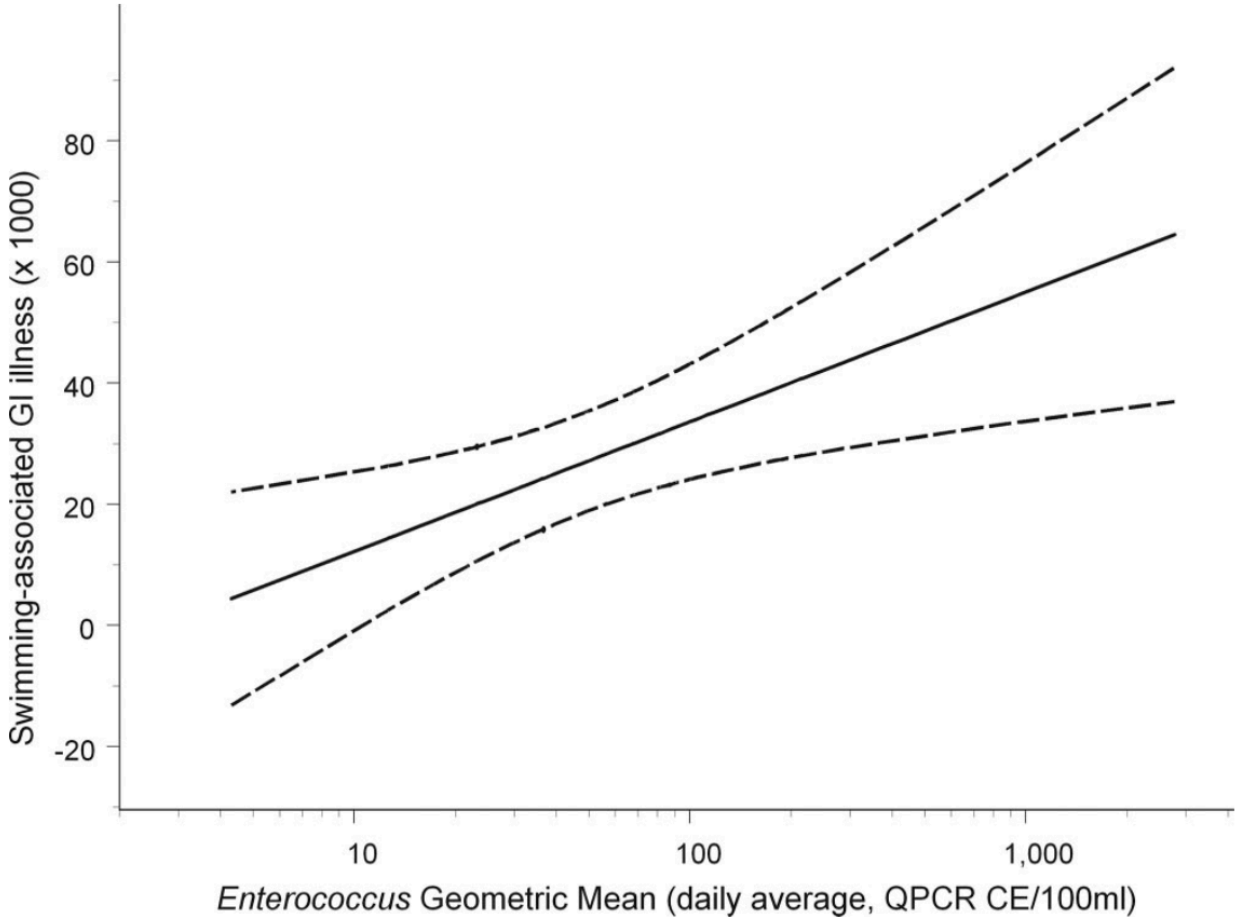

FIGURE 1. Swimming-associated GI illness rate (rate in swimmers minus rate in nonswimmers) among all subjects as a function of daily average Enterococcus QPCR Cell Equivalent exposure. Swimming-associated illness rate estimated from linear regression model, adjusting for factors described in Table 5. Swimming-associated GI illness = −0.0091816 + log 10 Enterococcus QPCR CE × 0.0213998. Solid line indicates rate; dashed line indicates 95% confidence interval.

Wade et al. (2008) *Epidemiology* 19 (3): 375–83

50% of surfers surfed at ≤ 3 breaks