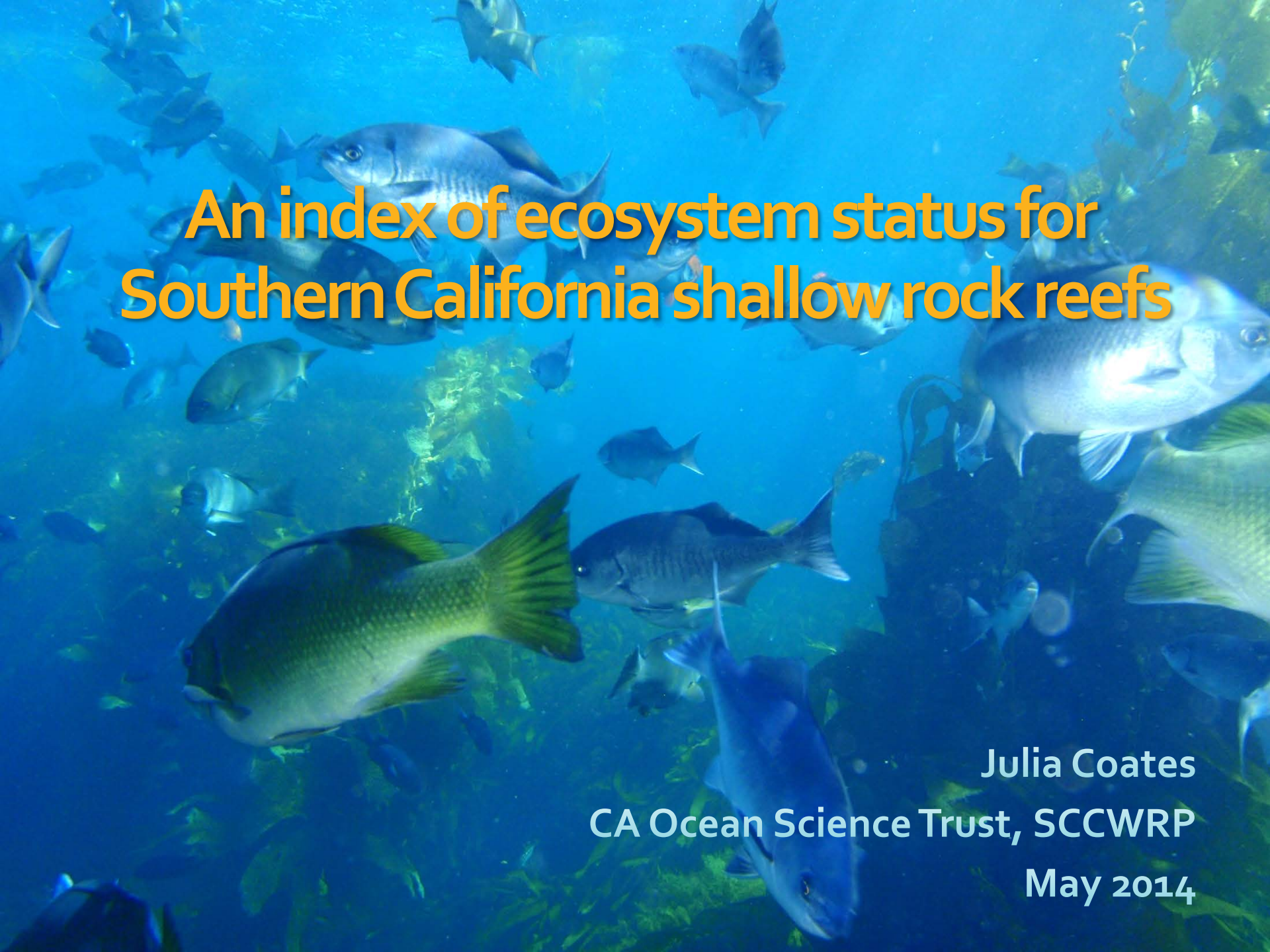


An index of ecosystem status for Southern California shallow rock reefs

Julia Coates
CA Ocean Science Trust, SCCWRP
May 2014

Failures of fishery management

- CA has struggled to effectively manage many harvested species associated with rocky reefs
- Functional extinctions
- Changes in abundance & size structure
- Non-fishery impacts – water quality, habitat loss, climate…

Jonathan Williams

A new strategy: ecosystem-based management

- Holistic approach
- Marine spatial management
- MPAs, South Coast in 2012
- Nearly all encompass some reef habitat
- Buffer against uncertainty
- Consideration of spatially varied
  - Abiotic conditions (SST, depth, relief)
  - Anthropogenic stressors

Monitoring whole ecosystems is challenging

- Large natural variability – spatial & temporal
- Large variation in anthropogenic stress – fishing pressure, water quality
- MPA effects obscured by this variation
- Large disconnected data sets
- Need quantitative, repeatable method for evaluating ecosystem integrity

http://spg.ucsd.edu/satellite_projects/modis_250m_data/modis_250m_data.htm

Overall approach

- Link resources and water quality communities
- Create quantitative indices of stressors and ecology
- Which has more impact, fishing or water quality?

3 regional scale indices

Fishing Pressure

Dan Pondella, Amanda Zellmer
VRG, Occidental College

Water Quality

Ken Schiff, Becky Shaffner
SCCWRP

Biological Response

Quantifying fishing pressure

- How do we allocate fishing pressure to individual reefs?
  - Current vs. historical
  - Catch amount vs. effort
  - Some fisheries more damaging than others?
- Commercial and recreational fishing are regulated and documented in CA
- Using these reports, quantify total amount harvested, historical & current
- Synthetic index integrates across
  - Time
  - Species
  - Gear types
  - Types of fishermen
  - Regulatory regimes
- Straightforward approach, but never attempted

Original Data:

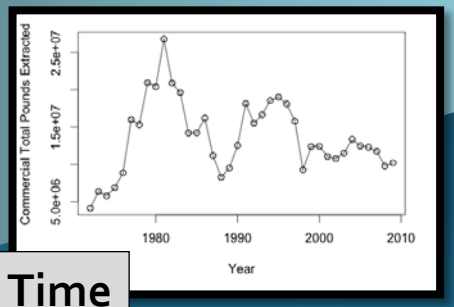
USGS
science for a changing world

- California Commercial Fisheries Data
  - (1972 – 2009)
  - CA Fish & Wildlife
- California Sport Fishing Data
  - (1980 – 2009)
  - CPFV Logbook

Filter:

So CA

Reef Species

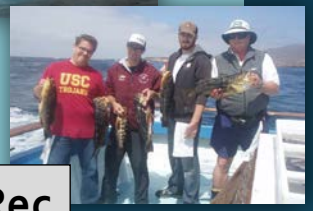


Time

1980-2009

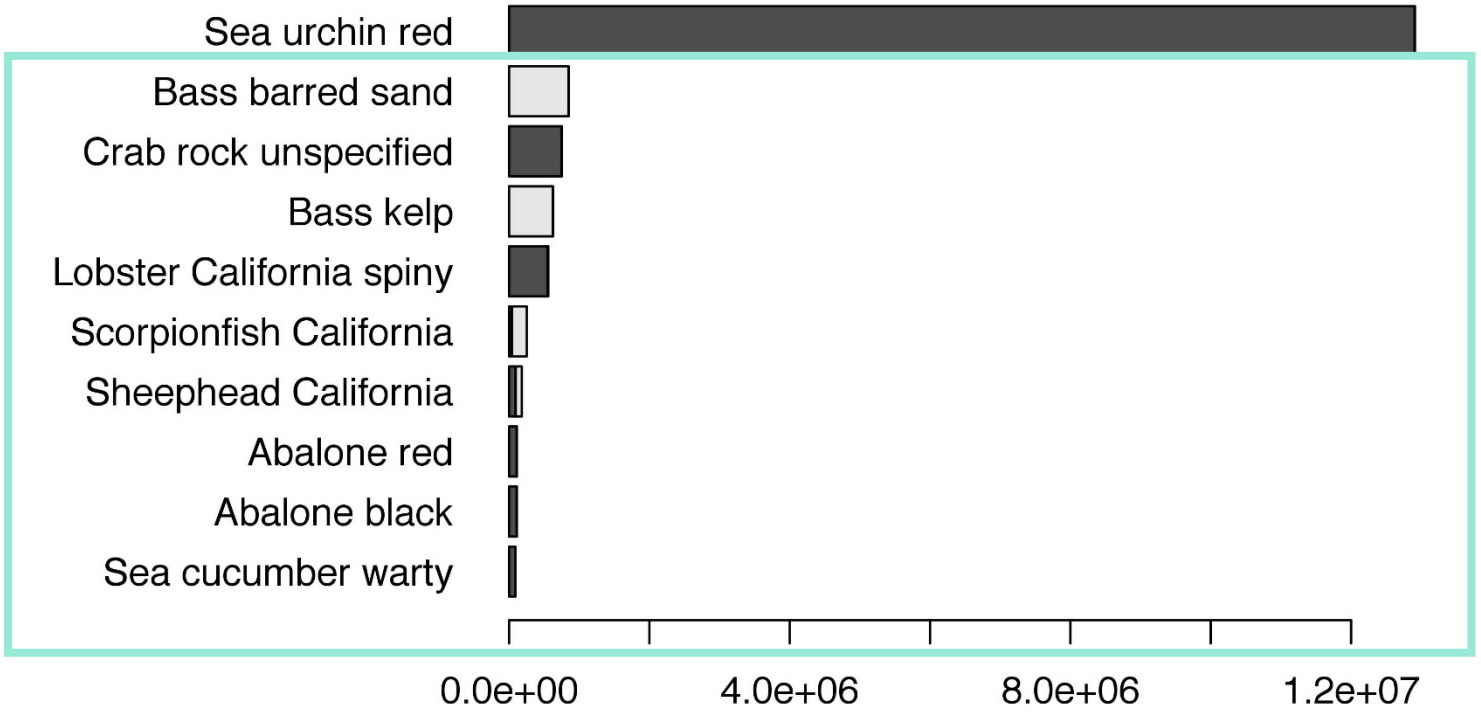
Summarize:

Com

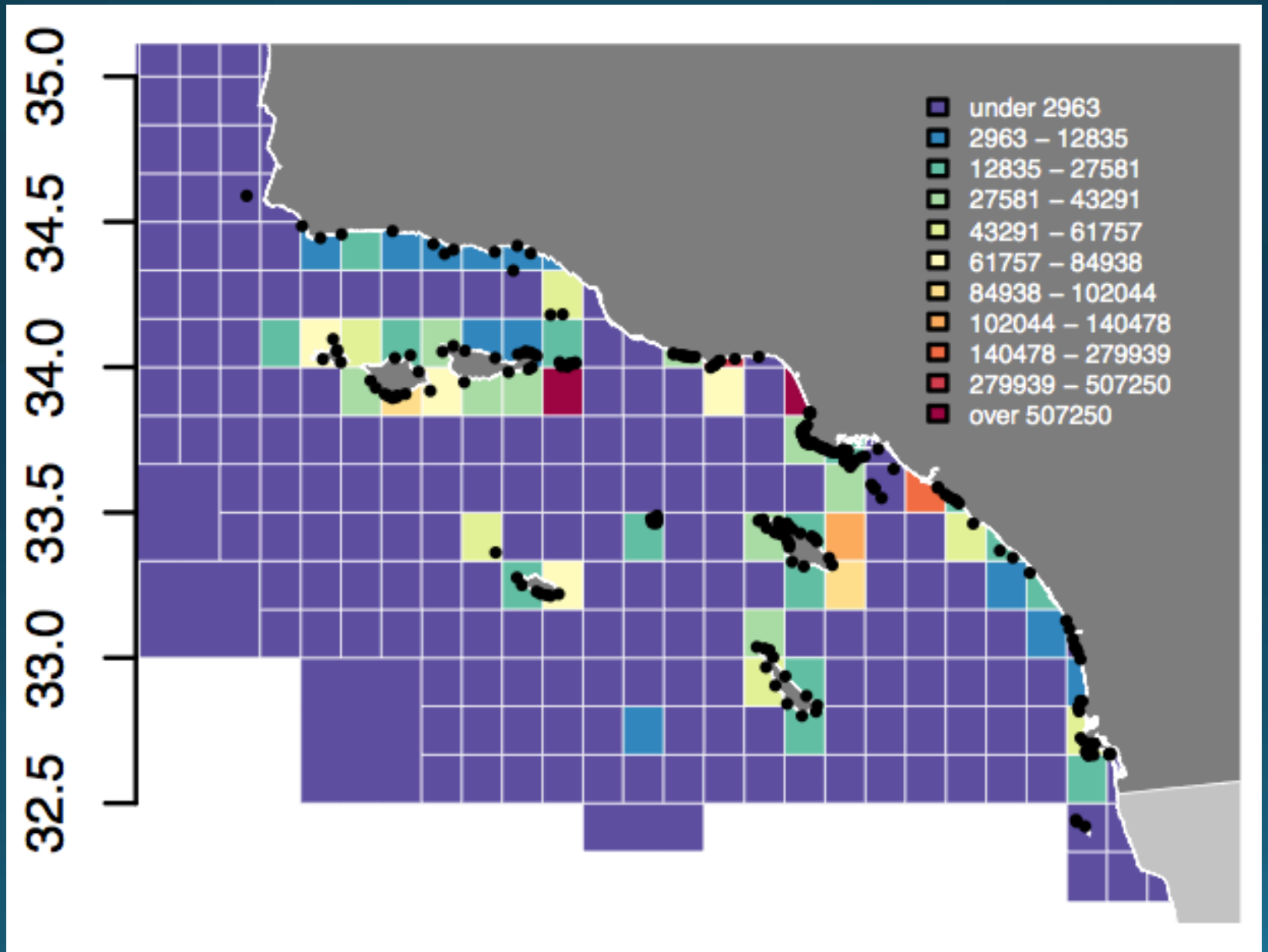


Rec

Spatial Fishing Pressure Index


Commercial
Recreational
Sea urchin red
Bass barred sand
Crab rock unspecified
Bass kelp
Lobster California spiny
Scorpionfish California
Sheephead California
Abalone red
Abalone black
Sea cucumber warty
0.0e+00
4.0e+06
8.0e+06
1.2e+07
Commercial and Recreational Total Pounds Extracted per Year

Total Pounds Extracted Per Year Per km² Reef Area
Commercial & Recreational 1980-2009



3 regional scale indices

Fishing Pressure

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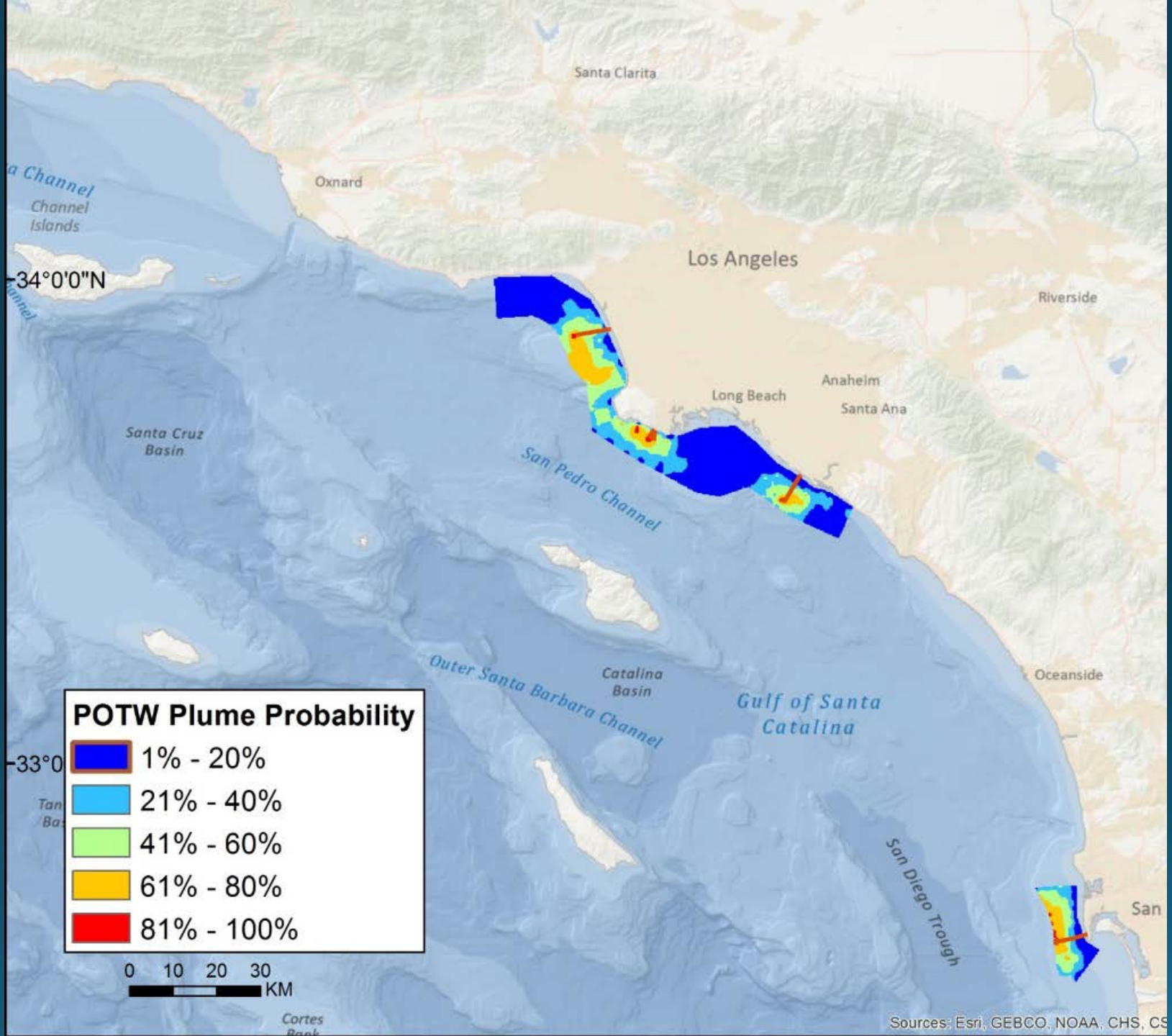
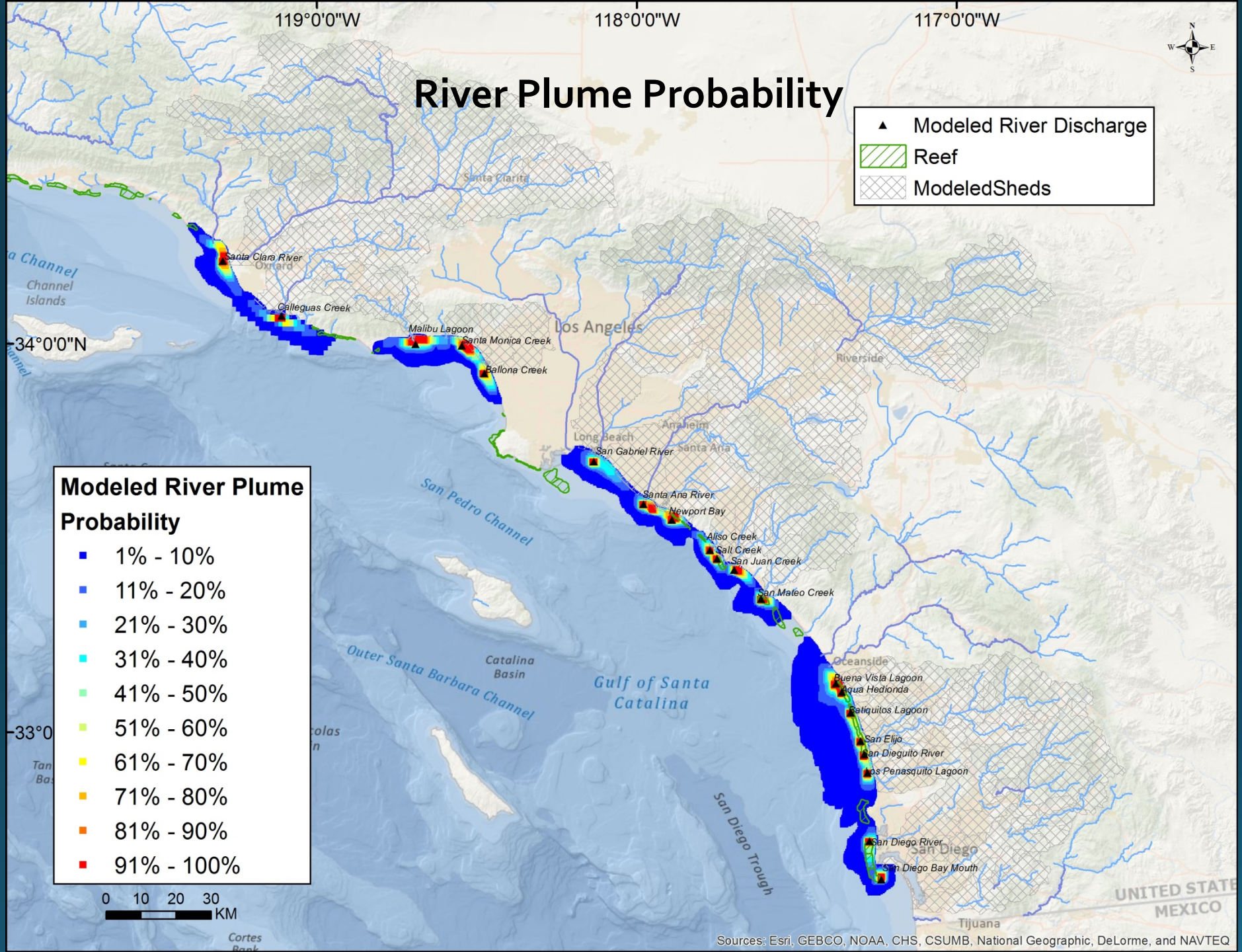
SCCWRP

Biological Response

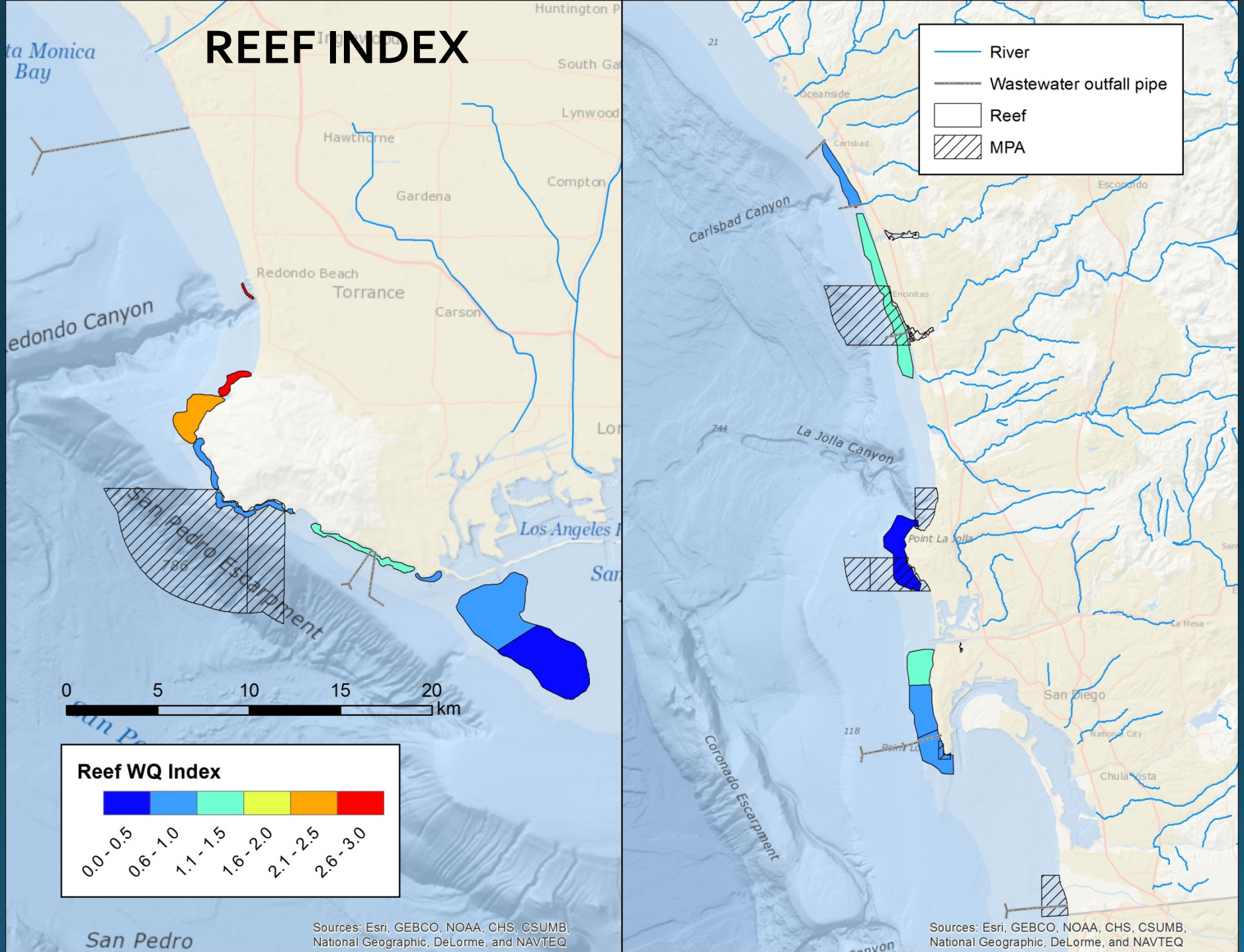
Quantifying pollution impacts

- Risk-based framework
  - Function of magnitude (load) and frequency of exposure (plume frequency)
- Focus on 2 major sources
  - POTWs
  - Stormwater
- Focus on nitrate, copper & TSS
- Generate a GIS layer of the Water Quality Index for the entire Bight
  - A map like this has never been attempted
  - Scored on a scale of 0-3


Santa Clarita
Oxnard
Channel Islands
Los Angeles
Riverside
34°0'0"N
Anaheim
Long Beach
Santa Ana
Santa Cruz Basin
San Pedro Channel
Outer Santa Barbara Channel
Catalina Basin
Gulf of Santa Catalina
Oceanside
San Diego Trough
POTW Plume Probability
1% - 20%
21% - 40%
41% - 60%
61% - 80%
81% - 100%
0 10 20 30
KM
Sources: Esri, GEBCO, NOAA, CHS, CS


River Plume Probability
Modeled River Discharge
Reef
ModeledSheds
Modeled River Plume Probability
1% - 10%
11% - 20%
21% - 30%
31% - 40%
41% - 50%
51% - 60%
61% - 70%
71% - 80%
81% - 90%
91% - 100%
0 10 20 30 KM
119°0'0"W
118°0'0"W
117°0'0"W
34°0'0"N
33°0
Santa Clara River
Calleguas Creek
Malibu Lagoon
Santa Monica Creek
Ballona Creek
San Gabriel River
Santa Ana River
Newport Bay
Aliso Creek
Salt Creek
San Juan Creek
San Mateo Creek
Buena Vista Lagoon
Agua Hedionda
Batiquitos Lagoon
San Elijo
San Dieguito River
Los Penasquito Lagoon
San Diego River
San Diego Bay Mouth
Los Angeles
Long Beach
Anaheim
Santa Ana
Riverside
Oceanside
San Diego
Tijuana
Channel Islands
San Pedro Channel
Outer Santa Barbara Channel
Catalina Basin
Gulf of Santa Catalina
San Diego Trough
UNITED STATES
MEXICO
Sources: Esri, GEBCO, NOAA, CHS, CSUMB, National Geographic, DeLorme, and NAVTEQ

REEF INDEX


River
Wastewater outfall pipe
Reef
MPA
Reef WQ Index
0.0 - 0.5
0.6 - 1.0
1.1 - 1.5
1.6 - 2.0
2.1 - 2.5
2.6 - 3.0
0
5
10
15
20
km
Redondo Canyon
San Pedro Escarpment
Carlsbad Canyon
La Jolla Canyon
Coronado Escarpment
Point La Jolla
Redondo Beach
Torrance
Carson
Gardena
Hawthorne
Compton
Lynwood
Oceanside
Carlsbad
Encinitas
Escondido
San Diego
National City
Chula Vista
La Mesa
San Pedro
Sources: Esri, GEBCO, NOAA, CHS, CSUMB, National Geographic, DeLorme, and NAVTEQ
Sources: Esri, GEBCO, NOAA, CHS, CSUMB, National Geographic, DeLorme, and NAVTEQ

3 regional scale indices

Fishing Pressure

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Water Quality

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SCCWRP

Biological Response

What is the biological impact?

- Other monitoring programs
  - Ecosystem described by status of each individual species
- Develop a multivariate, ecosystem-level biological index
  - Integrate direct & indirect effects due to organism interactions
  - Framework to account for habitat variability and focus on variation from stress
- Body of research in fresh water ecosystems
- Little research in marine ecosystems

Biological Data

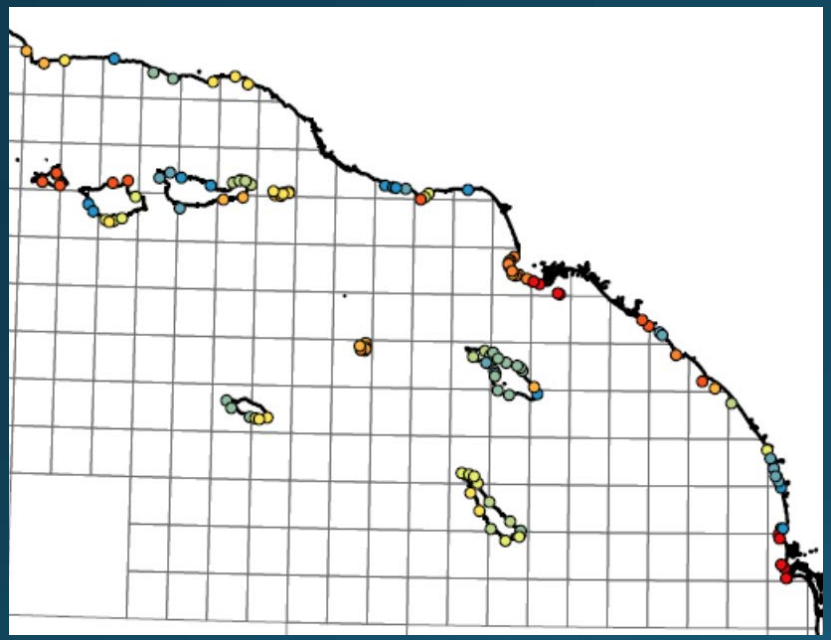
- Transect surveys performed in 2004, 2008, 2011, 2012
- CRANE, Bight, SC MPA Baseline
- 140 Sites
- 3 survey types
  - Fish
  - Mobile macroinvertebrates & algae
  - Sessile, colonial invertebrates & algae

O/E Index

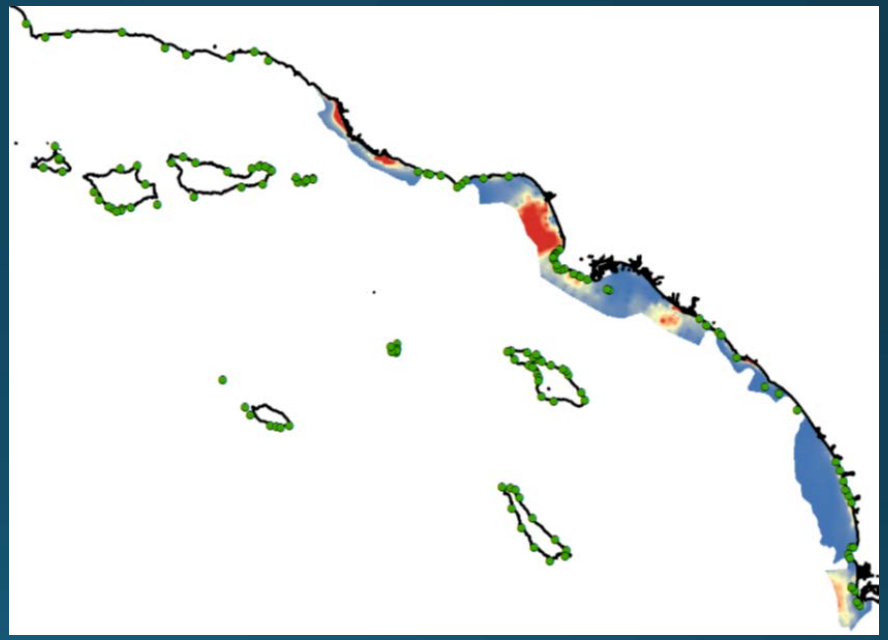
$$\frac{\text{Observed Biological Community}}{\text{Expected Biological Community}} = \text{Index Score}$$

- Observed - measured on transect surveys
- Expected - what should be living at this site?
- Reference site approach
- Model biological community & habitat relationships at reference sites
- 1 = "reference condition"
- Use model to predict expected values at test sites

Reference sites experience a relative absence of stress



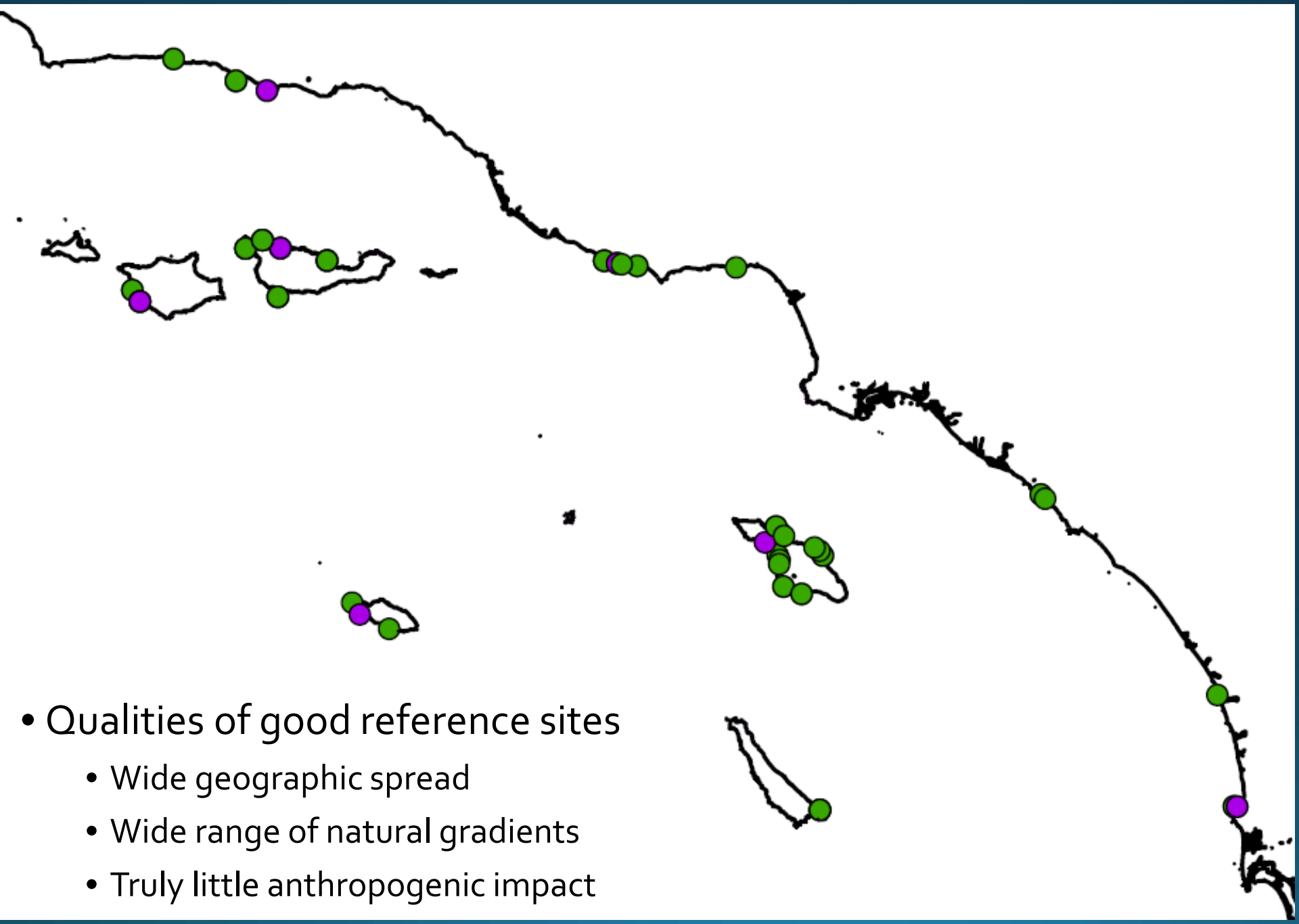
+



< 30th percentile of lbs taken

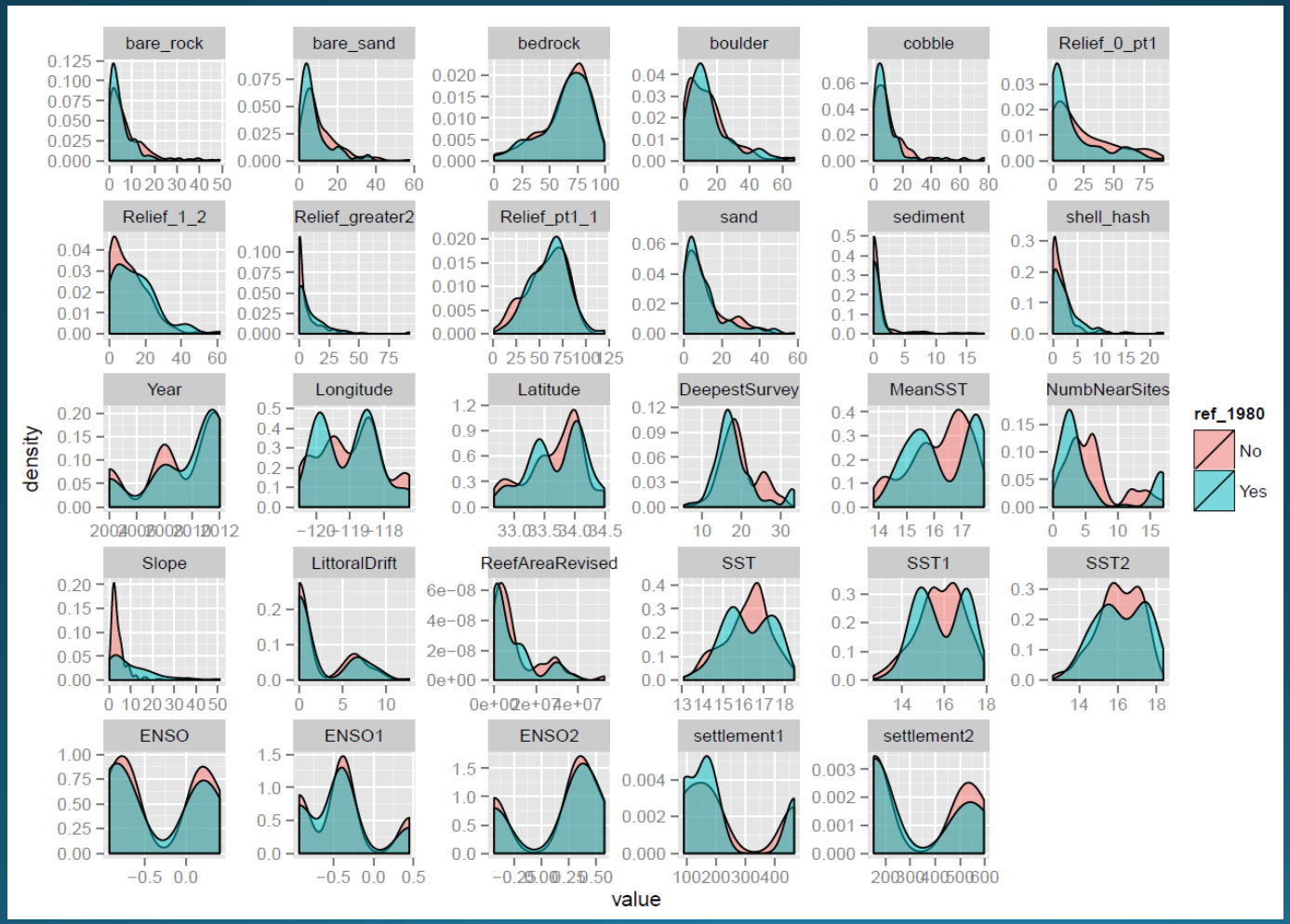
No water quality impact

=



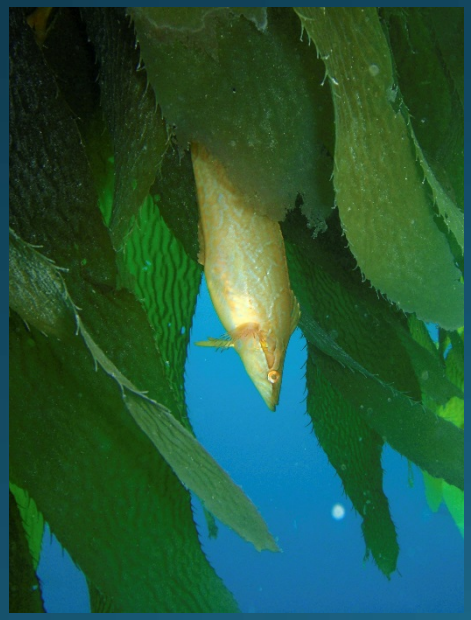
- Qualities of good reference sites
  - Wide geographic spread
  - Wide range of natural gradients
  - Truly little anthropogenic impact

Habitat at reference & non-reference sites



Index evaluation

- Accuracy, precision, bias
- Sensitivity (to stress)
- Best assemblage



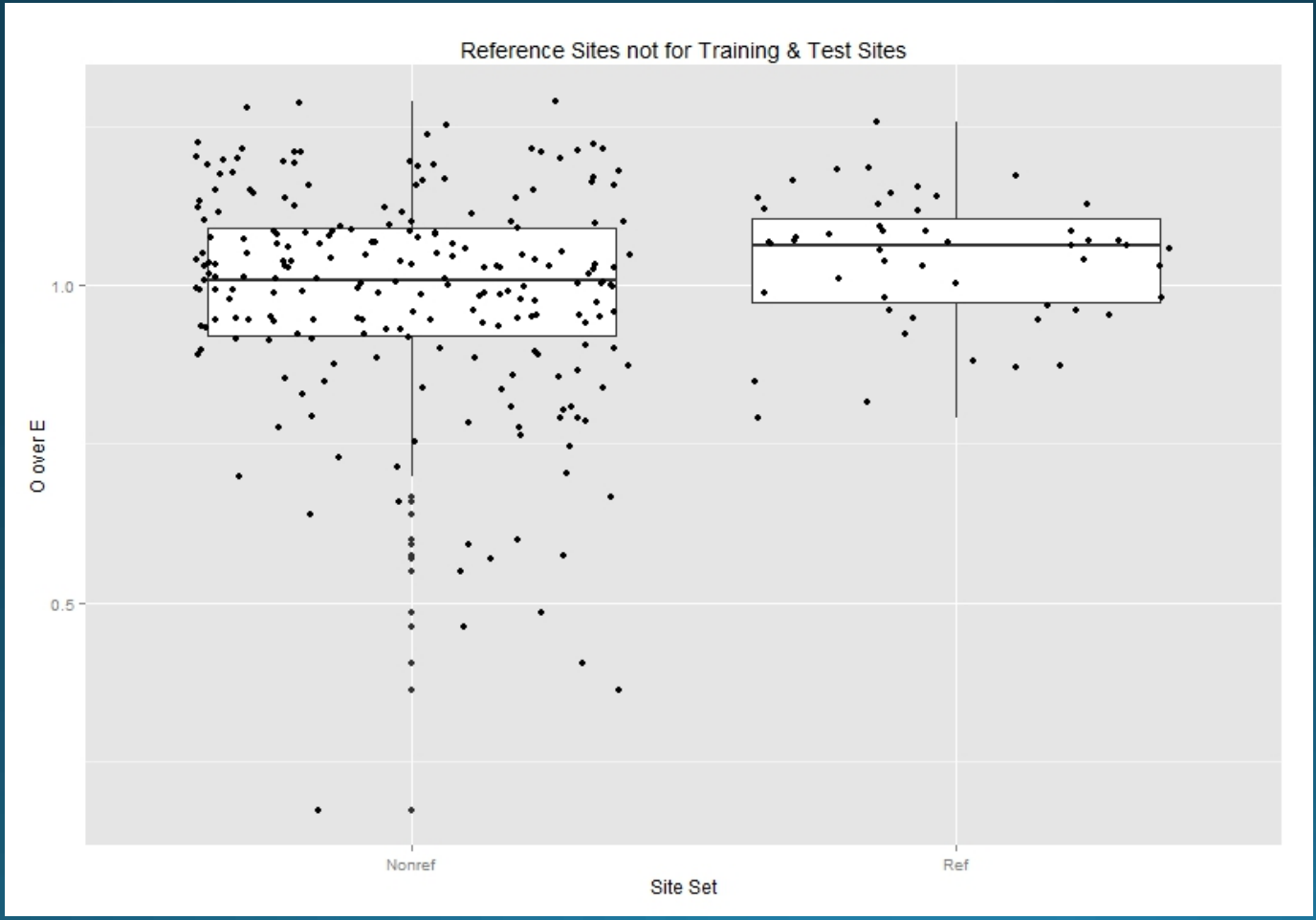
Accuracy & precision

- Null vs. predictive
- Accuracy indicated by reference means close to 1
- Precision indicated by small SD

	Calibration		Validation		Test	
	Mean	SD	Mean	SD	Mean	SD
Predictive	1.017	0.131	1.030	0.076	0.987	0.174
Null	1.000	0.156	0.981	0.135	0.995	0.204
% Precision Improvement		16		43		15

Sensitivity

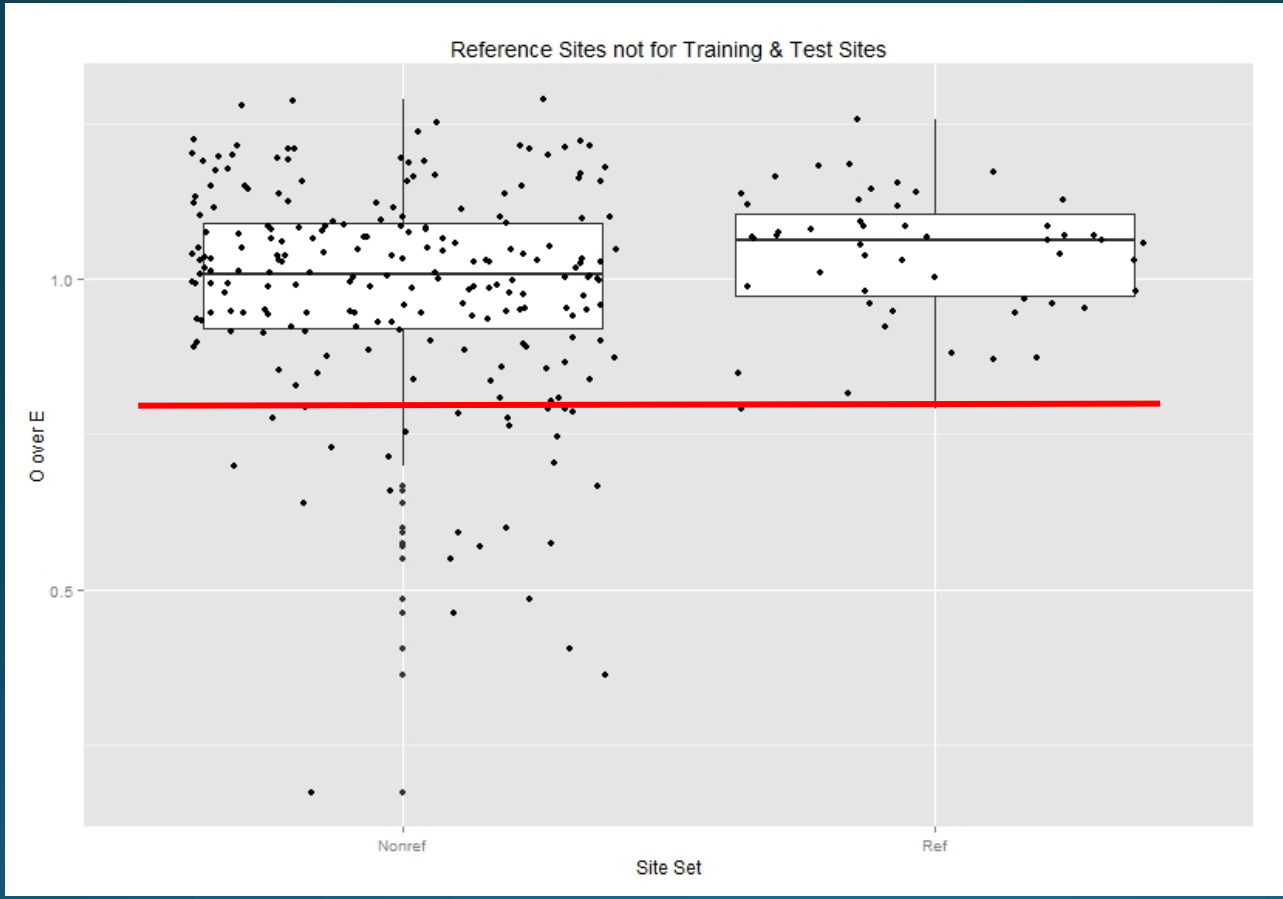
- Mean O/E scores significantly different for reference and non-reference samples (p=0.005)



Index application: understanding stress impacts

- A weight of evidence approach
- Threshold delineation
- Stress relative to O/E performance
  - Ranking sites: chi square
  - Comparing means: t-tests
- Continuous data: multiple regression

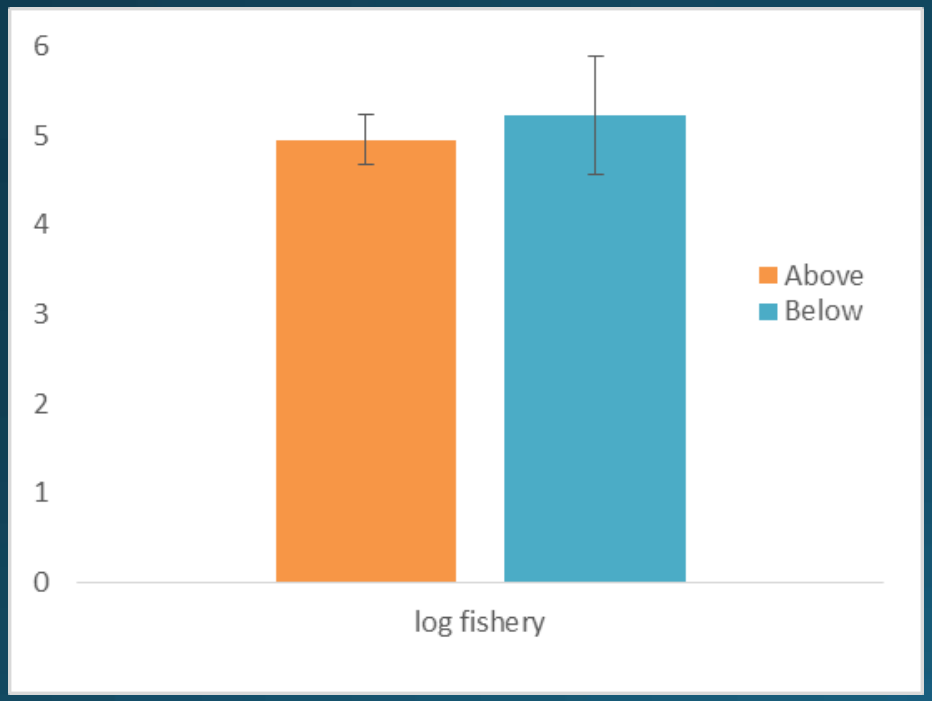
Threshold delineation

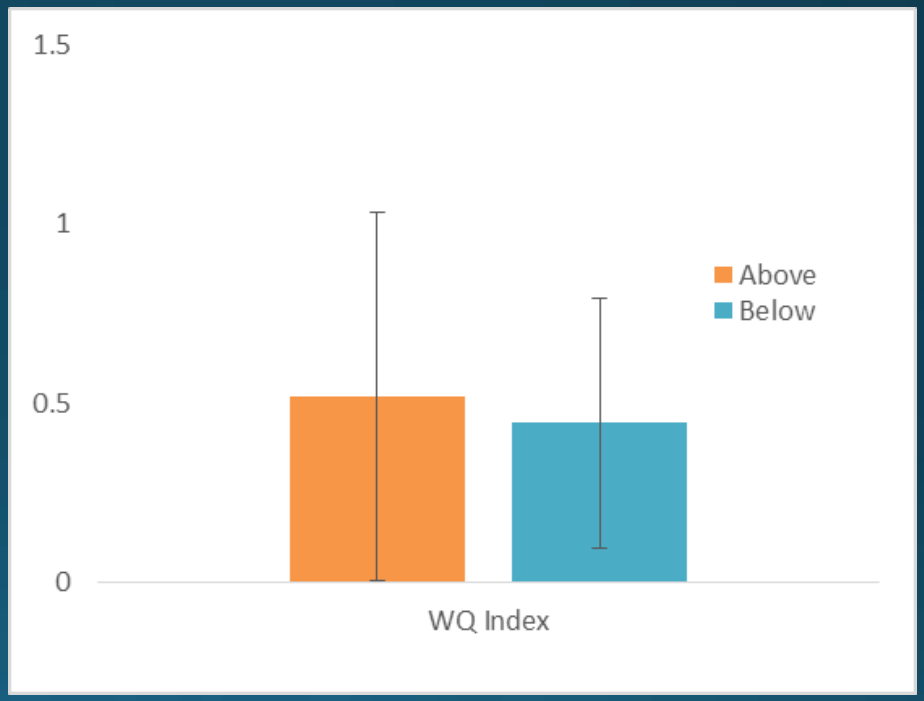


Chi squared test: number of low performing in impact categories

Impact Level	Low	Med Low	Med High	High
Fishing Pressure	↓	-	-	↑
Water Quality	-	-	-	-

Comparing means of stressors relative to threshold





Multiple predictors of O/E scores

- Multiple regression
  - Dependent variable: O/E scores
  - Independent variables: Stressors & key habitat variables
- Stepwise procedure reduced model
- Fishing pressure has strongest influence
  - Highly significant negative relationship
- TSS weakest
- Habitat important: low relief, bedrock, sand, cobble

Conclusions

- Successful collaboration between water quality and resources
- We can build a biological index for a marine habitat
  - Separates reference from non-reference conditions
  - Room for improvement
  - Preliminary application indicates fishing may be a more important stressor than water quality
- Potentially useful web portal tool