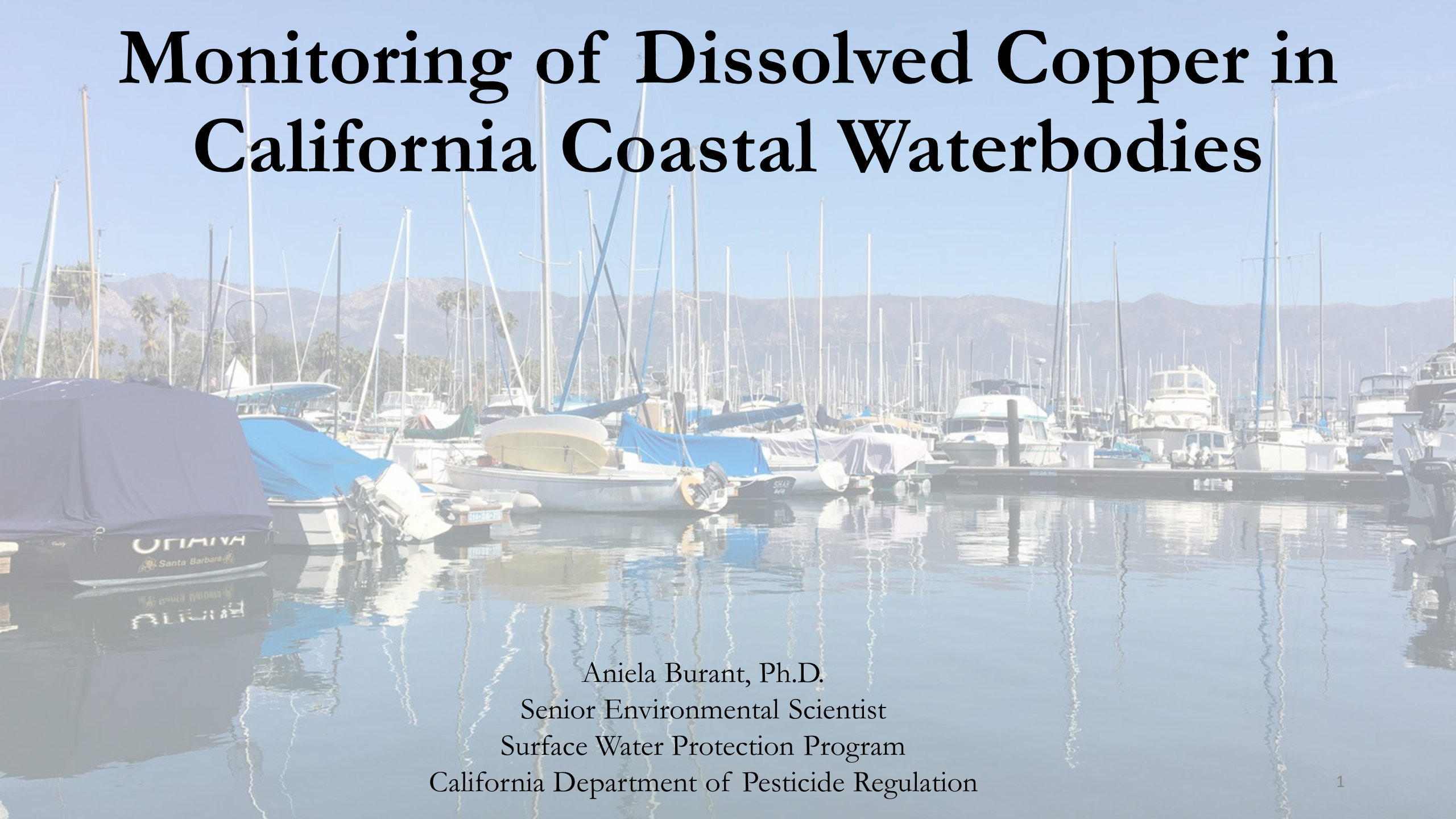
Monitoring of Dissolved Copper in California Coastal Waterbodies



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Outline

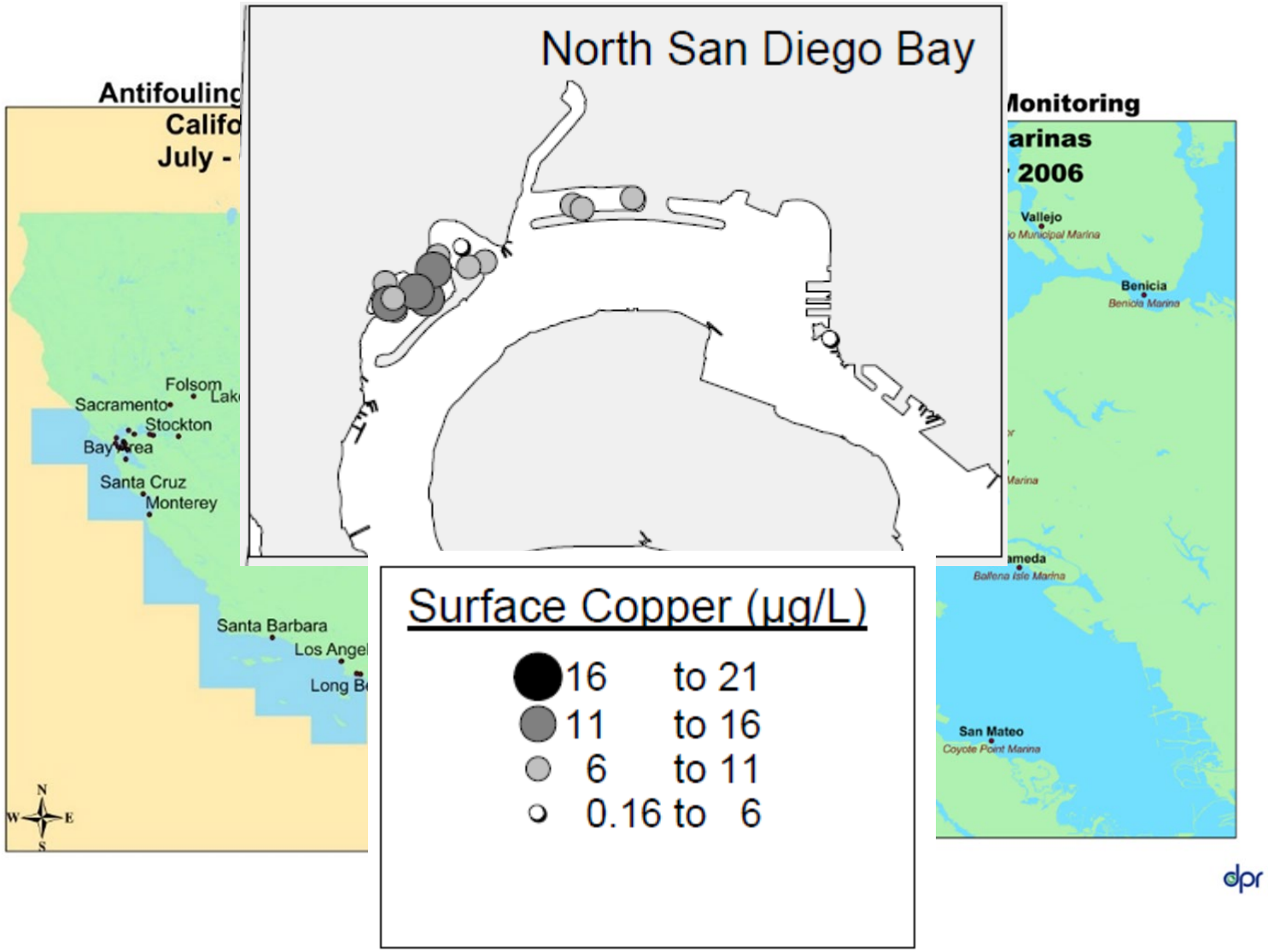
- Background on dissolved copper (DCu)
- Previous CDPR efforts
- Copper Antifouling Paint (Cu-AFP) Regulation
- CDPR Monitoring Study
  - Methods
  - Results
- Modeling
  - Spatial and Temporal Trends
- Limitations and Future Work

Copper and Water Quality

- Copper (Cu^{2+}) is toxic to both target and non-target organisms
  - Only as labile or bioavailable copper
- Species of concern are mussels (blue and Mediterranean)
- California Toxics Rule (CTR) is an enforceable water quality standard
- Dissolved Copper:
  - Acute water quality criterion: 4.8 µg/L
  - Chronic water quality criterion: 3.1 µg/L

Marinas and Water Quality

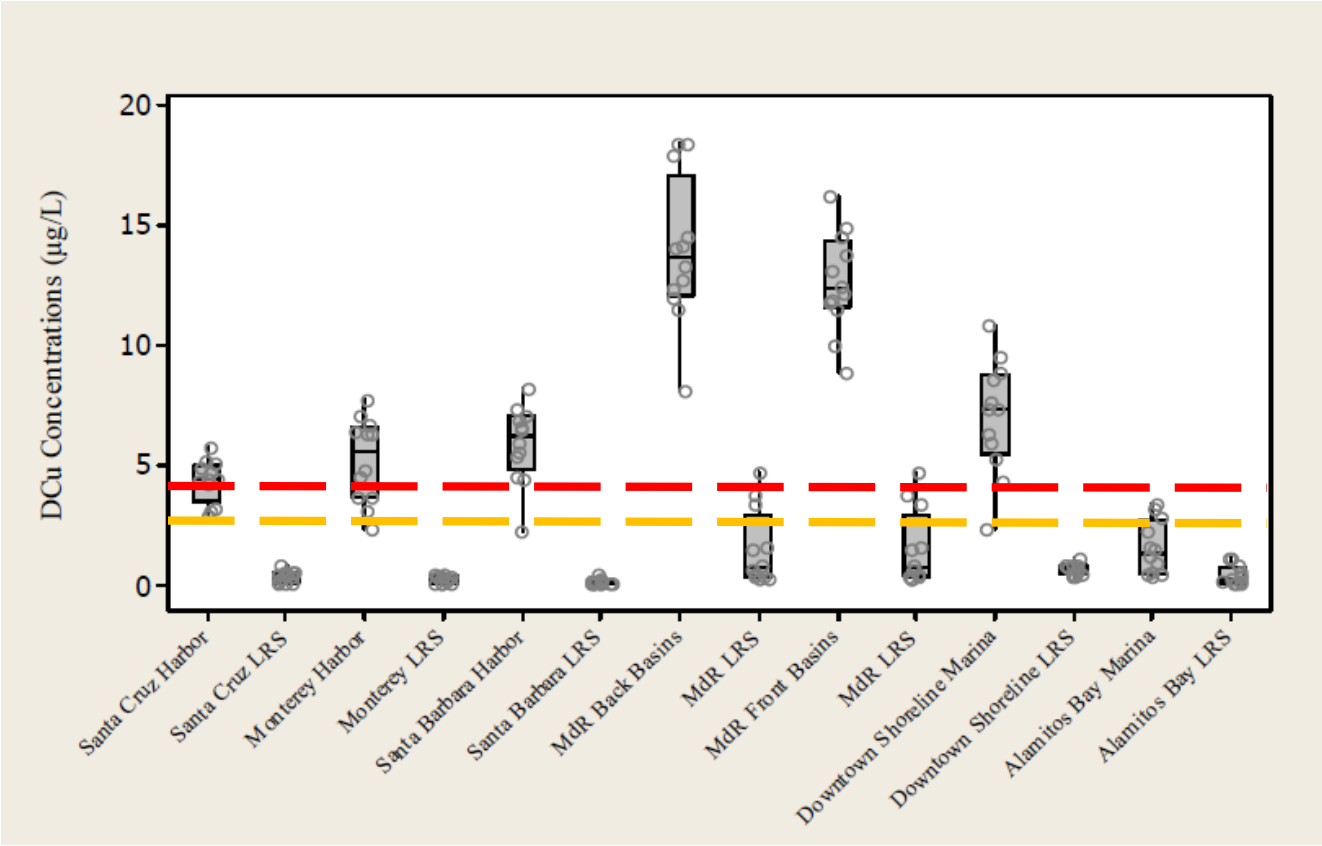
- Recreational marinas susceptible to Cu pollution
  - High concentration of boats
  - Long periods of time in marinas
  - Poorly flushed
- 303(d) listing of impaired waters
- CDPR Monitoring Study



Previous CDPR Efforts

- DCu and associated toxicity exceeding water quality standards in many California marinas

- Toxicant Identification Evaluation Tests showed DCu was the likely cause of toxicity



=Acute Water Quality Criterion, 4.8 µg/L

=Chronic Water Quality Criterion, 3.1 µg/L

LRS = Local Reference Site; OUT of the marina

Previous CDPR Efforts

- AB 425: CDPR needs to determine a leach rate cap and make mitigation recommendations
- Marine Antifoulant Model to Predict Environmental Concentrations (MAM-PEC)
- CTR chronic criterion of 3.1 µg/L dissolved copper is the goal
- What leach rate will be sufficient to achieve that concentration or lower in California marinas?

Copper AFP Regulation

3 CCR § 6190: No copper-based antifouling paint/coating shall be registered over a **leach rate** of 9.5 µg/cm^2/day

- Any currently registered paint above that leach rate was cancelled.
- For recreational boats only
- July 2018

Nanaimoboatyard.ca

Study Objectives

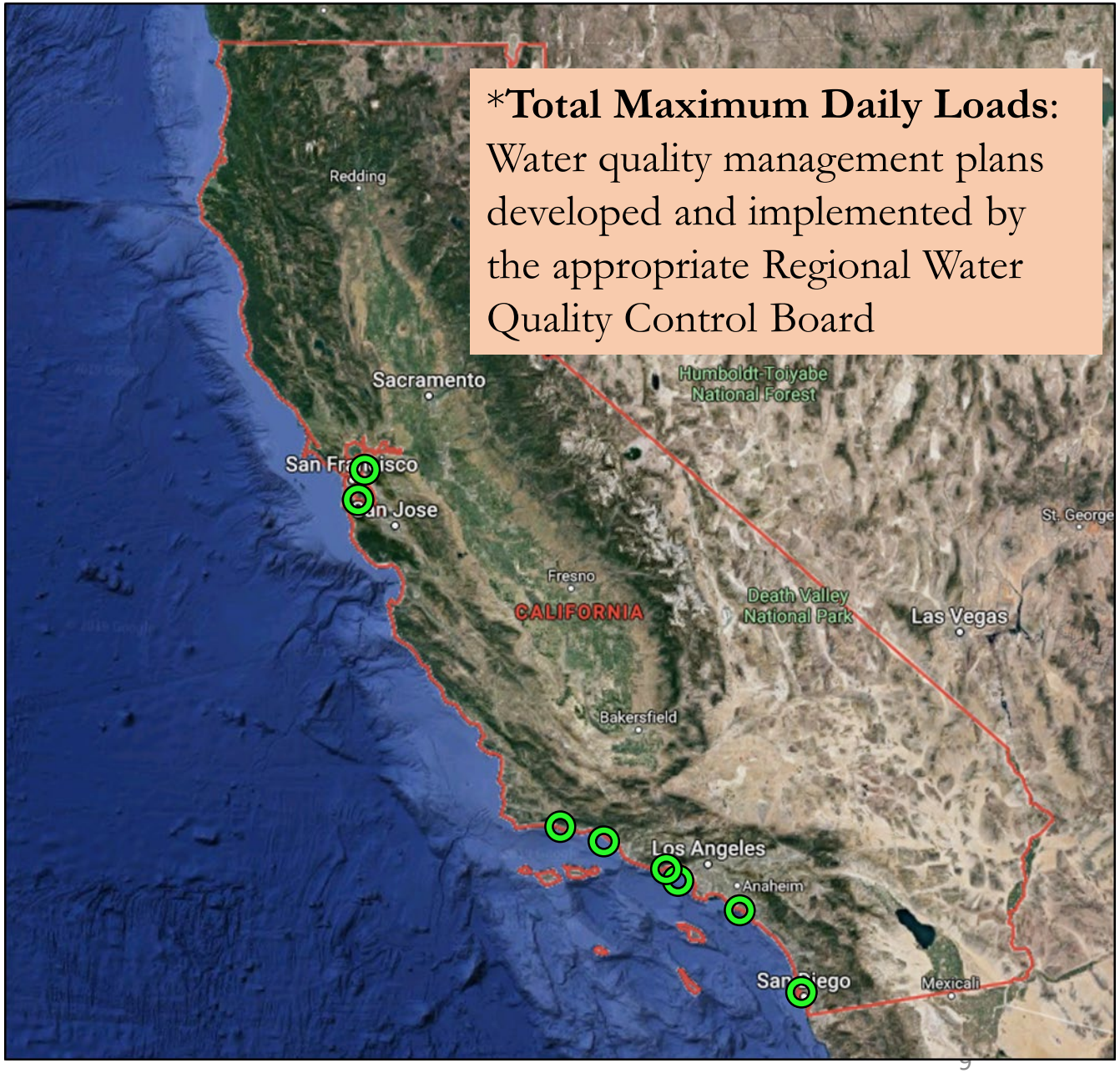
- Determine the concentrations of DCu in selected, representative waterbodies
- Determine the temporal and spatial trends in DCu across and within waterbodies
- Determine the potential toxicity of samples based on measured water chemistry parameters using the saltwater biotic ligand model.

Waterbody Selection

- Region
  - Site Specific Objectives in San Francisco Bay
  - Higher water temperatures in Southern California

- Size
  - Coyote Point Marina < 1000 vessels
  - Berkeley, Santa Barbara, and Redondo Beach < 2000 vessels
  - Channel Islands, Newport Bay*, Marina del Rey*, and Shelter Island Yacht Basin* > 2000 vessels

- Cooperation of marina owner/operator

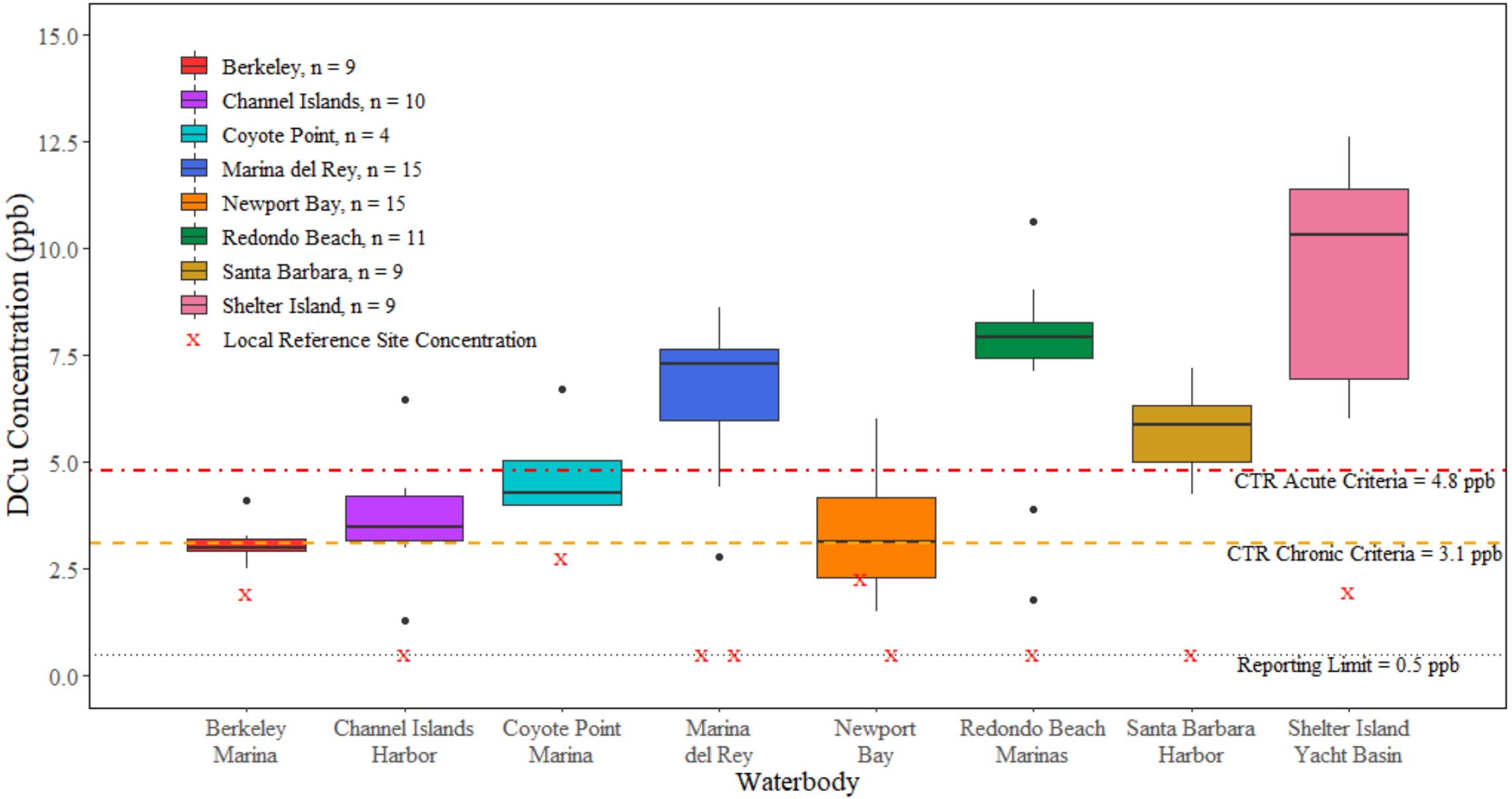


***Total Maximum Daily Loads**: Water quality management plans developed and implemented by the appropriate Regional Water Quality Control Board

Sampling Site Selection

- Number of samples dependent on size of waterbody
- Standardized sampling process
- In-line filtering
- Local reference sites
- Secondary constituent data

Results and Discussion



Results and Discussion

- **100%** detection frequency in the waterbodies
- Waterbody concentrations were 30% (Berkeley Marina) to **2030%** (Redondo Beach Marinas) higher than LRS sites
- CTR chronic criterion exceedance = **79%**
- CTR acute criterion exceedance = **52%**

Modeling – LASSO Regression

- LASSO Regression was used to determine a best fit model for predicting DCu concentrations
- Included 18 explanatory variables
- What variables contribute to DCu concentrations?

Spatial Trends

Results of Modeling

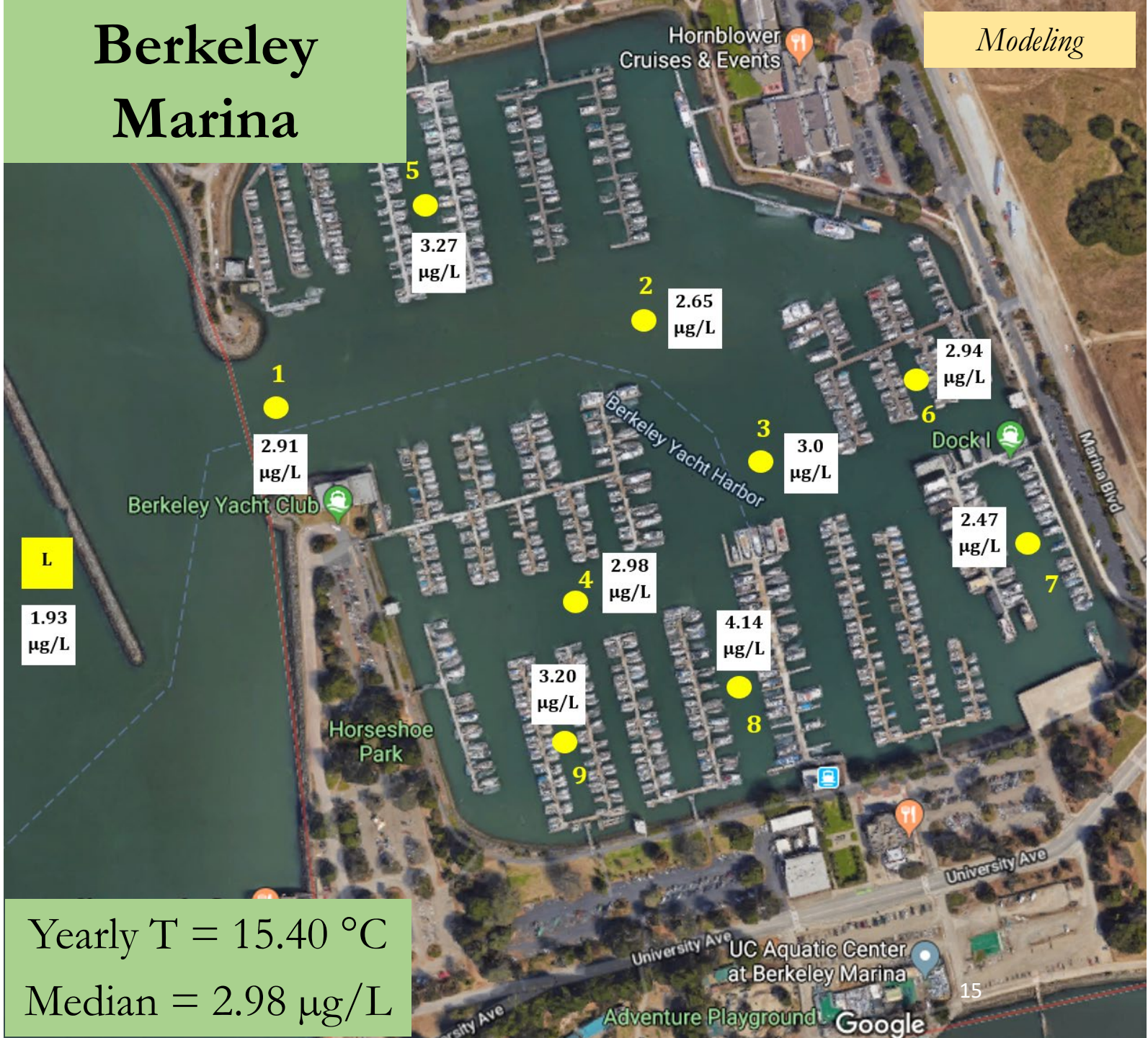
- Best fit modeling resulted 7 explanatory variables included in the model
  - Regional spatial trends
    - Trends between the waterbodies
  - Spatial trends
    - Trends within the waterbodies
  - Waterbody characteristic trends
- RMSE = 0.587, R_{adj}^2 =0.919

Regional Spatial Trends

- Latitude
- Yearly Average Temperature
- Temperature at Sampling

Berkeley Marina

Modeling



Yearly T = 15.40 °C

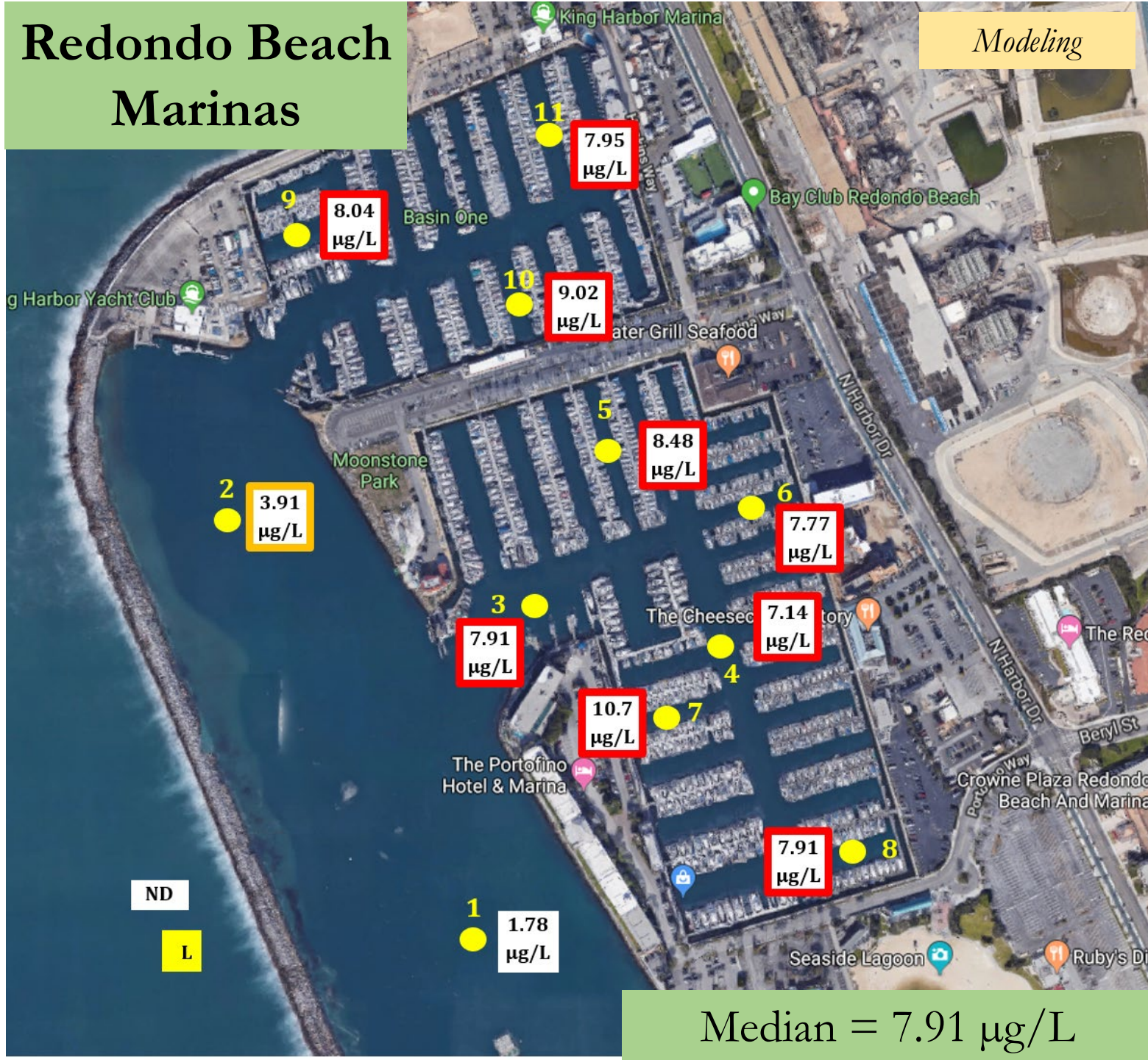
Median = 2.98 µg/L

Regional Spatial Trends

- Latitude
- Yearly Average Temperature
- Temperature at Sampling

Waterbody Spatial Trends

- Main Channels versus Fairways
- Distance to Mouth



Newport Bay

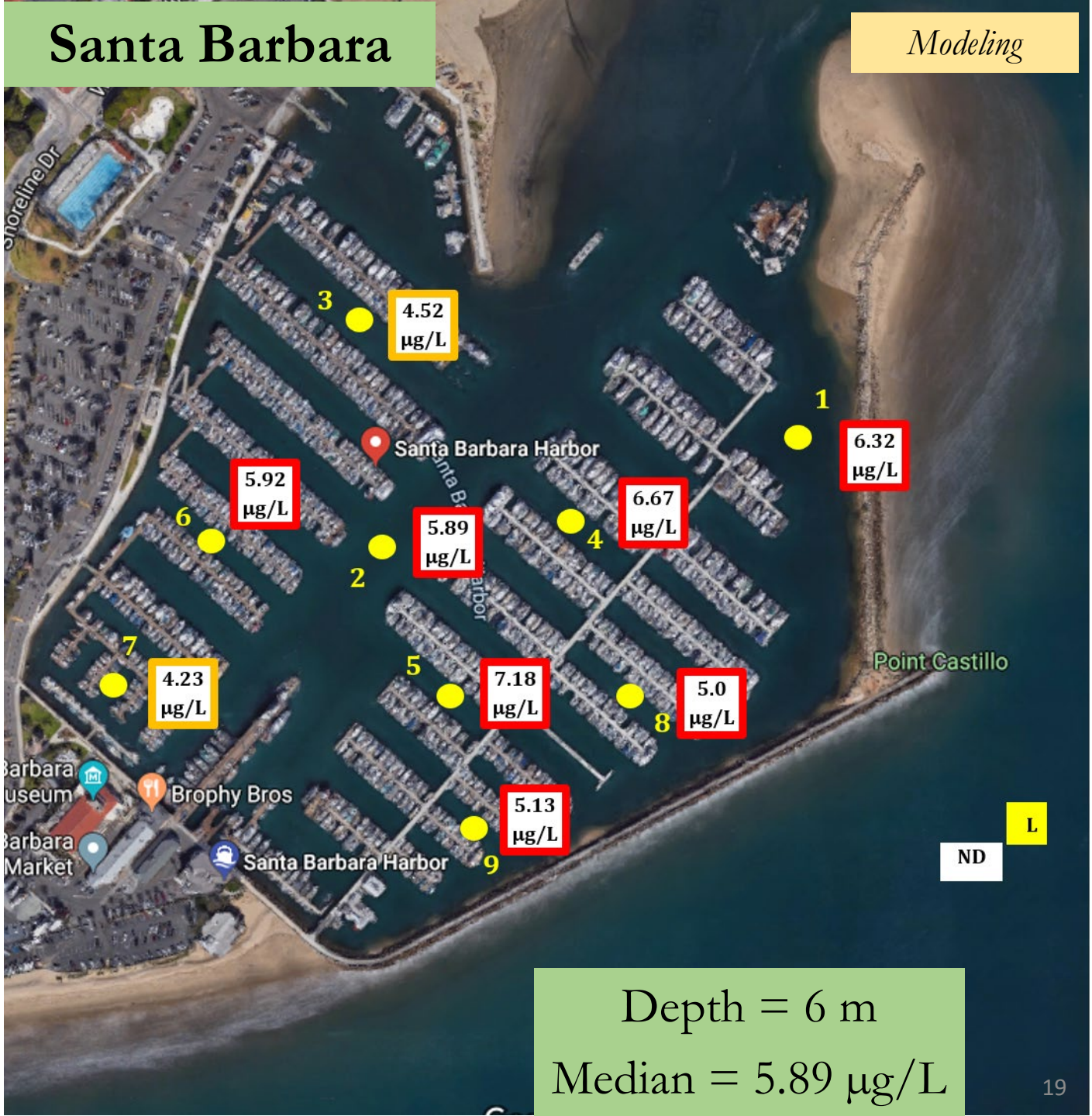
Modeling

Median = 3.12 µg/L

Waterbody Characteristic Trends

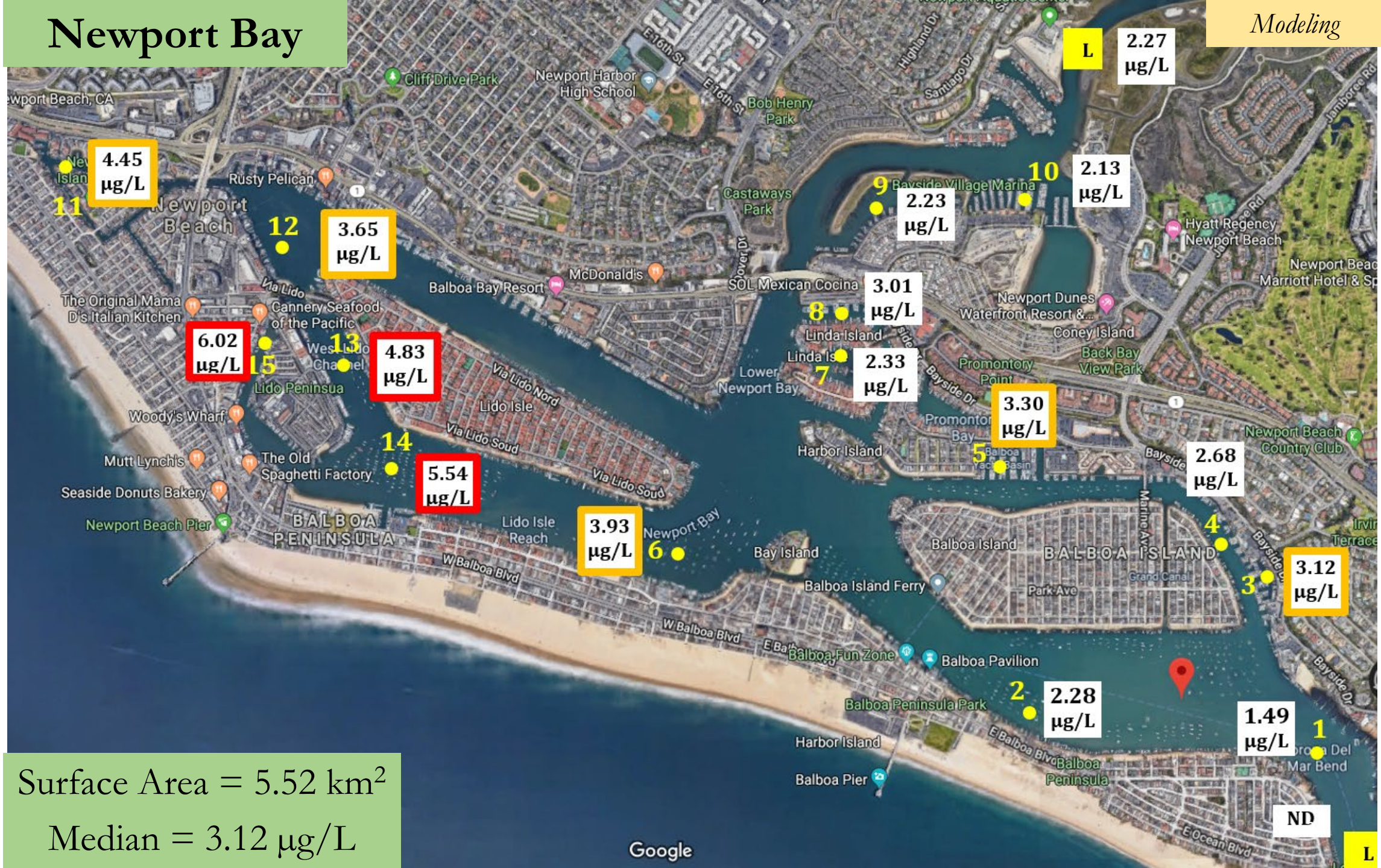
- Water Depth
- Surface Area

Newport Bay is ~3.3x larger than next largest waterbody (Marina del Rey)



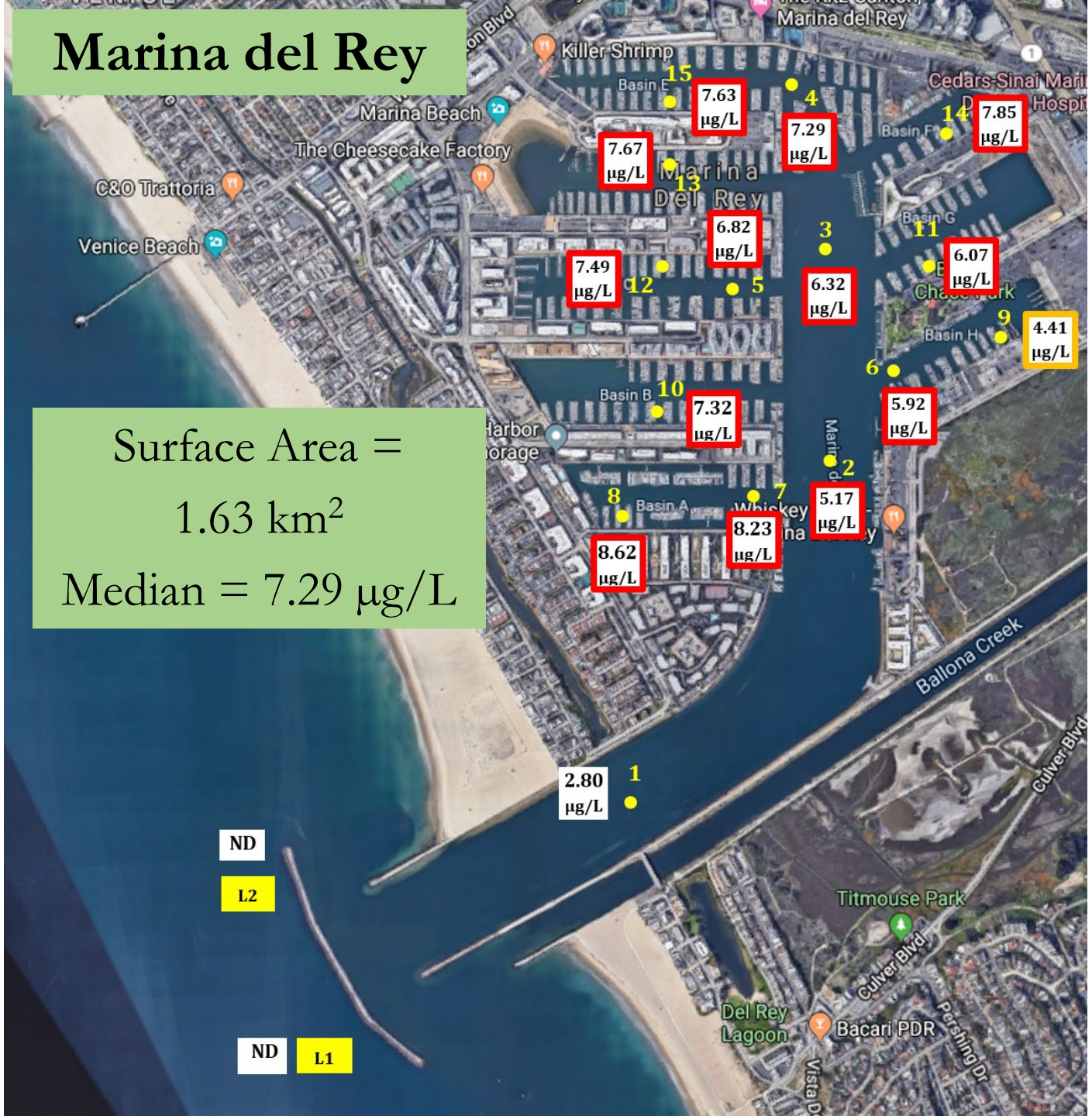
Newport Bay

Modeling



Surface Area = 5.52 km^2

Median = 3.12 µg/L


Marina del Rey
Surface Area = 1.63 km²
Median = 7.29 µg/L
15
7.63 µg/L
4
7.29 µg/L
14
7.85 µg/L
7.67 µg/L
13
6.82 µg/L
3
11
6.07 µg/L
7.49 µg/L
12
5
6.32 µg/L
9
4.41 µg/L
6
10
7.32 µg/L
5.92 µg/L
2
8
7
8.23 µg/L
5.17 µg/L
8.62 µg/L
2.80 µg/L
1
ND
L2
ND
L1
Killer Shrimp
Marina Beach
The Cheesecake Factory
C&O Trattoria
Venice Beach
Basin E
Basin F
Basin G
Basin H
Basin B
Basin A
Ballona Creek
Culver Blvd
Titmouse Park
Del Rey Lagoon
Bacari PDR
Pershing Dr

Biotic Ligand Modeling

- Four sites: Coyote Point Marina, Berkeley Marina, Newport Bay, and Marina del Rey
- Measured DOC at every site
- Took T (°C), pH, and salinity *in-situ* measurements
- Inputs into a model to predict toxicity
  - Water chemistry controls speciation of copper

BLM Results

- EC_{50} for *Mytilus galloprovincialis* (Mediterranean mussel)

- Four samples at Marina del Rey had toxic units ≥ 1.0
  - EC_{50} = 7.12 – 8.52 µg/L
  - DCu concentrations = 7.32 – 8.62 µg/L

- SCCWRP: Ambient toxicity rarely observed

- Need for additional samples at other waterbodies

Reference Point Concentrations

- Results presented here are considered a reference point to evaluate long-term trends
- Cu-AFPs are on vessels for years
- Boatyard capacity is limited

Limitations

Hull cleaning

- No distinction between spikes in passive leaching due to hull cleaning

Future Work

- Vertical concentration gradients
  - Spatial trends
  - DCu concentration are heterogeneous in the water column

- Tidal influence
  - Temporal trends
  - Tidal flushing affects DCu concentrations

Acknowledgments

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- Gary Laolagi from City of Redondo Beach
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Questions?

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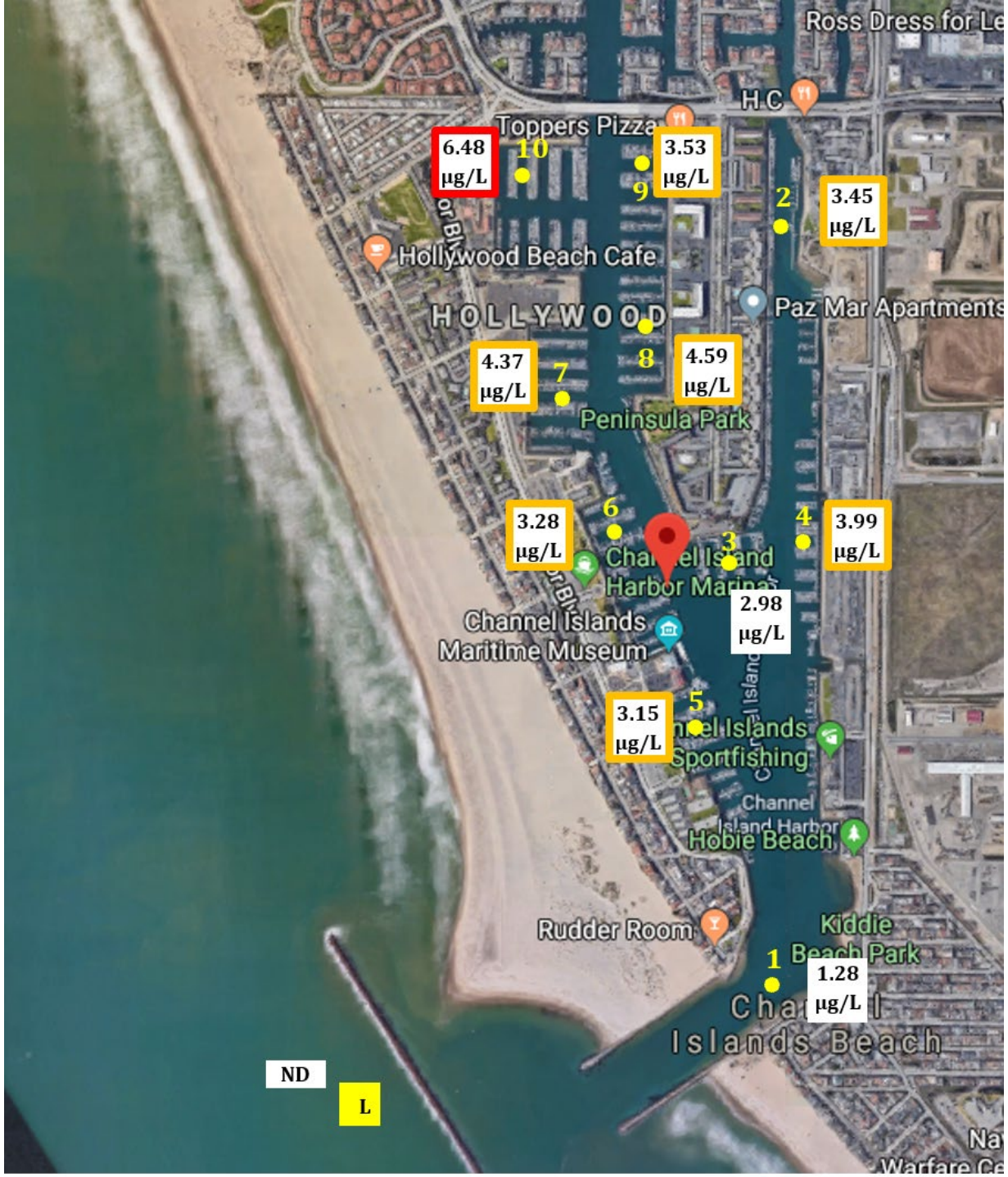
Channel Islands Harbor
Median = 3.49 µg/L




CuriOdyssey
Science & wildlife center for kids
Coyote Point Marina
1
6.70 µg/L
2
3.96 µg/L
3
4.02 µg/L
4
4.51 µg/L
L
2.78 µg/L
Coyote Point Yacht Harbor
Coyote Point Recreation Area
Large playground...
Coyote Point Yacht Club
Coyote Point Marina
Median = 4.26 µg/L