Assessment of antifouling paint (copper) tolerance across common fouling organisms

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SAN JOSÉ STATE UNIVERSITY

California State Lands Commission Marine Invasive Species Program

Means of limiting fouling

-Dry docking and hull cleaning

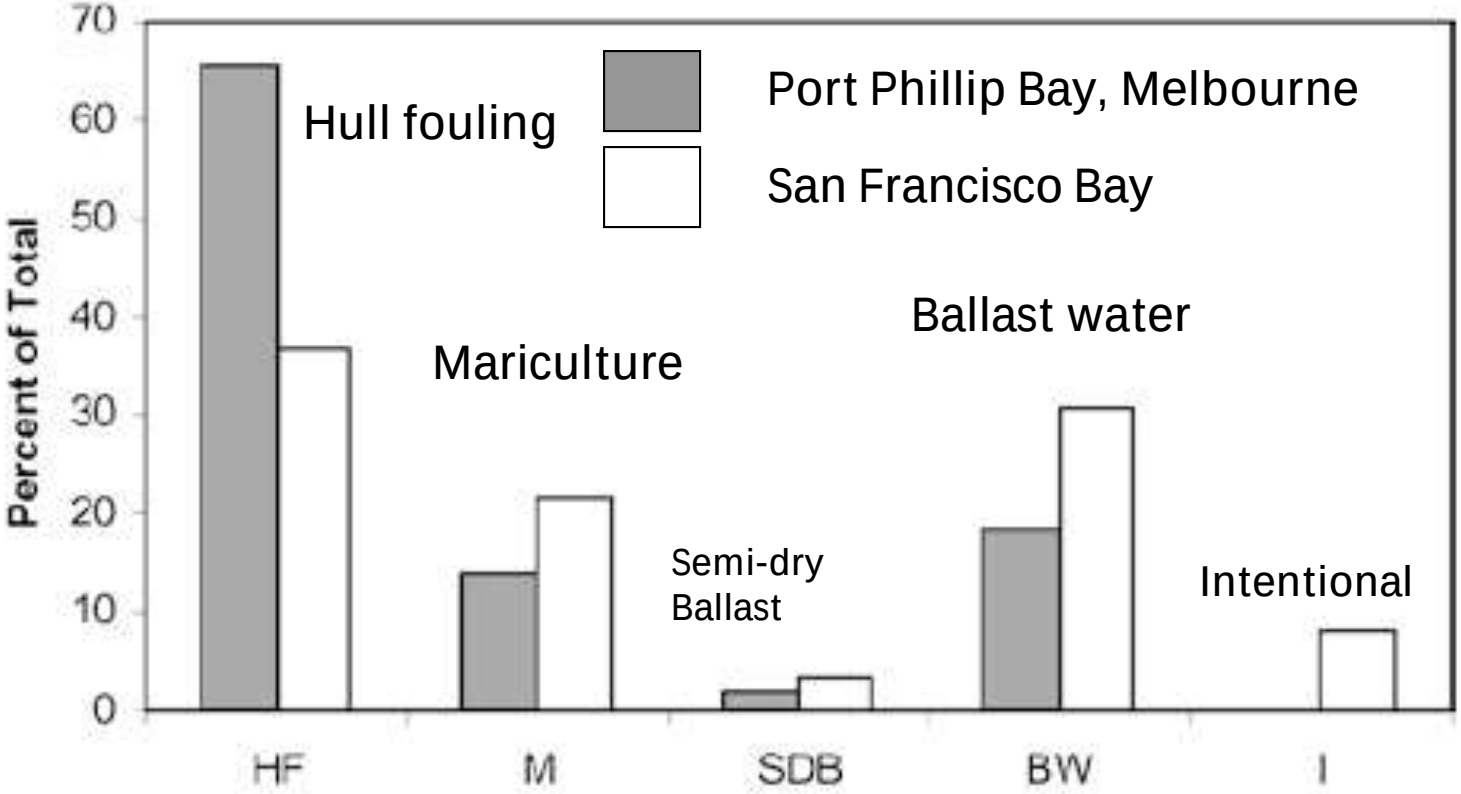
-Antifouling paints

Copper: 1700s-present

Tributyltin:
(1960s - c. 1990),
banned by International Maritime

Organization .

Hull fouling introductions —a major source of invasions



Likely mode of introduction

Hewitt et al. 2004, Marine Biology

One month of fouling, summer, Port Phillip Bay, Australia

Serpulid polychaete *Hydroides elegans,*
Ascidian - *Diplosoma listerianum*

Bryozoa, *Tricellaria*, *Watersipora*

(Other organisms removed)

Photo: Vicky Barmby

Factors that influence the spread of exotic organisms

-Propagule pressure (vector traffic)?

-Competitive interactions between species?

-The phenotypes in invasive populations?

Goal: studies of multiple locations to determine whether genotypes predict ecological patterns

Novel techniques for field assessment of copper toxicity on fouling assemblages

Emma Johnston • J. Angus Webb

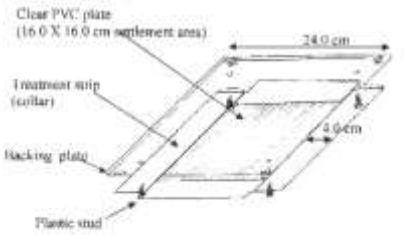
Biofouling (2000) 15:165-173

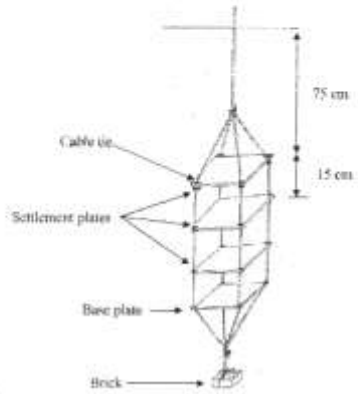
Aquatic pollution increases the relative success of invasive species

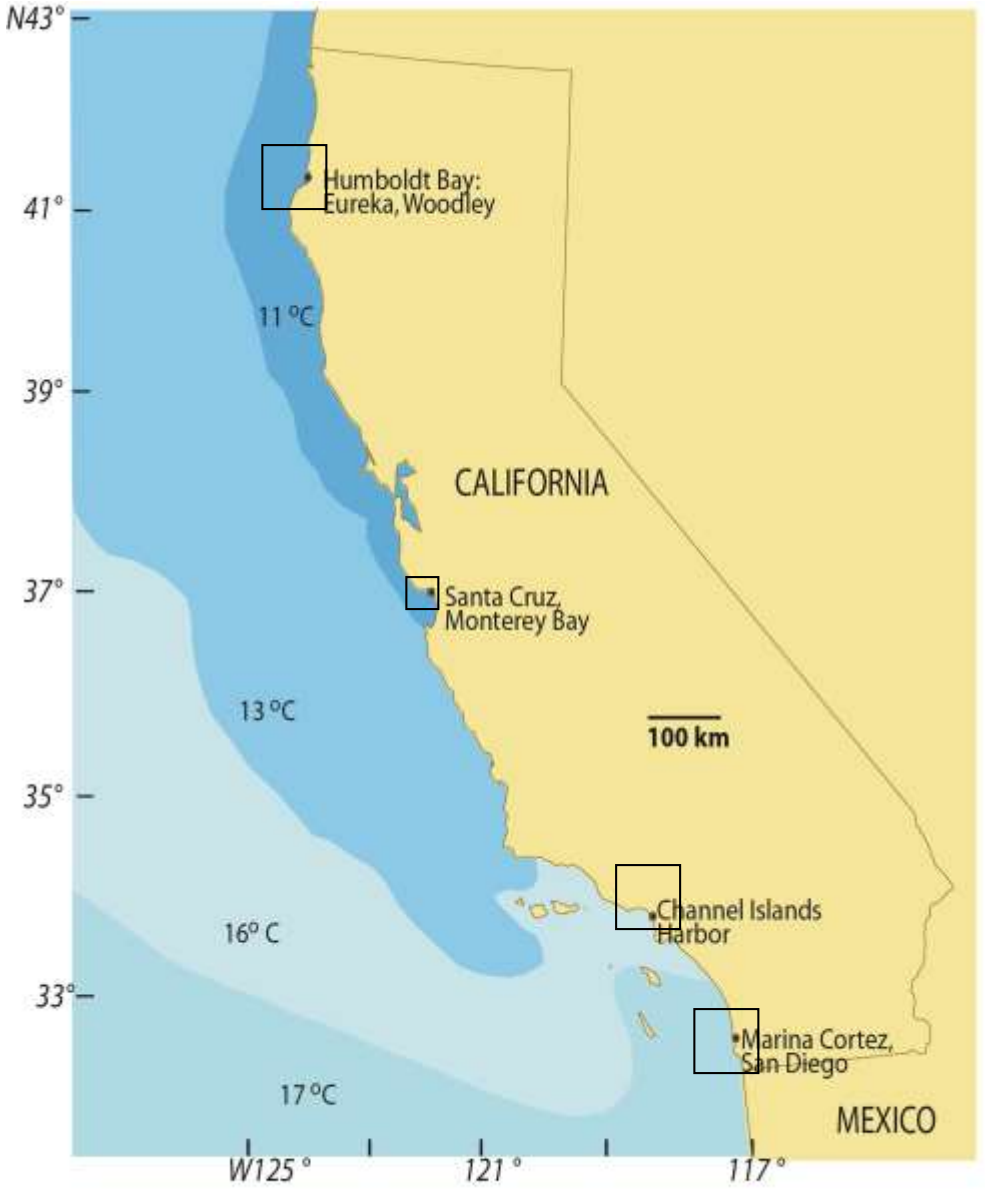
Jeffrey A. Crooks • Andrew L. Chang • Gregory M. Ruiz

Biol Invasions (2011) 13:165 – 176

Locations of settlement Panel surveys (2012-15)



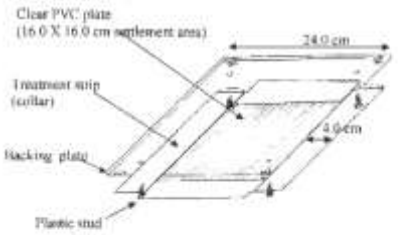


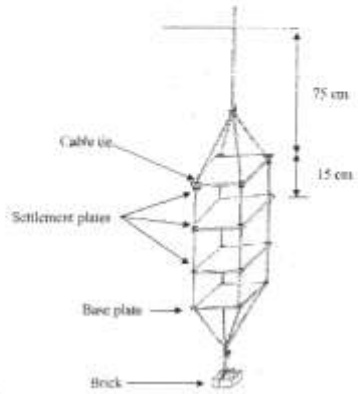


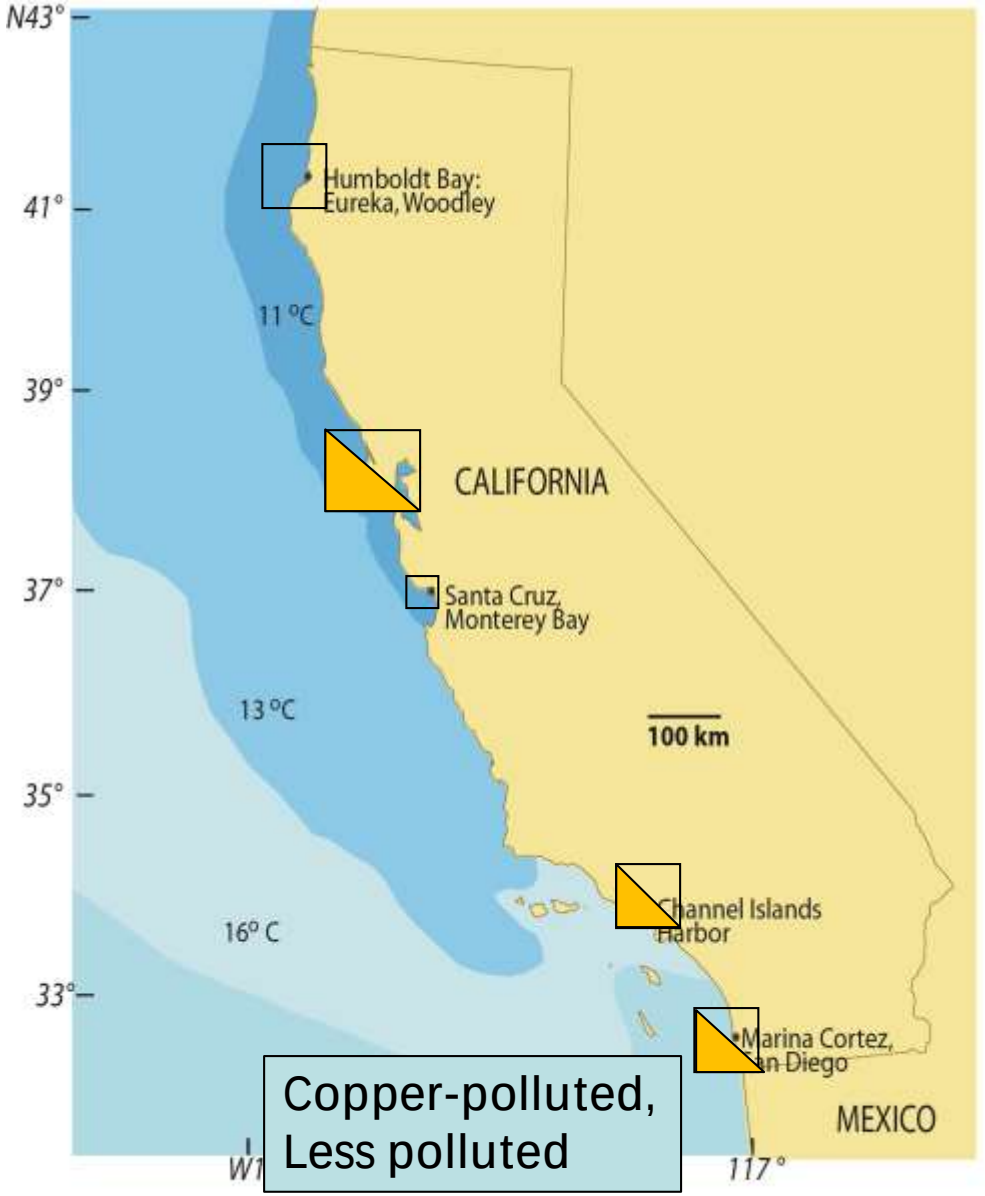
2012

J. Mackie, IA Meeting,
Fouling, Sept. 10, 2015

Locations of settlement
Panel surveys (2012-15)





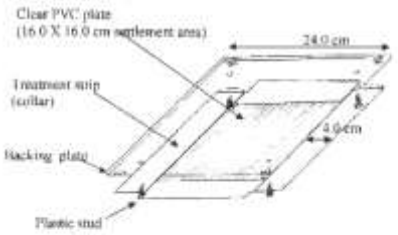


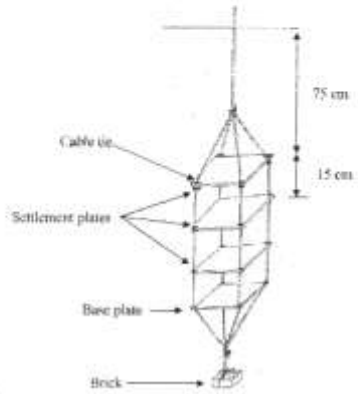
Copper-polluted,
Less polluted

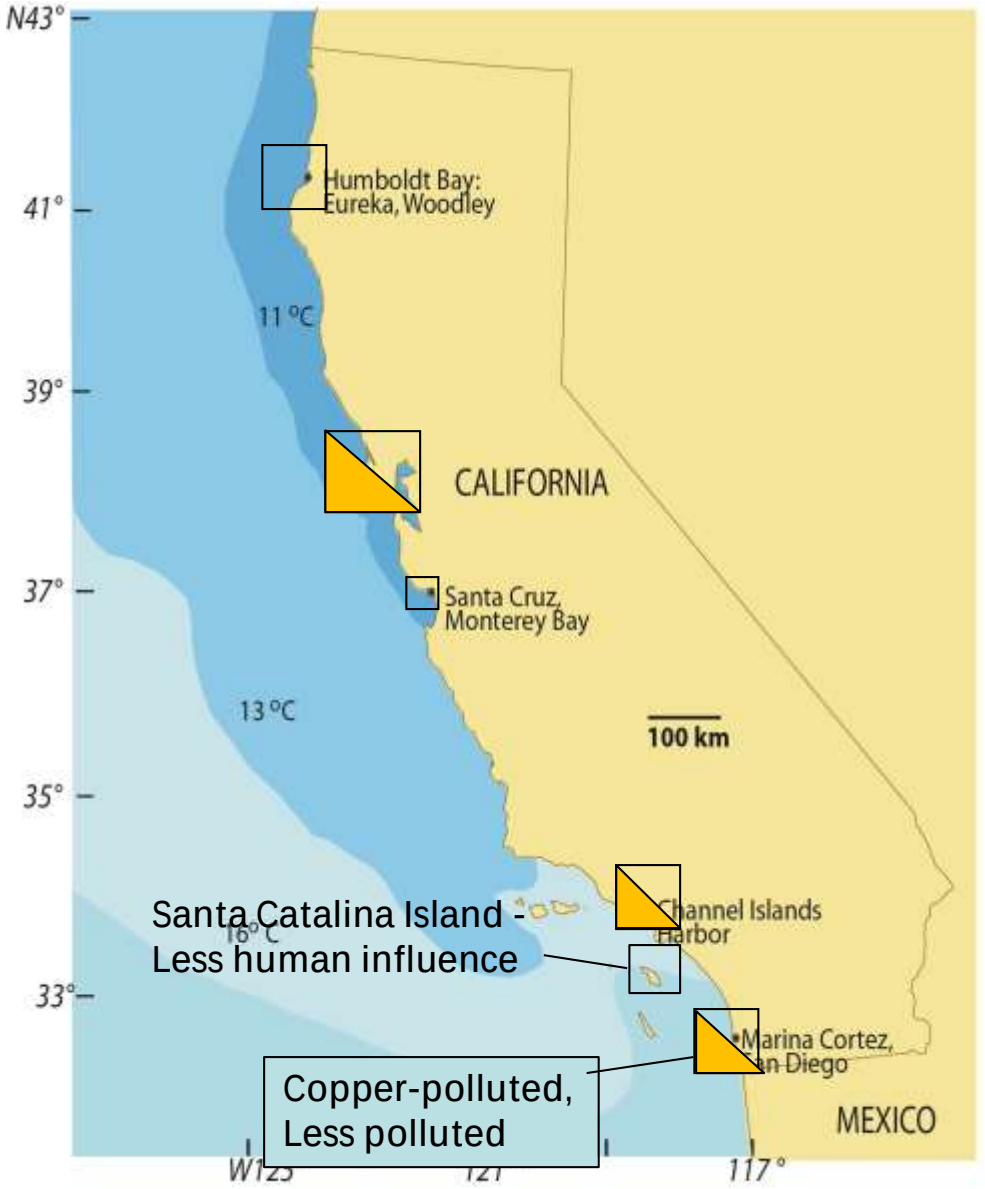
2014

J. Mackie, IA Meeting,
Fouling, Sept. 10, 2015

Locations of settlement Panel surveys (2012-15)



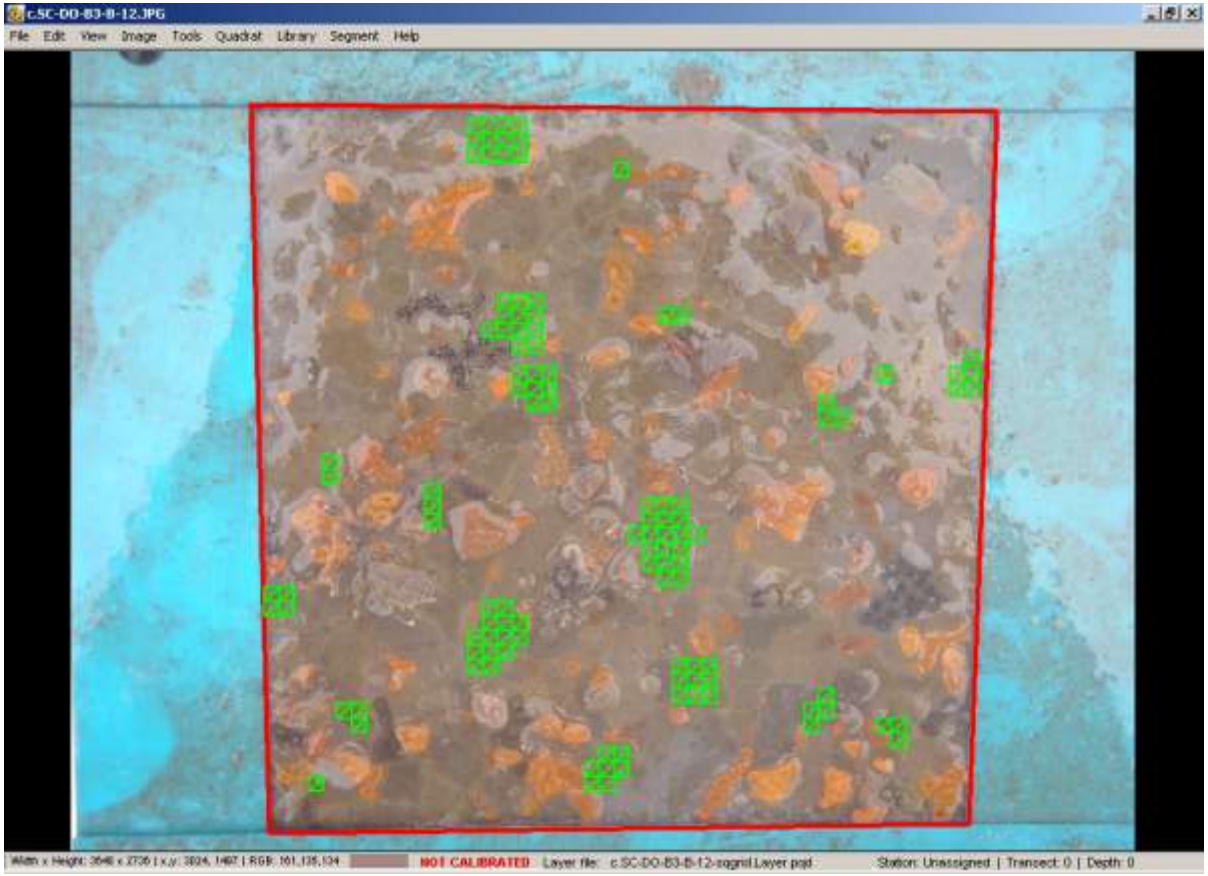




2015

J. Mackie, IA Meeting,
Fouling, Sept. 10, 2015

Trygonis, V., Sini, M., 2012. photoQuad: a dedicated seabed image processing software, and a comparative error analysis of four photoquadrat methods. J. Exp. Mar. Biol. Ecol. 424-425, 99-108



- Grid – 50 x 50 squares to make a total of 2,500 squares

- Activated cells – manually click on any cell that consists of target organism (≥ 25%)



Eureka Public Marina, Eureka (7 weeks)

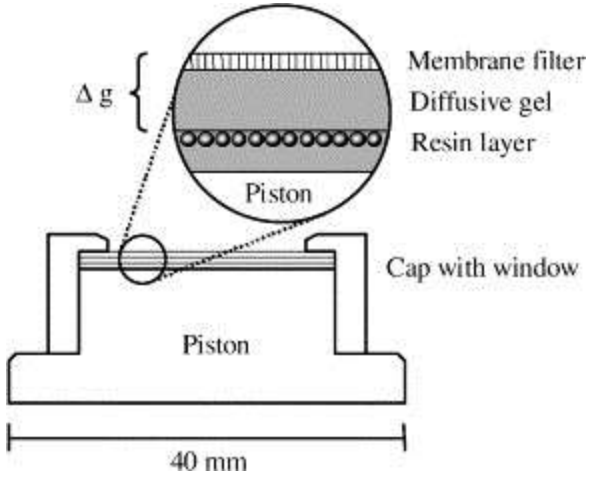


Woodley Island, Eureka

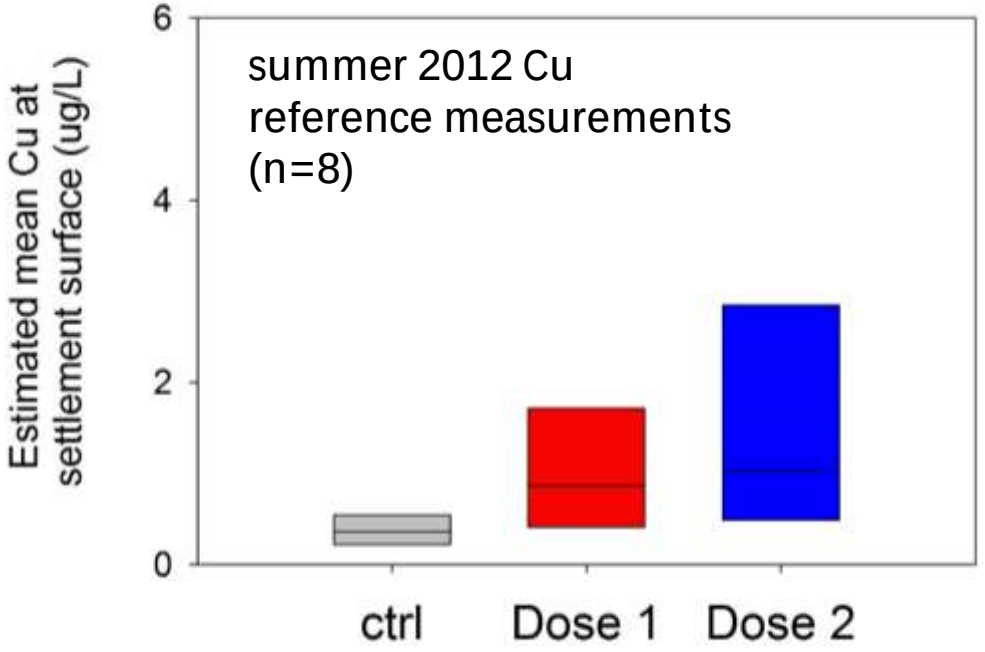
Channel Island Harbor, Oxnard, LA

Marina Cortez, San Diego

Diagram: Dahlqvist, Zhang et al. (2002)



Diffusive Gradient Thin Layer gel device (DGT)



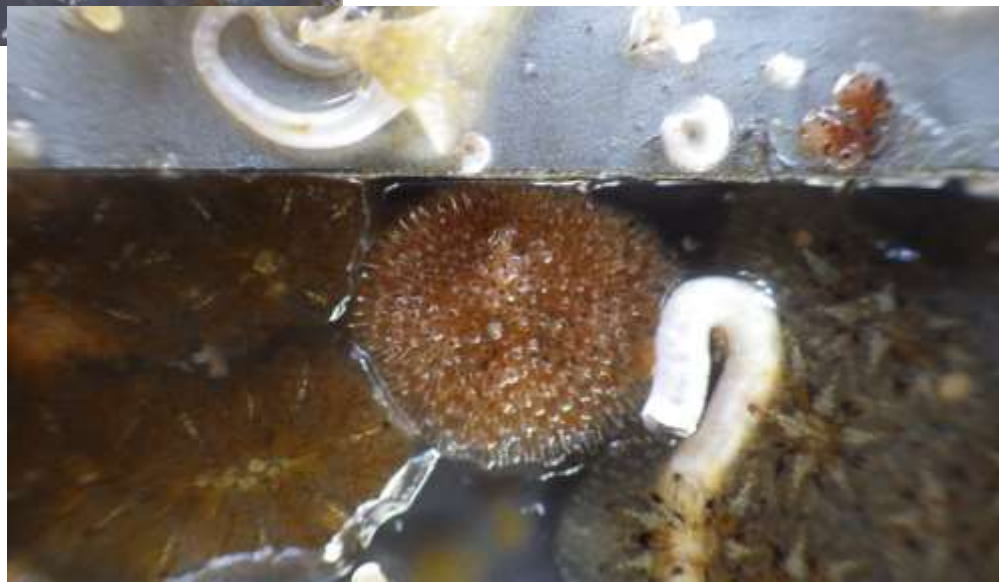
Biological specimens are collected for identification, COI gene sequencing to add **to genetic 'barcode' database.**

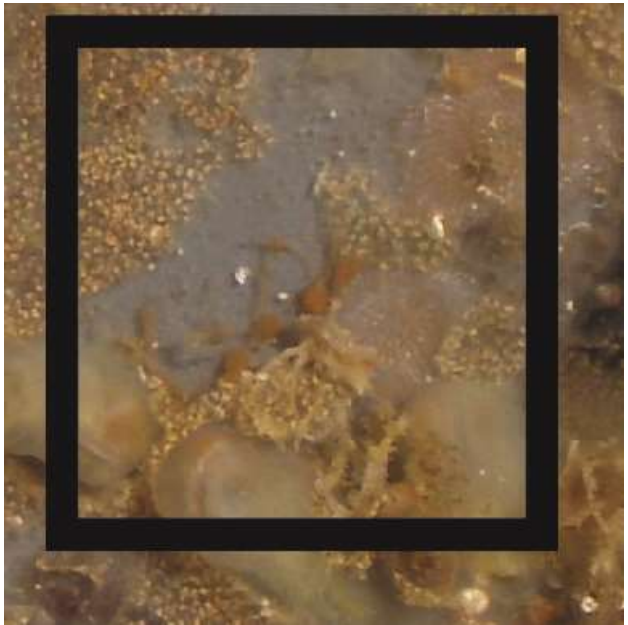
Comparison of abundance of
copper dosed and non-dosed (control)

p-value of no difference

	1.2E-11	***Metandrocarpa lewisi***	Ascidian - Native
Control > Copper	**1.1E-09**	***Diaperoecia californica***	Bryozoan - Native
	6.2E-07	***Cryptosula pallasiana***	Bryozoan - Native
	0.003	***Celleporaria brunnea***	Bryozoan - Native
	0.094	*Schizoporella* cf *errata*	
	0.234	*Watersipora subtorquata*	
	0.313	*Bugula californica/stolonifera*	
	0.377	*Botrylloides diegensis*	
Control ≈ Copper	0.386	*Bugula neritina* Type S	
	0.501	Open space	
	0.782	*Distaplia* sp.	
	0.782	*Botryllus shlosseri* (pale morph	
	0.850	*Ciona* spp.	
	0.024	***Botrylloides violaceus***	Ascidian - Introduced
	0.019	***Diplosoma listerianum***	Ascidian - Introduced
Control < Copper	**0.003**	***Hydroides elegans* (serpulid)**	Polychaete - Introduced

Copper sensitive species (California)

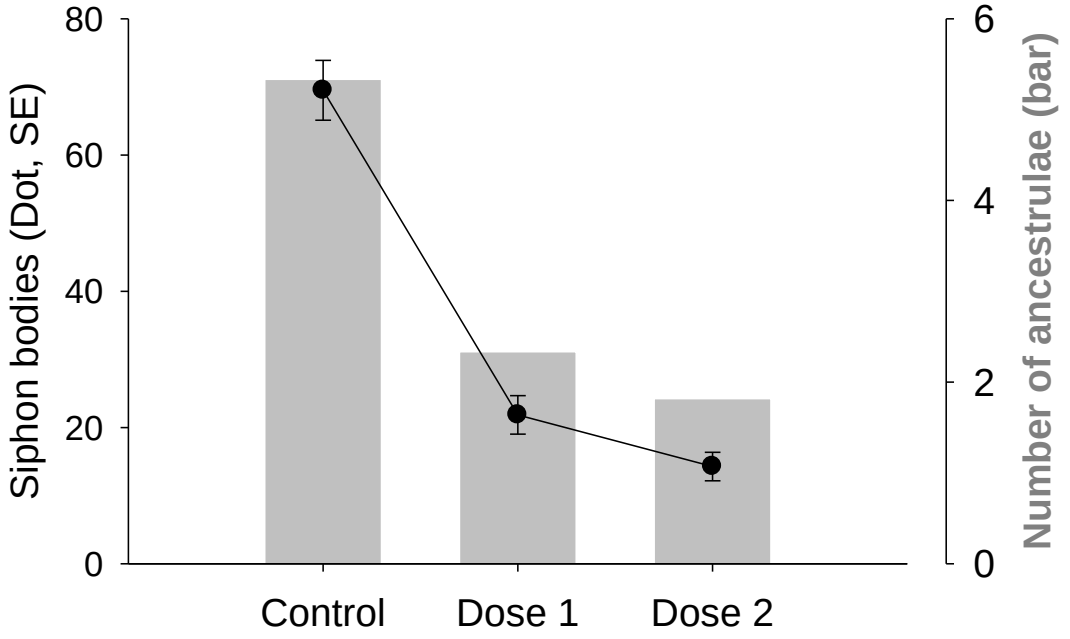




www.seanet.stanford.edu

Metandrocarpa lewisi

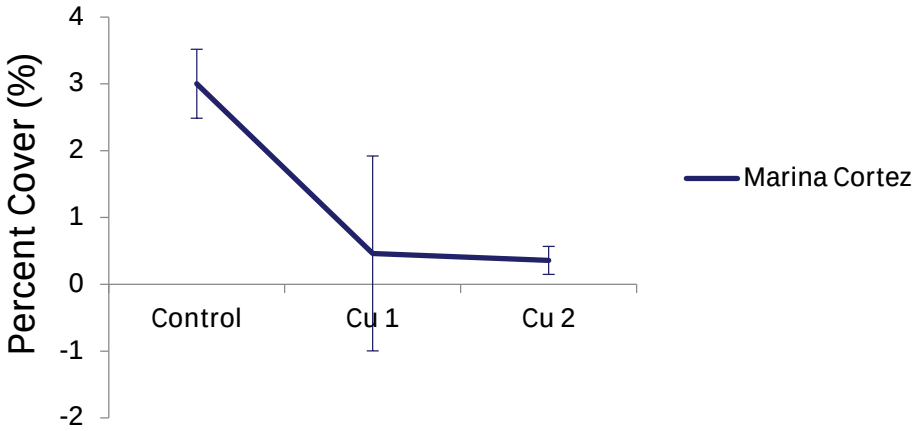
(Ascidian, endemic to California;
Site: San Diego West Marina)



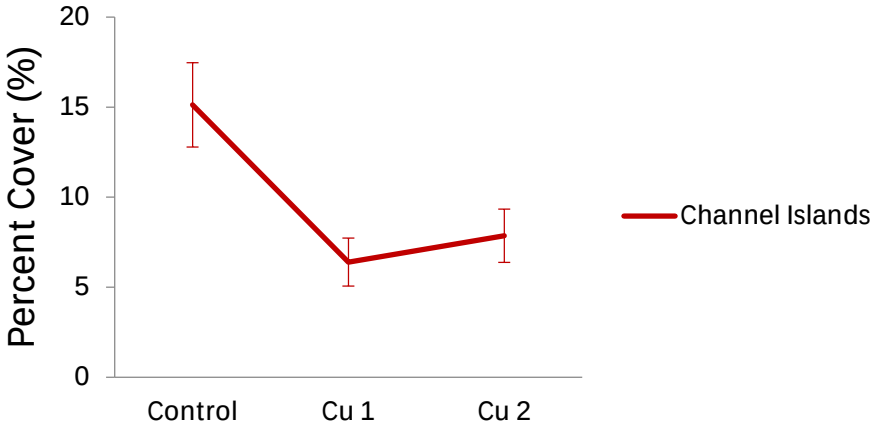
N=12 arrays
7-weeks: Jul-Sept, 2012

Native encrusting bryozoans analyzed in California were relatively sensitive of the copper

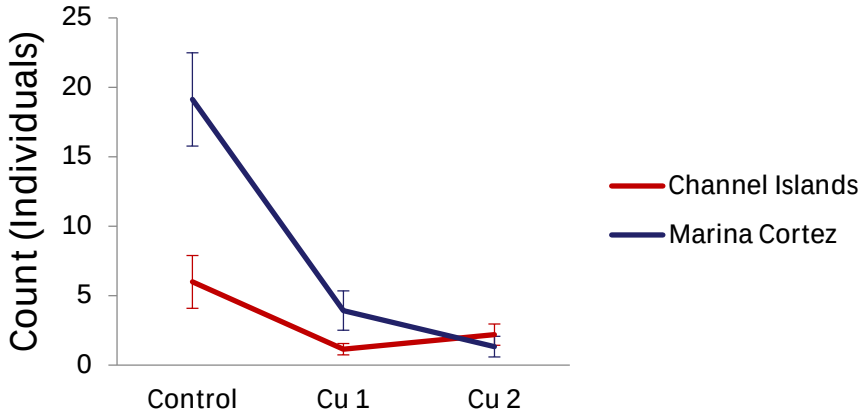
Cryptosula pallasiana



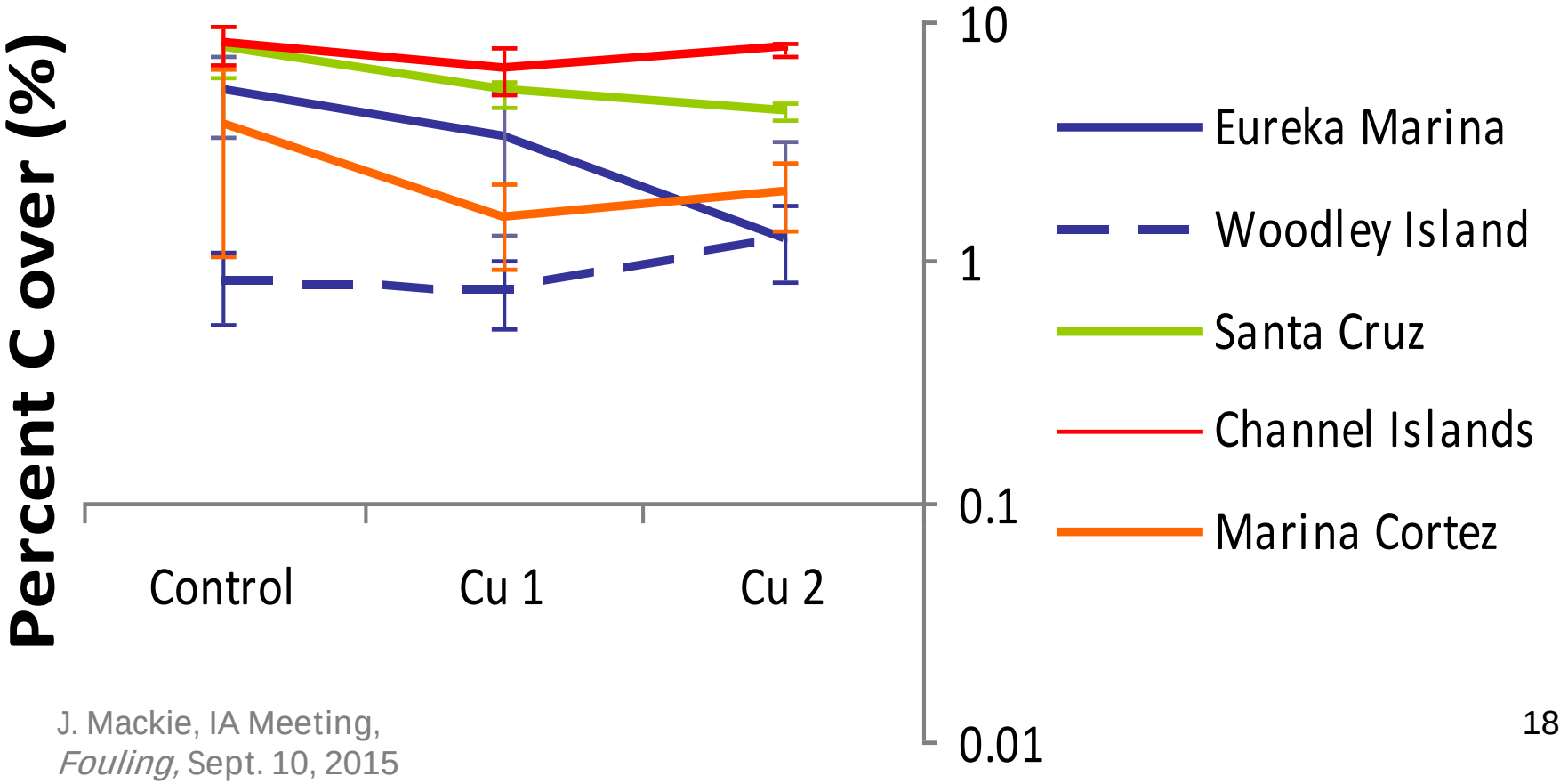
Celleporaria brunnea



Diaperoecia californica

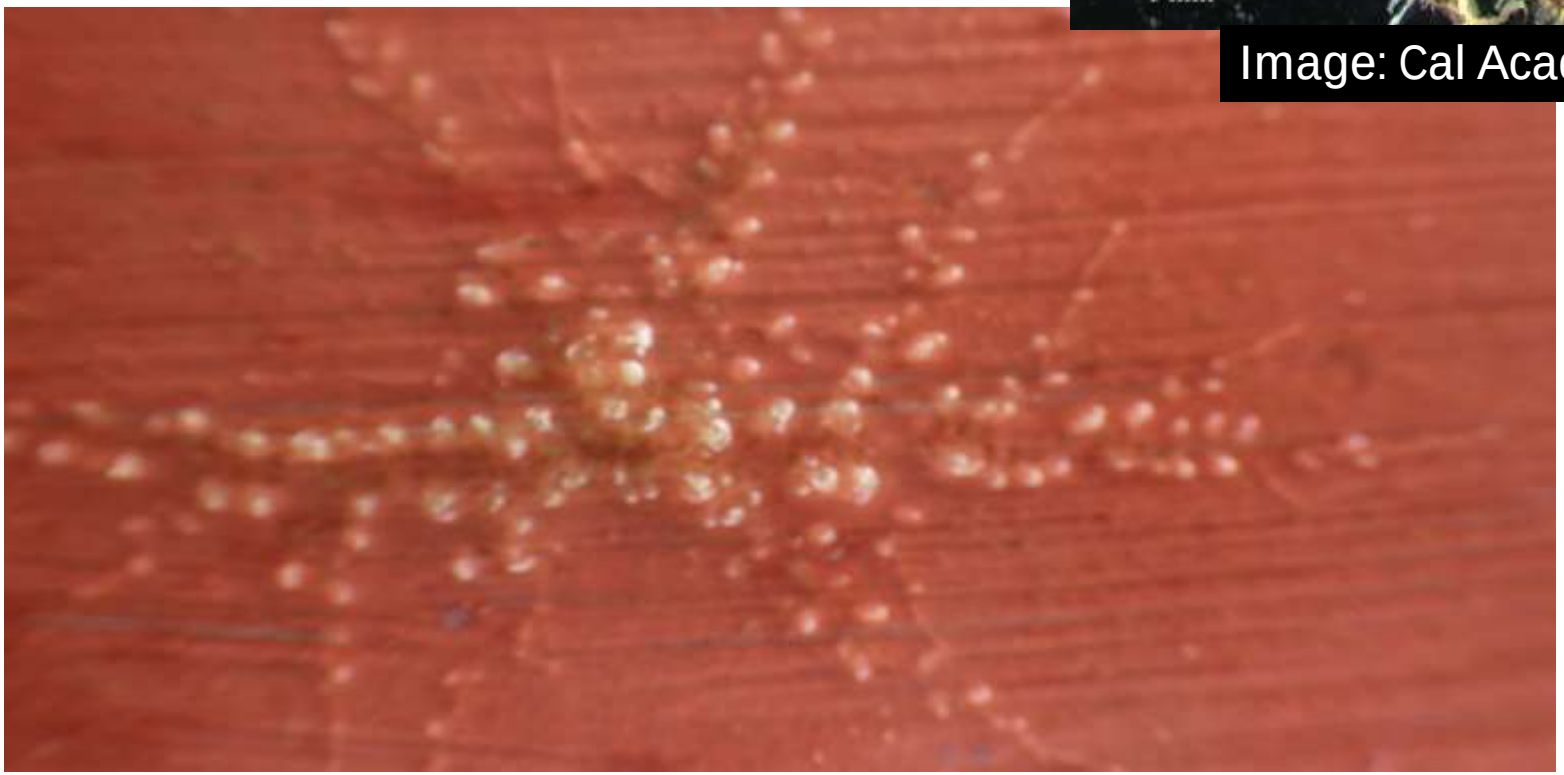


Watersipora subtorquata

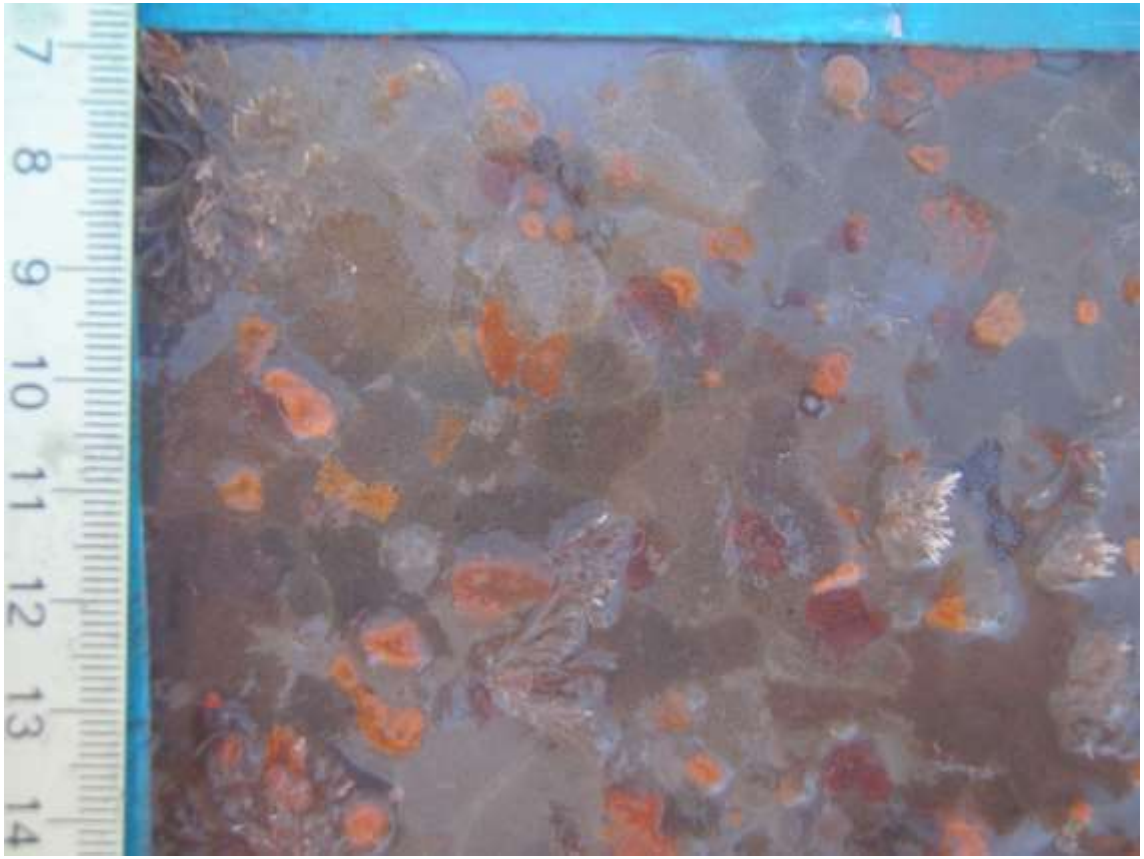


Bowerbankia sp
(Ctenostome bryozoan) — directly attracted to lower-dose paint. Frequently observed.

Image: Cal Academy



Diplosoma listerianum —
introduced (source unknown)
was consistently increased in the presence of copper in California.

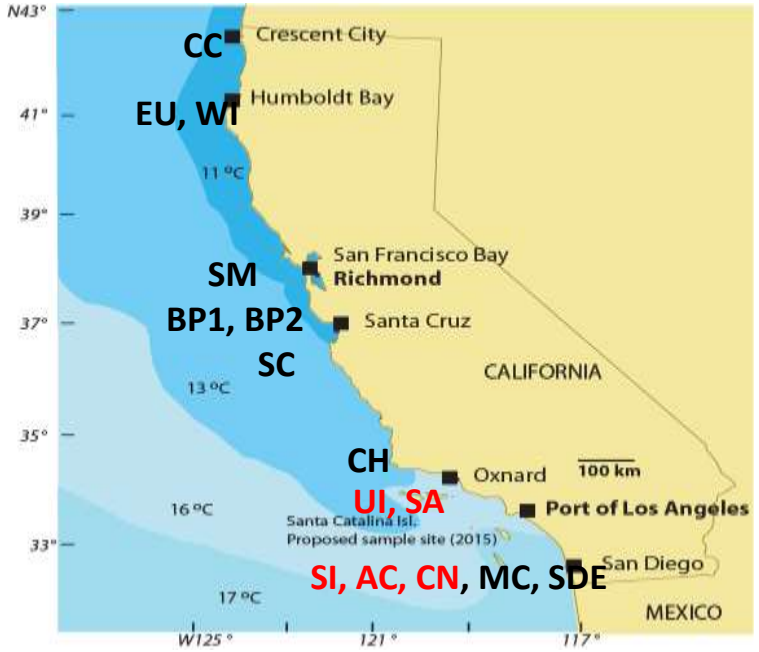


Next steps…

- More locations
- Does copper tolerance predict community composition along pollution gradients?
- Examination of genomes to understand mutations that control the copper tolerance, or response to different temperatures.


EVERGREEN


Los Angeles
Long Beach
San Pedro
Newport Beach
Two Harbors
Catalina Island
Avalon
Dana Point



B) Shelter Island, inner harbor, San Diego Bay

Locations from North to South.

Copper pollution hotspots[1]: USS Iowa (UI), SA Recycling (SA), Konakai (SI), Americas Cup (AC1,2), Crows Nest (CN).

Other sites: Crescent City (CC), Eureka Marina (EU), Woodley Island (WI), Schoonmaker (SM), British Petroleum dock (BP1,2), Santa Cruz Harbor (SC), Channel Islands Marin, Oxnard (CH), Marina Cortez (MC), East San Diego Bay, (SDE1,2).

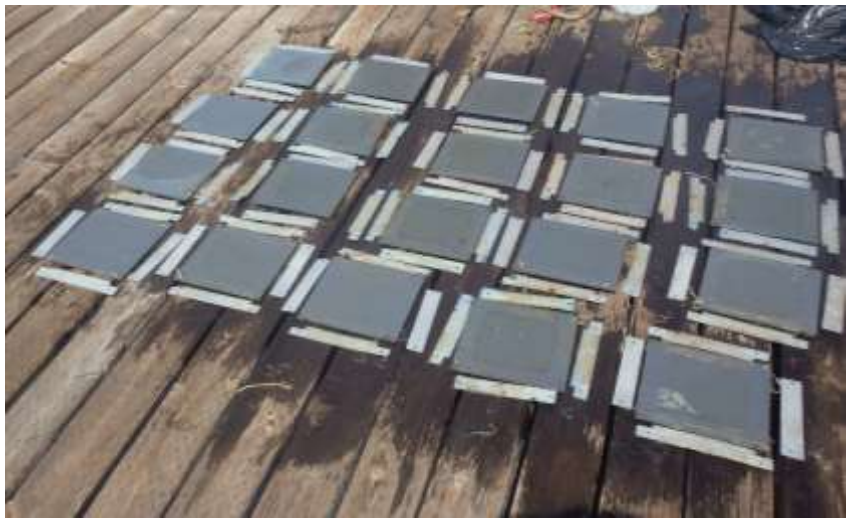
[1]Historical measurements of >3.1 mg/L dissolved copper (EPA water qual. criterion)

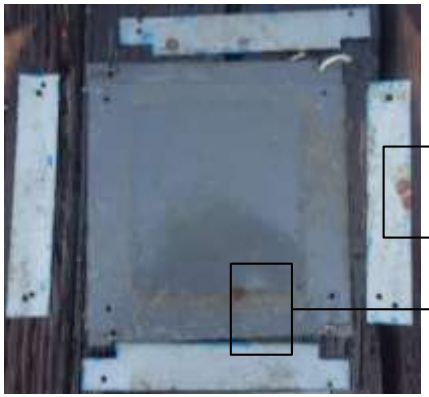
Benchmark paper (sedimentary communities) — eg:

Neira C, Levin LA, Mendoza G, Zirino A. 2013. Alteration of benthic communities associated with copper contamination linked to boat moorings. Marine Ecology 35:46-66.

Aiming to update dissolved copper level estimation across the coast

Does removing predators increase fouling?





Areas under strips versus the exposed area— an (initial) predator exclusion experiment

Thank you

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