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
Locations of settlement
Panel surveys (2012-15)
Locations of settlement
Panel surveys (2012-15)

Santa Catalina Island -
Less human influence

Copper-polluted,
Less polluted

- 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 ($\geq 25\%$)
Eureka Public Marina, Eureka  (7 weeks)

Woodley Island, Eureka
Channel Island Harbor, Oxnard, LA

Marina Cortez, San Diego

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

<table>
<thead>
<tr>
<th>Comparison</th>
<th>p-value</th>
<th>Species</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control &gt; Copper</td>
<td>1.2E-11</td>
<td><em>Metandrocarpa lewisi</em></td>
<td>Ascidian - Native</td>
</tr>
<tr>
<td></td>
<td>1.1E-09</td>
<td><em>Diaperoecia californica</em></td>
<td>Bryozoan - Native</td>
</tr>
<tr>
<td></td>
<td>6.2E-07</td>
<td><em>Cryptosula pallasiana</em></td>
<td>Bryozoan - Native</td>
</tr>
<tr>
<td></td>
<td>0.003</td>
<td><em>Celleporaria brunnea</em></td>
<td>Bryozoan - Native</td>
</tr>
<tr>
<td></td>
<td>0.094</td>
<td><em>Schizoporella cf errata</em></td>
<td>Bryozoan - Native</td>
</tr>
<tr>
<td></td>
<td>0.234</td>
<td><em>Watersipora subtorquata</em></td>
<td>Bryozoan - Native</td>
</tr>
<tr>
<td></td>
<td>0.313</td>
<td><em>Bugula californica/stolonifera</em></td>
<td>Ascidian - Native</td>
</tr>
<tr>
<td></td>
<td>0.377</td>
<td><em>Botrylloides diegensis</em></td>
<td>Ascidian - Native</td>
</tr>
<tr>
<td>Control ≈ Copper</td>
<td>0.386</td>
<td><em>Bugula neritina</em> Type S</td>
<td>Open space</td>
</tr>
<tr>
<td></td>
<td>0.501</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>0.782</td>
<td><em>Distaplia</em> sp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.782</td>
<td><em>Botryllus shlosseri</em> (pale morph)</td>
<td>Ascidian - Introduced</td>
</tr>
<tr>
<td></td>
<td>0.850</td>
<td><em>Ciona</em> spp.</td>
<td>Ascidian - Introduced</td>
</tr>
<tr>
<td></td>
<td>0.024</td>
<td><em>Botrylloides violaceus</em></td>
<td>Ascidian - Introduced</td>
</tr>
<tr>
<td></td>
<td>0.019</td>
<td><em>Diplosoma listerianum</em></td>
<td>Ascidian - Introduced</td>
</tr>
<tr>
<td>Control &lt; Copper</td>
<td>0.003</td>
<td><em>Hydroides elegans</em> (serpulid)</td>
<td>Polychaete - Introduced</td>
</tr>
</tbody>
</table>
Copper sensitive species (California)
Metandrocarpa lewisi
(Ascidian, endemic to California; Site: San Diego West Marina)

J. Mackie, IA Meeting,
*Fouling*, Sept. 10, 2015
Native encrusting bryozoans analyzed in California were relatively sensitive of the copper.

**Cryptosula pallasiana**

**Celleporaria brunnea**

**Diaperoecia californica**
Watersipora subtorquata

![Graph showing percent C over (%) for different sites and treatments.](attachment:image.png)

*Bowerbankia sp* (Ctenostome bryozoan) — directly attracted to lower-dose paint. Frequently observed.
*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.
Copper pollution hotspots: 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).

Benchmark paper (sedimentary communities) — eg:

Aiming to update dissolved copper level estimation across the coast

1Historical measurements of >3.1 mg/L dissolved copper (EPA water qual. criterion)
Does removing predators increase fouling?

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

Thank you

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