

Copper in Puget Sound Marinas: the role of antifouling paint

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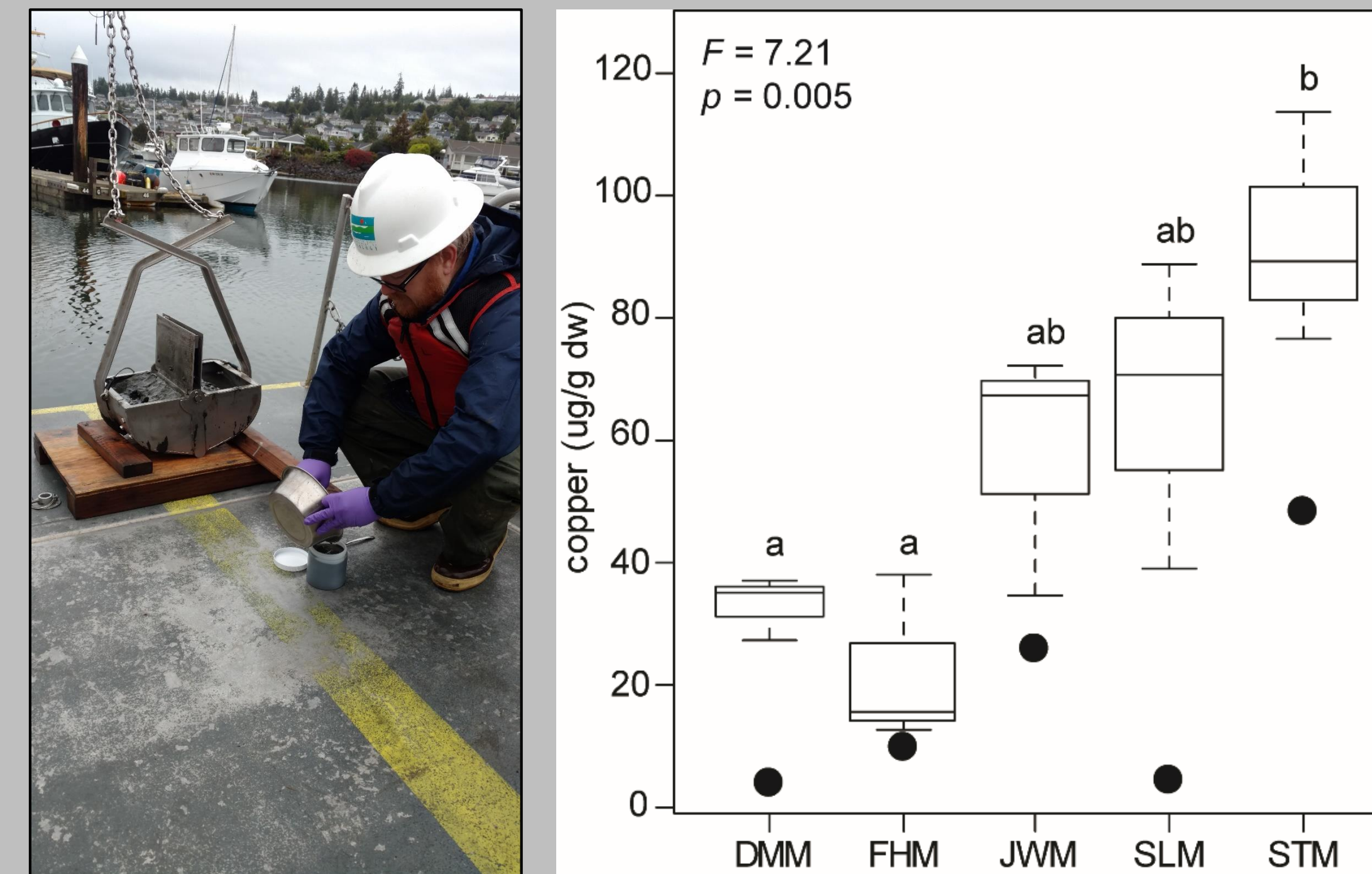
Introduction

Marinas have been shown to contribute elevated levels of metals to marine waters, copper (Cu) in particular. The Cu comes primarily from antifouling paints which are designed to discourage biofouling (barnacles, mussels, and other organisms) of boat hulls. In 2011 the Washington State Legislature passed SSB5436 to phase out Cu in marine antifouling paints. This legislation states that new recreational vessels with Cu-containing bottom paint may not be sold in the state after January 1, 2018. In June 2018 Substitute House Bill 2634 was passed into law. This bill extends the use of anti-fouling paints containing copper until January 1, 2021. This study provides baseline data for Cu in five marinas of different configuration and size within Puget Sound and assesses potential impacts to marine biota.

Methods and Findings

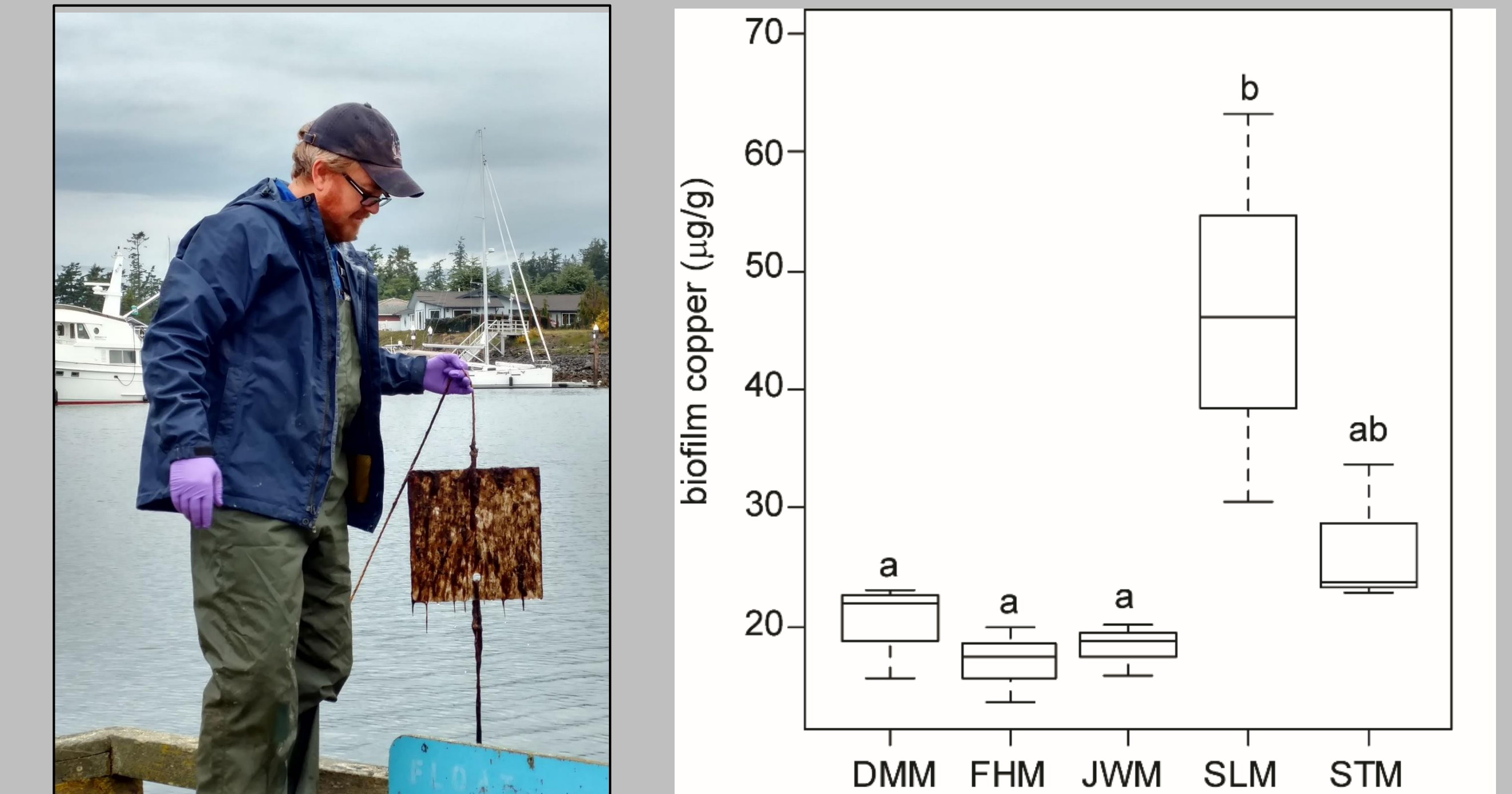
Four sampling events were conducted between September 2016 and June 2017. Sample media included: water (dissolved and total fractions of metals), sediments (suspended and bottom), and biota (transplanted mussels and biofilms). We found strong evidence, across sample media that Cu accumulate inside marinas to higher levels than outside marinas, regardless of marina configuration. Marinas that are more enclosed, where water is slower to flush in and out, accumulated higher levels of Cu than more open marinas. However, concentrations of Cu were rarely high enough to be above the state water quality criterion for acute impacts to aquatic life. Sediment Cu was also not above the state criteria for the protection of benthic invertebrates.

Bottom sediments



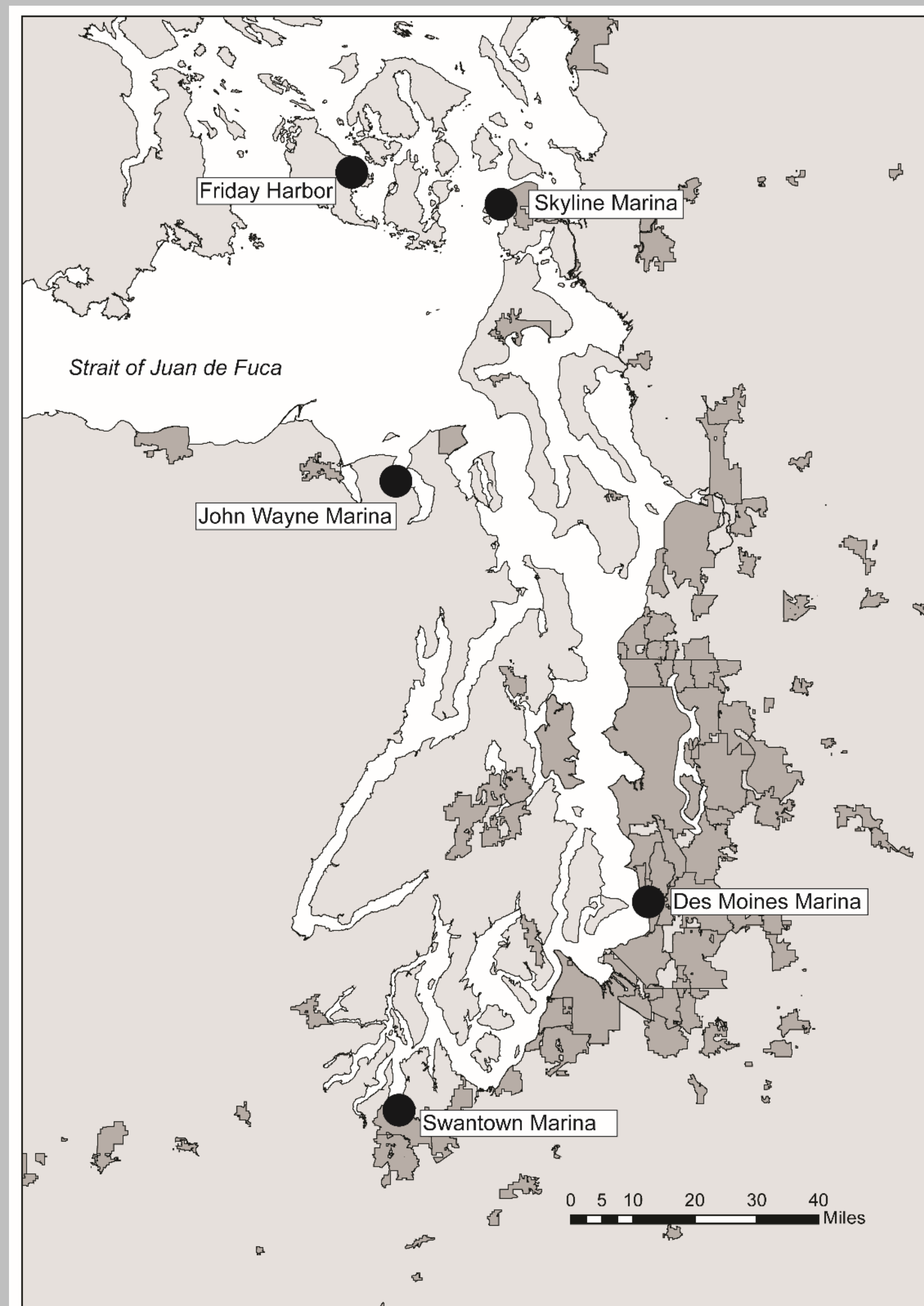
Higher concentrations inside the marinas compared to outside. No samples exceed state criteria for the protection of benthic invertebrates.

Biofilms



Biofilms (mostly algae, with microbial communities and detritus) had the highest Cu concentrations in the marina with the highest dissolved Cu in the water column and were correlated with Cu in sediment traps.

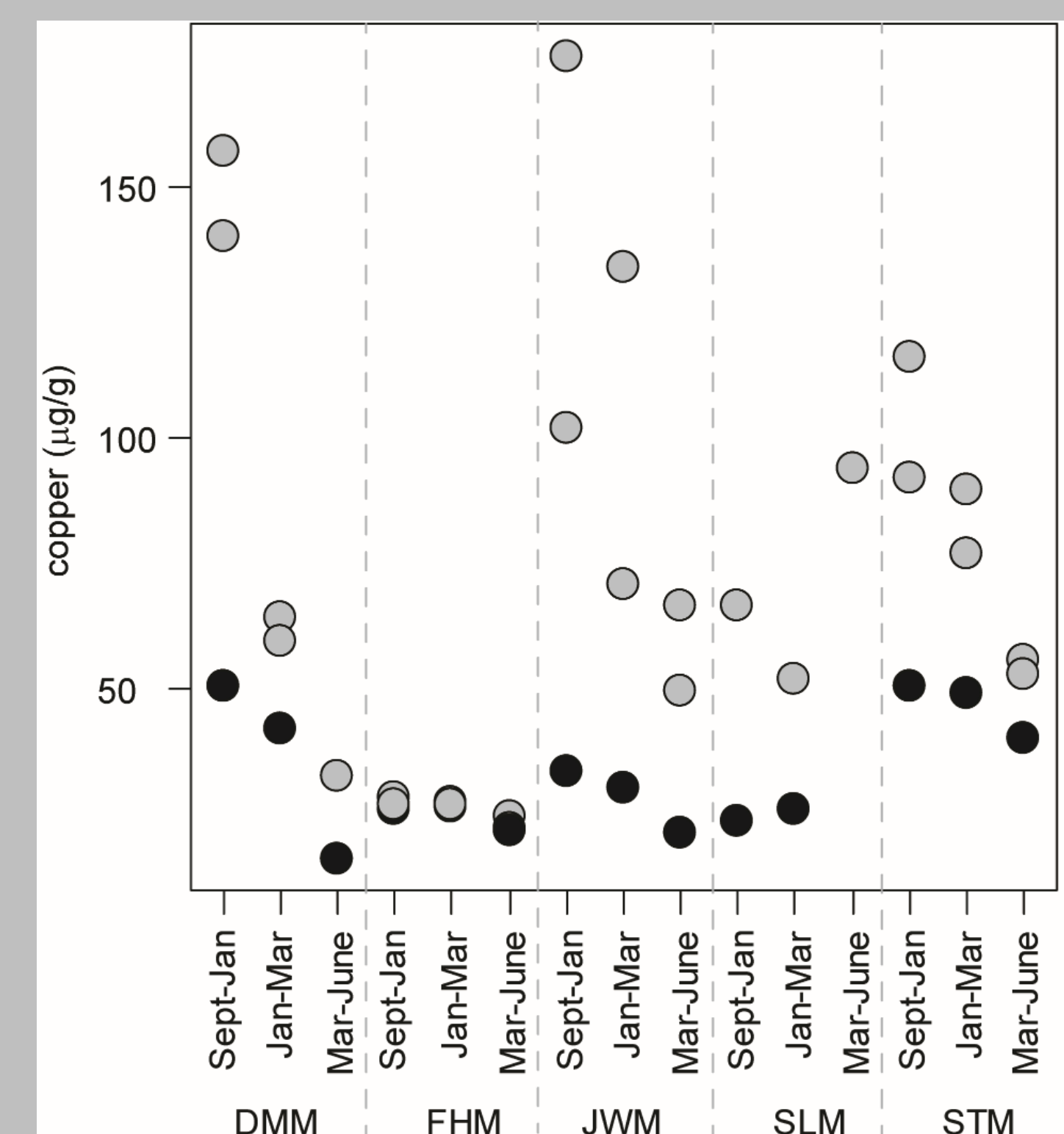
Study marinas



Sediment traps



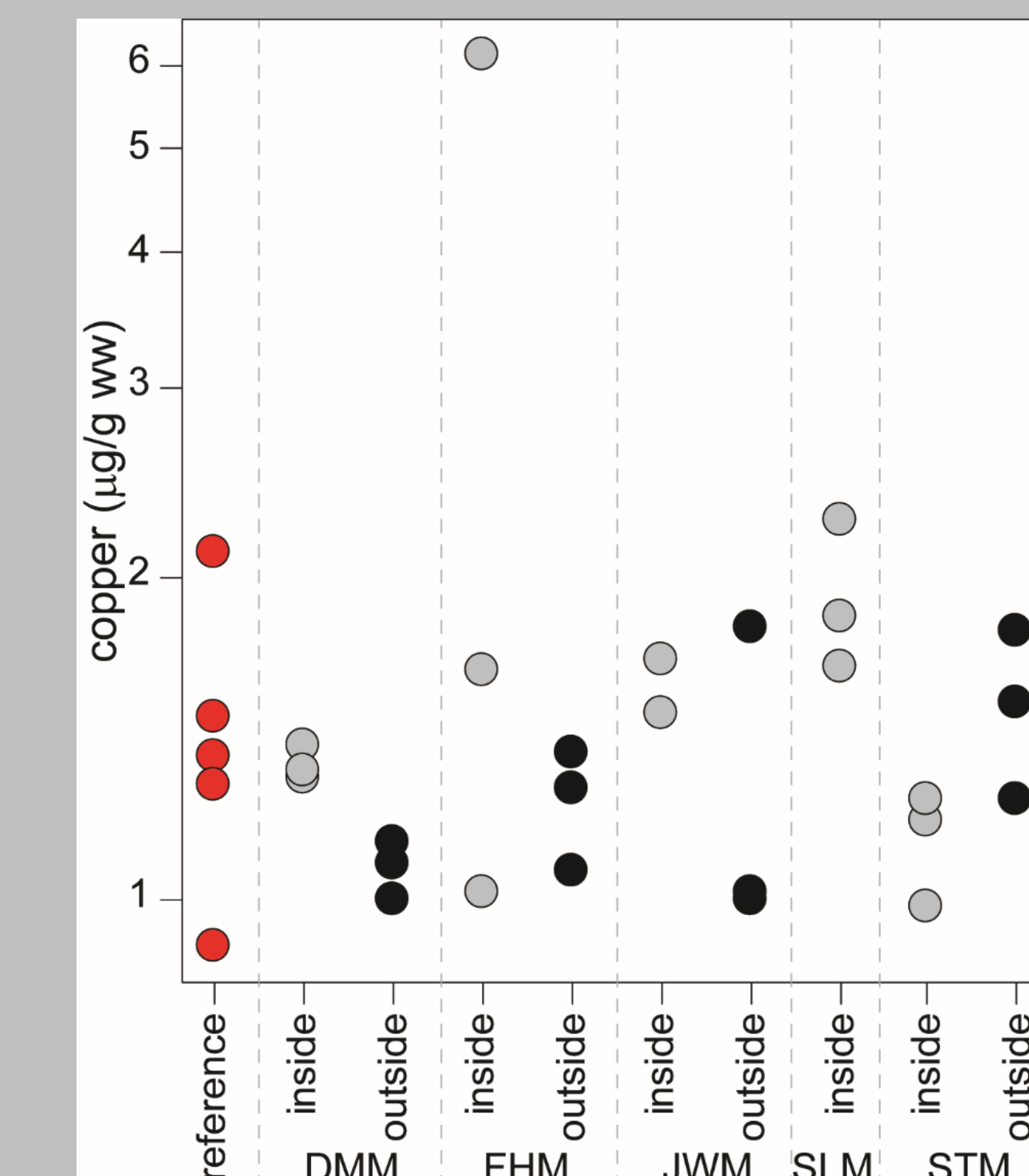
Cu concentrations of sediment trap collections from inside the marinas (grey) and outside the marinas (black).



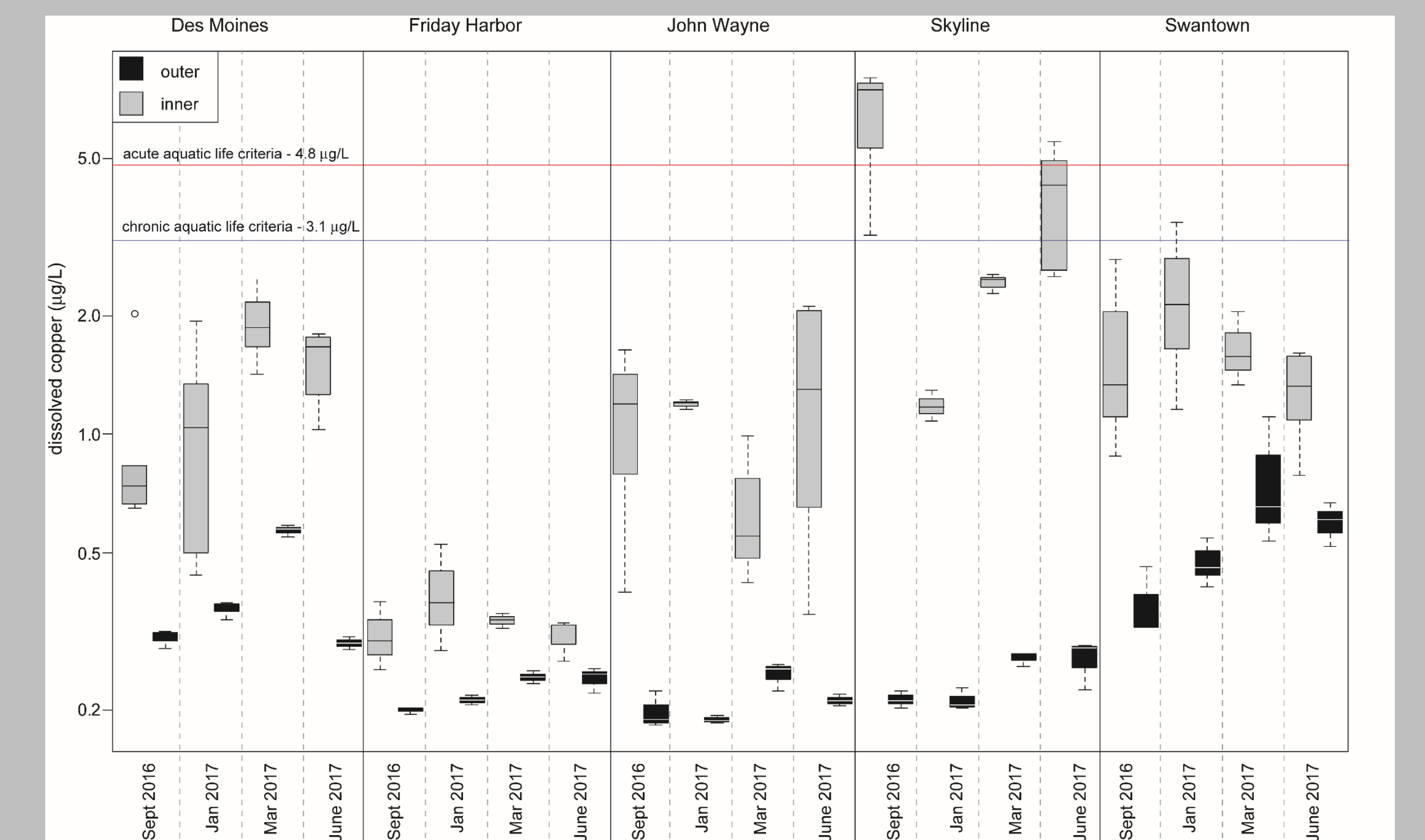
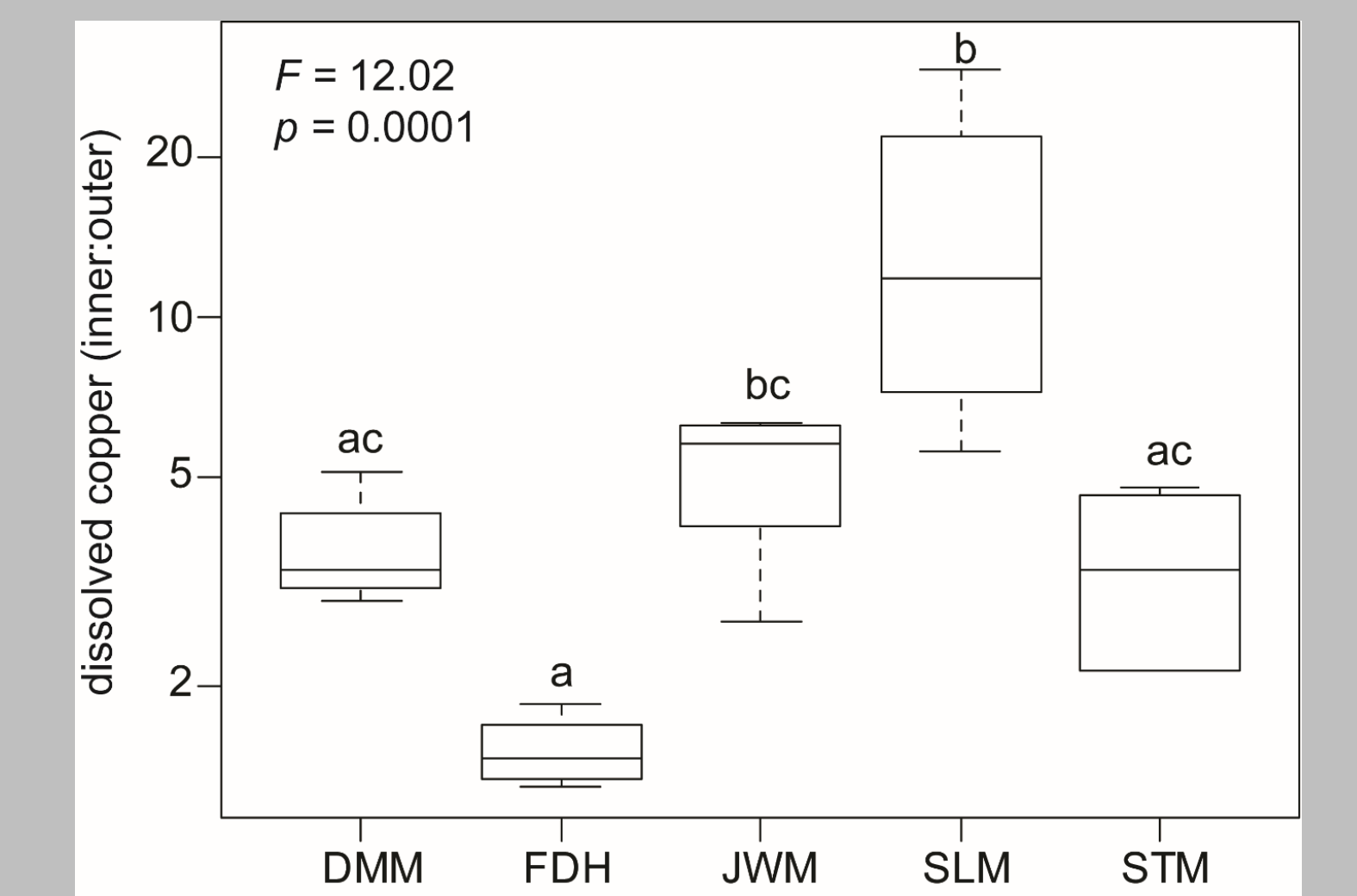
Mussel tissue



Mussels did not show any differences in Cu accumulation compared to reference conditions and 4 of 5 marinas showed no difference between inside and outside Cu concentrations in mussel tissue.



Water



(upper right) Cu enrichment (inside:outside) for all marinas over all sampling events. Lowest Cu accumulation in the most open marina configuration; highest Cu accumulation in the most enclosed. (lower) dissolved Cu concentrations inside the marinas (grey) and outside (black).