Coral settlement on and next to effective antifouling coatings

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Coral settlement

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Introduction

Competition between early coral recruits and algae, driven by nutrient discharges, overfishing and ocean warming, poses a growing threat to tropical coral reef habitats[a]. Small coral recruits can be overgrown and outcompeted by algae, impeding the recovery of degraded reefs[b]. In response to widespread coral degradation, innovative and environmentally friendly restoration techniques are needed to reduce algal dominance and support coral recovery[c]. Here, as a potential tool for future restoration approaches, we (i) investigated a suite of antifouling (AF) coatings for their **fouling inhibition efficiency** and (ii) tested coral larval **settlement as an indicator of potential toxicity**.

Methods

We applied three distinct self-fabricated AF coatings, including **CeO_{2-x} nanoparticles**[d] (NPs), and **antiadhesive**[e] and **encapsulated dichlorooctylisothiazolinone**[f] (DCOIT), to the surfaces of plugs in two ways: fully-coated (FC) and partially-coated (PC) with an uncoated control area in the center. Biofouling classes (crustose coralline algae (CCA), non-coralline (*soft*) algae and bare substrate) were monitored over a period of 37 days and analyzed automatically with the Trainable Weka Segmentation[g] (TWS) plugin in ImageJ (Fig. 1). Subsequently, ***Acropora tenuis*** larvae were tested for settlement on the plugs and compared across treatments, both on the direct AF regions and the uncoated control area.

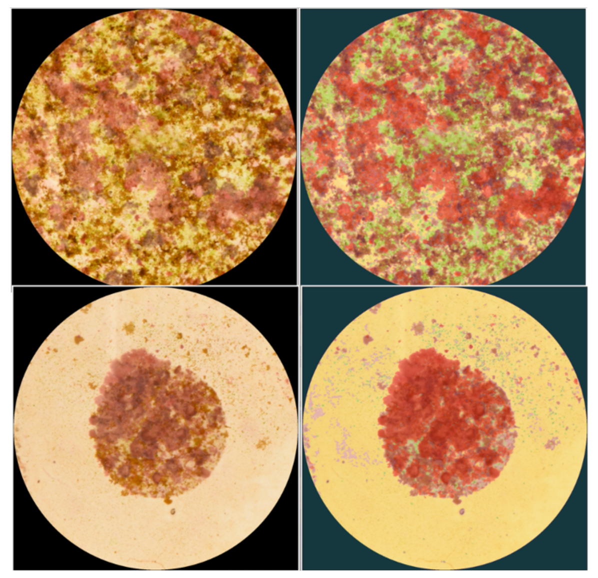

Fig. 1 Original (left side) and corresponding TWS classified (right side) images (top: FC; bottom: PC). Each fouling class is specified with a specific color (right side): red (CCA), violet (brown algae), green (green algae), yellow (bare substrate), dark grey (background).

Results

Biofouling (i)

Uncoated plugs became were heavily fouled with only 4-8% (FC & PC) bare substrate remaining on upper surfaces after 37 days (Fig. 2). During the whole experiment, the DCOIT-coating showed the highest average inhibition of fouling among all FC plugs of 51% (bare substrate), with the antiadhesive coating inhibiting an average of 23% and the nanoparticle (NP) coating 2.4% (Fig. 3). The same fouling pattern was observed on the PC plugs (therefore, the results are not included here).

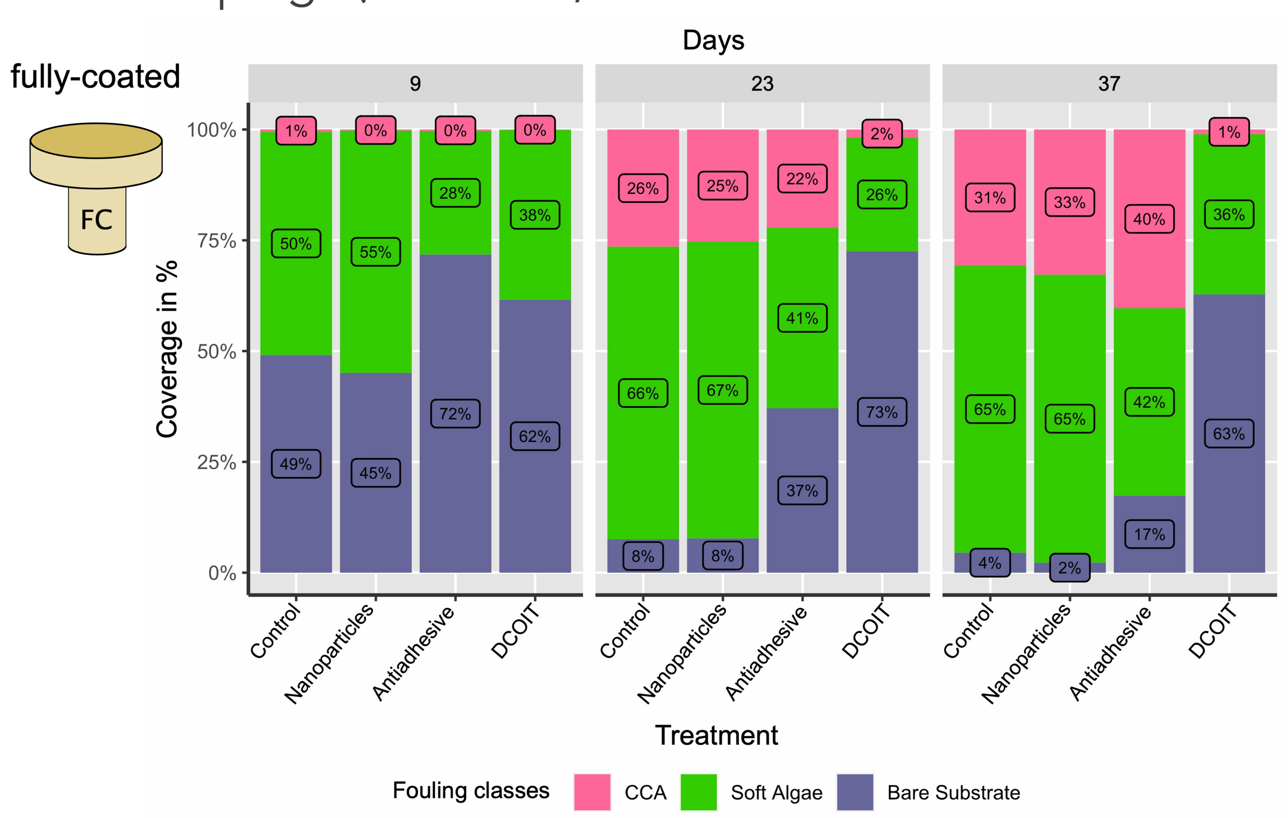

Fig. 2 Average fouling classes proportions (%) on fully-coated (FC) plugs and control (n=45) plugs over time. Note, fouling coverage at experimental start (day 0) was 0.

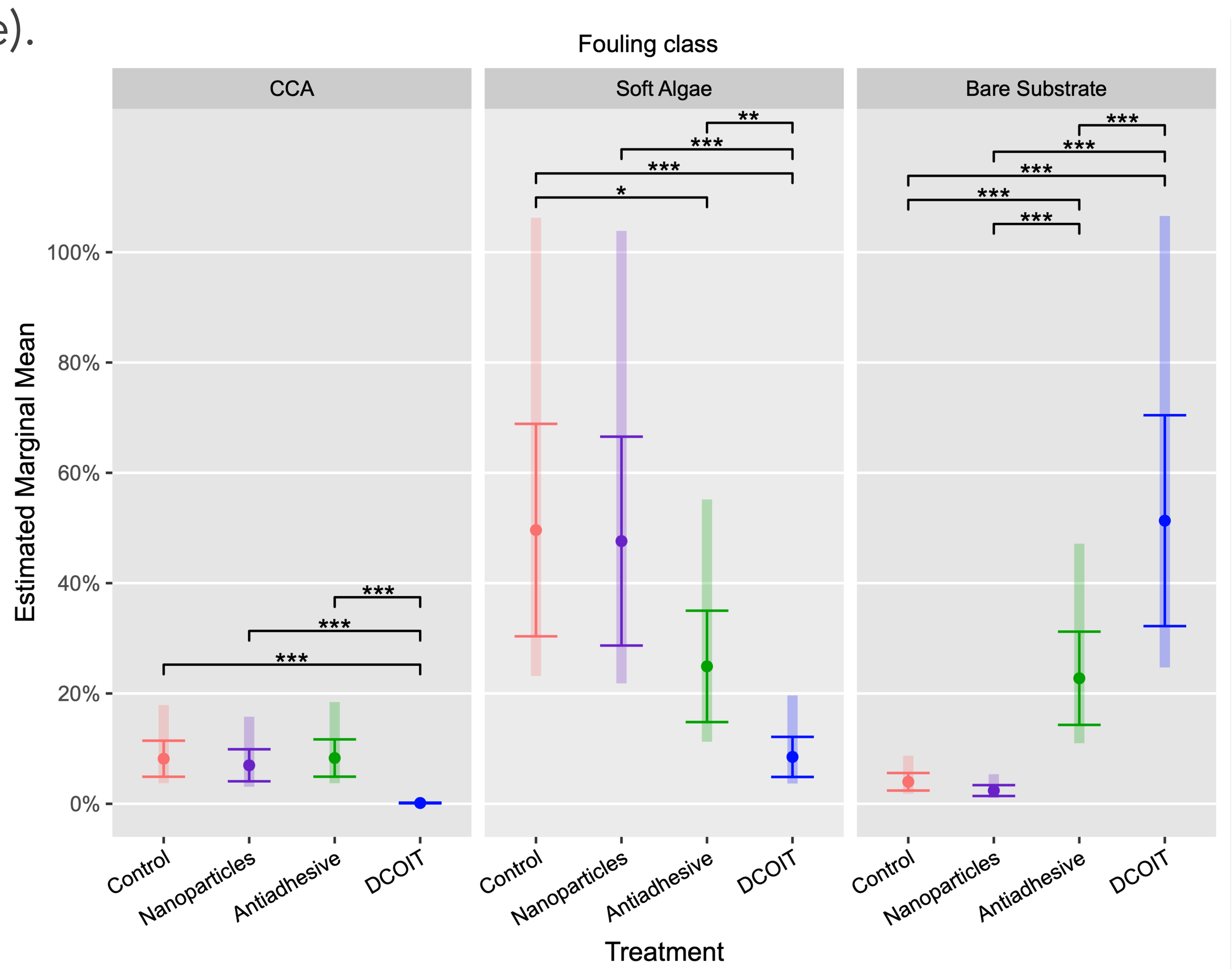

Fig. 3 Estimated marginal means (response), SE and upper and lower confidence levels (CL) of the fouling classes on the fully-coated (FC) plugs. Asterisks indicate statistically significant differences based on pairwise post-hoc tests with estimated marginal means ($p < 0.05$).

Settlement (ii)

Average *A. tenuis* settlement on the coatings of the FC plugs did not statistically differ from settlement on the uncoated controls. However, settlement on the NP-coating was generally the highest and was significantly higher than the lowest settlement found on the antiadhesive coating (Fig. 4). Settlement on the control (0.797 settler/cm^2) and PC NP-coated area (0.87 settler/cm^2) was significantly higher than settlement on the PC antiadhesive-coated area (0.403 settler/cm^2) and PC DCOIT-coated area (0.44 settler/cm^2) (Fig. 5; Fig. 6).

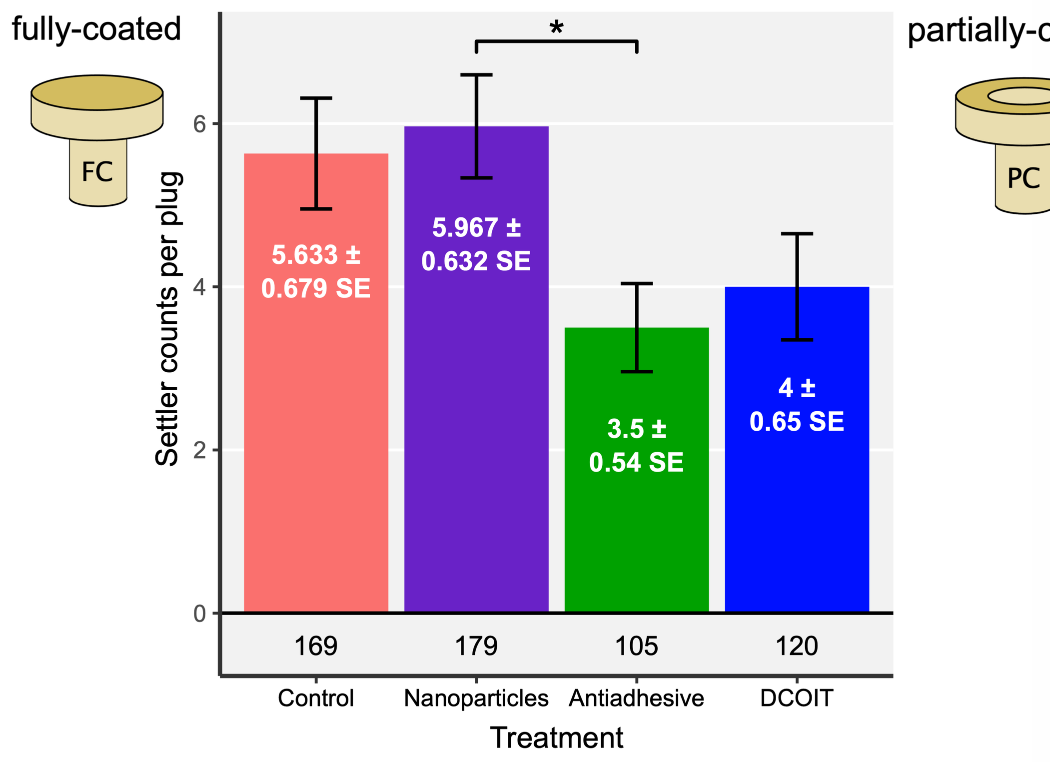

Fig. 4 Average settler counts per plug in the control and each fully-coated (FC) treatment (n=30). Numbers below bars indicate total settler counts (out of 450 larvae in total) in the corresponding treatment. Error bars represent SEM. Asterisk indicates a statistically significant difference based on pairwise post-hoc tests with least-squares means ($p < 0.05$).

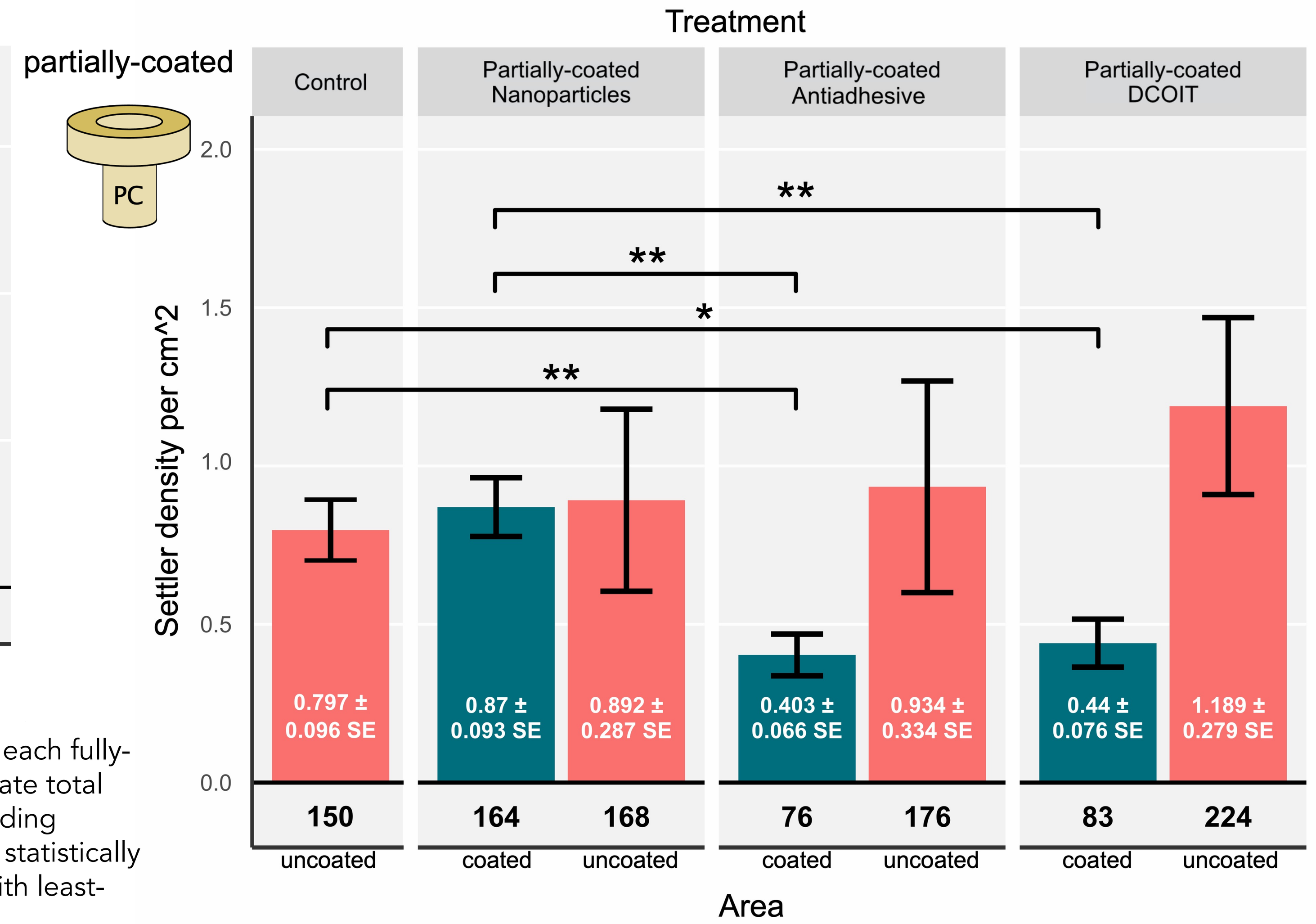

Fig. 5 Average settler density (per cm^2) on areas (coated/uncoated) of the partially-coated (PC) plugs and control (n=30). Numbers below bars indicate total settler counts (out of 450 larvae in total) in the corresponding treatment. Error bars represent SEM. Asterisks indicate statistically significant differences based on pairwise post-hoc tests with estimated marginal means ($p < 0.05$).

Conclusions

This study successfully demonstrates the **AF efficiency of an antiadhesive coating and an encapsulated DCOIT-coating without significantly decreasing coral settlement.** However, on these two most effective AF coatings, coral larvae tended to settle on an uncoated area if given the choice, leading to higher settler densities. Our results suggest that AF coatings can reduce fouling intensity while preserving coral settlement, a first step towards controlling fine-scale competition with other benthic organisms. Further research on the effects of these coatings on recruit survival is needed to advance our understanding of the potential applications in reef restoration.

References

[a] Anton et al. (2020), Glob. Chang. Biol. 26, 4316–4327.
[b] Box & Mumby (2007), Mar. Ecol. Prog. Ser. 342, 139–149.
[c] Randall et al. (2020), Mar. Ecol. Prog. Ser. 635, 203–232.
[d] Herget et al. (2017), Adv. Mater. 29, 1603823–1603n/a.
[e] Detty et al. (2013), Acc. Chem. Res. 2014, 47, 2, 678–687.
[f] Santos et al. (2020), Applied Sciences 10, no. 23: 8579.
[g] Arganda-Carreras et al. (2017), Bioinformatics 33, 2424–2426.

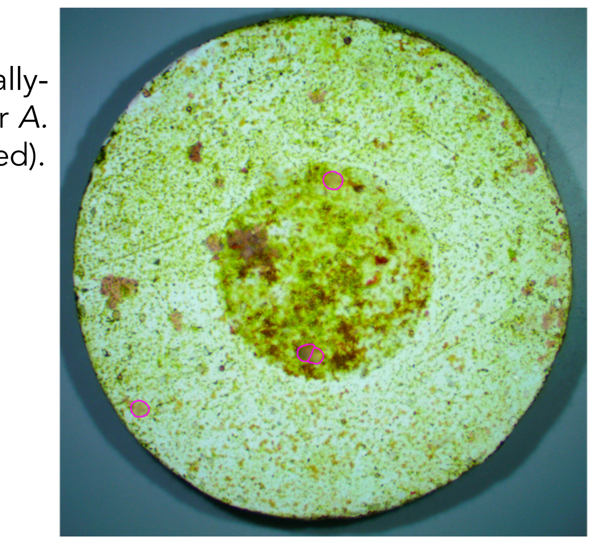

Fig. 6 Antiadhesive partially-coated (PC) plug with four *A. tenuis* settlers (circled in red).

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