



Fleshy Macroalgae Share Dominance with Other Organisms on Degraded Coral Reefs

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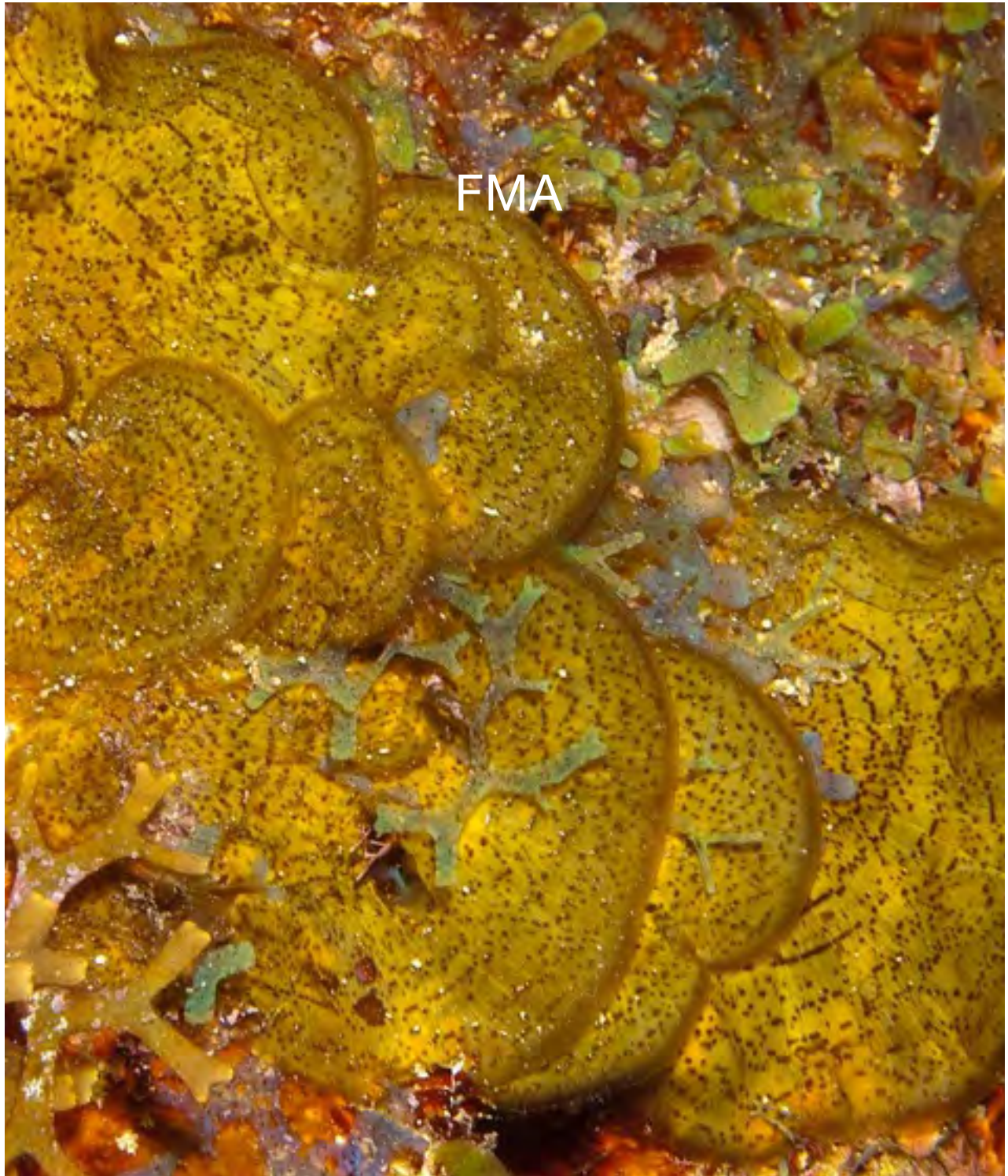
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When herbivores are scarce, fleshy macroalgae can expand over dead corals, outcompete live corals and prevent coral larvae from settling. But they are not the only players in the benthic spatial competition game.

481 reefs at depths of 1-30 m (mean=10 ± 5.5 m) in the wider Caribbean were surveyed by the AGRRA protocols in 2011-2013. Any benthic group occupying at least 25% of the substratum at a site is here considered a spatial dominant. Sites can have more than one spatial dominant. All cover benthic point count values are “corrected” to remove any sand or mud as coral larvae are unlikely to settle here.


1. *Detractors*: Major Coral Competitors

Fleshy macroalgae (FMA)




FMA: highest mean cover (31±18.5%; max. = 84%), most abundant below 6 m and dominants at 60% of the sites. Often found growing with CMA.

Calcareous macroalgae (CMA)




CMA: cover = 6.5±5% but a spatial dominant at only 3 sites. When added to FMA, dominance of macroalgae increased to 77% of sites.

Turf Algal Sediment Mats (TAS)




TAS: present in 77% of sites and most abundant in <6 m, averaging 6.5±5% cover, but spatial dominants at only 10% of the sites.

Peyssonnelids (PEY)



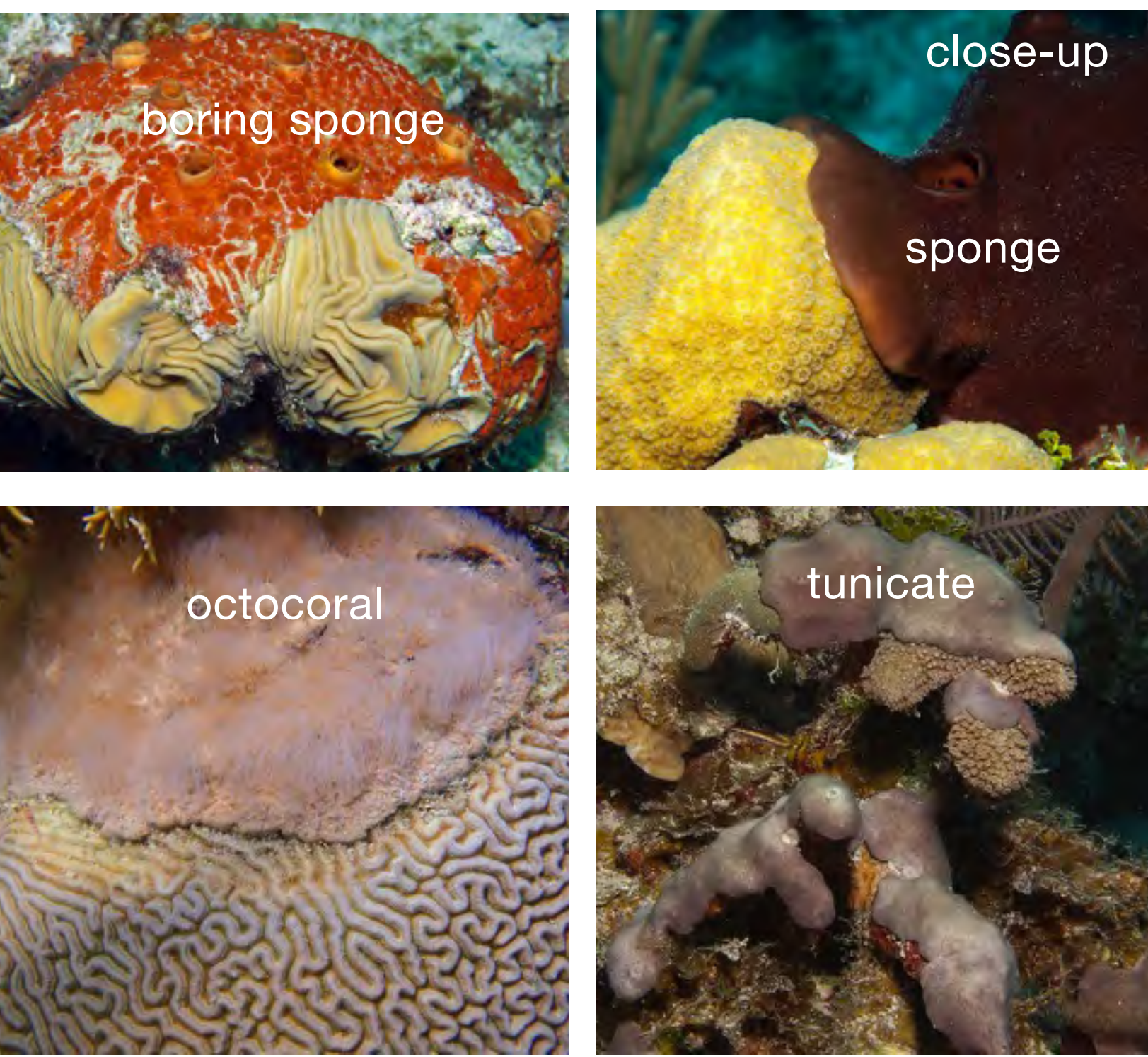
PEY: overall uncommon (1.5±4%; max. = 56%), but rapidly expanding over dead *Orbicella annularis* on some reefs and dominants at 2 fore reefs.

Cyanobacteria (CYAN)



CYAN: usually scarce (1.5±2.5% cover; max. = 16%). Thin films don't harm corals which are killed by thick CYAN masses.

“Aggressive” Invertebrates (AINV)



AINV: boring and certain overgrowing sponges, cnidarians (milleporans, octocorals, zoanthids) and tunicates. Found in 82% of sites, collective mean cover of 2±2.5% (max. = 23%).

3. Benthic Index: An attempt at integration

For each site:
Sum “reef promoters” cover: LC + CCA + sparse TA—a sign of herbivory and potential for coral larval settlement. Assign a score using the “promoter” threshold values below.
Sum “reef detractors” cover: FMA + CMA + TAS + PEY + CYAN + AINV—all can displace LC and CCA. Assign a score using the “detractor” threshold values below.

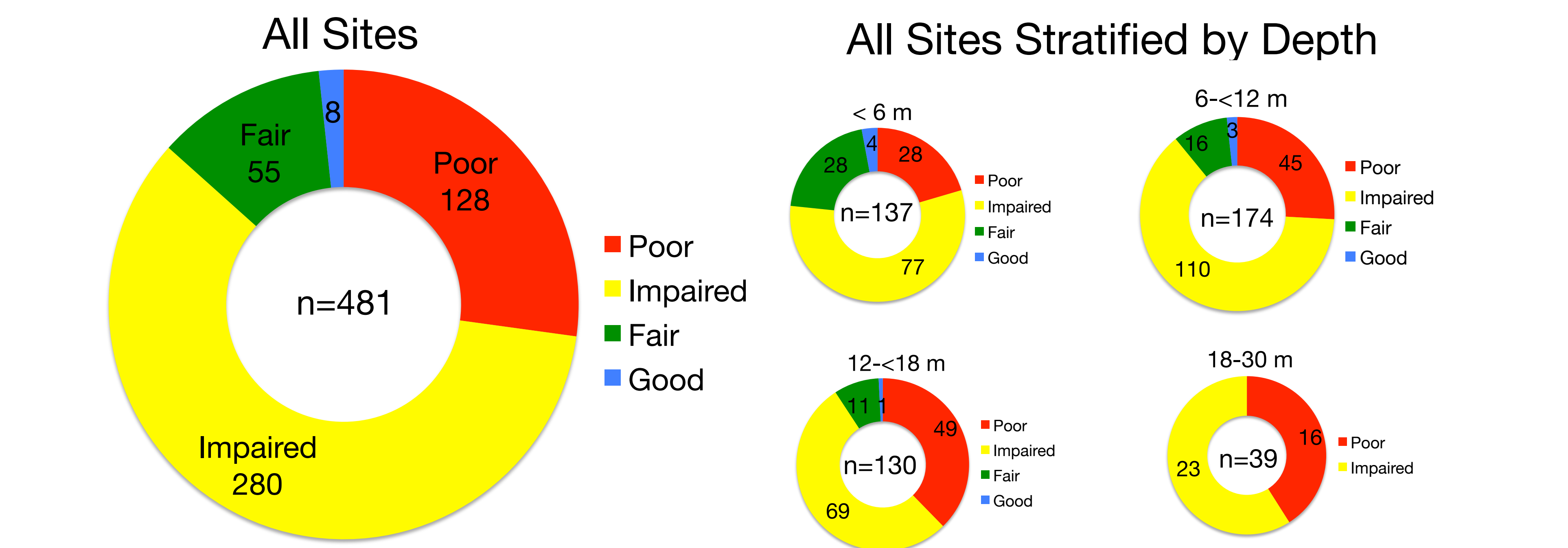
| Sum Cover | 1 (Poor) | 2 (Impaired) | 3 (Fair) | 4 (Good) |
|--------------|----------|--------------|----------|----------|
| "Promoters" | <15% | 15-29.9% | 30-59.9% | ≥60% |
| "Detractors" | ≥60% | 30-59.9% | 15-29.9% | <15% |

Average the two scores; assign a grade using the **Benthic Index** threshold values below.

| Grading Scale | Poor | Impaired | Fair | Good |
|---------------|-------|----------|-------|------|
| Benthic Index | 1-1.5 | 2-2.5 | 3-3.5 | 4 |

Note that BI, or any of the other indicators we assess on reefs, may reflect effects of both the ambient environment and human activities: some sites naturally are in better condition than others.

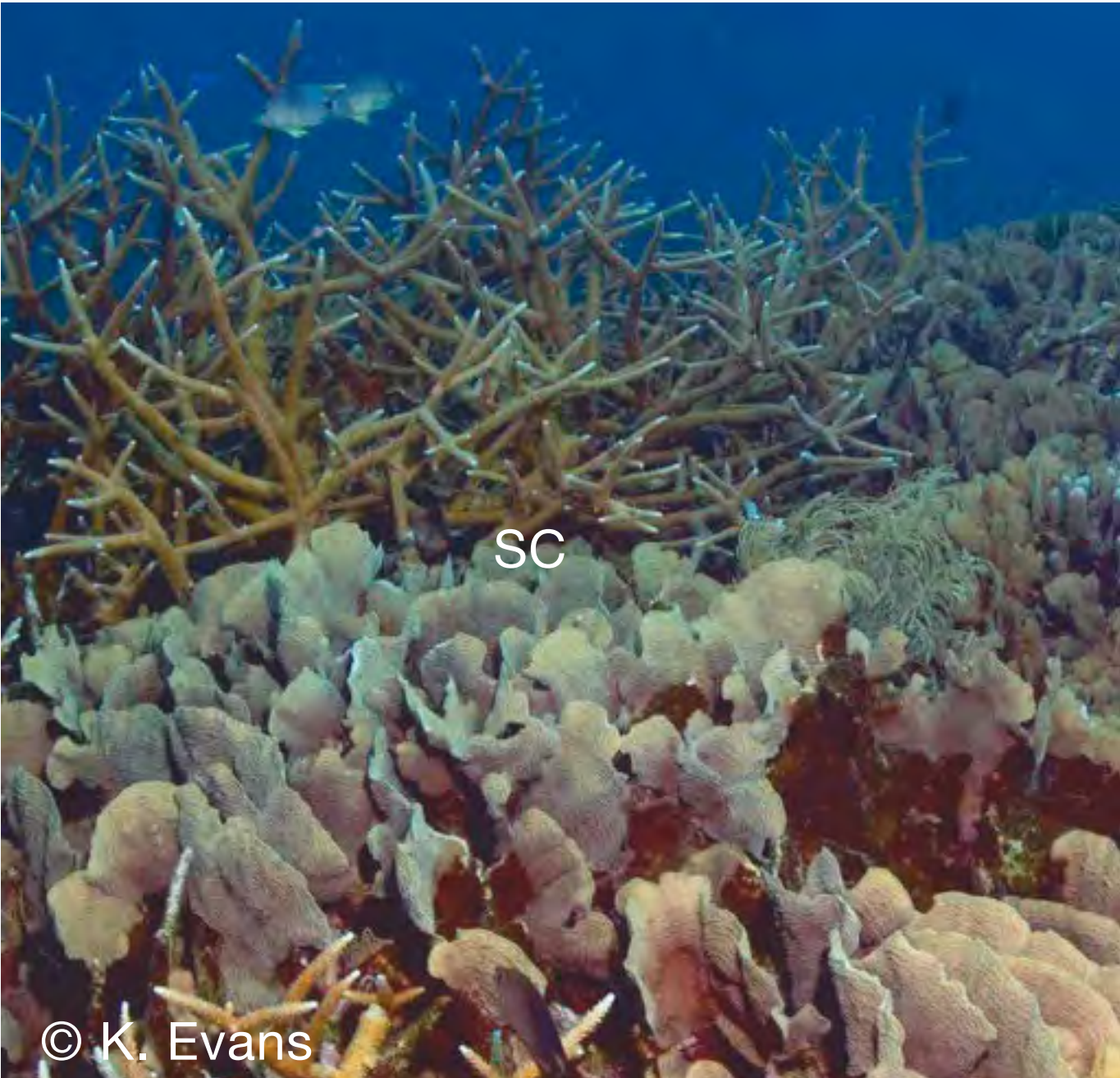
Examples of Benthic Indices in the Wider Caribbean



4. Results. “Impaired” is the most common BI score overall and at each depth range. The proportion of “fair” and “good” sites decreased with increasing depth. Most (n = 329) surveys were in fore reefs. Offshore banks (n = 29) had the highest proportion of “good” sites (~7%); intertidal crests (n=43) the highest proportion of “fair”(~30%).


2. *Promoters*: Major Reef Calcifiers

Stony corals (SC)



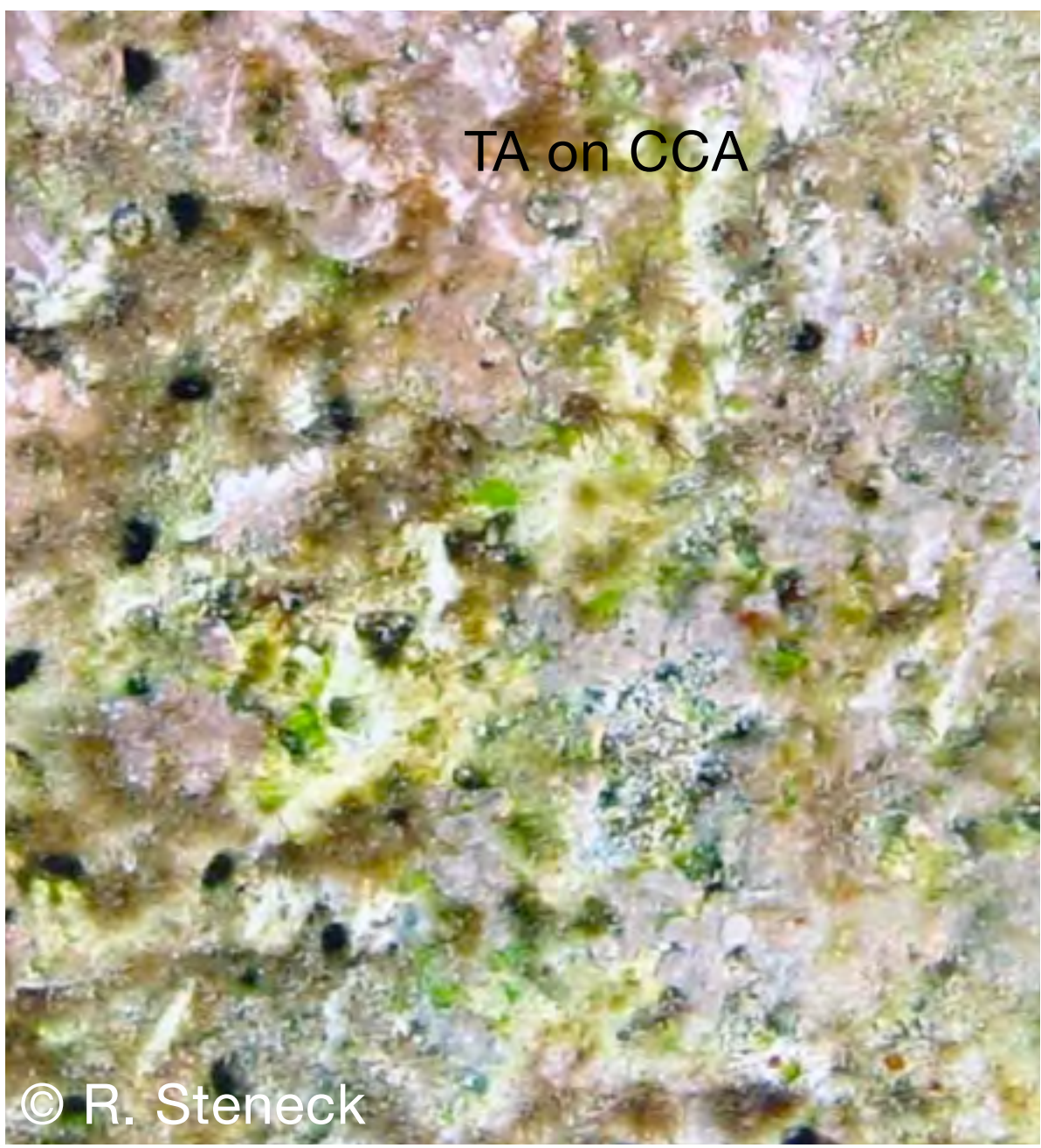
Live SC: averaged 14±10% (max. = 73%), were spatial dominants at 11% of sites. Highest cover was on bank reefs (26±18.5%) and at depths of <12 m.

Crustose Coralline Algae (CCA)



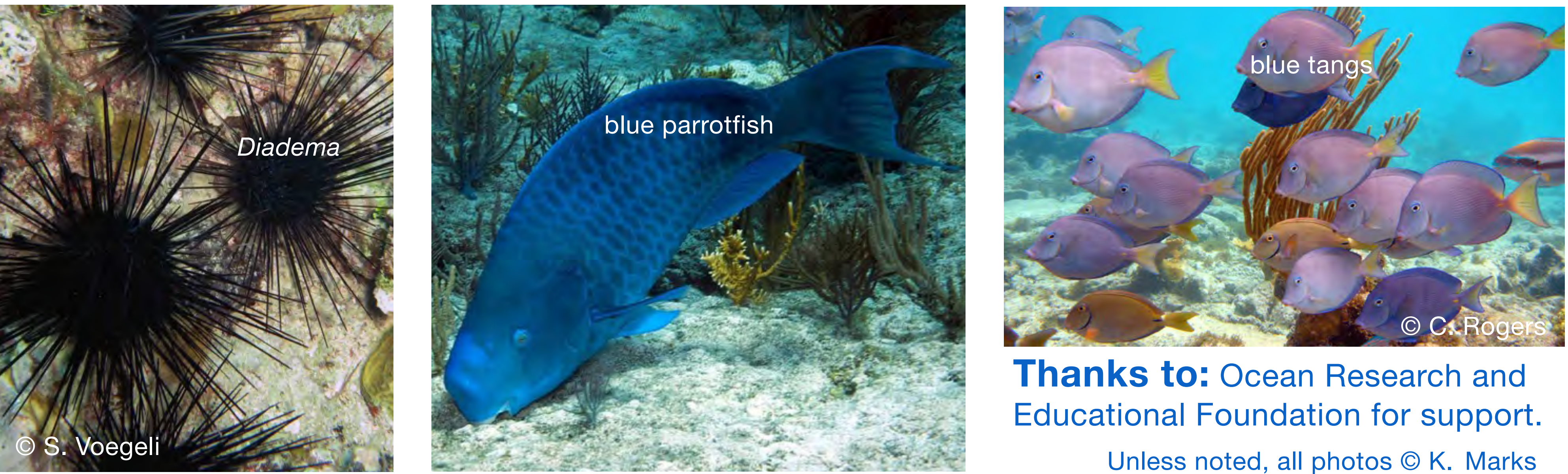
CCA: mean cover 10±8% (max. = 43%), spatial dominants in 6% of sites. Coral larval settlement sites; also spatial competitors of corals.

Plus Sparse Turf Algae (TA)



TA cover averaged 11.5±11% (max. = 56%), and declined with increasing depth. They were spatial dominants in 11% of sites.

5. Management Implications. Caribbean reefs need diverse herbivores—the echinoid *Diadema antillarum* (to consume TAS, PEY, MA), large scarids (to help remove MA holdfasts), and acanthurids (to graze MA)—plus fewer nutrients, sediment and other pollutants on nearshore reefs (to facilitate coral health).



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