Coral Reef Assessment: An Index Utilizing Sediment Constituents

C. Daniels[1], P. Hallock[1]
[1]College of Marine Science, University of South Florida, St. Petersburg, Florida, USA

UNIVERSITY OF SOUTH FLORIDA
COLLEGE OF MARINE SCIENCE

Introduction

To effectively apply resources for mitigation efforts and coral reef protection and restoration, resource managers need inexpensive bioindicators to evaluate the health of coral ecosystems and to inform decisions on when and where to utilize more expensive assessment techniques. Following USEPA Guidelines for Evaluating Ecological Indicators, we have developed the SEDCON Index (SI), a rapid-assessment protocol that utilizes reef sediment composition to assess the integrity of coral-reef communities. Implementation and assessment of this diagnostic tool has been completed for the Florida Middle Grounds (FMG) and the Coral Reef Evaluation and Monitoring Program (CREMP) sites in the Florida Keys National Marine Sanctuary (FKNMS).

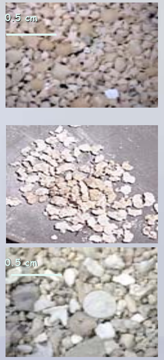
Rationale

Reef sediment composition is an indicator of dominant processes influencing community structure

Community structure
Birkeland (1987), Hallock et al. (1988)

- animal-plant symbiosis predominate
- calcareous algae and grazers predominate
- fleshy algae and bioeroders predominate

Sediment composition
Hallock (2003)

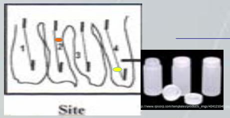


Dominant processes

- symbiotic calcification & physical erosion
- calcification by autotrophs & heterotrophs
- bioerosion

Materials and Methods

1. Collection of fore-reef surficial sediment, ~10g per sample



2. Wet sieve each sample and place into drying oven (50-80ºC)

3. Dry sieve for grain size analysis (Folk, 1974)

4. Sprinkle 1g of sediment from 0.5-2mm range onto gridded tray and archive residual sample

5. Constituent analysis of 300 sediment grains under a stereoscope

6. Data entry

- inexpensive methodology
- easily integrated into existing monitoring programs
- negligible impact on reef resources
- applicable to reefs worldwide

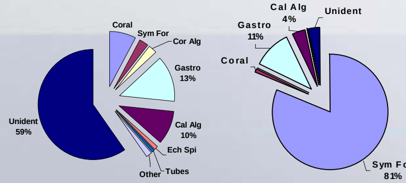
Index Formula

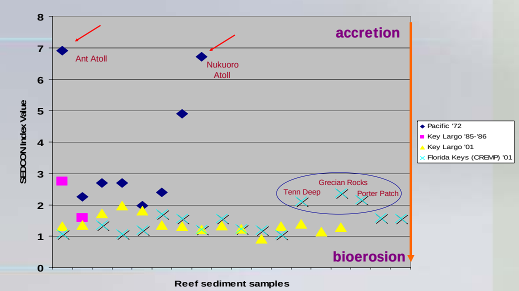
- Determine sediment functional group proportions ($P_x = N_x/300$)
  P_c - coral grains
  P_f - larger, symbiont-bearing foraminifera
  P_{ah} - coralline red algae, gastropods, calcareous algae, echinoid spines, worm tubes, & other skeletal fragments
  P_u - unidentifiable grains
- SEDCON Index (SI) equation:

$$SI = (10*P_c) + (8*P_f) + (2*P_{ah}) + (0.1*P_u)$$

Magnitude of values indicate dominant process
-Higher values reflect conditions favoring accretion
-Lower values reflect dominance of bioerosion

Results





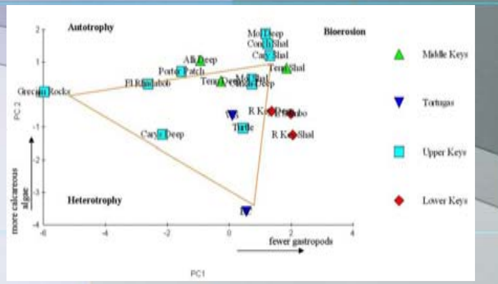
Sediment composition for most Florida Keys sites were primarily composed of unidentifiable constituents, yielding a low SI value. Higher index values were observed in samples from Ant atoll in the Pacific (red arrows) and contained large quantities of symbiotic foraminifera. The blue circle indicates Florida Keys sites with the largest SI values.

Key Largo Replicates (One Way ANOVA)

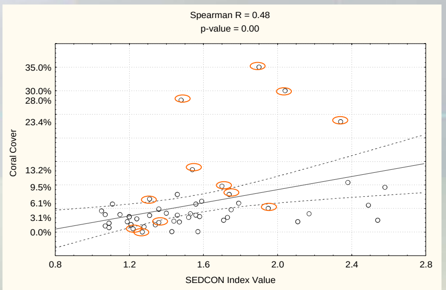
Source of Variation	SS	df	MS	F	p-value
Between Sites	3.093	9	0.343	25.753	**< 0.001**
Within Sites	0.017	1	0.017	0.098	0.756
Error	0.115	9	0.012		

CREMP (Two Way ANOVA—3 year data)

Source of Variation	SS	df	MS	F	p-value
Among Sites	2.731	10	0.273	4.286	**< 0.002**
Among Years	0.016	2	0.008	0.132	0.876
Error	1.274	20	0.063		



Principle Components Analysis information was obtained using both sediment constituent data and SI values. According to this data for the Florida Reef Tract, bioerosion and autotrophy were the dominant processes. Conditions favoring accretion were not represented at any of the Florida Keys sites.



Weak correlations were found for a majority of reef sites deeper than 20m (orange circles), when comparing CREMP coral cover data to SI values. This is to be expected, since wave action would be of minimal influence to sediment composition at these depths.

Conclusions

•Strengths: discrimination between sites and low intrasite variability (2-3 samples sufficient)
•Restrictions: no interannual responses and depth limited
•Index should only be used for periodic assessments ($\geq$ 5 yrs.) and applied to sites <20m
•Bioerosion has overtaken accretion in the Florida Keys

Future Investigation

•Subsequent work will focus on adjusting the SEDCON Index equation to discriminate more effectively between sites controlled by auto or heterotrophy (mid SI) and sites dominated by bioerosion (low SI).

•Compare SI data to other independent parameters used to assess coral reef health (species diversity, mortality vs recruitment)

Acknowledgements

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