A geological perspective on the preservation and restoration of Florida’s coral reefs

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Habitat
Islamorada, FL Keys, after Hurricane Irma

Shoreline protection

Tourism

$375 billion/yr to Florida’s economy (NOAA)
Reef erosion is becoming a dominant process

Reef erosion rate: \(-5.5 \pm 3.2 \text{ mm yr}^{-1}\)

Harold Hudson’s “monuments” (\(n = 28\)) used to measure reef erosion (est. 1998)

One of the only direct measurements of reef erosion rate in Florida

Kuffner, Toth, et al. in review
The past is the key to the future

185 radiometric ages from 46 cores from throughout the Florida Keys

USGS Core Archive: http://olga.er.usgs.gov/coreviewer/
Coral reef development in south Florida

Average Holocene reef thickness
- 1 m
- 5 m
- 10 m

Toth et al. 2018. Global Change Biology
Florida’s reefs have grown little in the last 3000 years.
Cold-water coral mortality

Timing of reef shutdown

Differences in duration of reef development explain spatial variability in reef thickness

Reef accretion

Reef erosion

Holocene Thermal Maximum
Climatic cooling

Reefs influenced by Florida Bay stop growing

Geological shutdown of Florida’s coral reefs

Cold-water coral mortality

Global temperature anomaly (°C)

Toth et al. 2018. Global Change Biology
Changes in reef composition

Geological reef framework

- Acropora palmata
- Orbicella spp.
- Siderastrea siderea
- Other corals
- Porites astreoides

Modern Reefs

- Acropora palmata
- Orbicella spp.
- Siderastrea siderea
- Other corals
- Porites astreoides

Holocene reef framework

>90% cover on modern reefs

Toth et al. in press. Ecology

Collaborators: Rob Ruzicka and Mike Colella (FWRI, FL FWCC)
http://myfwc.com/research/habitat/coral/cremp/
Optimizing coral restoration

- **Acropora cervicornis** only accounts for 2% of the reef framework in our cores from the Florida Keys.
- Does not build lasting reef structure.
A geological perspective on coral-reef management

• Changing **climate** and the influence of **Florida Bay** have suppressed reef growth in Florida has been suppressed for \(~3000\) **years**

• The outcomes of coral-reef management and restoration can be optimized by prioritizing efforts that **promote reef growth** and **mitigate reef erosion**
  
  • Preserving the **geologic structures** that remain is a worthy management goal

• **Focus on restoration of reef-building corals** such as **Acropora palmata** and **Orbicella spp.**
Spatial patterns of reef development

No significant difference in reef accretion among sectors

\( F_{5,44} = 0.09, \ p = 0.99 \)
Geological senescence of Florida’s coral reefs
The carbonate budget of a coral reef

**Carbonate Production**
(calcification x coral cover x rugosity)

**Bioerosion**
(+ sediment export and dissolution)

Reef accretion

1971

P.W. Glynn

E.A. Shinn

USGS
The carbonate budget of a coral reef

**Carbonate Production**
(calcification x coral cover x rugosity)

**Bioerosion**
(+ sediment export and dissolution)

Reef erosion

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2001

E.A. Shinn

P.W. Glynn

USGS
The carbonate budget of a coral reef

Carbonate Production
(calcification x coral cover x rugosity)

Bioerosion
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Reef erosion

E.A. Shinn
2001

P.W. Glynn
Large-scale trends in reef erosion since the 1930s

Maui, Hawaii
-81 Mm³

Upper & Lower Florida Keys
-38 Mm³
-6 Mm³

St. Thomas, USVI
-22 Mm³

Buck Island
St. Croix, USVI
-3 Mm³

Empire State Building Volume
= 1 Mm³

Seafloor Elevation Change (m)

-0.4 m
-0.3 m
+0.1 m

Kim Yates, Dave Zawada, et al.
2017 Biogeosciences