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

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U.S. Department of the Interior
U.S. Geological Survey

Habitat

Shoreline protection


Islamorada, FL Keys, after Hurricane Irma Erik S. Lesser/EPA

Tourism

$375 billion/yr to Florida's economy (NOAA)

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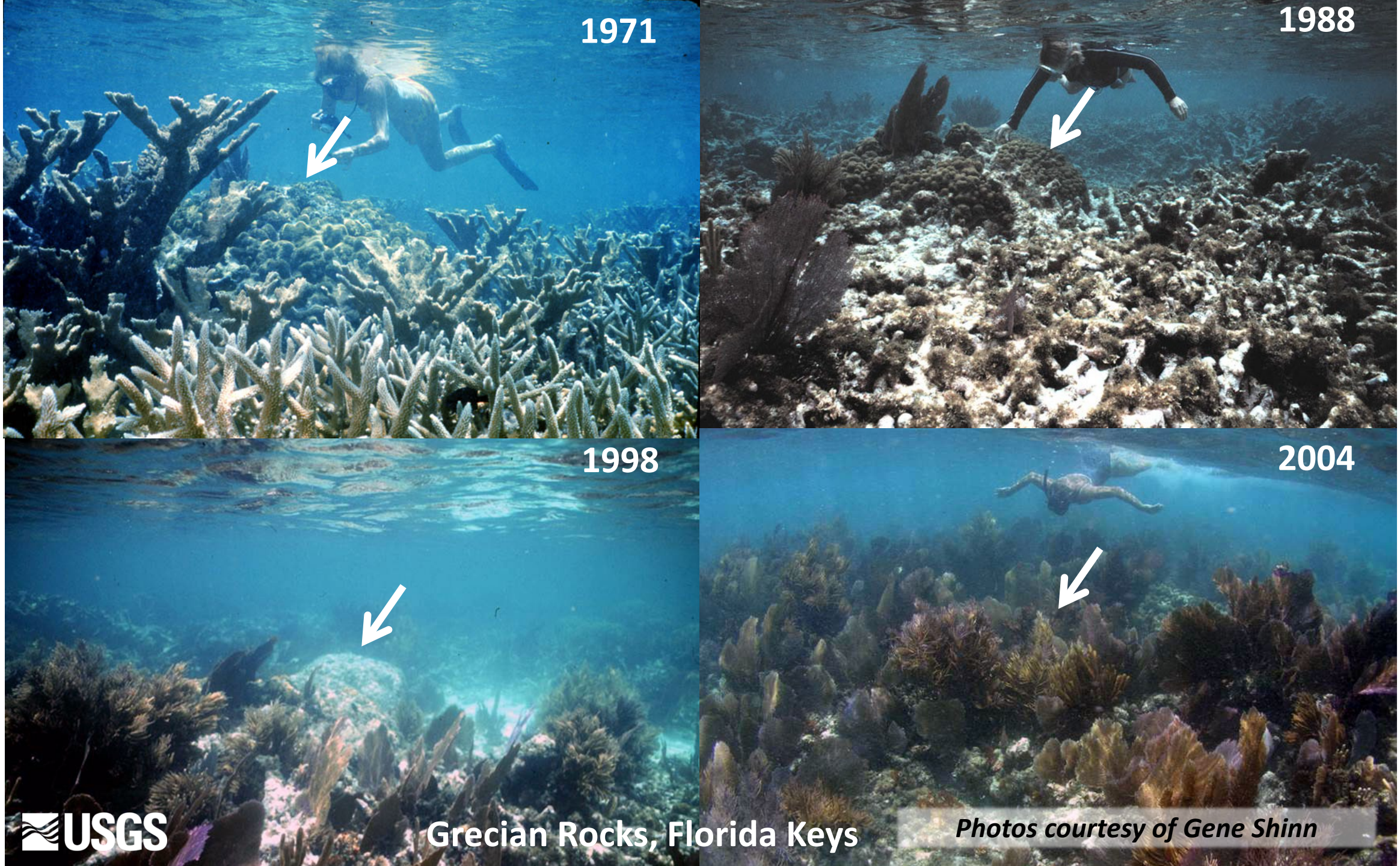

1971
1988
1998
2004
USGS
Grecian Rocks, Florida Keys
Photos courtesy of Gene Shinn

Reef erosion is becoming a dominant process

1998 elevation

2015 elevation

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*

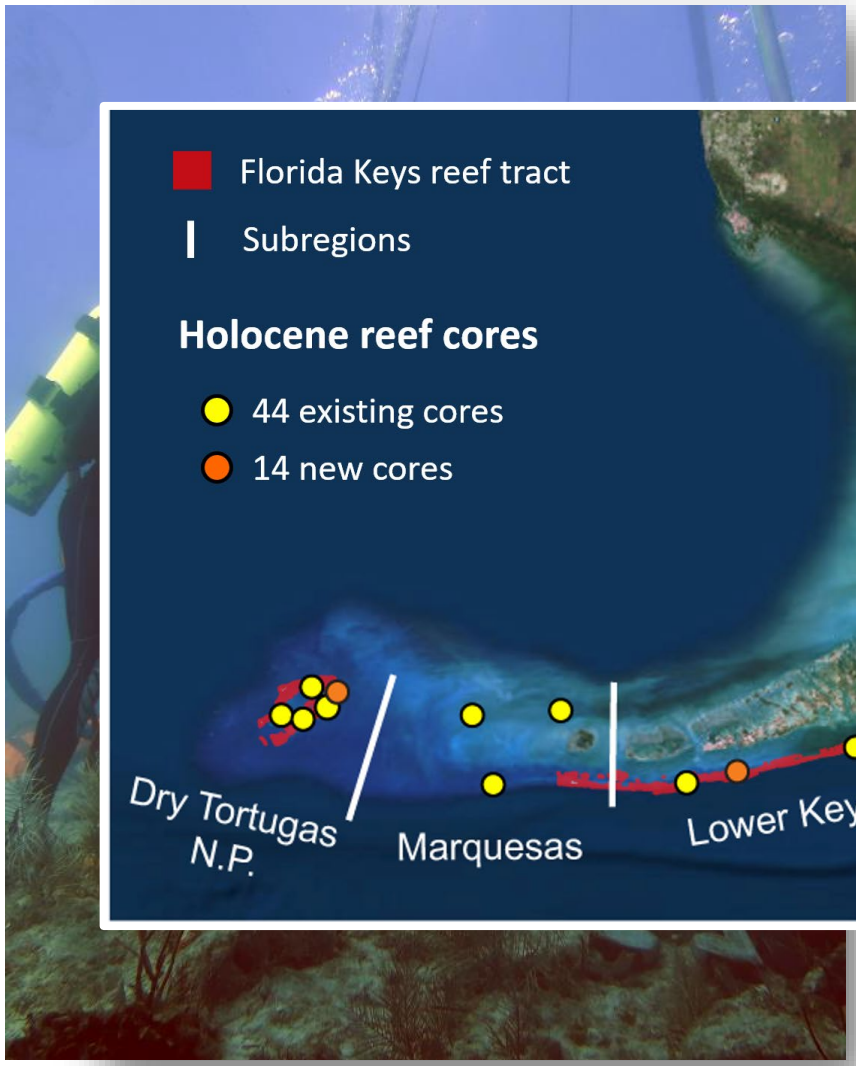
USGS

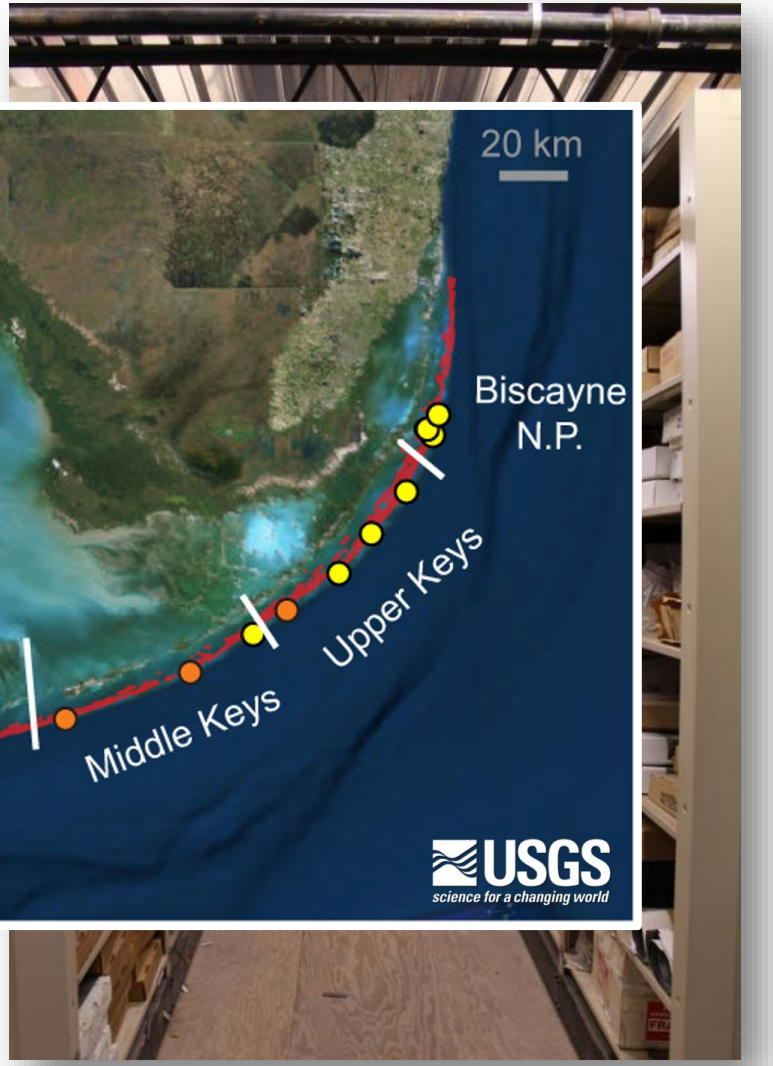
Reef erosion rate:

-5.5 ± 3.2 mm yr^{-1}

Hen & Chickens Reef, FL Keys

The past is the key to the future





185 radiometric ages from 46 cores from throughout the Florida Keys

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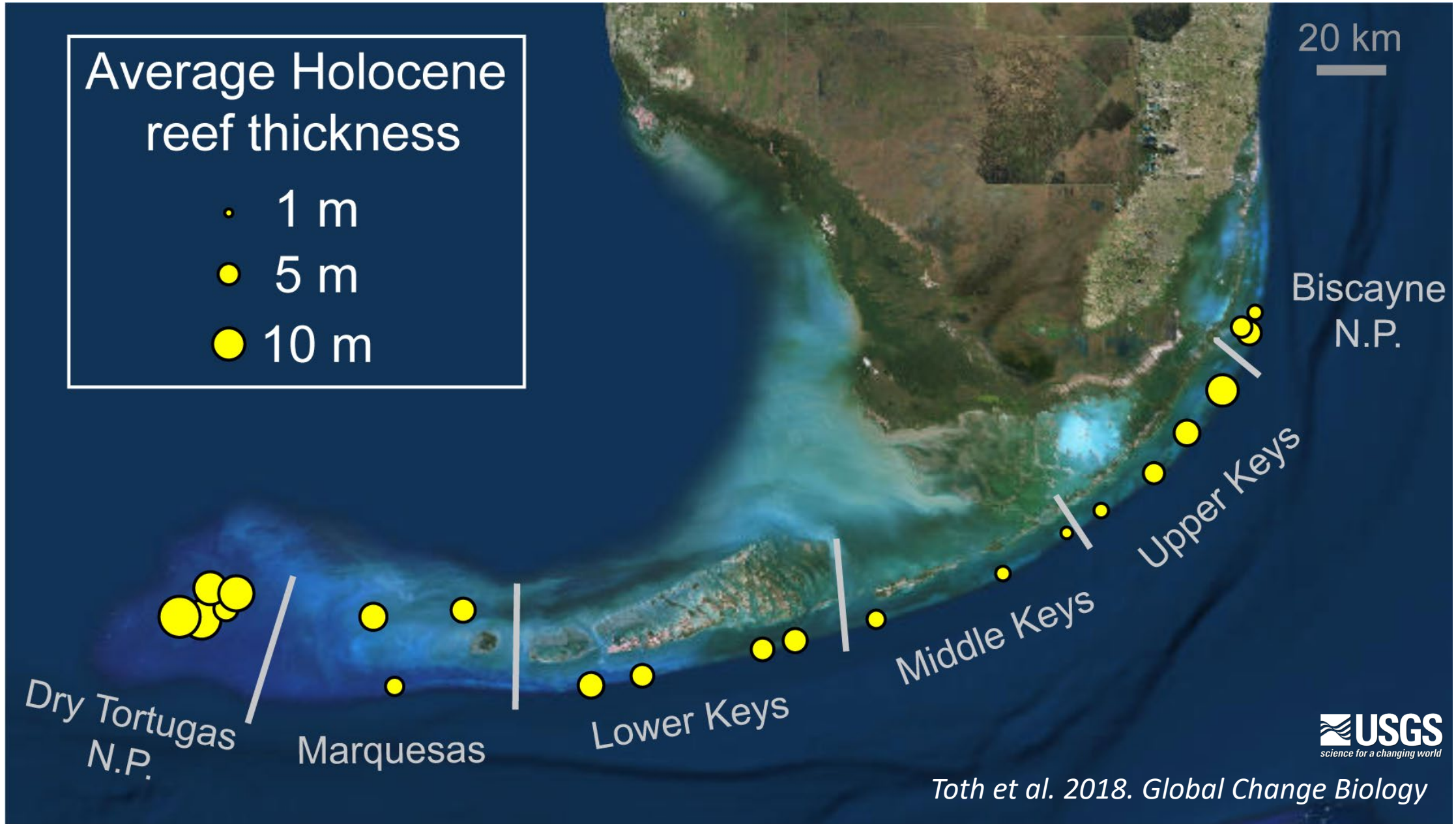
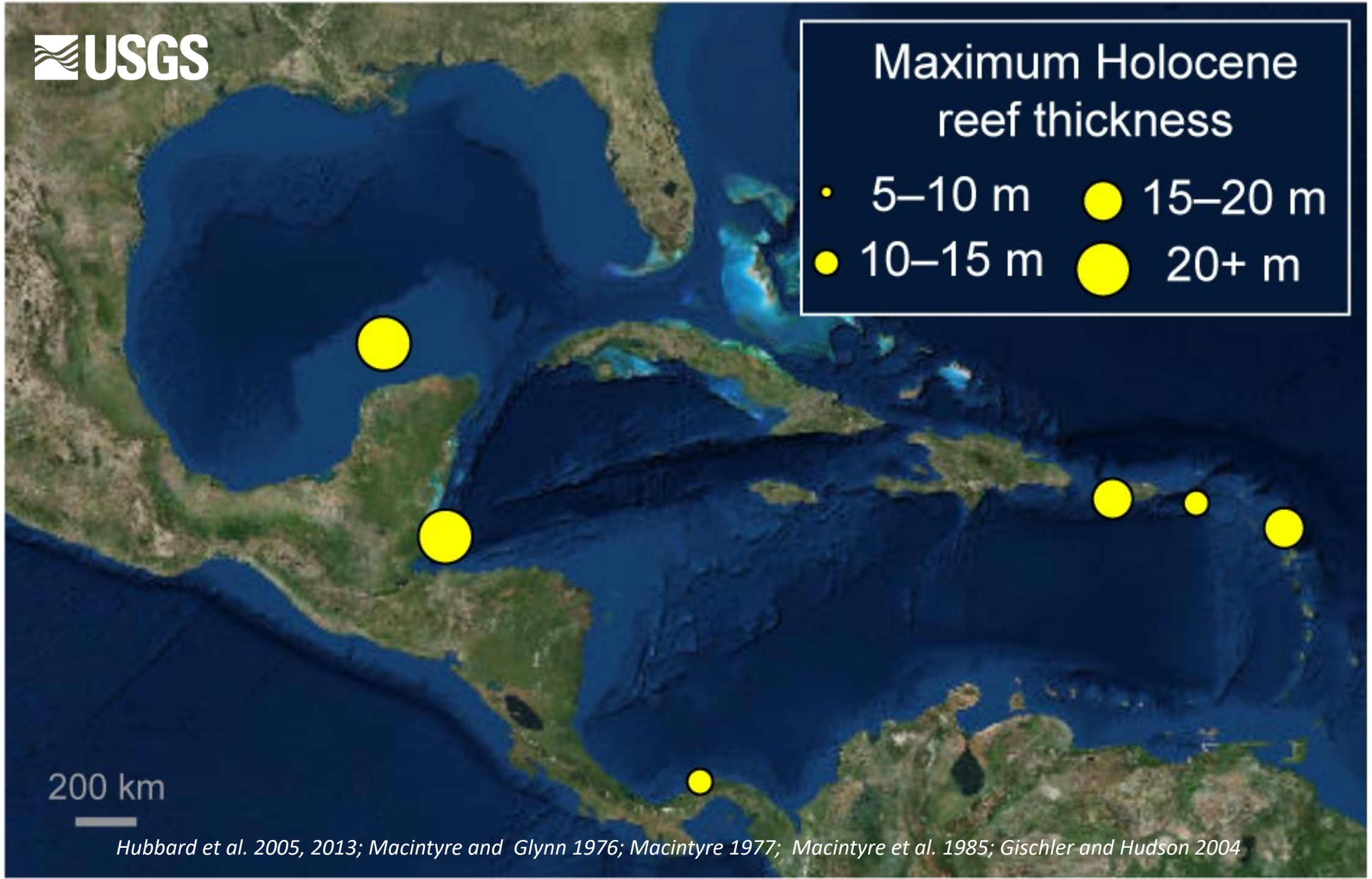
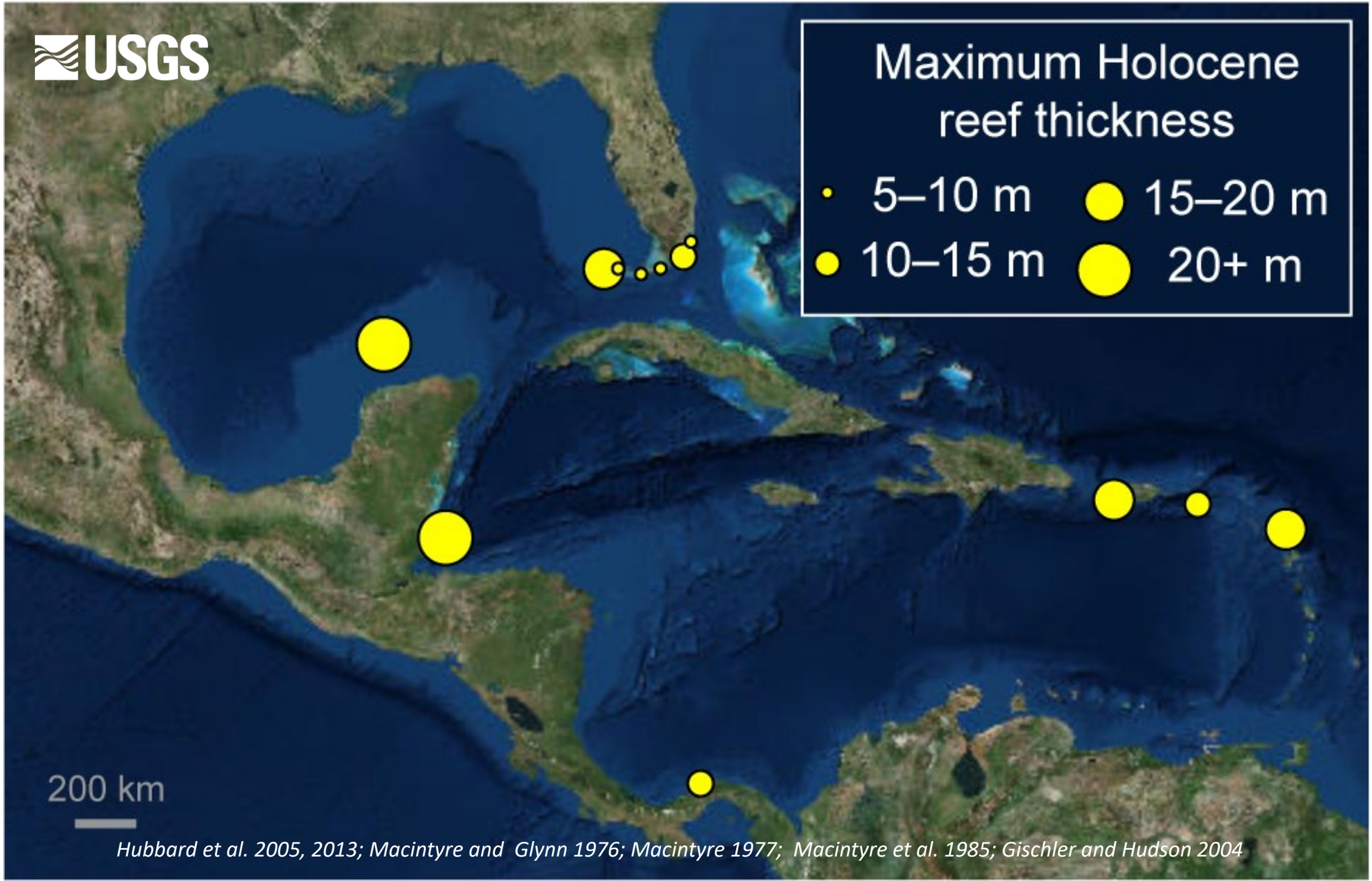
USGS Core Archive: http://olga.er.usgs.gov/coreviewer/

Coral reef development in south Florida



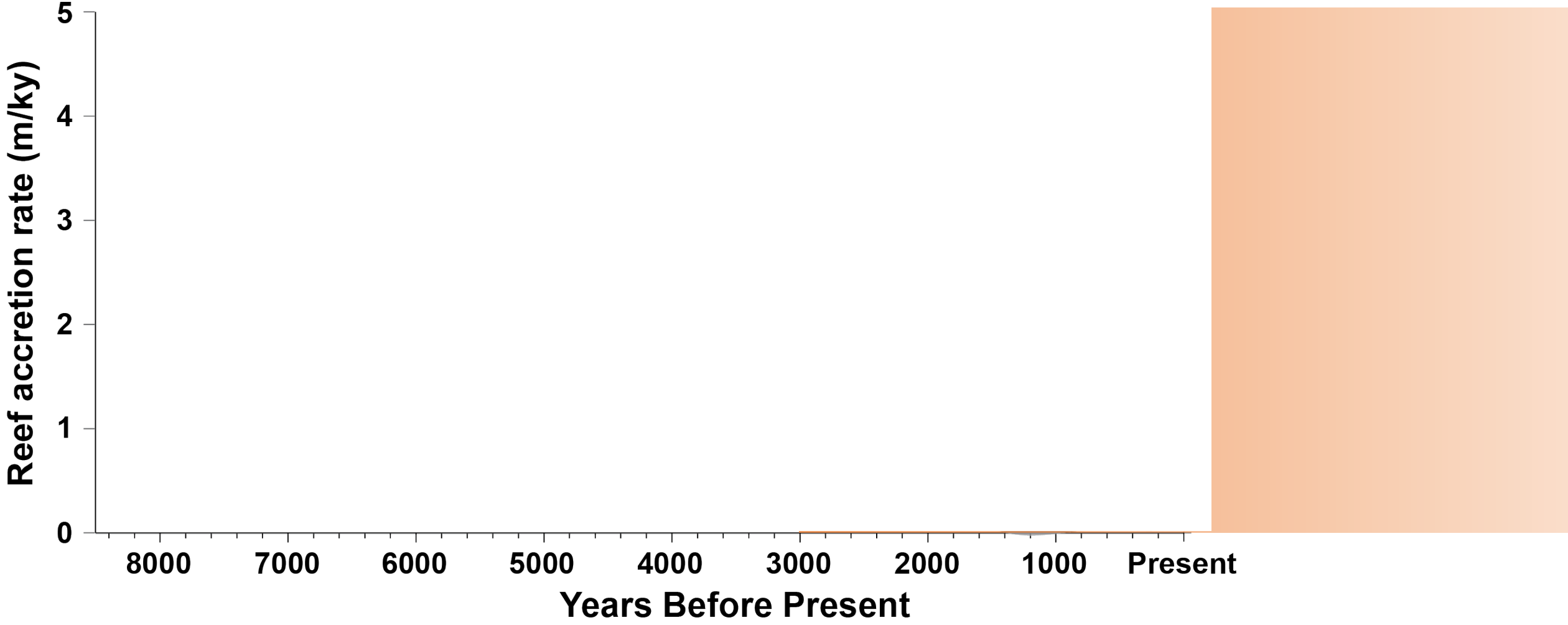


Hubbard et al. 2005, 2013; Macintyre and Glynn 1976; Macintyre 1977; Macintyre et al. 1985; Gischler and Hudson 2004



Hubbard et al. 2005, 2013; Macintyre and Glynn 1976; Macintyre 1977; Macintyre et al. 1985; Gischler and Hudson 2004

Florida's reefs have grown little in the last 3000 years



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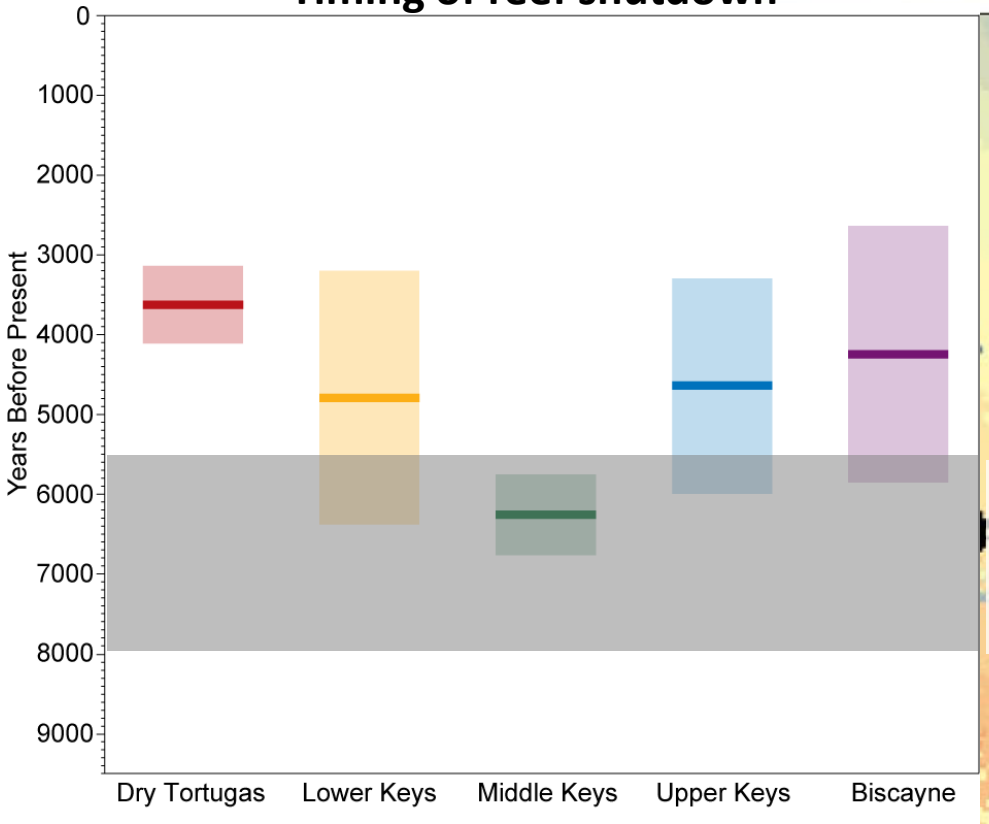
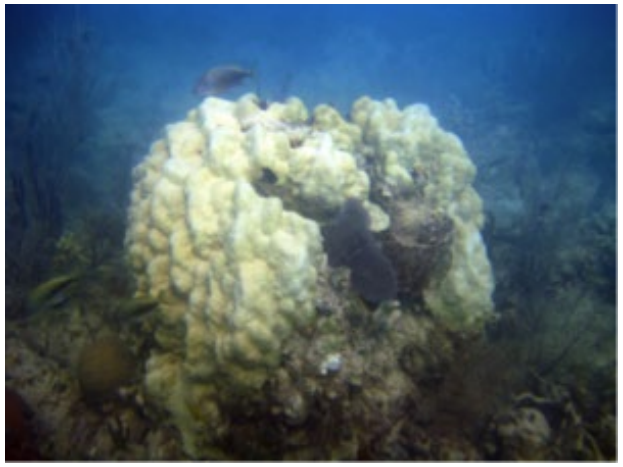
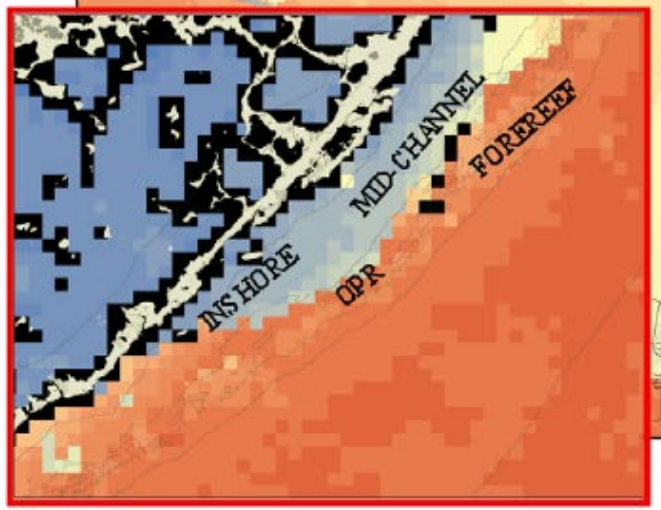
Toth et al. 2018. Global Change Biology

Timing of reef shutdown

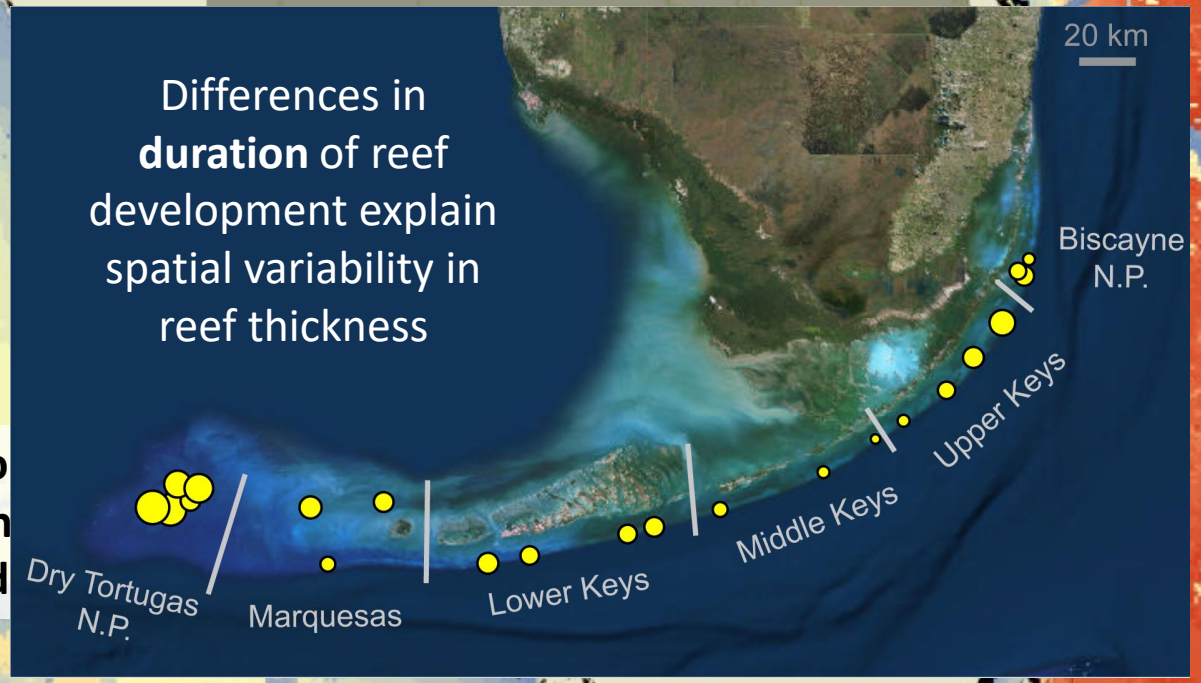


Cold-water coral mortality

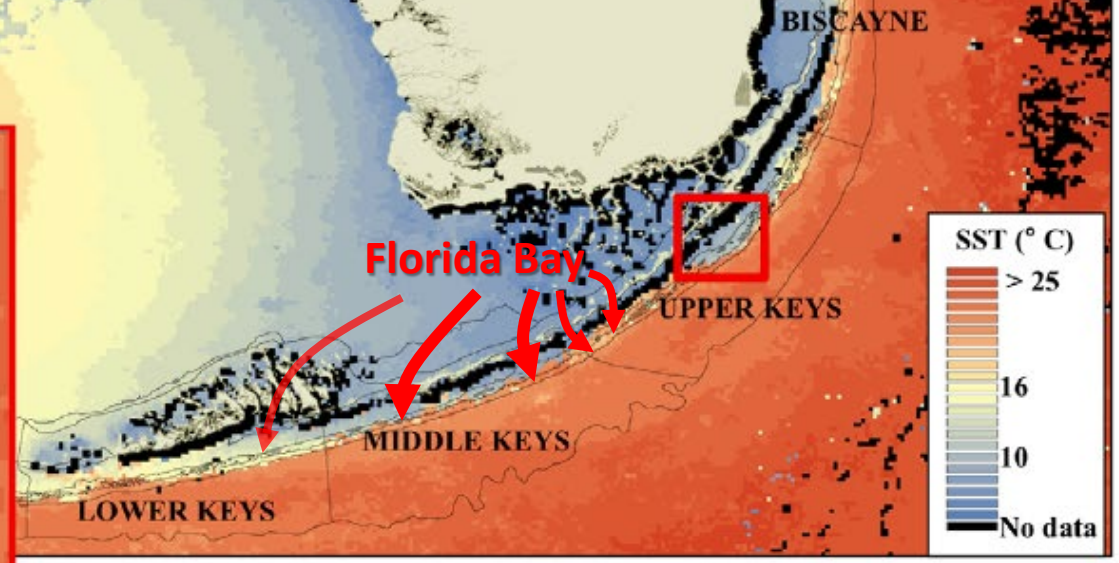




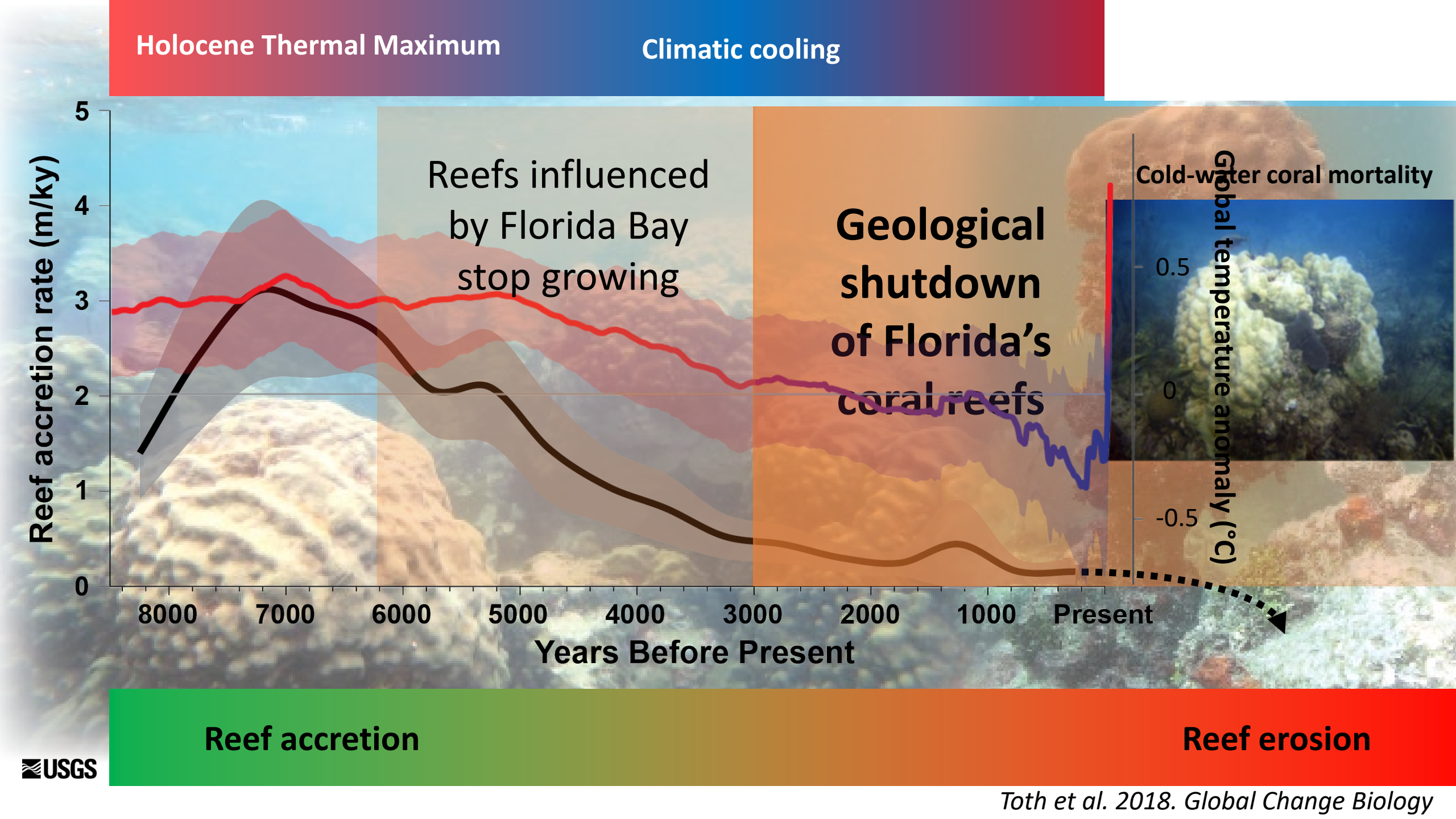
Differences in **duration** of reef development explain spatial variability in reef thickness



Flo
con
Florid



Lirman et al. 2011. PLoS One



Toth et al. 2018. Global Change Biology

Changes in reef composition

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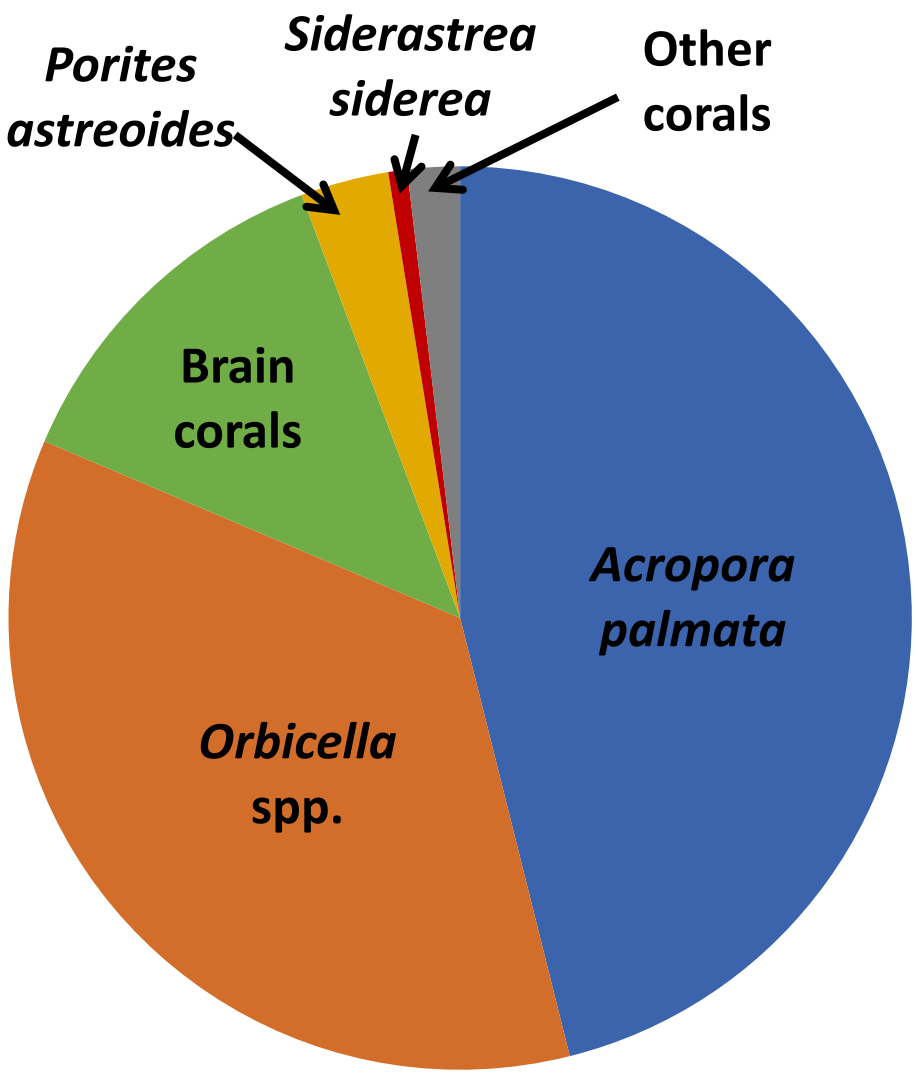
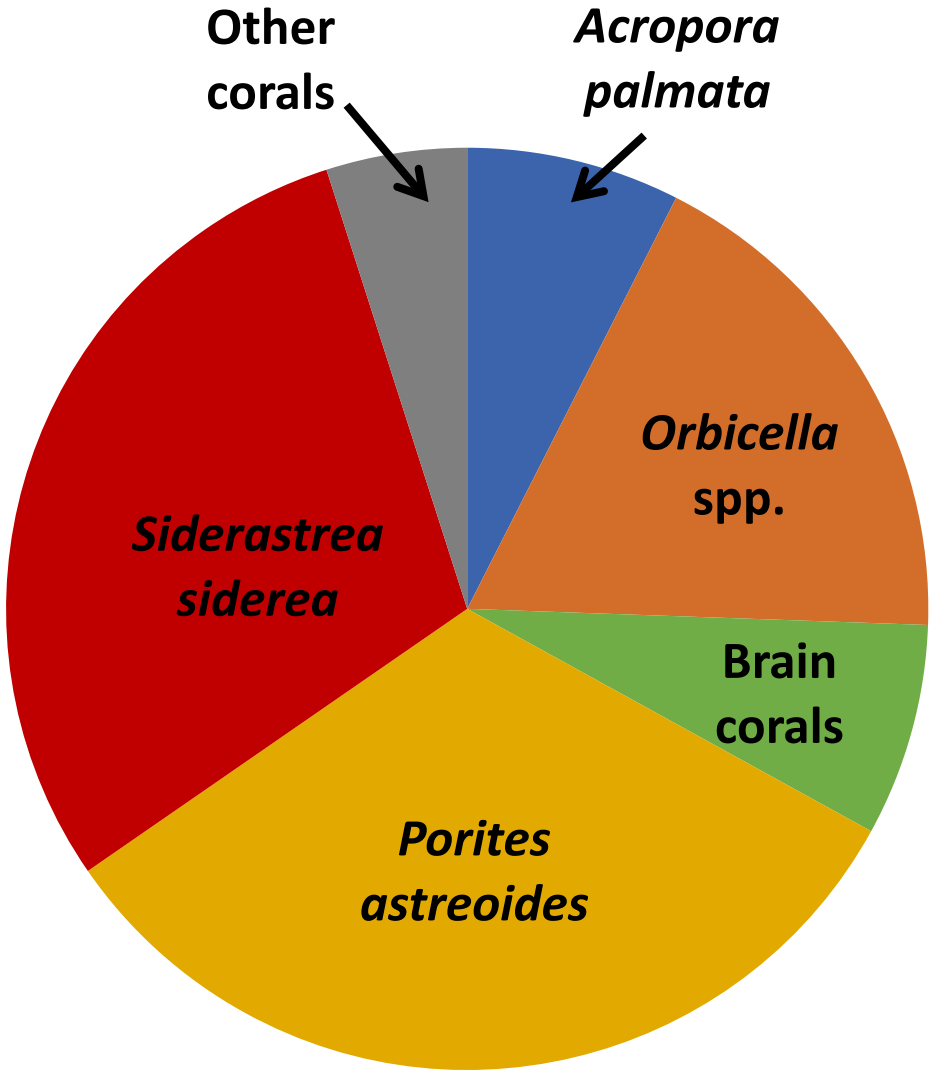
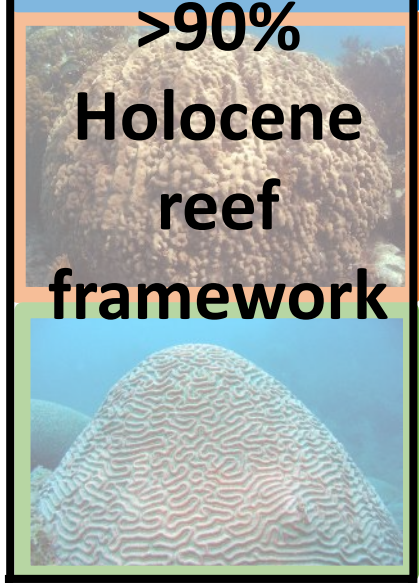
Geological reef framework

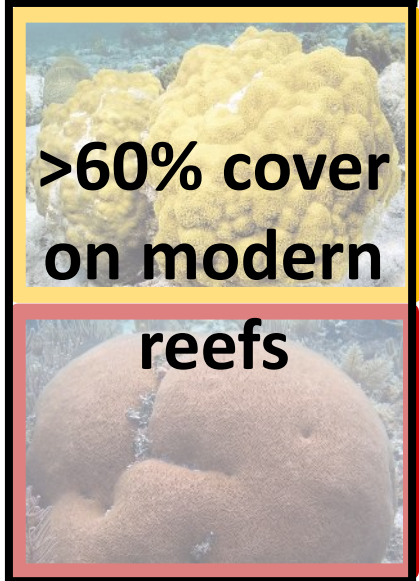


Modern Reefs



>90% Holocene reef framework





>60% cover on modern reefs

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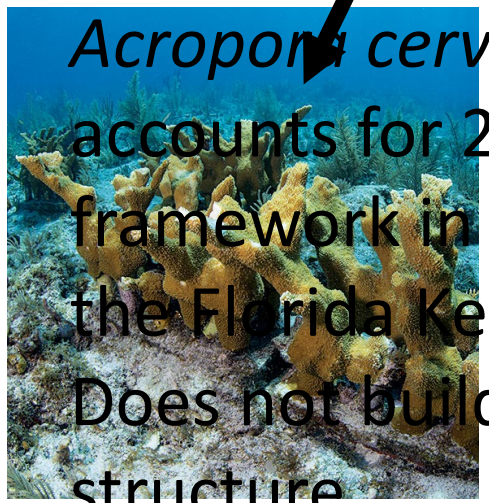
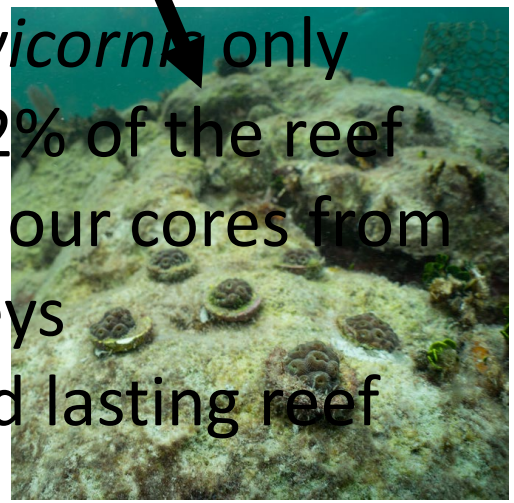
Toth et al. in press. Ecology

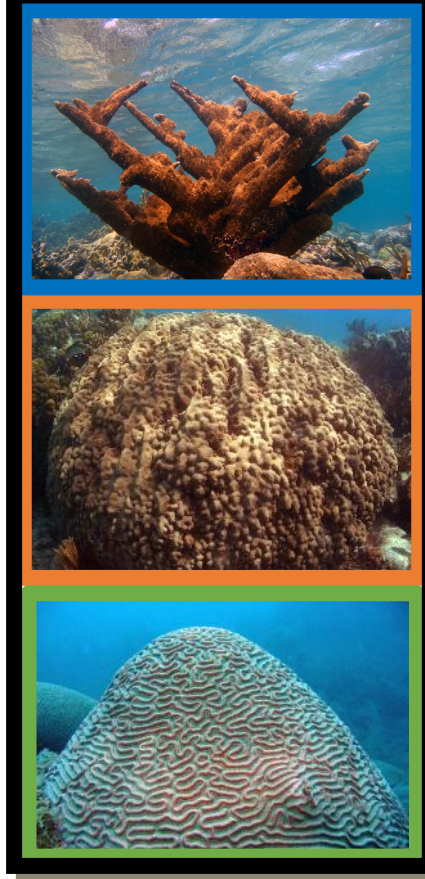
Collaborators: Rob Ruzicka and Mike Colella (FWRI, FL FWCC)
http://myfwc.com/research/habitat/coral/cremp/

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.

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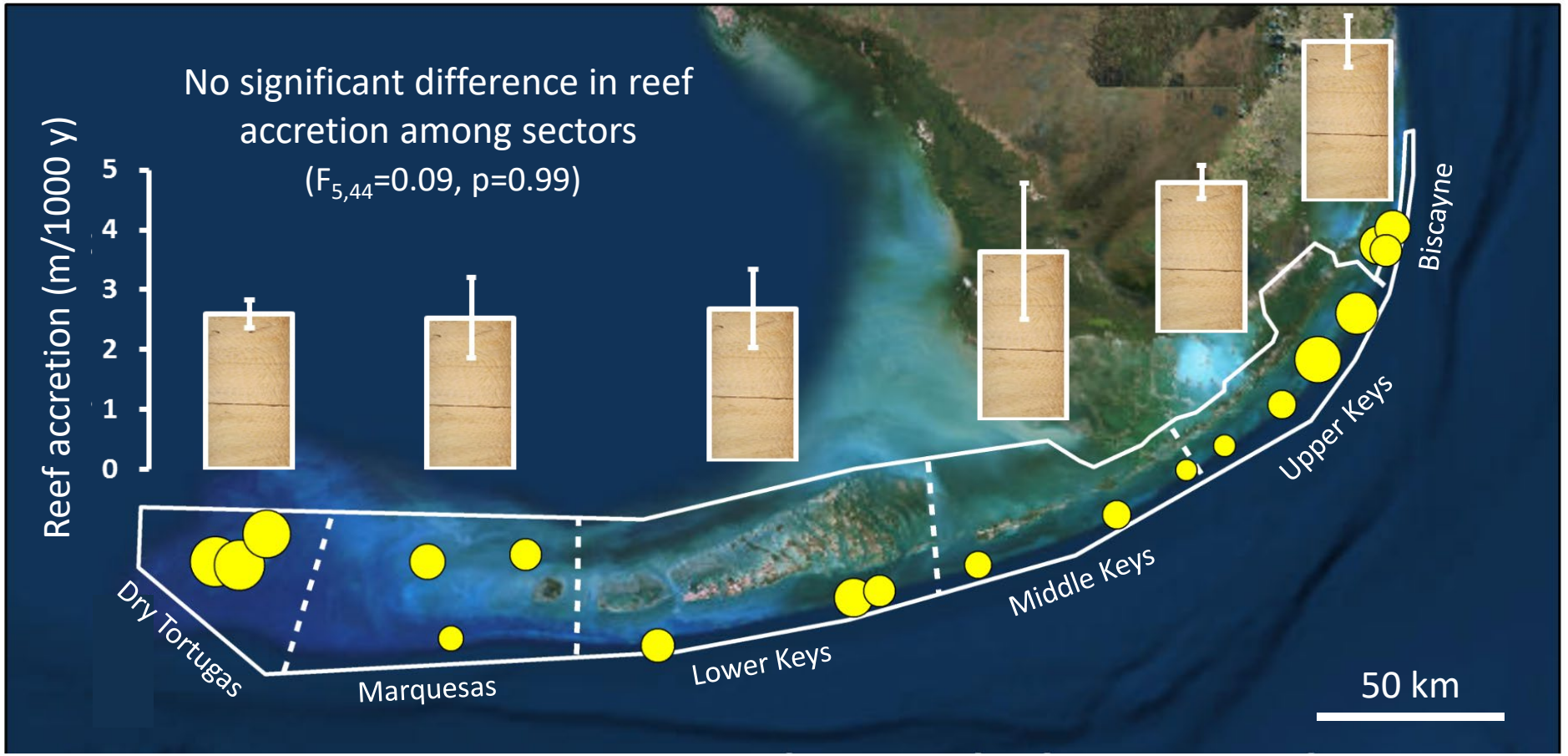
Spatial patterns of reef development



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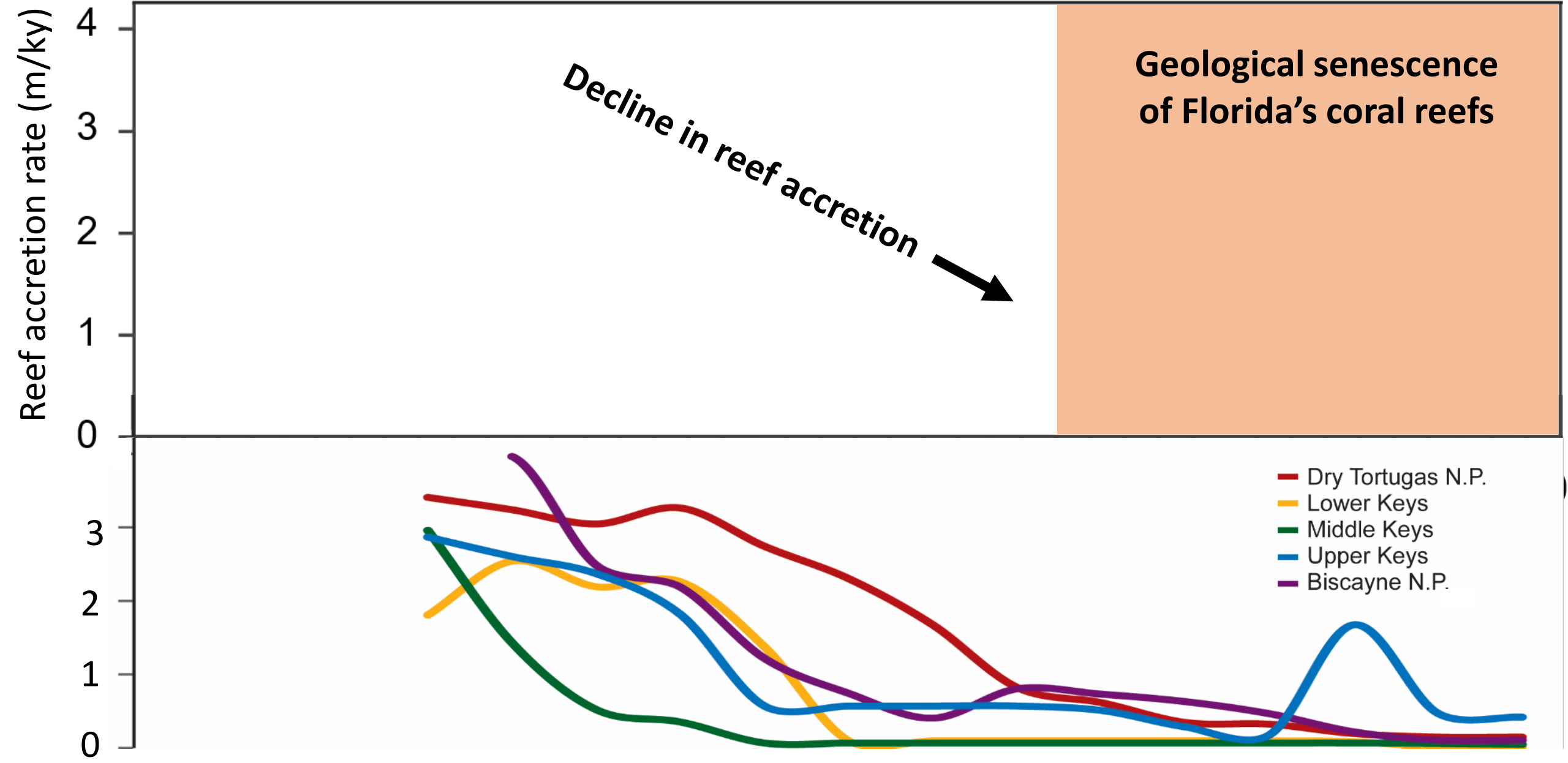
Reef accretion rate (m/ky)
4
3
2
1
0
Decline in reef accretion
Geological senescence of Florida's coral reefs
3
2
1
0
Dry Tortugas N.P.
Lower Keys
Middle Keys
Upper Keys
Biscayne N.P.

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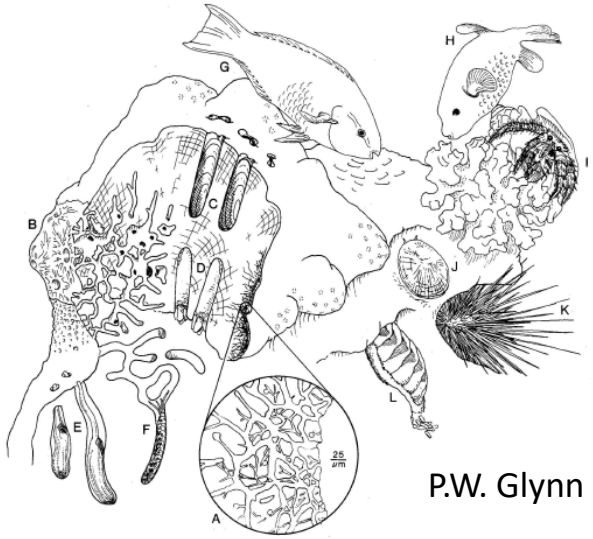
The carbonate budget of a coral reef

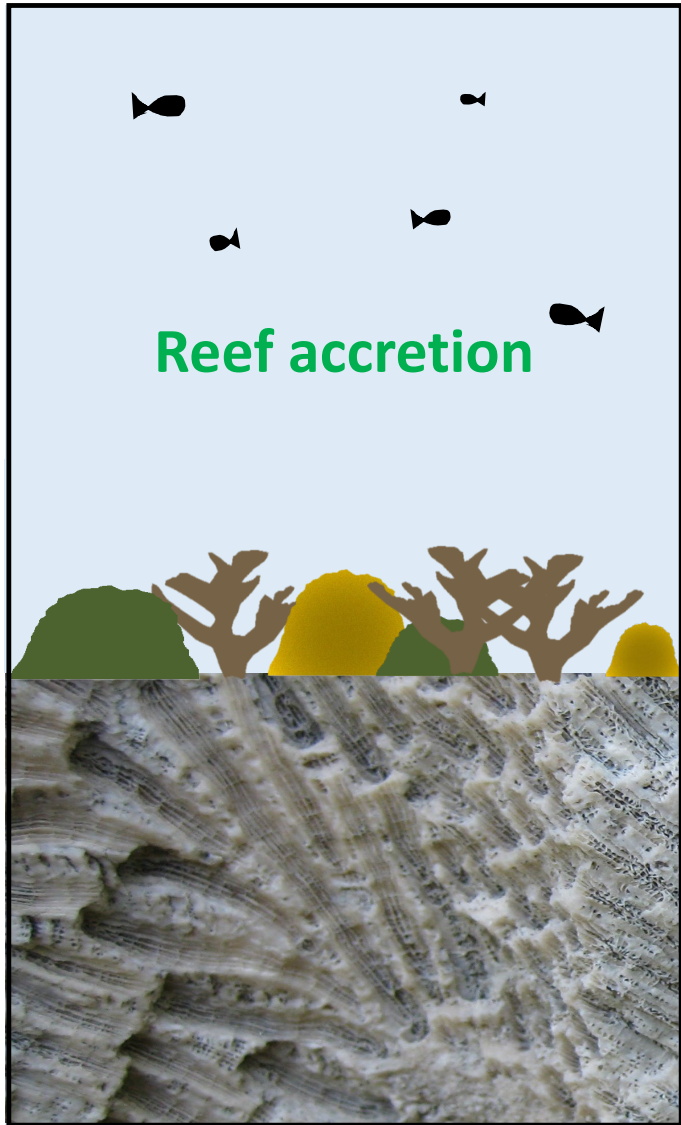
Carbonate Production

(calcification x coral cover x rugosity)

Bioerosion

(+ sediment export and dissolution)





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The carbonate budget of a coral reef

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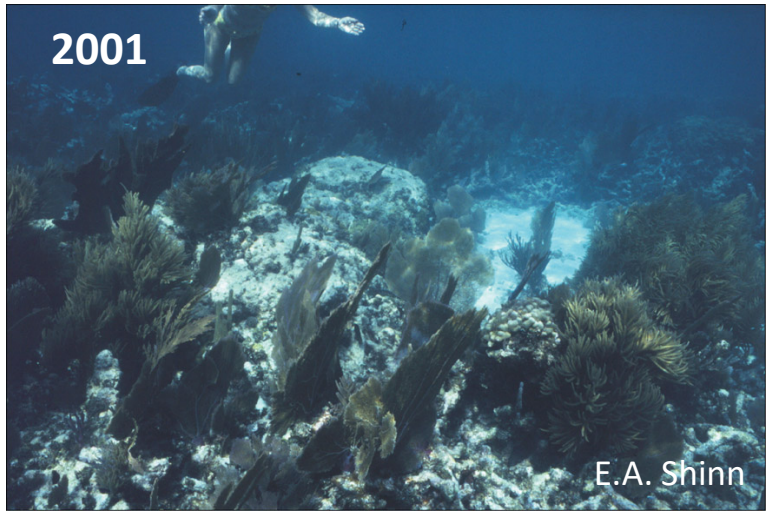
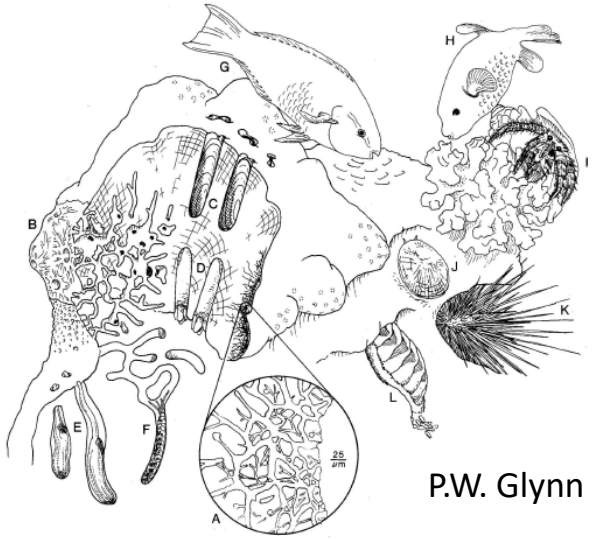
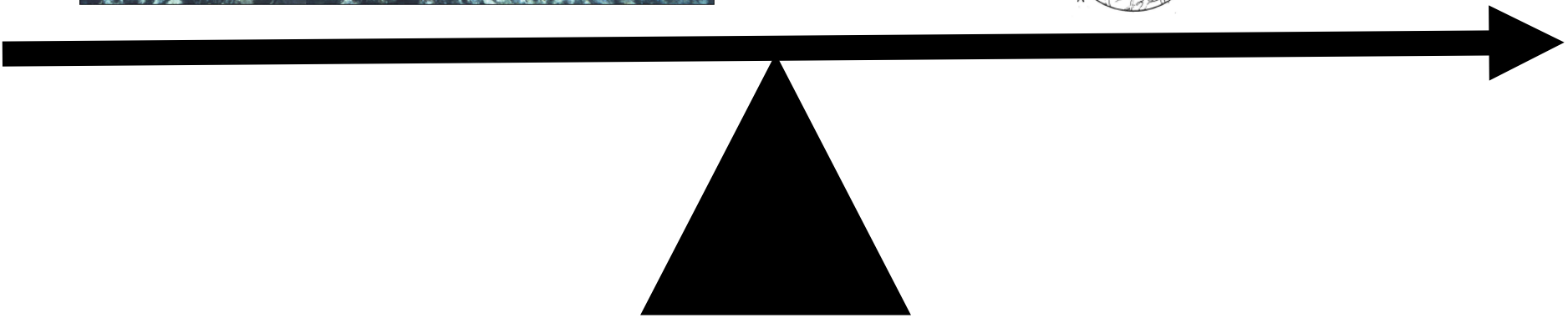
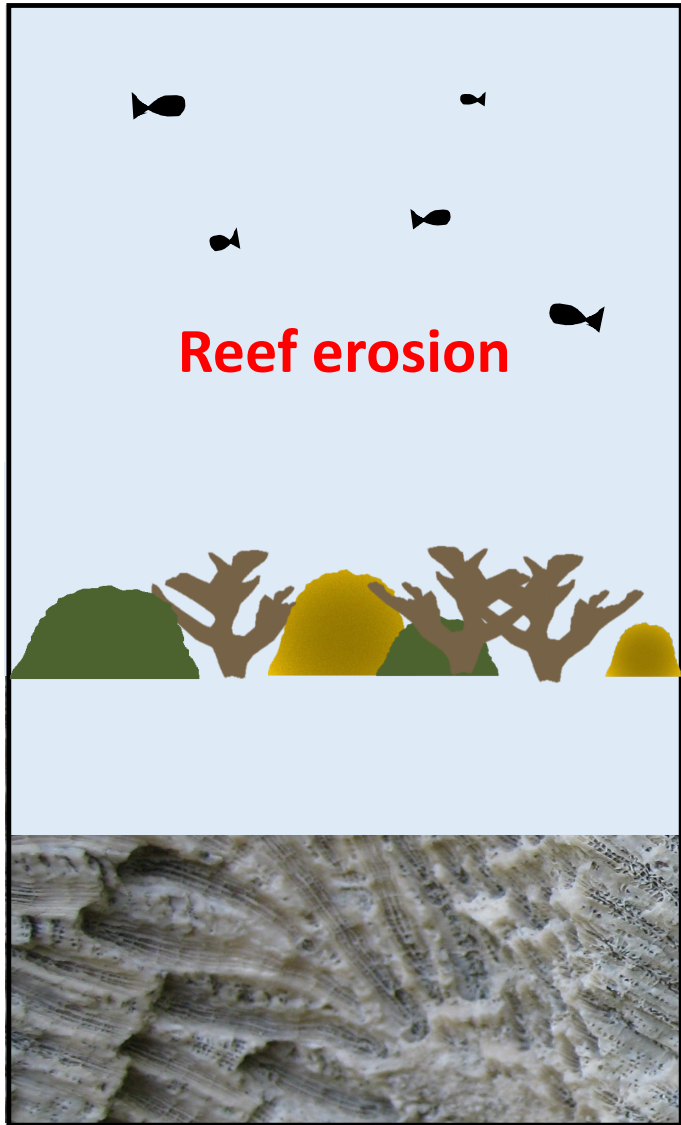


Bioerosion

(+ sediment export and dissolution)







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The carbonate budget of a coral reef

Carbonate Production

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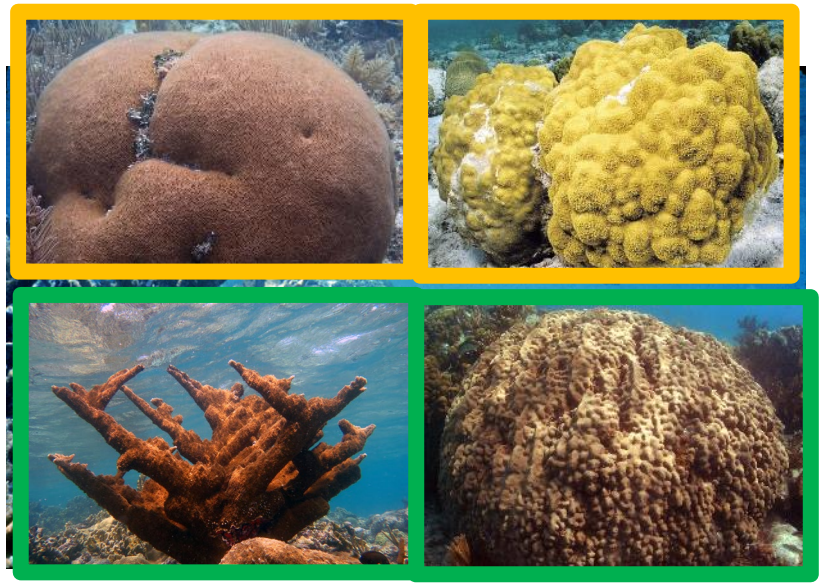
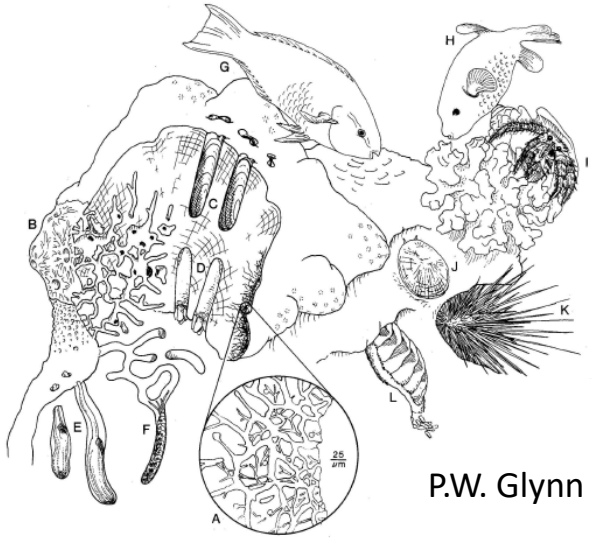
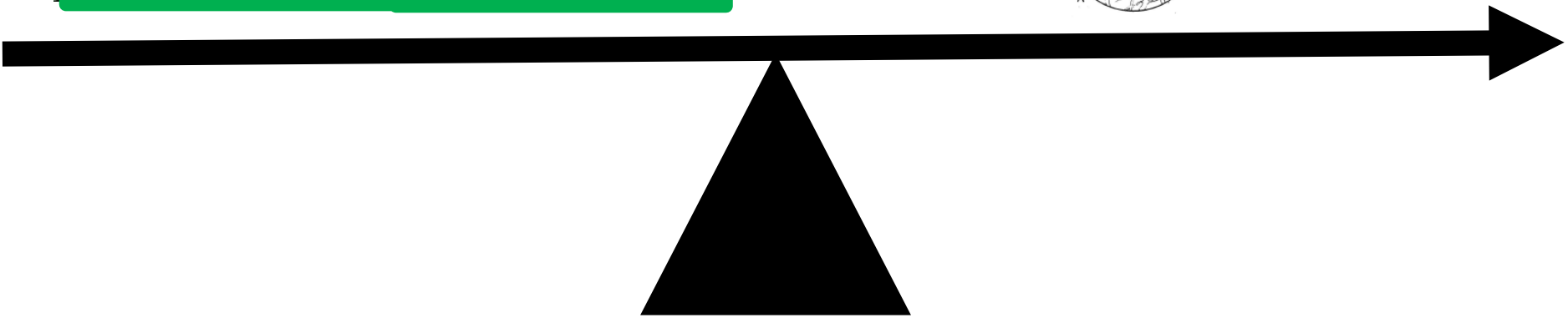


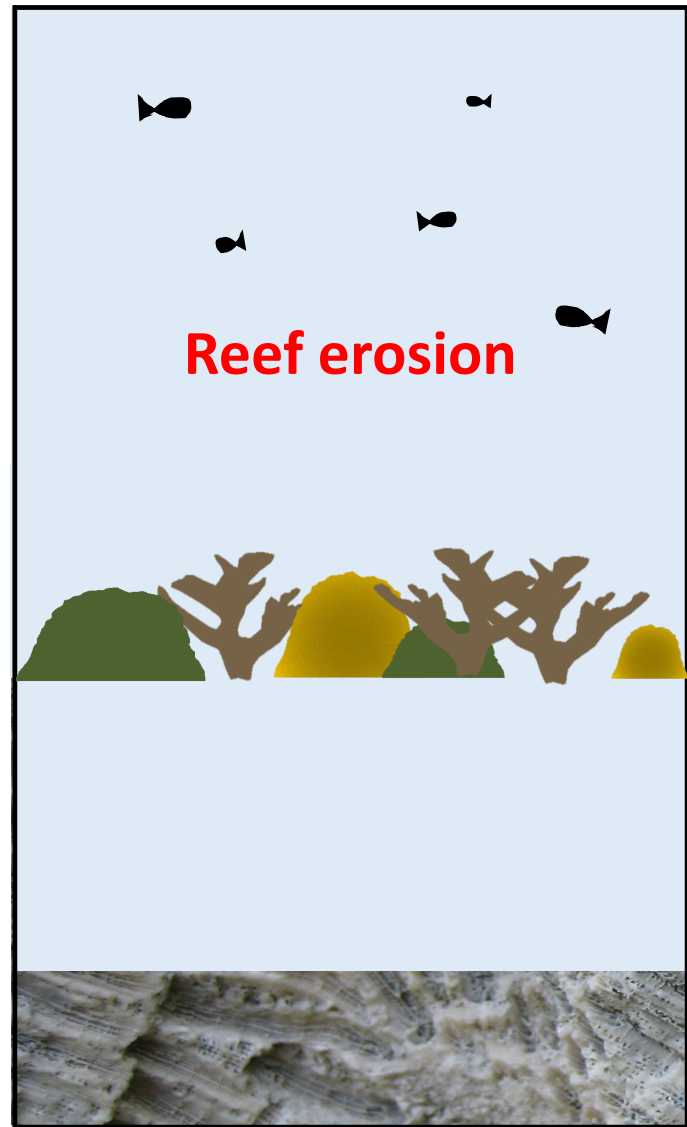
Bioerosion

(+ sediment export and dissolution)



P.W. Glynn





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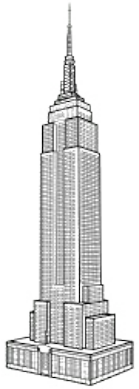
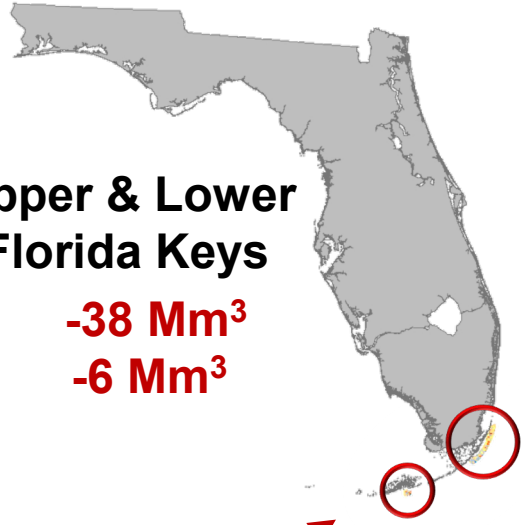
Large-scale trends in reef erosion since the 1930s

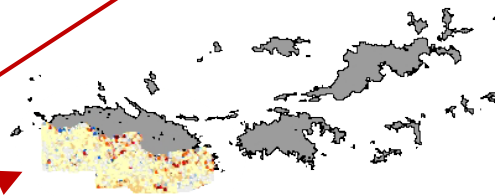


Empire State Building Volume = 1 Mm^3

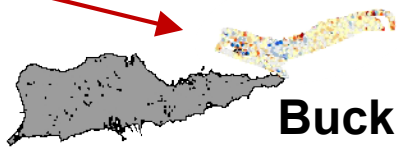
Maui, Hawaii
-81 Mm^3



Upper & Lower Florida Keys
-38 Mm^3
-6 Mm^3

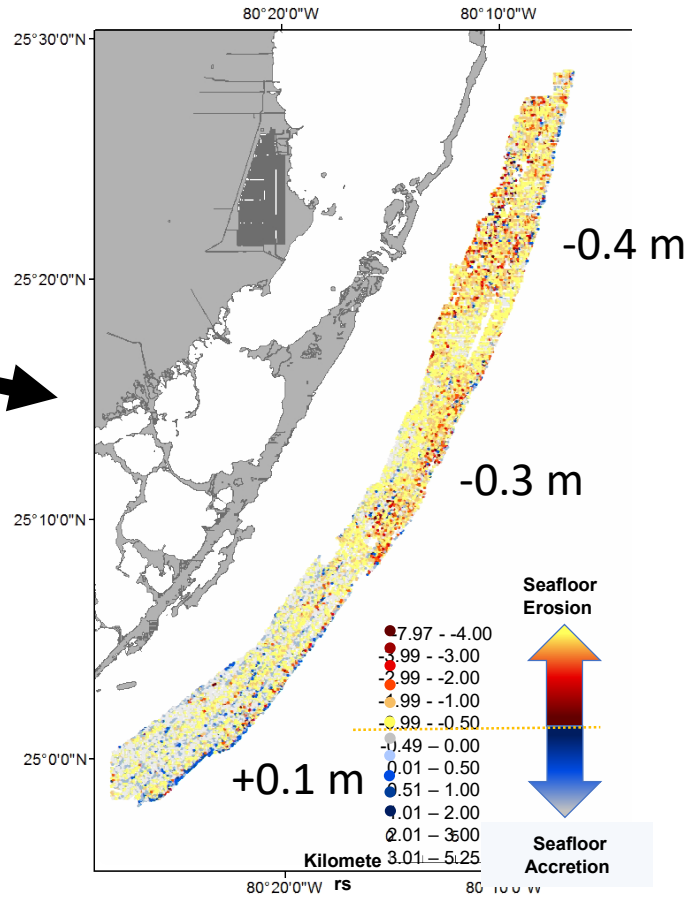


St. Thomas, USVI
-22 Mm^3



Buck Island
St. Croix, USVI
-3 Mm^3

Seafloor Elevation Change (m)



Kim Yates, Dave Zawada, et al.
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