Opening Thought Question – 3/15

List some of the stressors that can lead to coral bleaching

Investigating the distribution and ecological function of a crucial calcifier inside the hidden coral reef habitats of West Maui, Hawaii

Marine Bioinformatics
Anna Rothstein
Dr. Maya S. deVries
San Jose State University
March 16th, 2023

BACKGROUND ⇨METHODS ⇨RESULTS ⇨CONCLUSION

BACKGROUND

Benefits of Coral Reefs

Biodiversity

Coastal Protection

Fisheries

Tourism

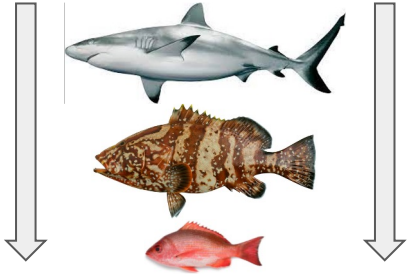
Medicine

Cultural Significance

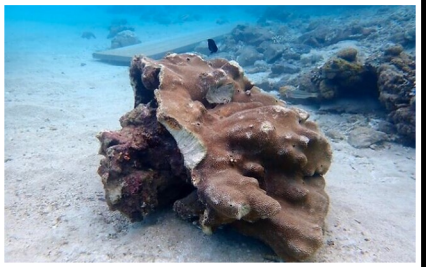
Threats to Coral Reefs

Temperature Rise

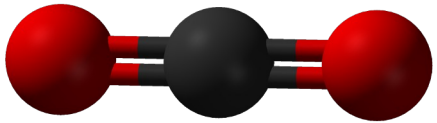
Overfishing



Storm Damage



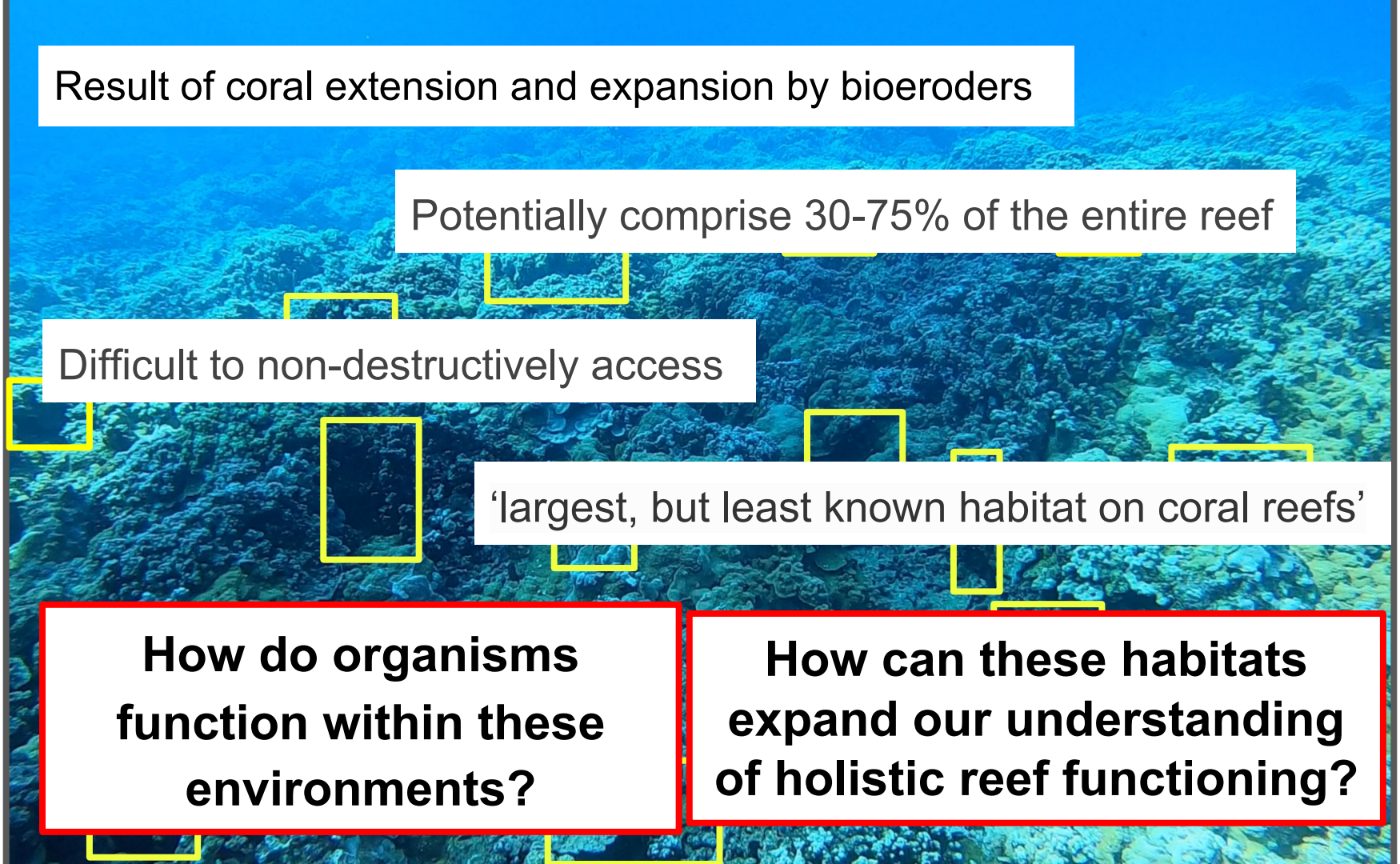
Ocean Acidification



Coastal Inputs

Coral Disease

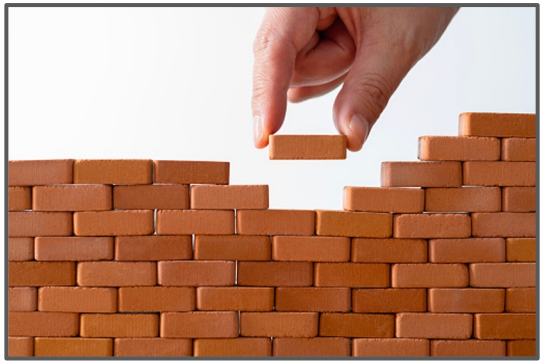

Molokini Crater, August 2022


Result of coral extension and expansion by bioeroders
Potentially comprise 30-75% of the entire reef
Difficult to non-destructively access
‘largest, but least known habitat on coral reefs’
How do organisms function within these environments?
How can these habitats expand our understanding of holistic reef functioning?

Crustose Coralline Algae (CCA)

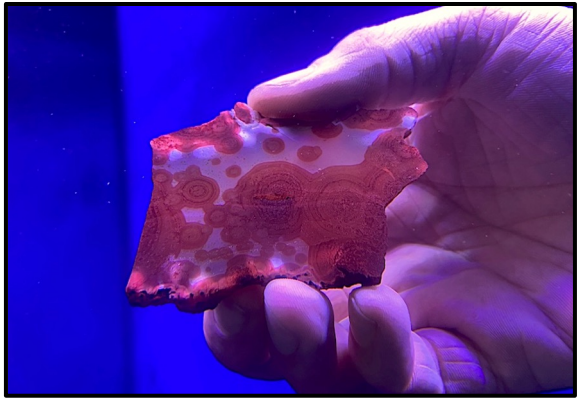
Coral Recruitment Habitat

Accretion

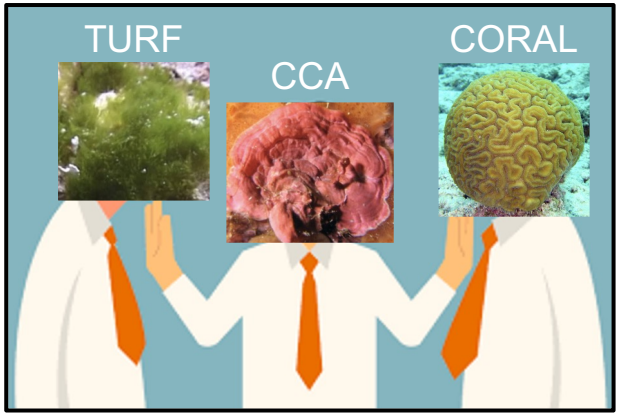


Stabilizes Sediments

Low light, no problem!



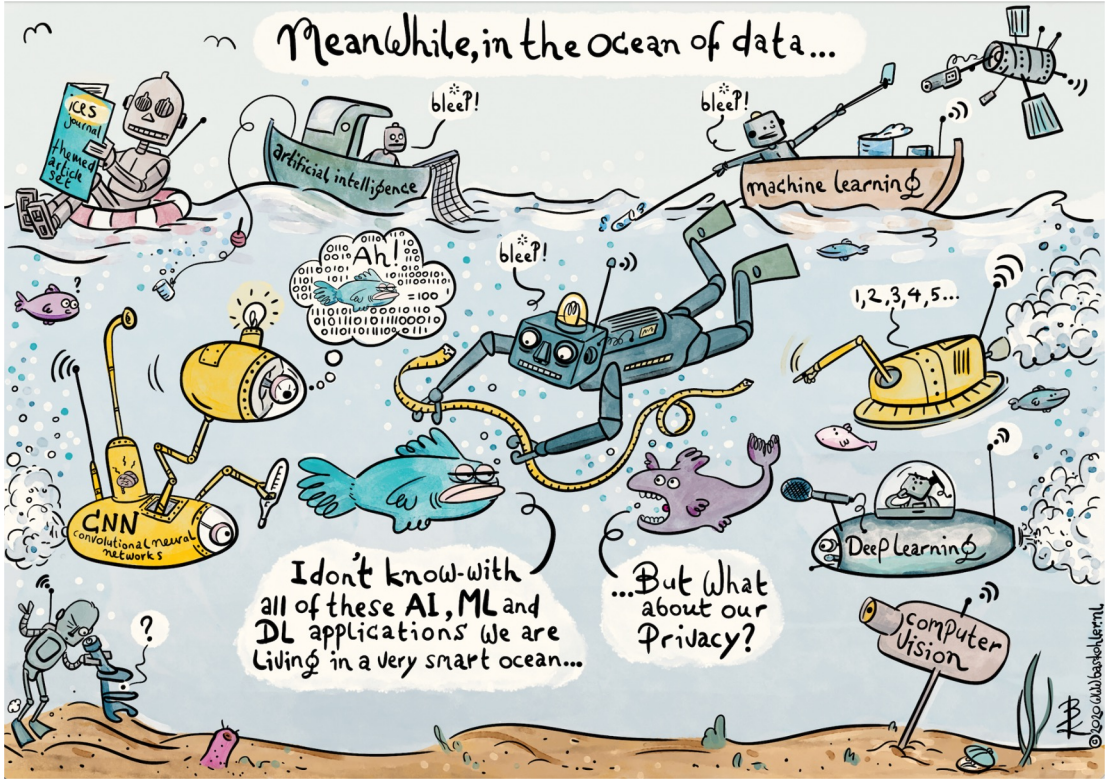
Ecological Mediators



Artificial Intelligence and the Ocean

- Can deep machine learning models analyze percent cover of benthic organisms autonomously?

Dr. Philip Heller, Professor of Computer Science, SJSU



ICES, 2020

Questions/Hypotheses

Question 1

Where is CCA found in crevices?

Hypotheses:

1. **CCA cover will decrease as you go deeper into the crevice**
    - Deeper crevices -> less light -> less CCA growth

1. **CCA cover will be greater on the ceiling of crevice than the wall**
    - Sediment less likely to settle on ceiling

Questions/Hypotheses

Question 2

What abiotic factors may govern CCA distribution?

Hypotheses:

1. **Light**
   - Higher CCA cover in crevices with higher light availability

1. **Sediment**
   - More sediment/sediment-laden turf on wall than ceiling
   - Higher CCA cover will be associated with lower sediment/sediment laden turf cover

Questions/Hypotheses

Question 3

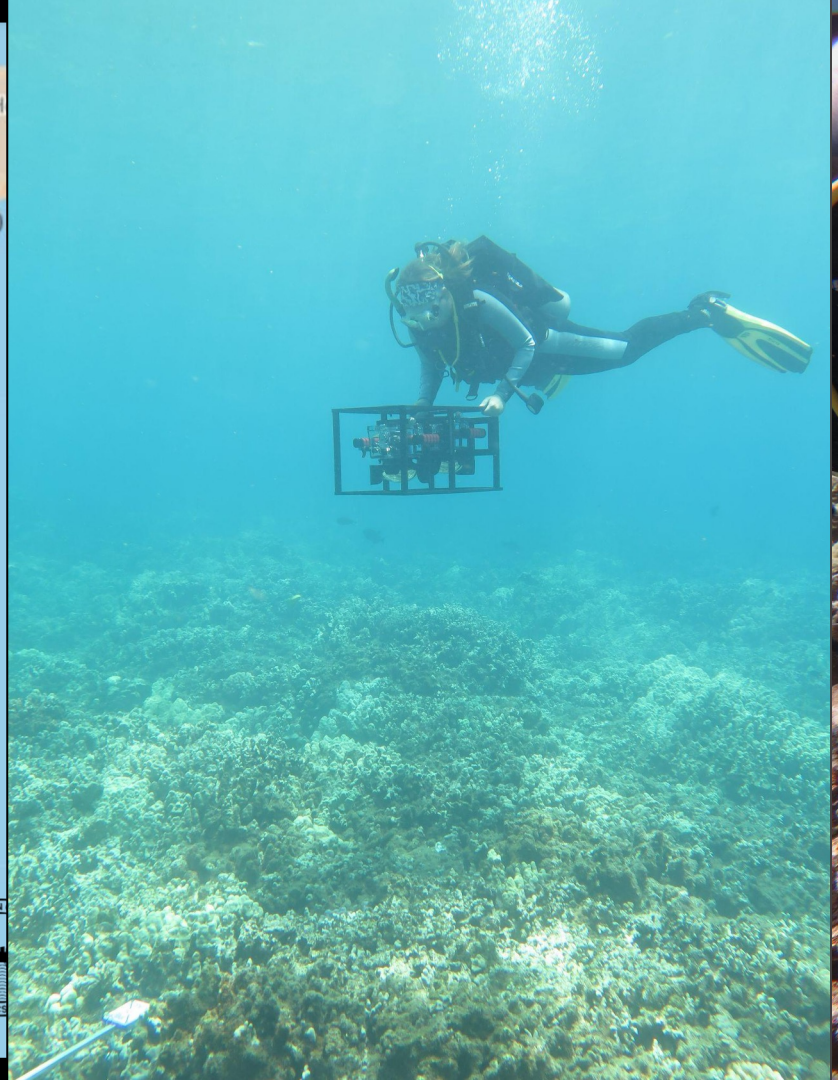
How does internal reef CCA contribution compare to top-reef CCA contribution?

Hypothesis: **Too many complex ecological interactions to consider**

	TOP-REEF	CREVICE
Light	⇧	⇩
Sediment	⇩	⇧
Grazers	⇧	⇩
Benthic Competition	⇧	⇩

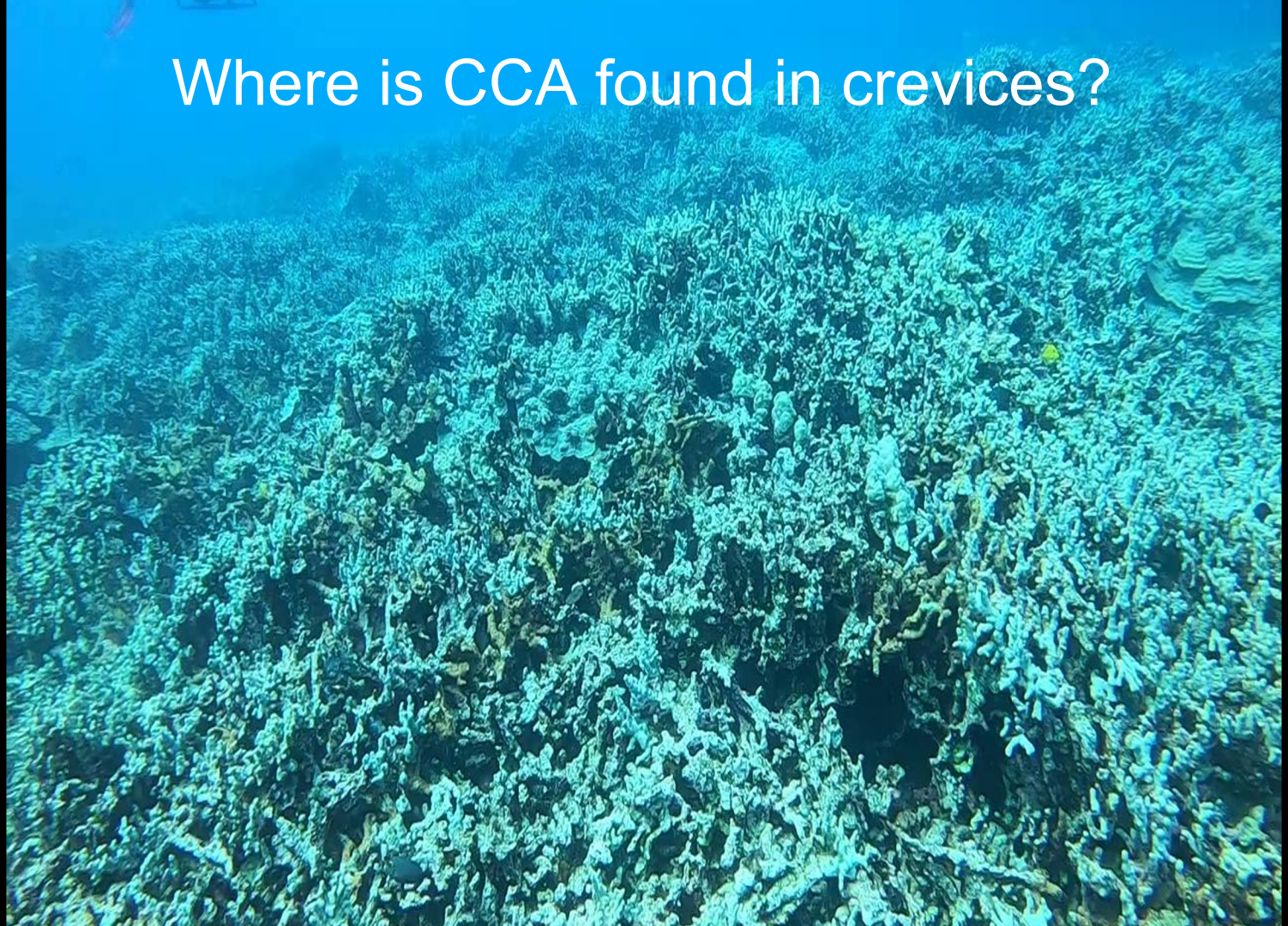
*** pink arrows indicate conditions that benefit CCA

METHODS



Question 1: Where is CCA found in crevices?

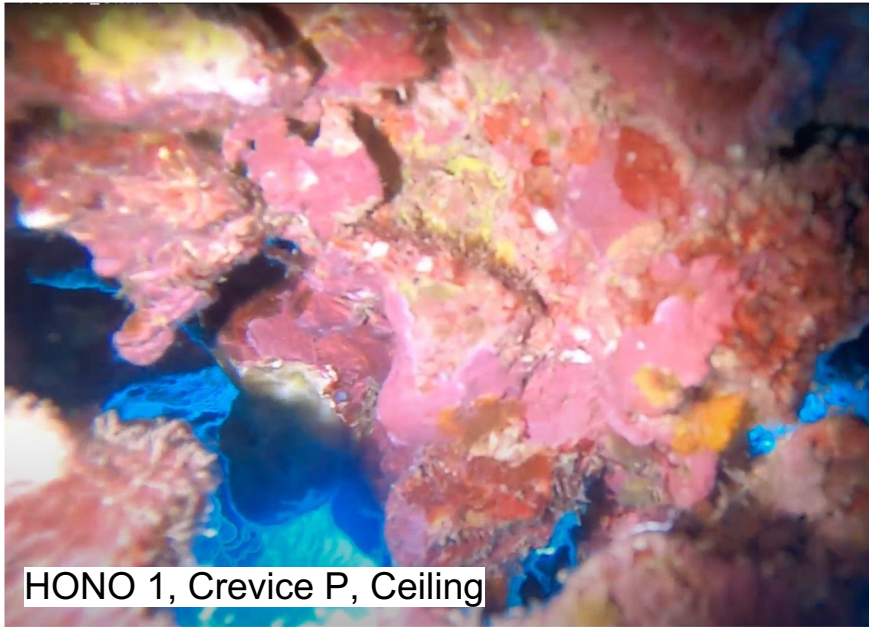
Where is CCA found in crevices?



Quantifying CCA % Cover

- Screenshot of wall and ceiling taken at max probe depth

HONO 1, Crevice P, Wall

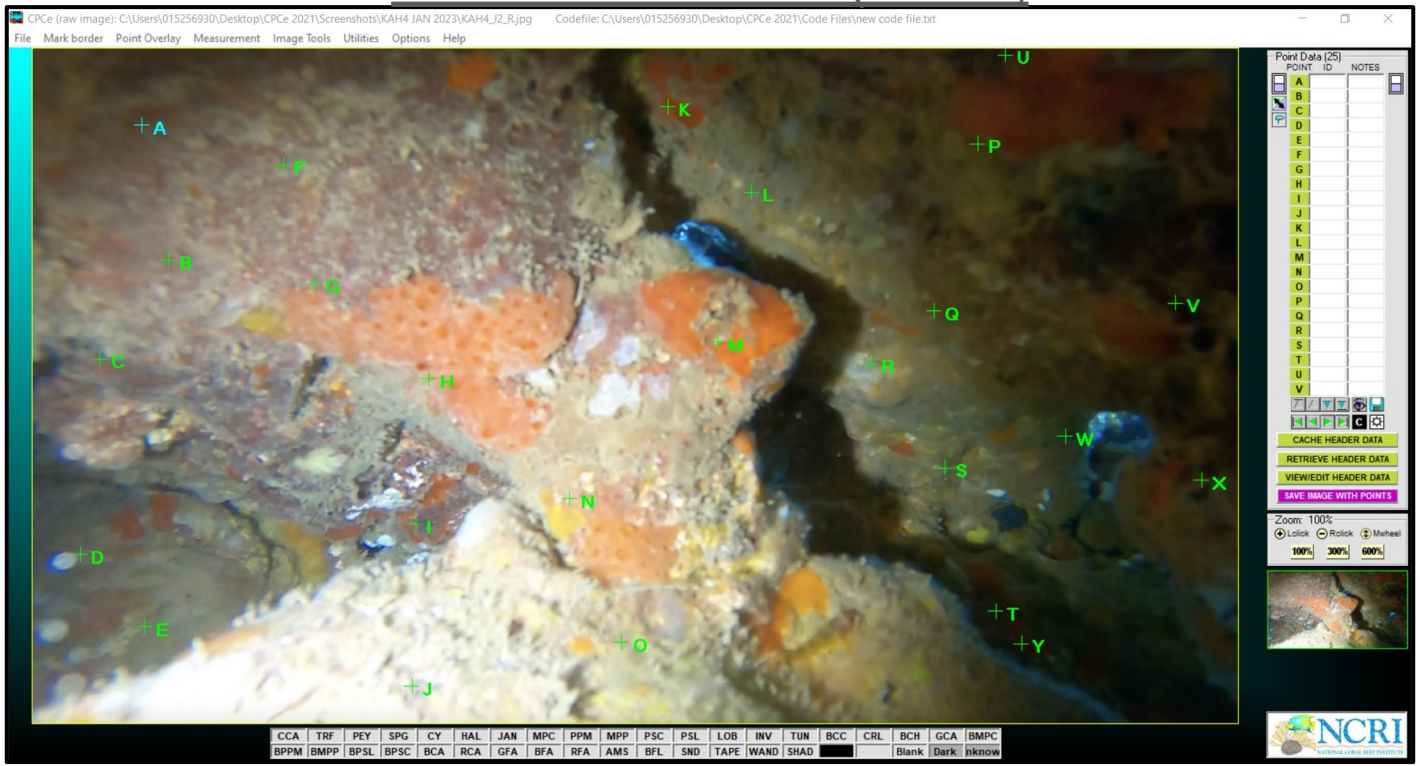


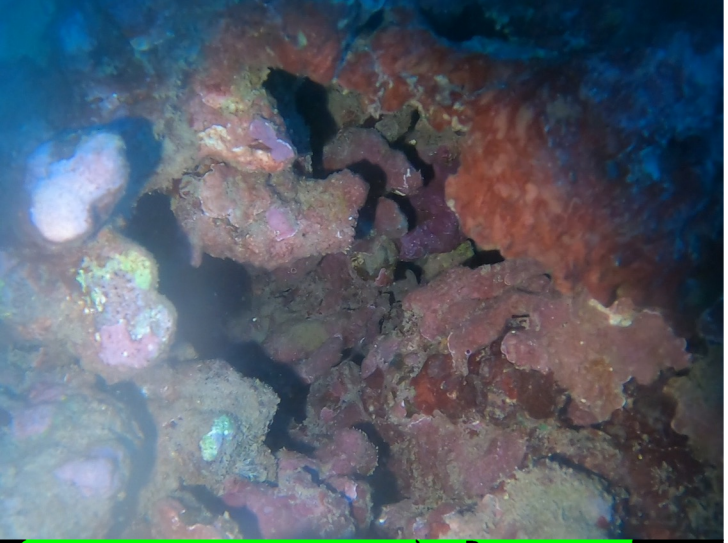
HONO 1, Crevice P, Ceiling

Quantifying CCA % Cover

- Calculated percent cover of benthic species

Coral Point Count (CPCe)



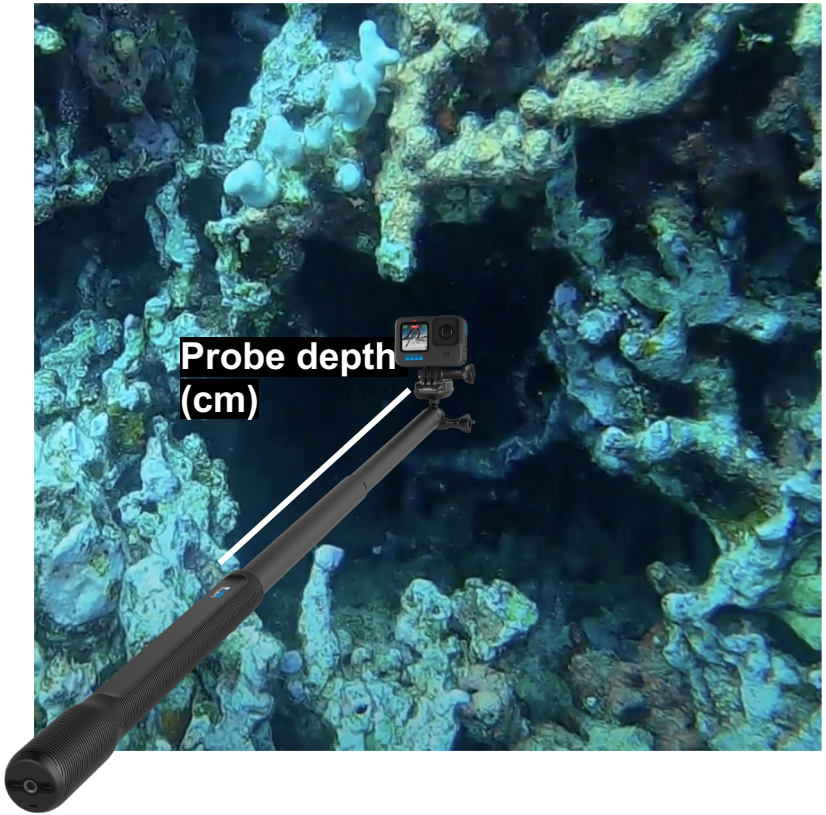


Quantifying benthic cover: CPCe vs. AI

- **Deep Machine Learning Technique**
  - Fully automated- improves accuracy and removes human user.
  - Trained to trace CCA “patches”
    - calculates percent cover by comparing # of pixels traced (pink) to total # of pixels of image.

Quantifying CCA Zonation in Crevices

- Compared % cover of CCA to probe depth of camera.
- Compared % cover of CCA between wall and ceiling.



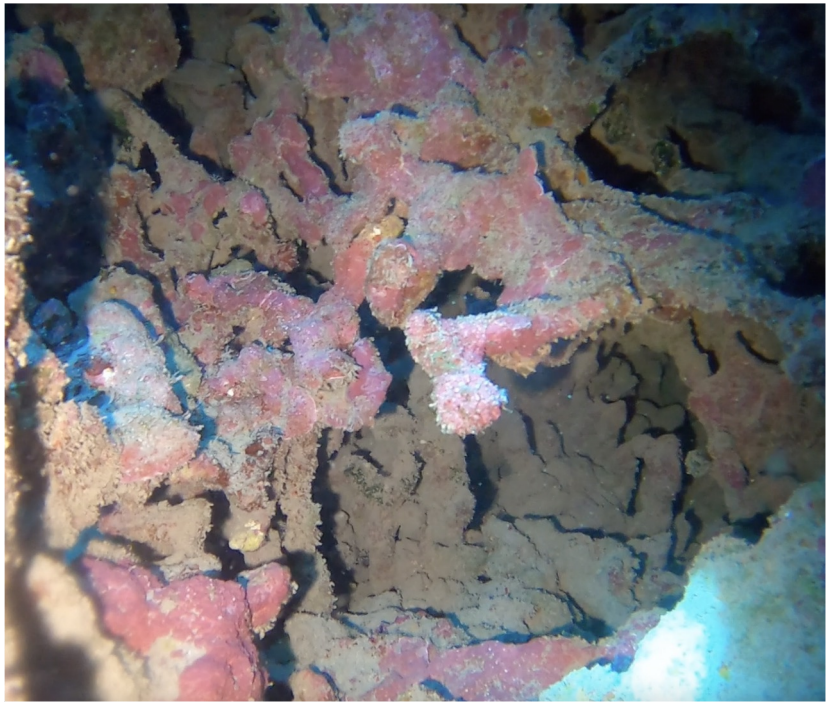
Question 2: What abiotic factors may govern CCA distribution?

Measuring Abiotic Factors- Light

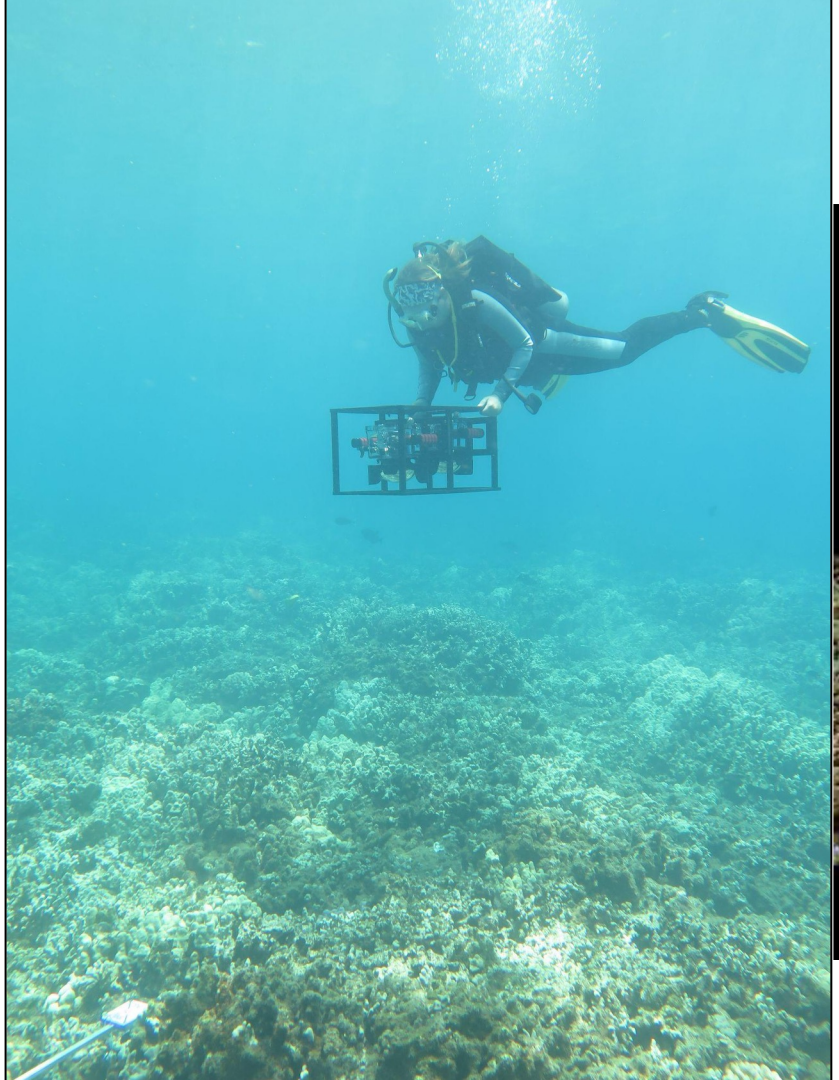
- HOBO pendant light loggers left in crevice for ~1min at same probe depth as GoPro.
- Average light (lumens) compared to % cover of CCA.

Measuring Abiotic Factors- Sediment

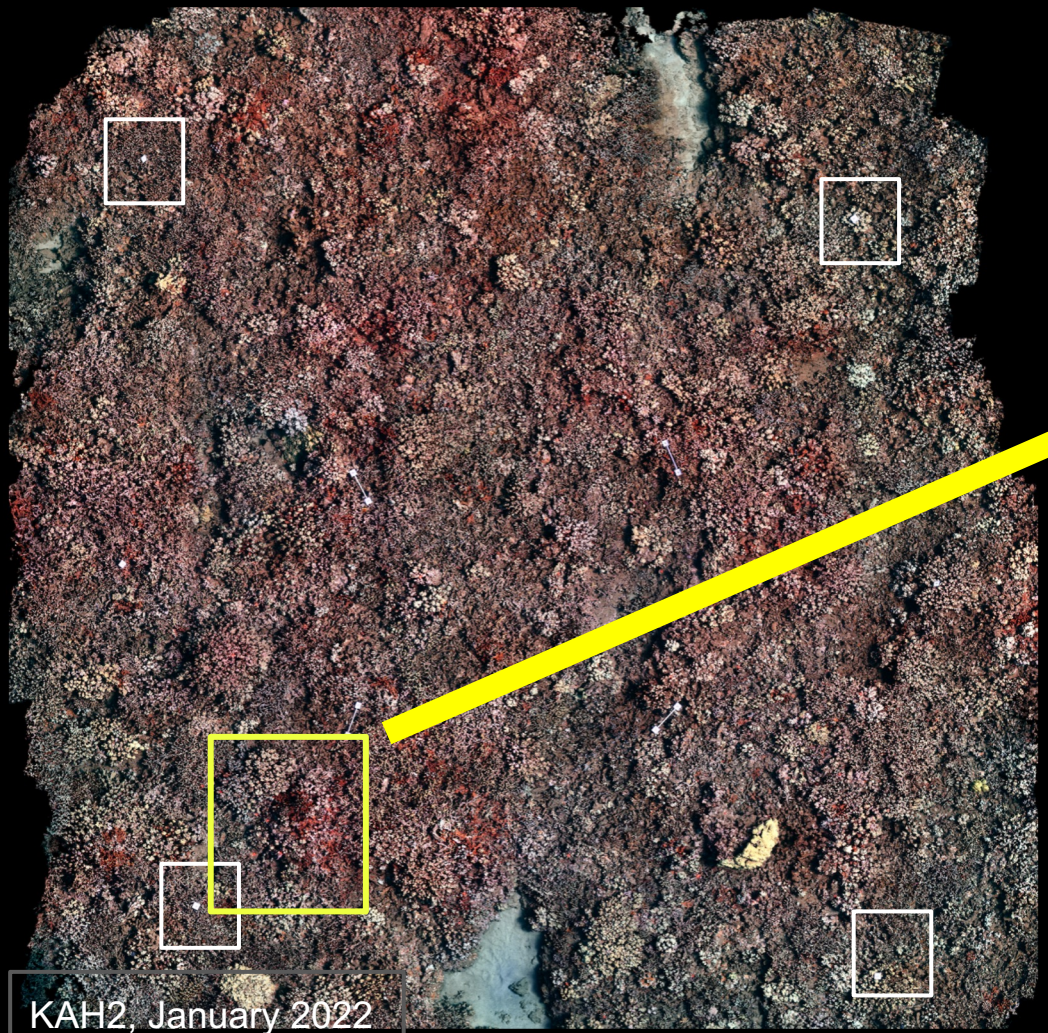
- Measured percent cover of sediment + sediment laden turf
  - CPCe
- Compared CCA % cover to sediment % cover
  - Wall vs. Ceiling



Question 3: How does internal reef CCA contribution compare to top-reef CCA contribution?




BAR
1001IslandChallenge.org



KAH2, January 2022

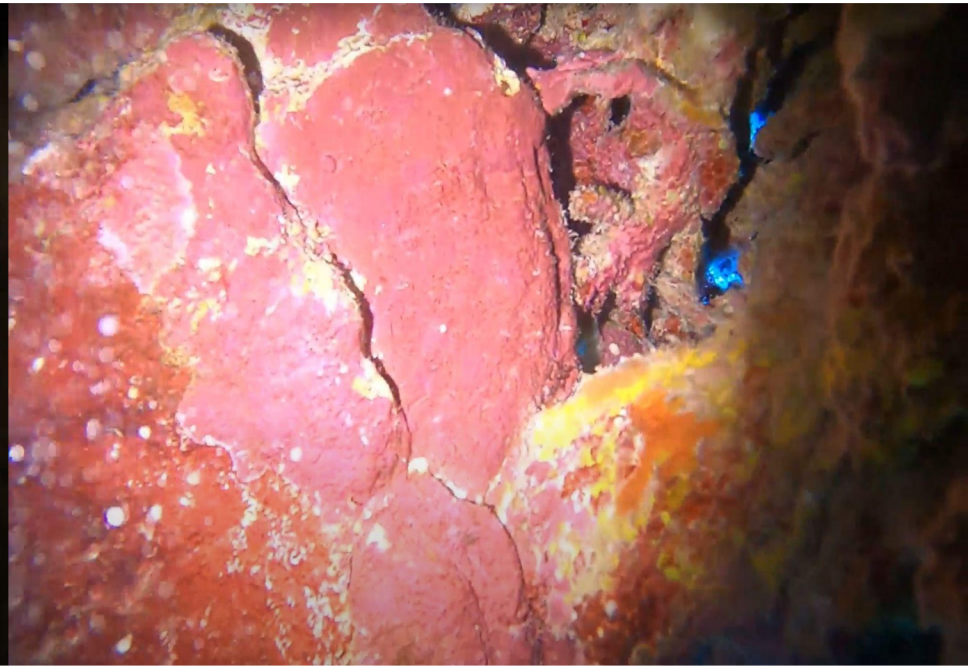
- Extract 12 “quadrats” covering entire plot
  - Calculate CCA % cover
  - Compare to average internal reef CCA cover at same site

RESULTS

Question 1: Where is CCA found in crevices?

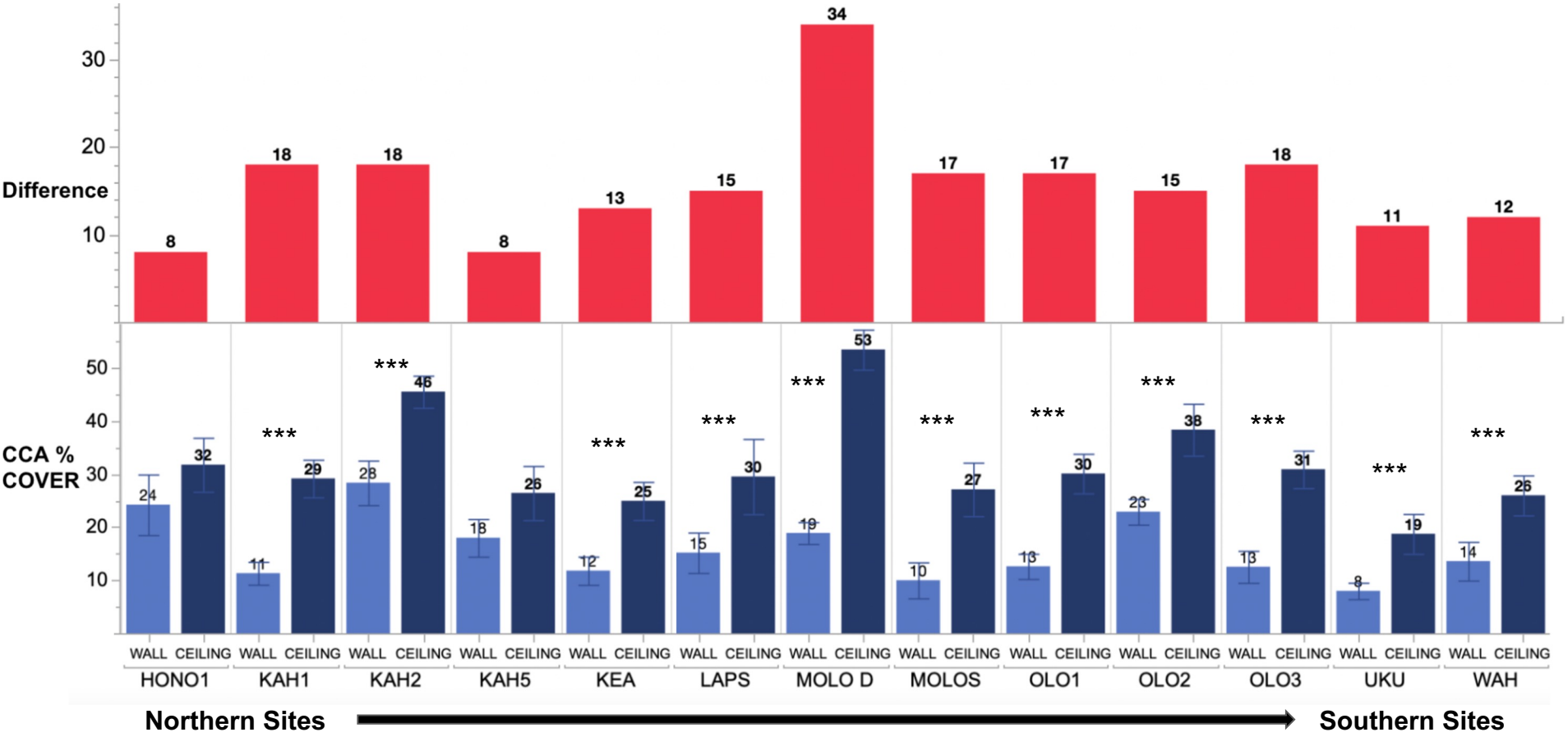
Results: Ceiling vs. Wall

Wall

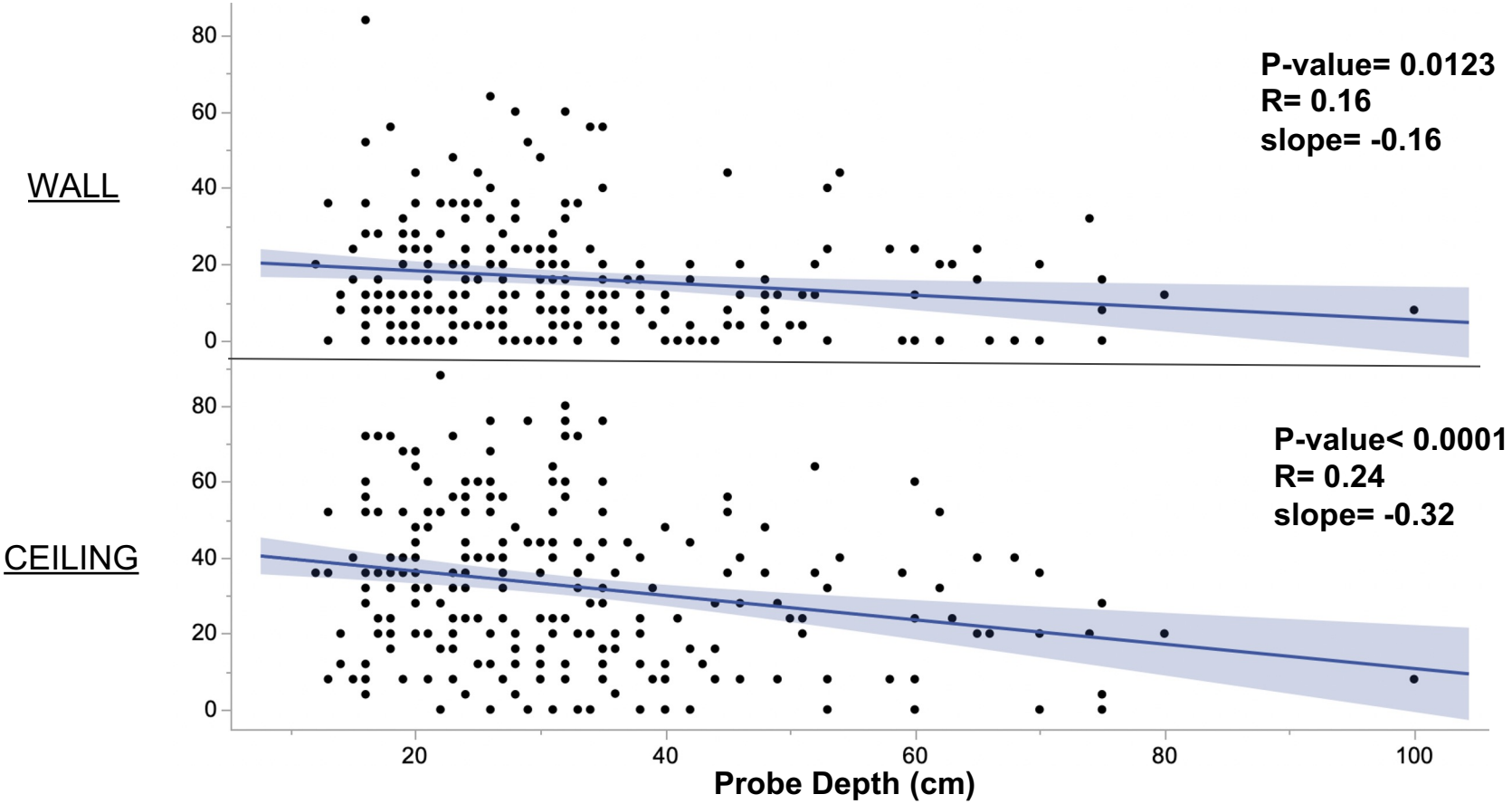


Ceiling

Results: More CCA on Ceiling than Walls at all Sites

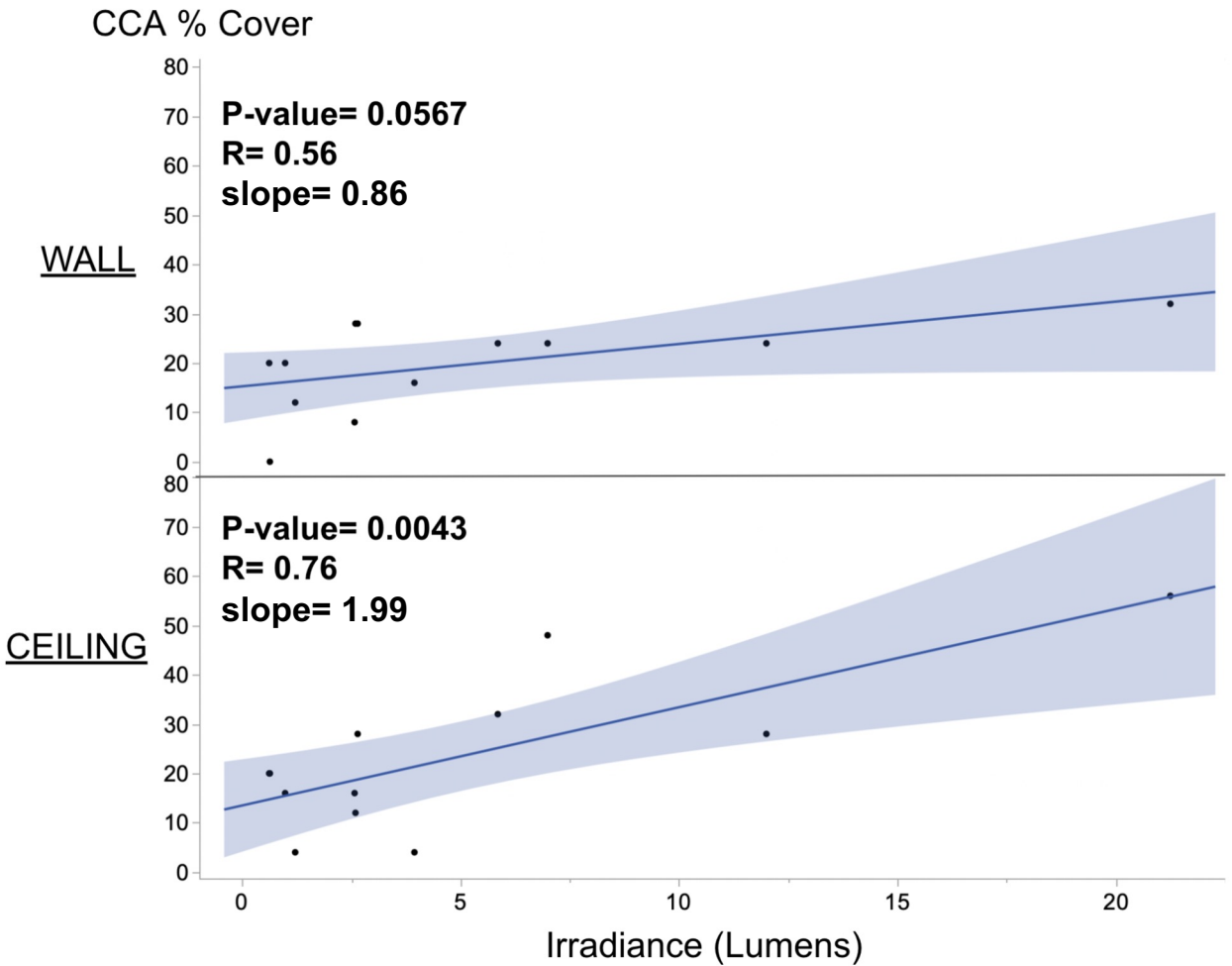


Results: CCA Zonation in Crevices

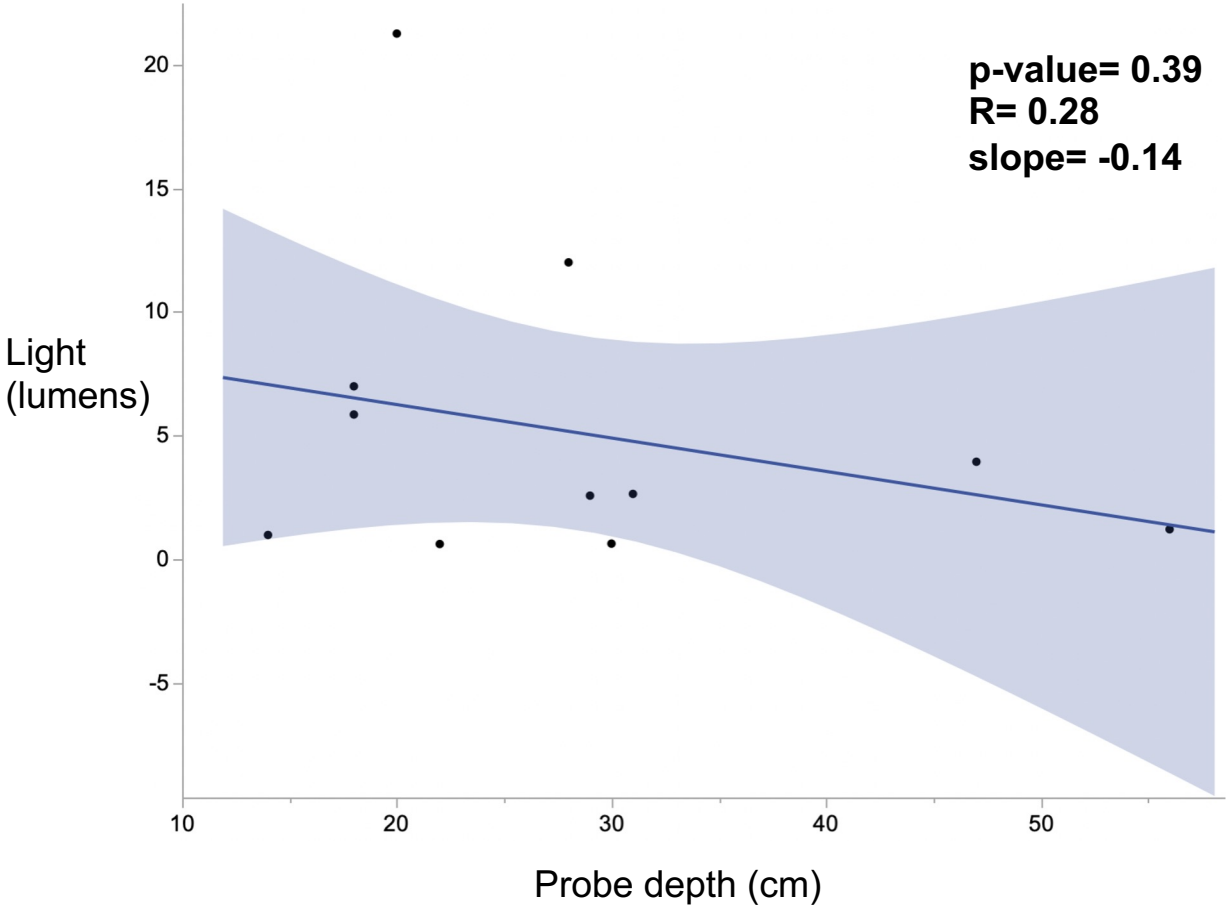


Question 2: What abiotic factors may govern CCA distribution inside crevices?

Results: More CCA Associate with Increased Light Availability



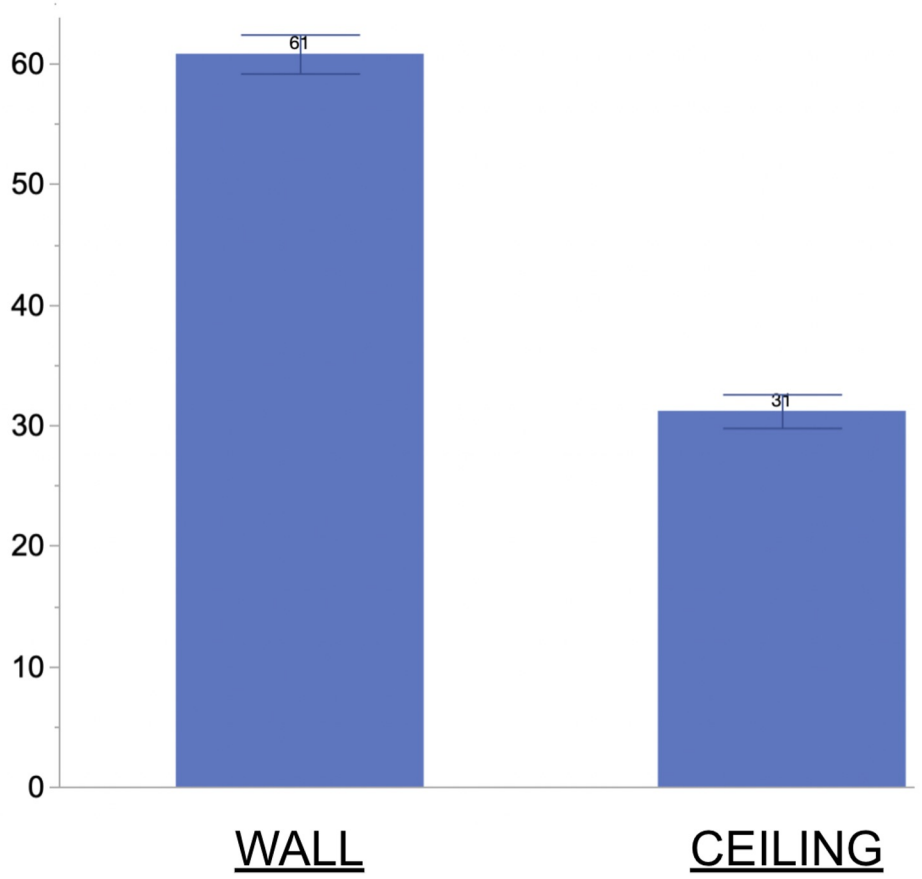
Light zonation in crevices



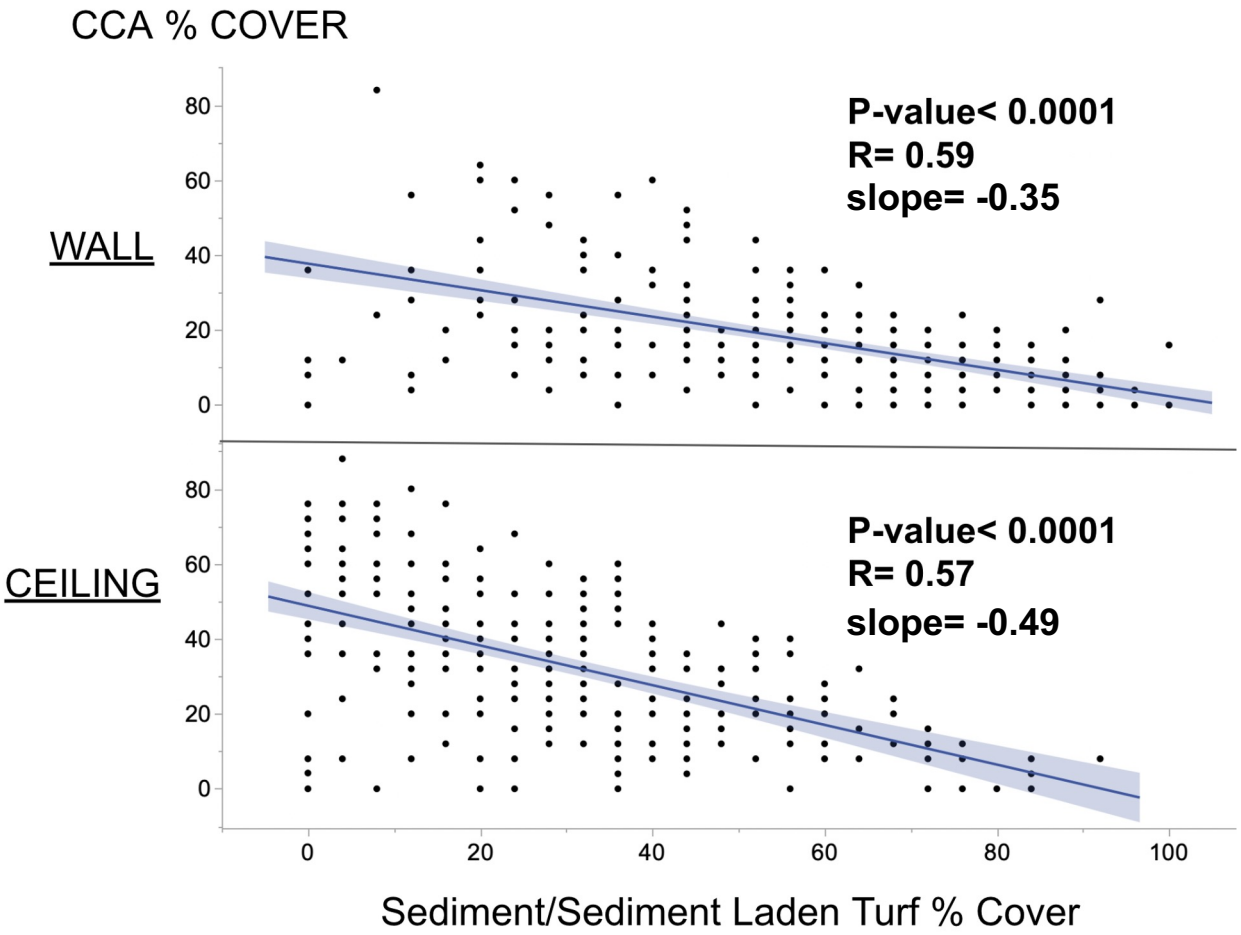
- Higher CCA cover associated with more light
- Deeper probe depth not associated with less light
  - Cracks in matrix

Results: More Sediment on Wall Associated with Less CCA

Sediment/Sediment Laden Turf % Cover



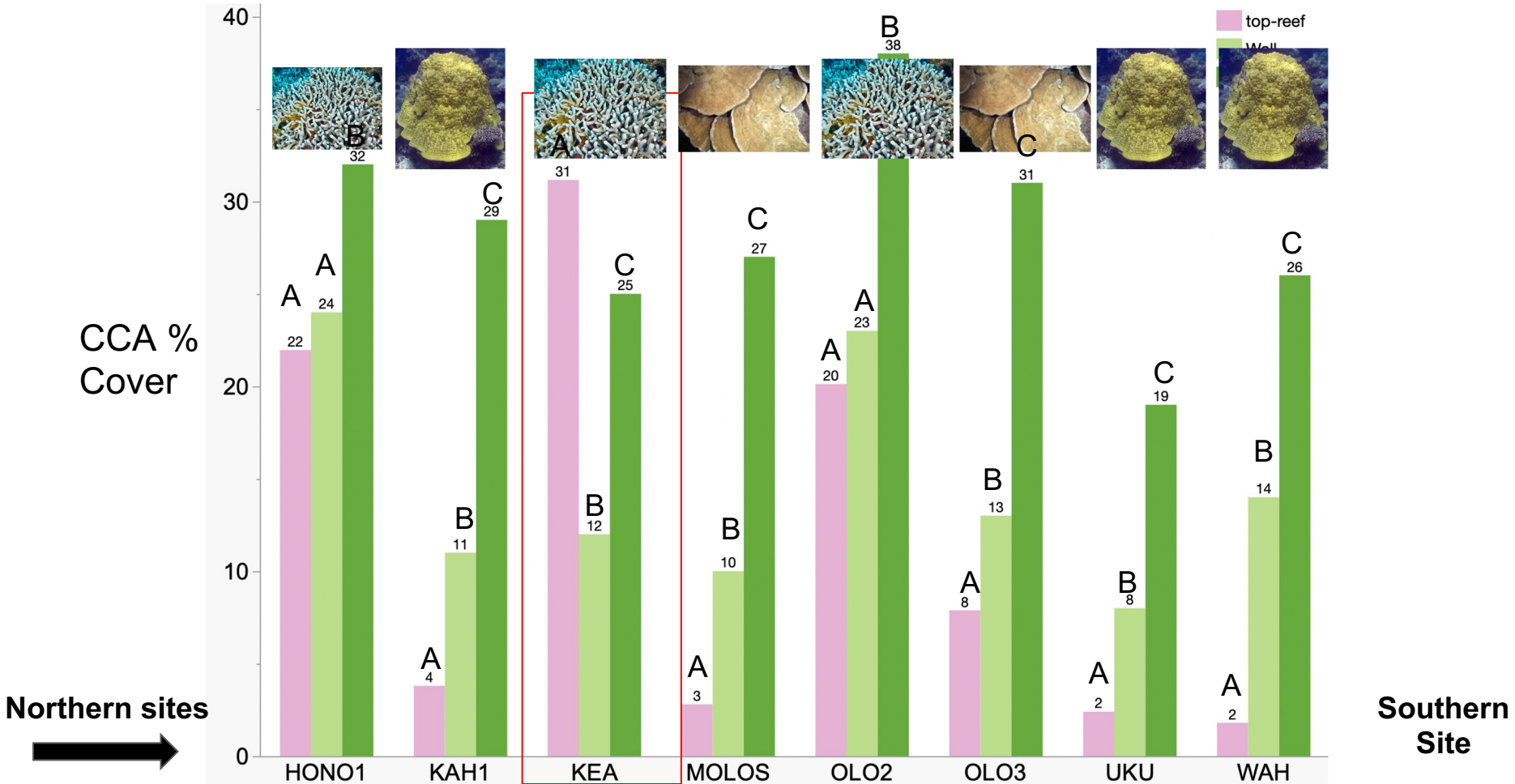
Results: More Sediment on Wall Associated with Less CCA



- Higher sediment/sediment laden turf cover associated with lower CCA cover
  - Found on both wall and ceiling

Question 3: How does internal reef CCA contribution compare to top-reef CCA contribution?

Results: Top-reef CCA less than internal reef CCA cover



Results: Top-reef CCA less than internal reef CCA cover

Conclusions

To Review:

<u>Question 1</u>: Where is CCA found in crevices?

- Most CCA found on the ceiling at crevice openings

<u>Question 2</u>: What abiotic factors may govern CCA distribution inside crevices?

- More light = more CCA
- More sediment = less CCA

<u>Question 3</u>: How does internal CCA contribution compare to top-reef?

- More CCA inside the reef than outside (all sites but one)

Limitations

- Equipment size= bias in crevice size
- We didn’t actually measure sediment
- We couldn’t group light data since different dive times = different light availability
- Didn’t look at crevice orientation
- Can only draw conclusions about Hawaiian reefs

Potential Mechanism

- Is it sediment or is it light?
- Connell, 2003 tested this:
  - Light played a bigger role than sediment
  - Oversimplified

Marine Biology (2003) 142: 1065–1071
DOI 10.1007/s00227-003-1021-z

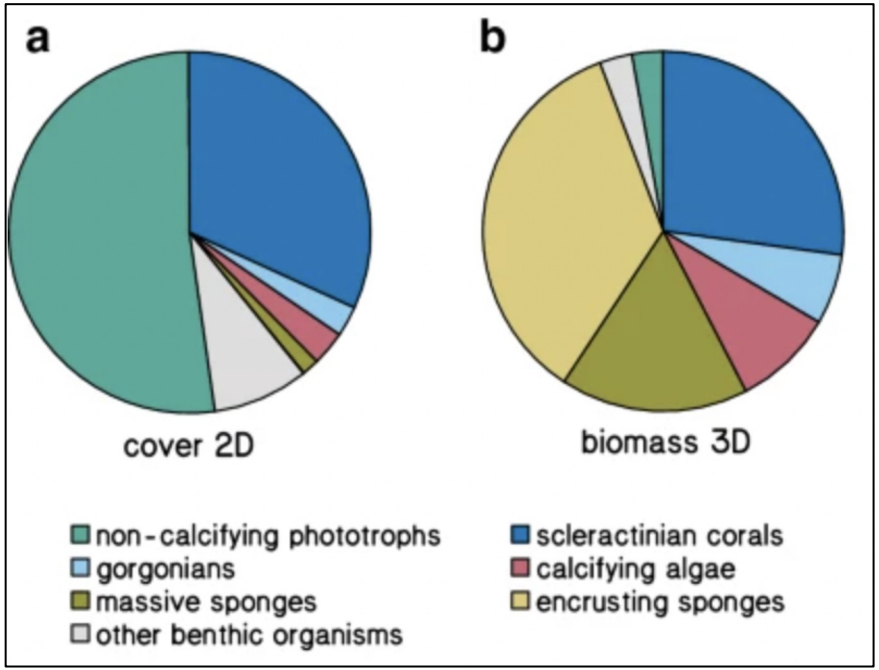
S. D. Connell

The monopolization of understorey habitat by subtidal encrusting coralline algae: a test of the combined effects of canopy-mediated light and sedimentation

(Connell, 2003)

Supportive Findings

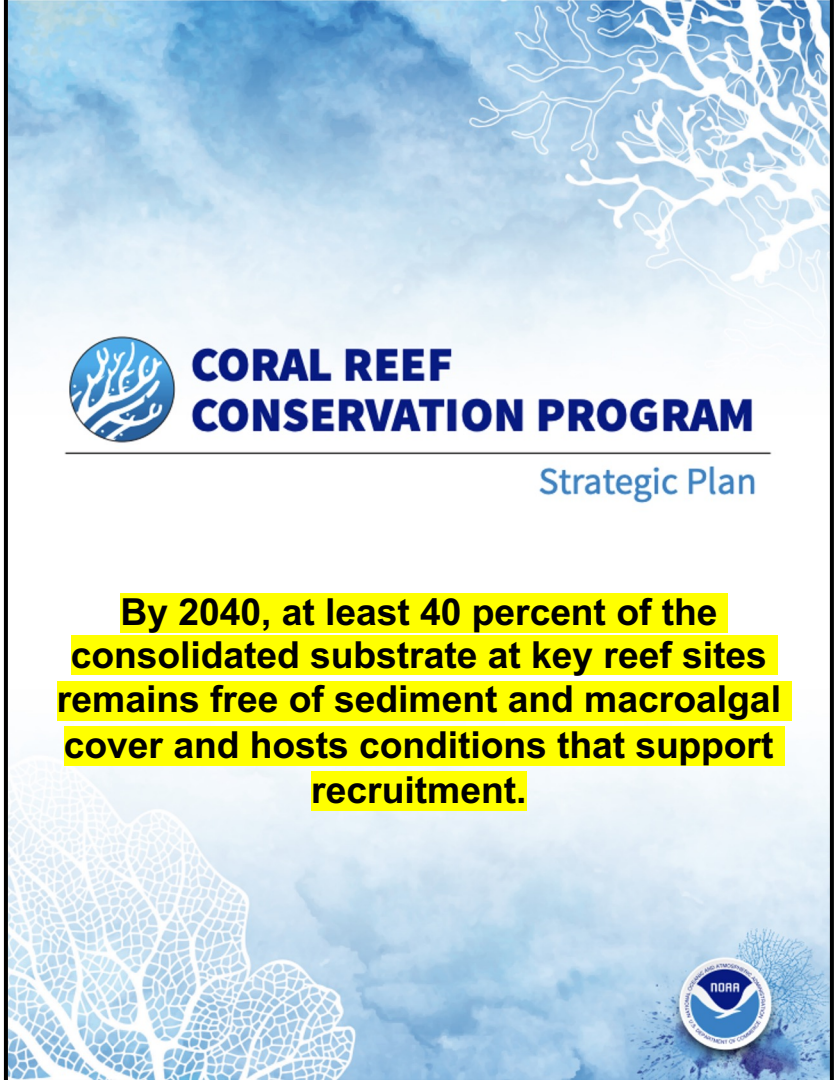
- Confirmed 2D studies are missing things (Kornder et al., 2021)
- Still does not look inside crevices



Implications

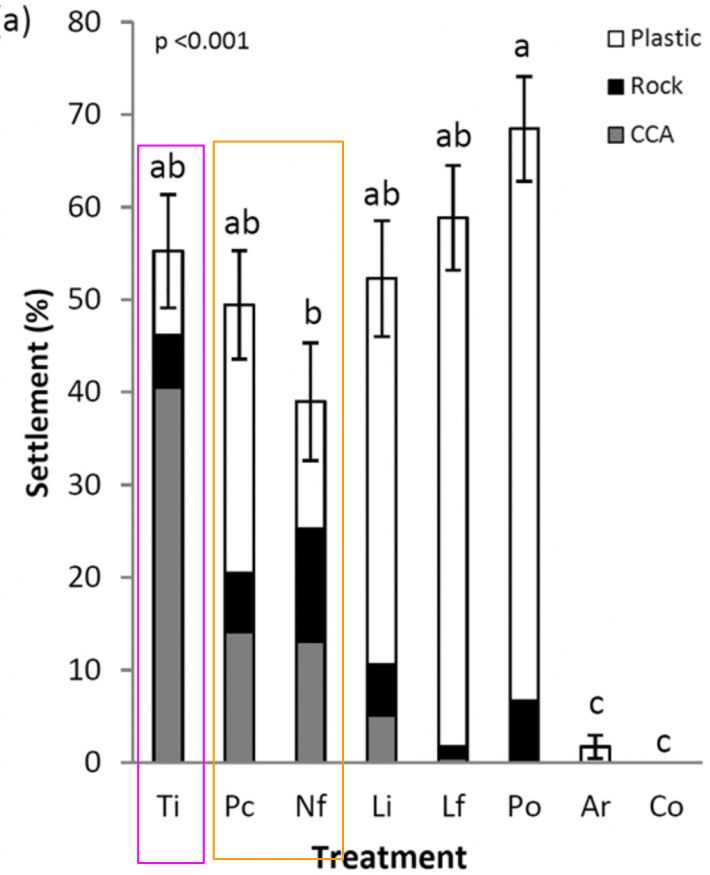
Coral Recruitment Habitat

- Ceilings of crevice openings are pre-existing CRH
  - Free of sediment
  - Free of macroalgae
  - Plenty of CCA



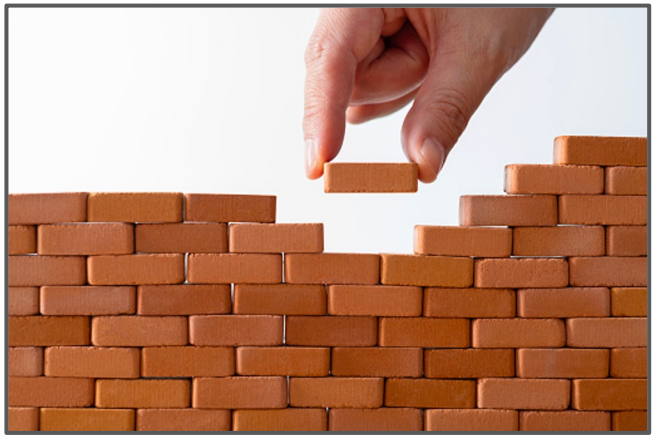
Coral Recruitment Habitat

- Coral polyps more likely to settle on cryptic species of CCA vs. exposed species
  - Subcryptic- vertical walls, large overhangs
  - Fully cryptic- crevices and under rubble



Jorrisen et al., 2021

Accretion and Sediment Stabilization



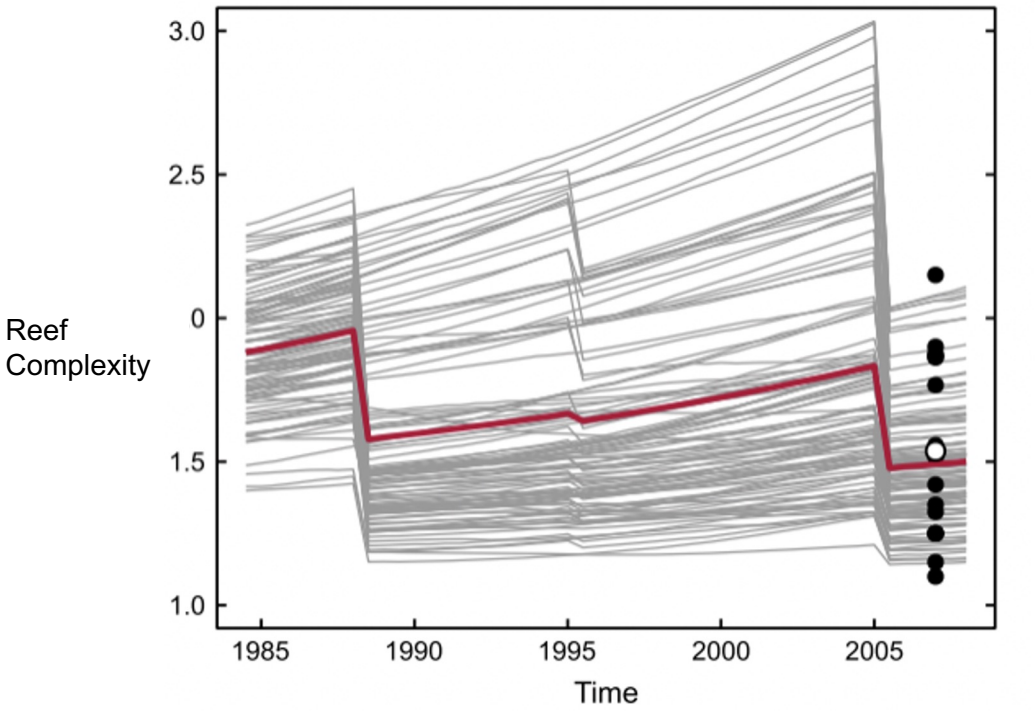
- High CCA abundance inside reefs = reef building and stabilization taking place from inside the reef!
  - 3D matrix is huge and heavy

Methods for Monitoring Cryptic Habitats

- Calcium Accretion Units (CAUs) as a standardized method for quantifying recruitment/ new accretion (Johnson et al., 2022).

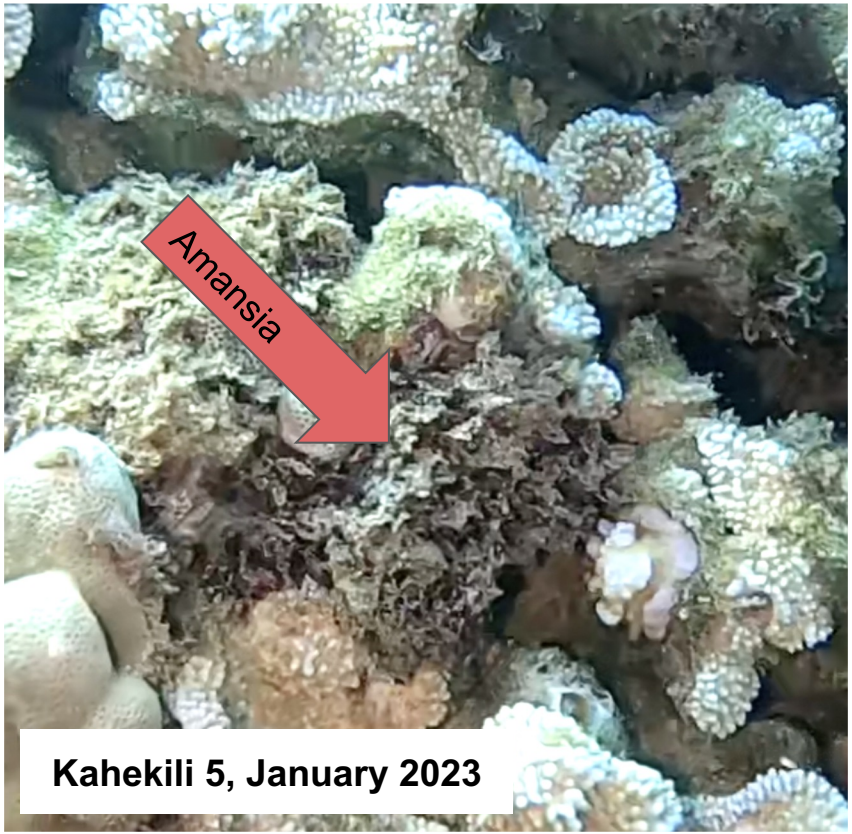
- What about *in situ* measurements?

Threats to Crevice Habitats



- Habitat complexity
  - Predicted to decrease substantially in 20-30 years (Bozec et al., 2015)

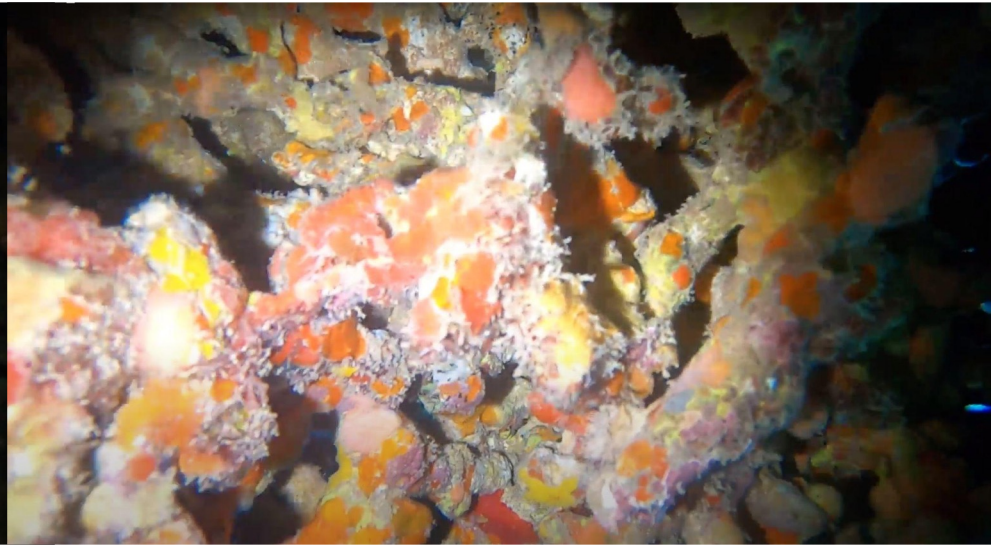
Threats to Crevice Habitats



- Macroalgae negatively impacts CCA in crevice
  - Blocks sunlight
  - Limits sediment clearing
  - Excludes grazers

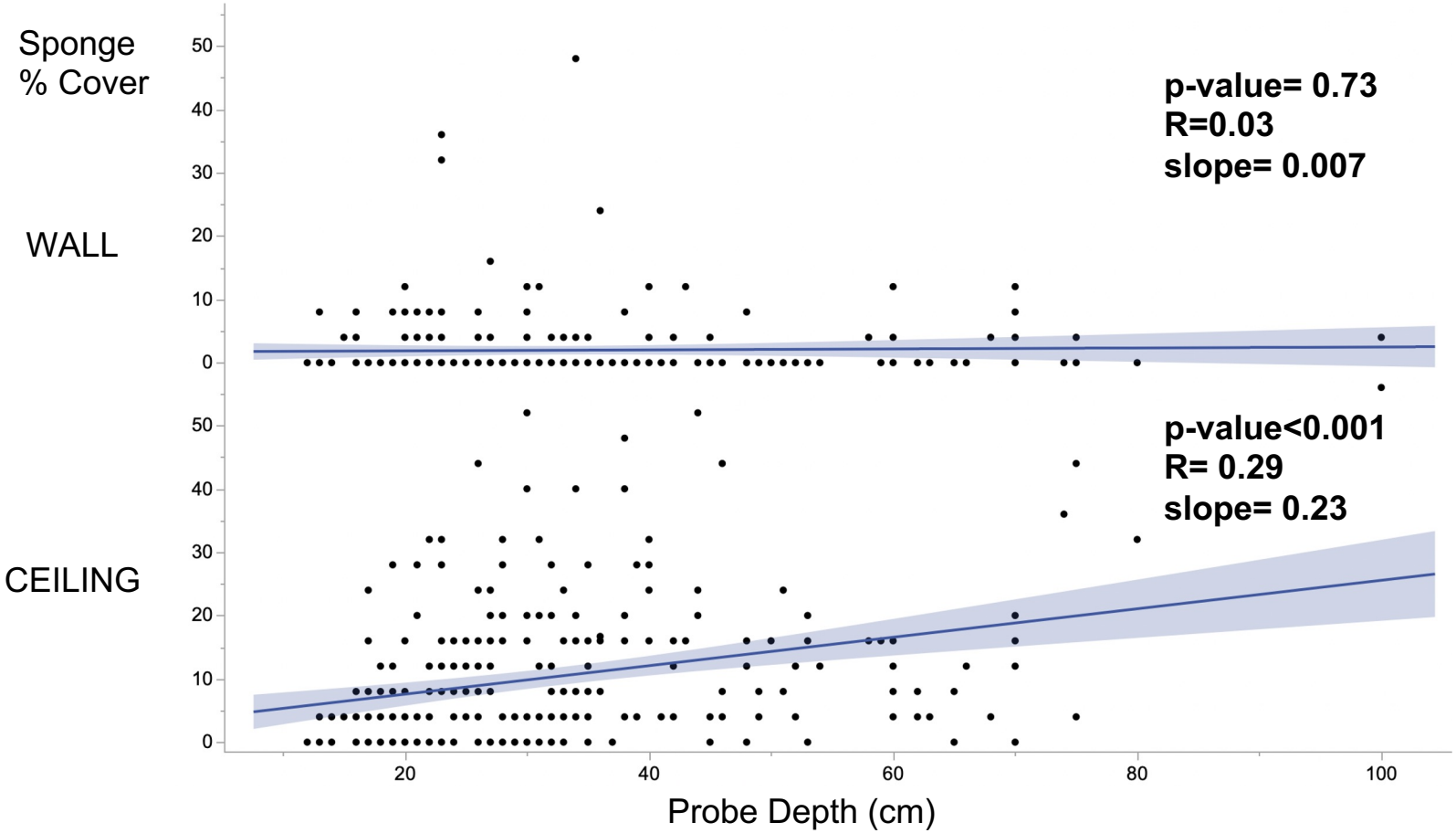
Other Observations: Sponge!

Wall

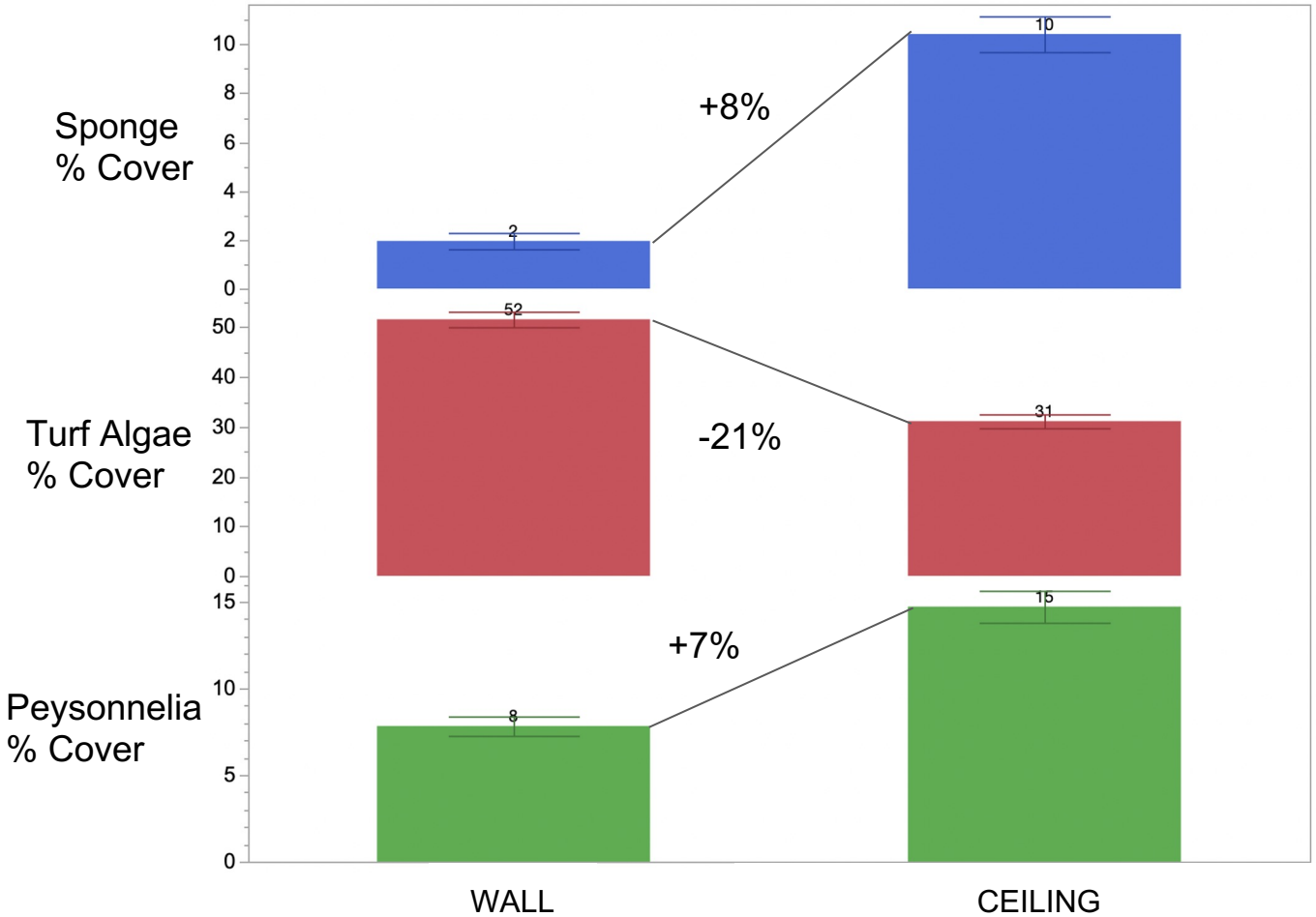


Ceiling

Sponge Zonation on Ceilings



Other Observations:



Future Research

- Further break down mechanisms describing CCA (and other major groups) success in crevices
- Species comparisons- metabarcoding
- Accretion rates of cryptic vs exposed CCA species
- Crevices are potentially more acidic already due to trapped respiration
    - how does this impact CCA and other calcifiers living in crevices?

Acknowledgements

Dive buddies: Dr. Maya deVries, Dr. Philip Heller, Orion McCarthy, Sophie Luu, Roxanne Garibay, Dr. Jennifer Smith, Sarah Romero, Samantha Smith, Ryan Hallisey and Noah Kolander

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Citations

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15. Jorissen et al. 2021 *Scientific Reports*, 11.
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17. Bozen and Mumby 2015 *Soc Lond B Biol Sci,* 370

Images:

eAtlas, Northeast Australia Seascape Connectivity Project

Smithsonian Ocean Portal

Methods in Ecology and Evolution

MIT Science Policy Review

ReefCause

ASC News

NOAA CRCP Conservation Plan

Questions?