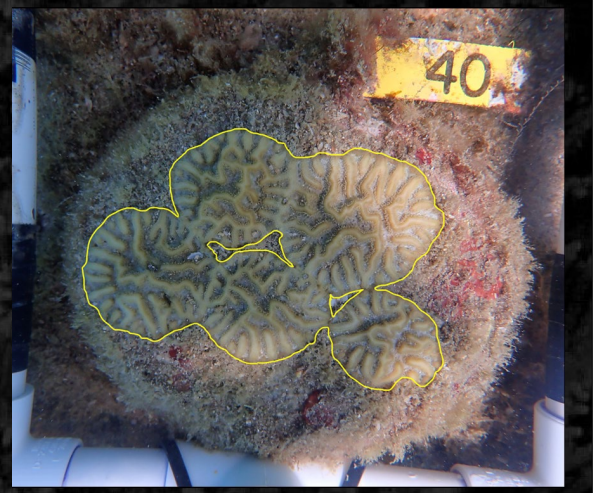
Coral Genetic Diversity, Connectivity, and Restoration in the Face of Bleaching and Disease



Joshua Voss, Gabby Pantoni, Ryan Eckert, Sydney Bell, Milena Nesic, Erin Shilling, Ashley Carreiro

Bill Sharp, Erinn Muller, John Hunt, Dave Gilliam, Diego Lirman, Amanda Bourque

HARBOR BRANCH

FLORIDA ATLANTIC UNIVERSITY

Ocean Science for a Better World™

My Lab

Ryan Eckert, Allie Klein, Gabby Pantoni, Milena Nesic, Erin Tharp, Olivia Faris, Thomas Quello, Zoe Willis, Alexis Sturm*, Ashley Carreiro*, Erin Shilling*, Haley Davis*, Sydney Bell*

HBOI Team

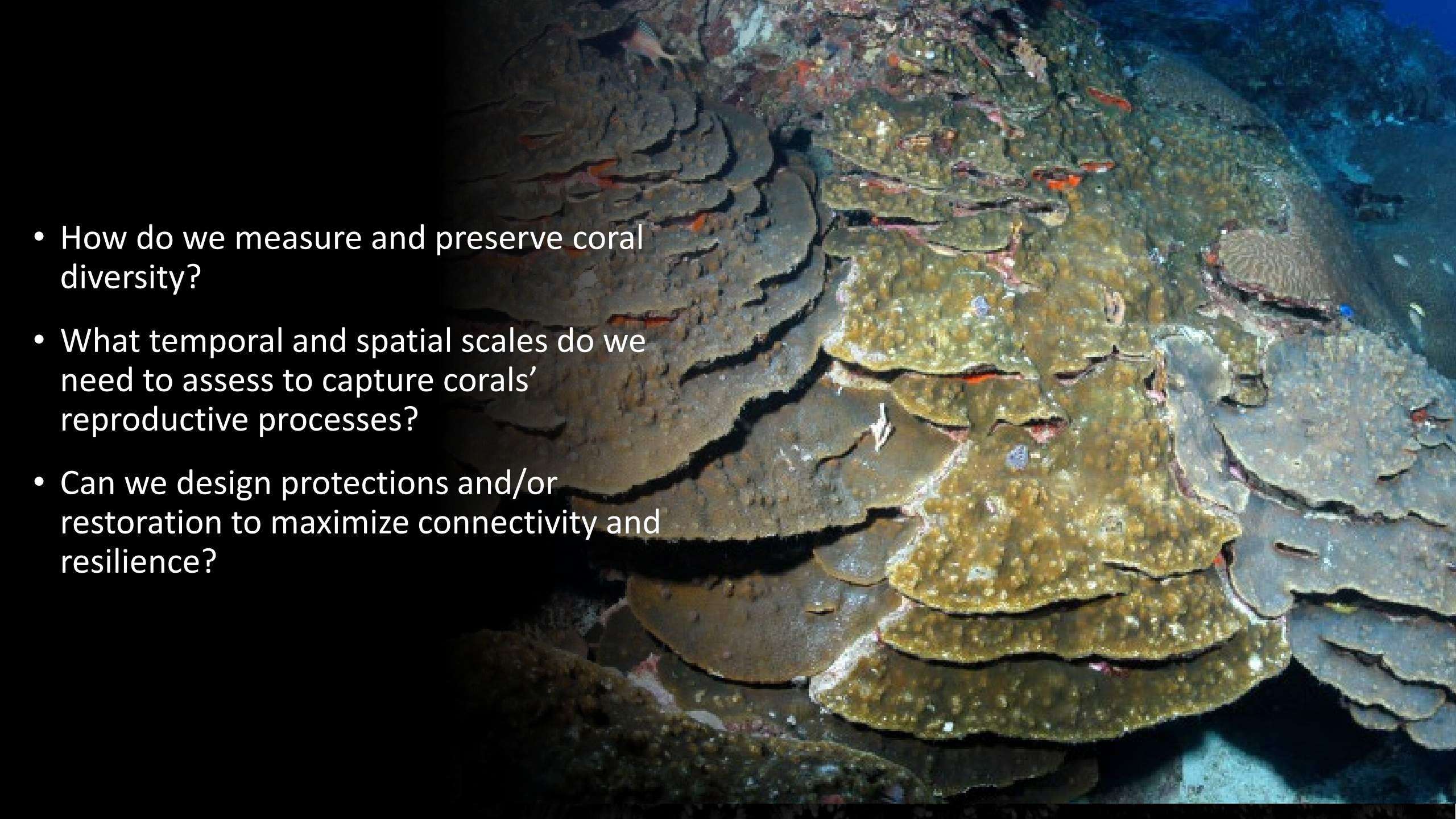
John Reed, Jimmy Nelson, Dave Heuberger, Matt Roy

Collaborators & Partners

FKNMS, NCCOS, NOAA Fisheries
Santiago Herrera, Peter Etnoyer, etc.
FWC, Mote, Reef Relief, Coral Restoration Foundation, NSU, Biscayne NP,
Bill Sharp, Erinn Muller, John Hunt, Dave Gilliam, Diego Lirman, Amanda Bourque, Sarah Hamlyn, Kristene Parsons, Amelia Moura, Ken Nedimeyer

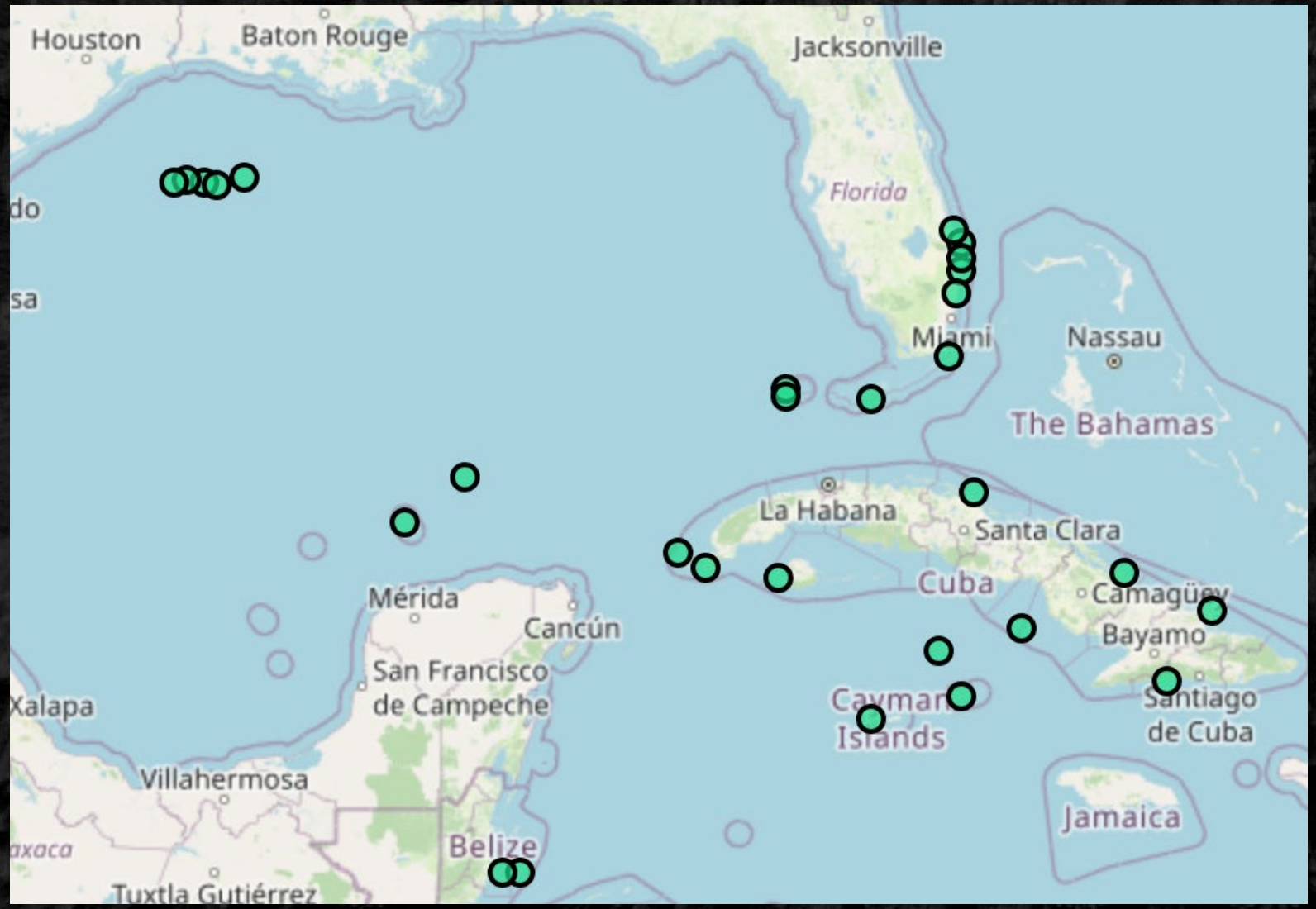
Ship and ROV Crews

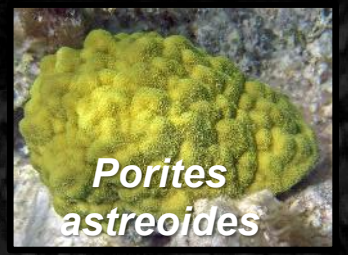
RV Walton Smith, UNCW Undersea Vehicles Program (Jason White)



- How do we measure and preserve coral diversity?
- What temporal and spatial scales do we need to assess to capture corals' reproductive processes?
- Can we design protections and/or restoration to maximize connectivity and resilience?

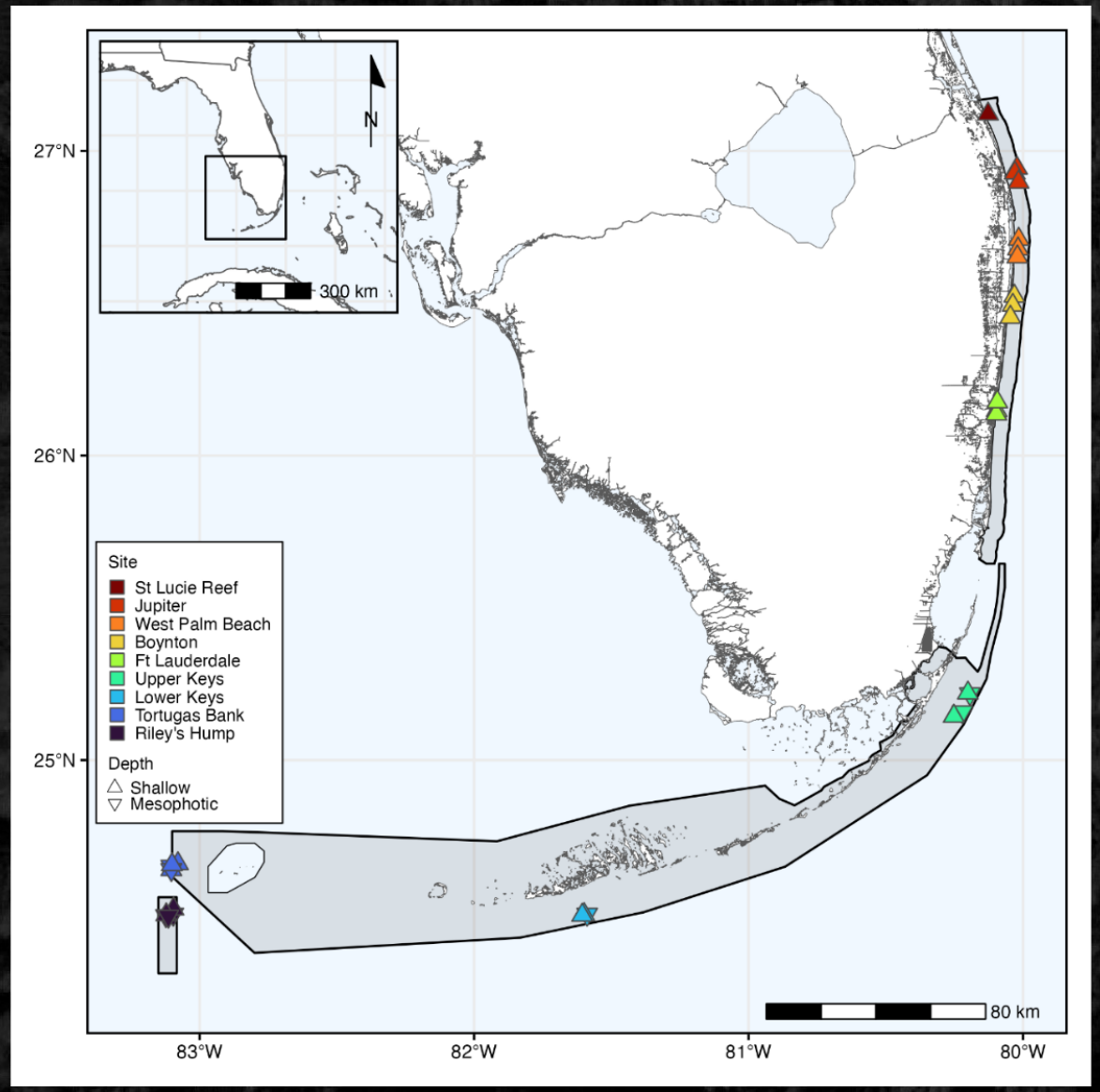
Population Genetics & Connectivity for Management & Restoration Planning





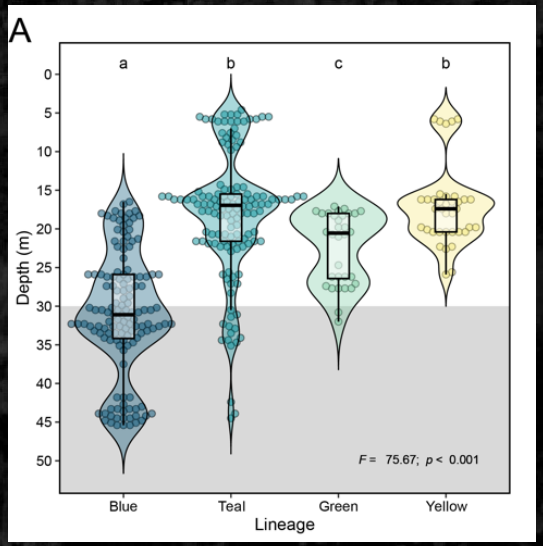
- Mesophotic and shallow
- Genetics/connectivity by 2bRAD
- Algal symbionts via ITS2
- 3491 collected, 2742 sequenced
- 3.4B reads, >44000 SNPs

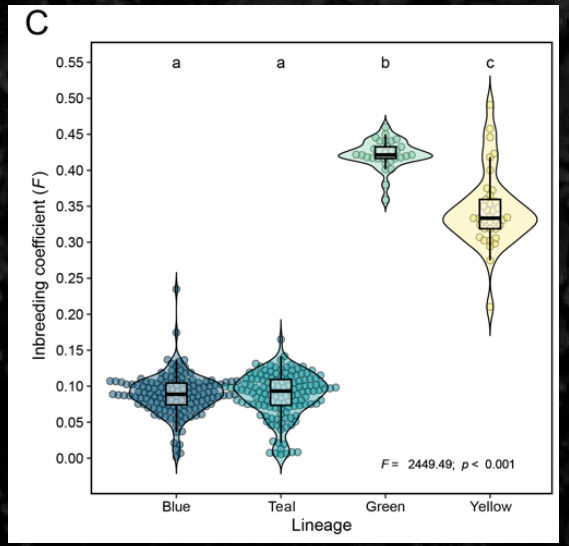
Stephanocoenia interseptal genetic diversity in South Florida



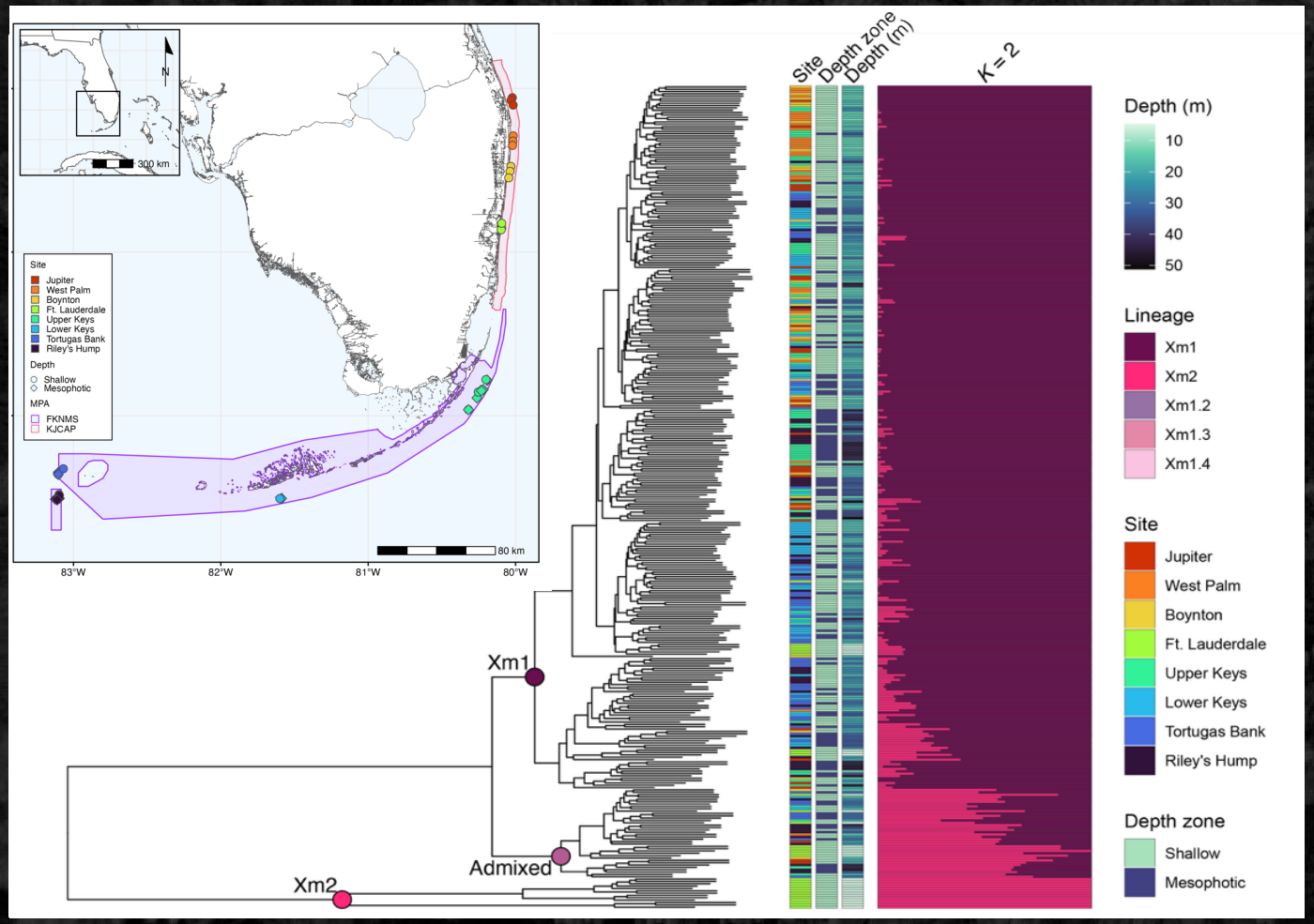
- 4 cryptic lineages (5th in FGBNMS)
  - 2 shallow specialists, 2 depth generalists
- Higher rates of inbreeding in shallow populations
- Evidence of mesophotic to shallow connectivity in FL Keys

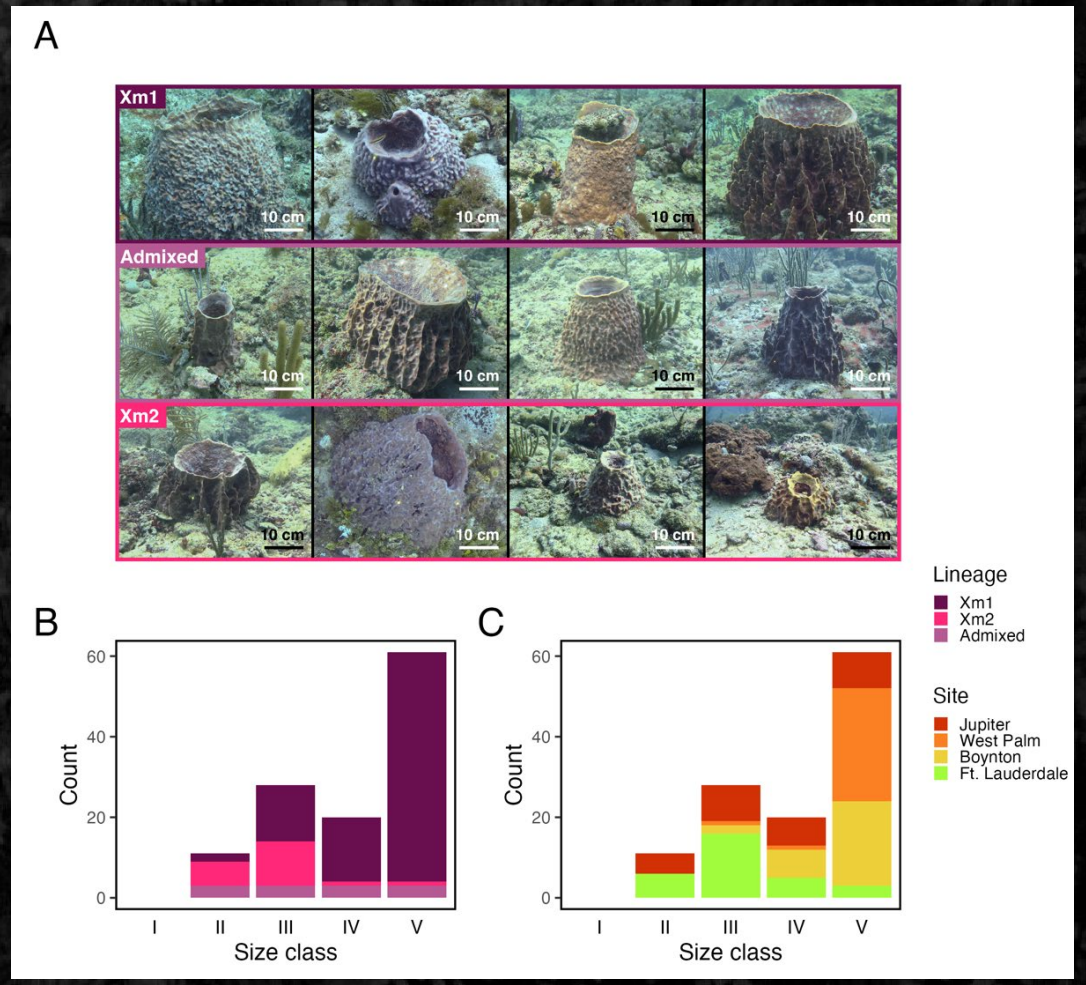
Eckert et al. 2024 Heredity





Cryptic lineages in *Xestospongia muta* too





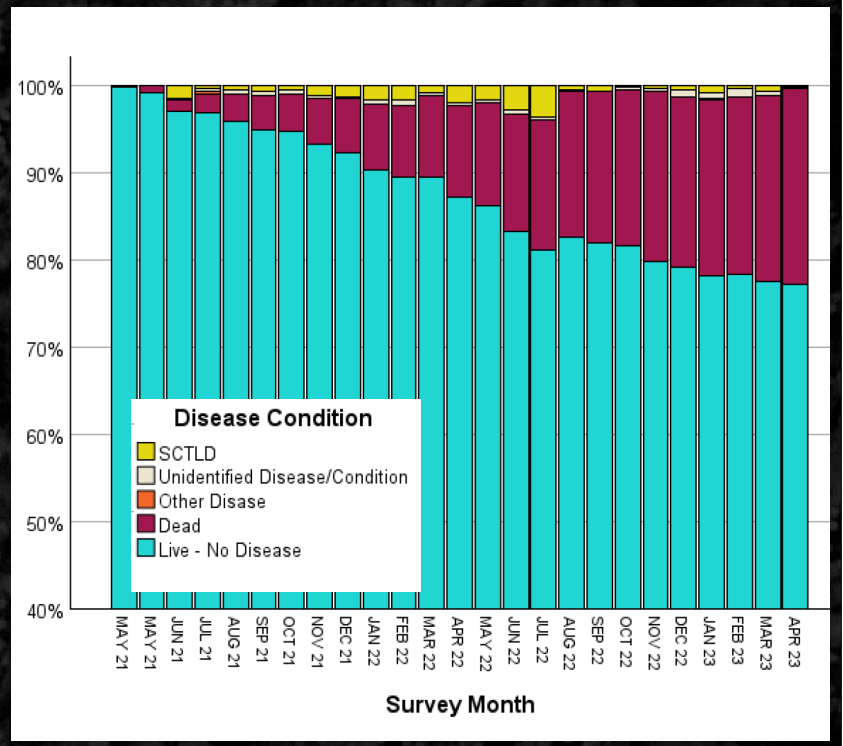
- Two lineages with morphological variation (*X. bebe*?)
- Reinforces and expands work in Upper Keys (Deignan et al. 2018, Evans et al. 2021)
- Significant genetic diversity and admixture in mesophotic reefs, lower prevalence of disease

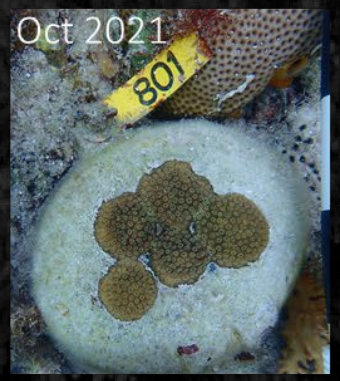
Shifting Baselines and Tipping Points

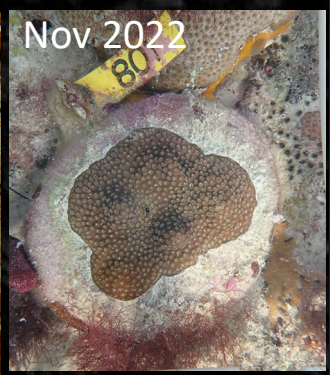
Coral Restoration Team Trials

Pantoni et al. In review, Sharp et al. In prep

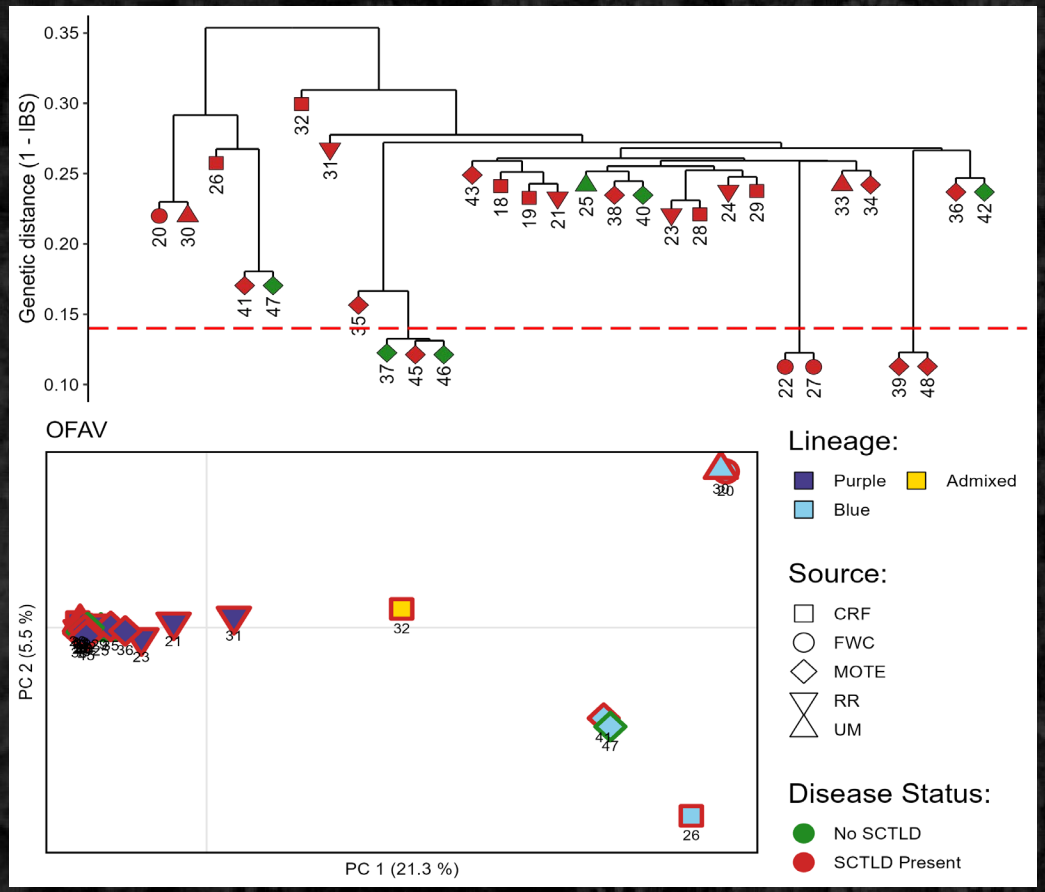
- *Montastraea cavernosa*
- *Orbicella faveolata*
- *Pseudodiploria clivosa*
- 73% survival after 3 year
- 1.4% mean SCTLD prevalence
- Significant interactions between coral sources and outplant locations

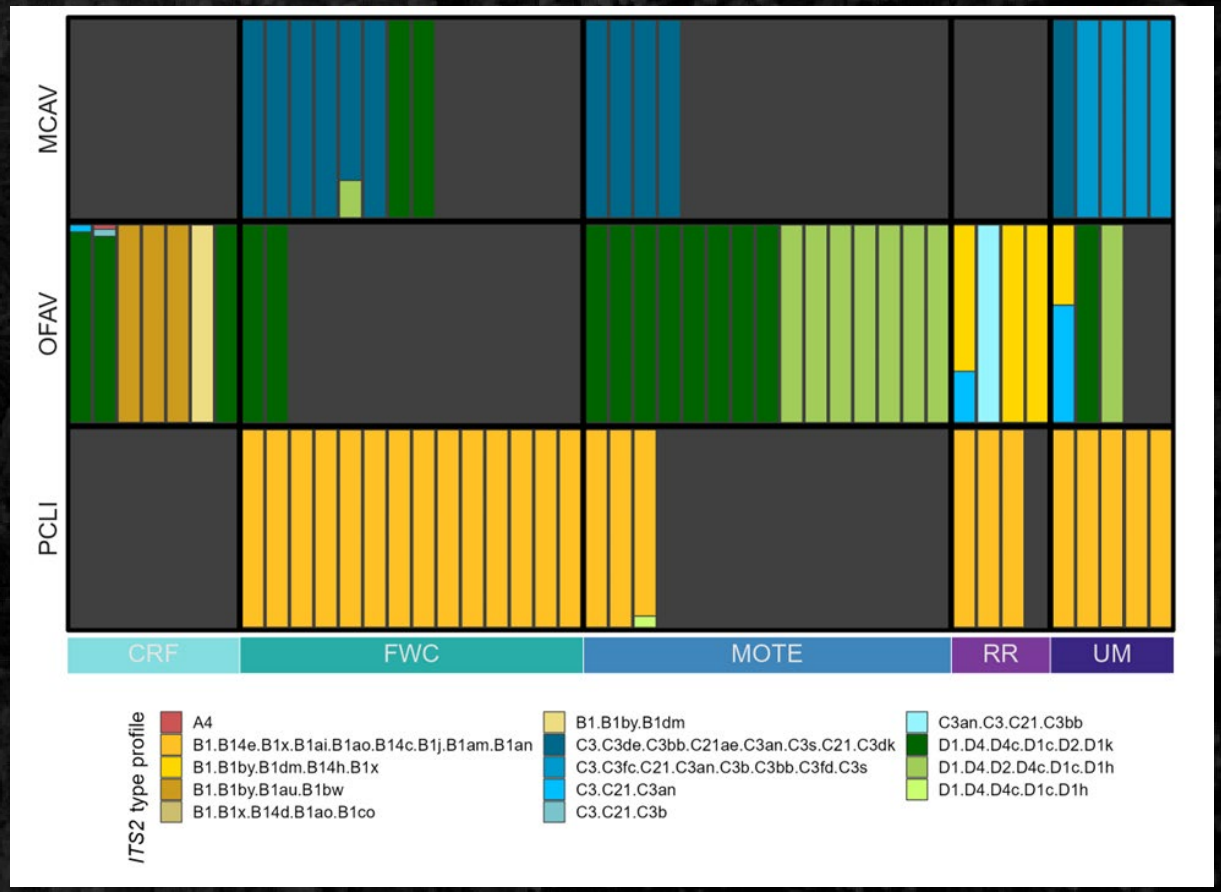






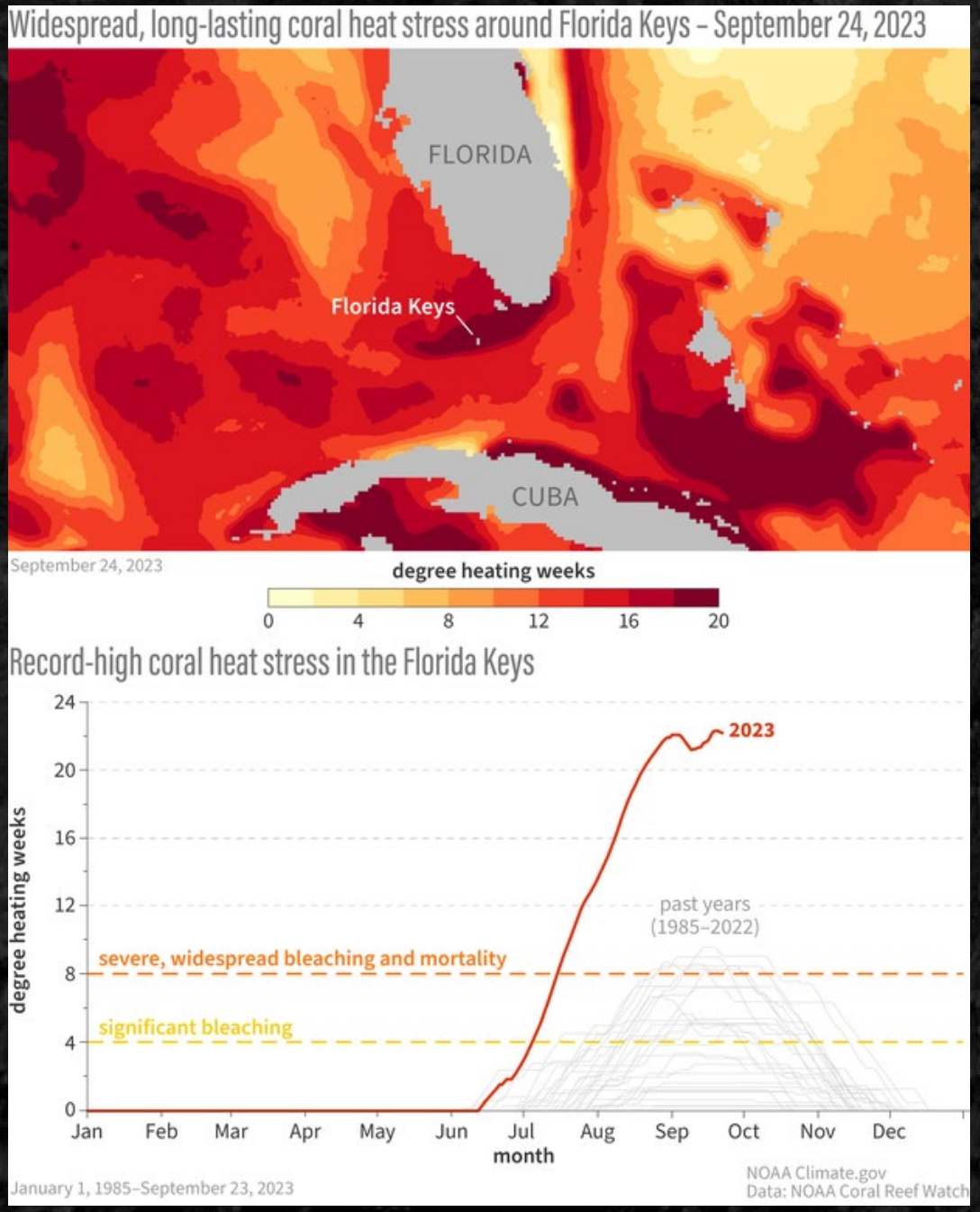
RTT: Neither coral genetic lineage nor initial algal symbiont types impacted SCTLD susceptibility or survival





- 2bRAD revealed cryptic lineages, unknown clones, unintended congeners, etc.
- Genetic management plans/strategies key for restoration

Bell et al. 2025 Restoration Ecology



2023 Bleaching Event

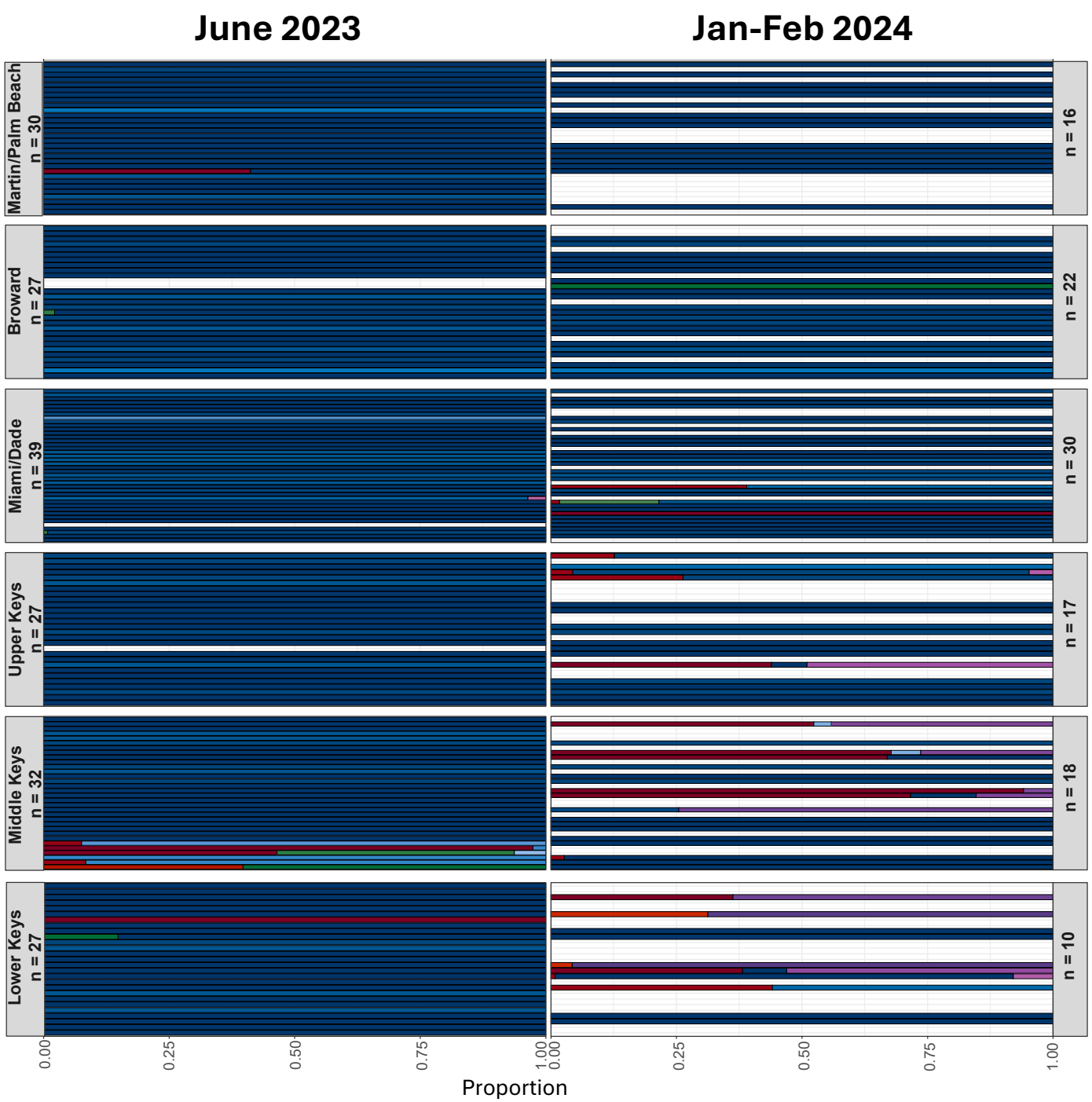
- Regionally disparate impacts
  - Limited thermal stress in SEFL/KJCAP
  - Significant DWH in Miami, UK, MK, LK

- RTT corals evaluated and resampled in Jan-Feb 2024
  - Still ~60% survival
  - Widespread adaptive bleaching?
  - 64M ITS2 reads, ~43,800 per sample

Species	June 2023	Jan-Feb 2024
OFAV	476	389
MCAV	180	148
PCLI	185	119
Total	**841**	**656**

Pseudodiploria clivosa

- 36% loss after 2023 bleaching
- *Breviolum* largely retained from initial RTT outplanting through 2024
- Minor but significant increases in *Durusdinium* in Middle and Lower Keys



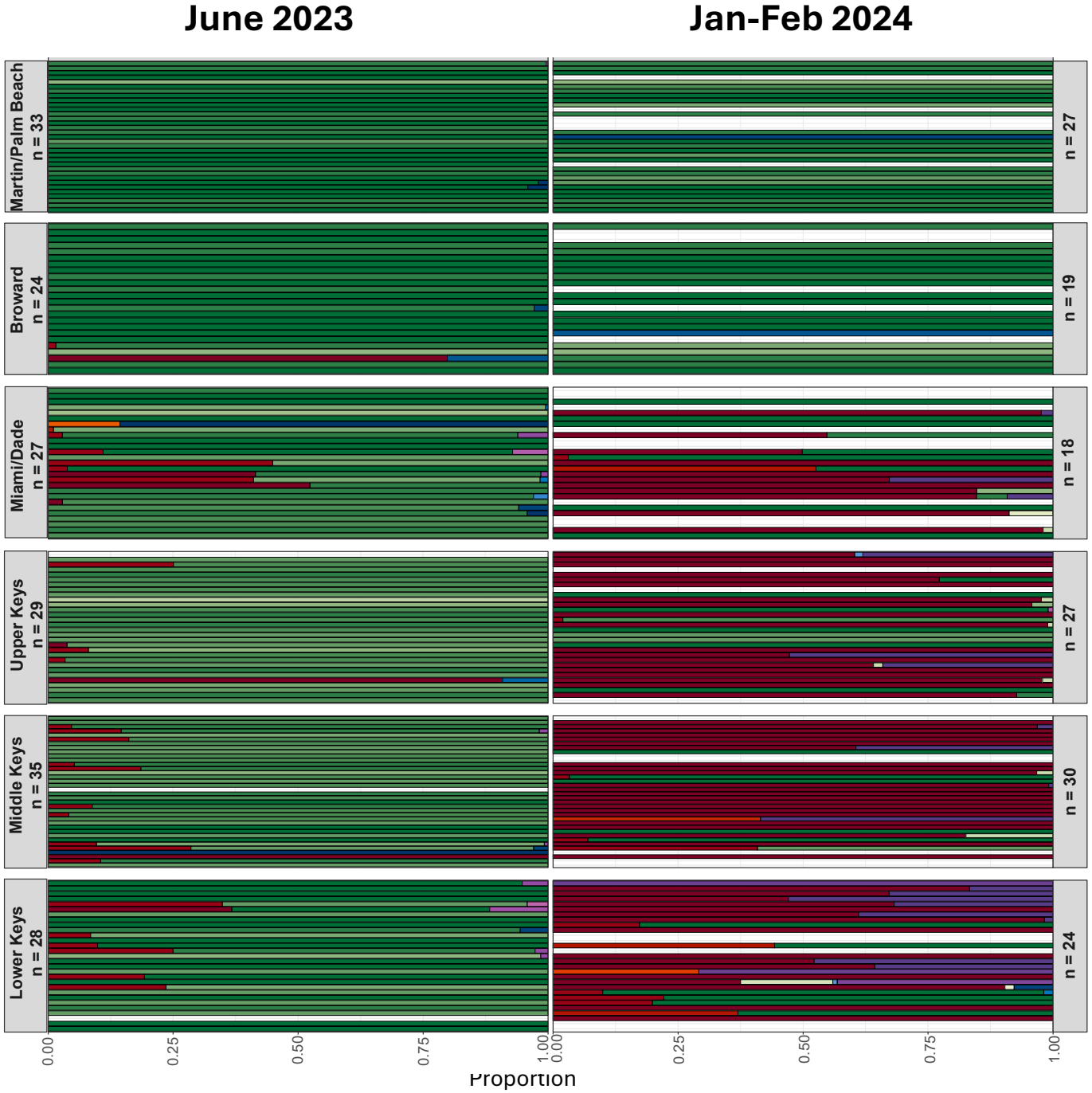
Symbiodinium
- A13
- A13.A1pt
- A13.A1pu.A1pv
- A13.A1pu
- A13.A3
- A13.A1py.A13m.A1px.A13p
- A4.A4.3.A4a.A4o.A4s.A4bg

Breviolum
- B1.B14e.B1ai.B1x.B1j.B1ao.B14c.B1am.B14b.
- B1.B1co.B1ai.B1x.B14d.B1t.B1az.B14c
- B1.B1x.B1ai.B1j.B1ao.B14e.B1am.B1eh.B14c
- B1.B1co.B14d.B1x.B1hg.B1be.B1hh
- B1.B14d.B1x.B1ao.B14b.B1co.B1dn.B5dc
- B1.B1by.B1bw.B1dm.B1au.B14h.B1x.B1bx
- B1.B1by.B1au.B1bw.B14h.B1dm.B20b
- B1.B1gy.B1br
- B1.B5dx.B1gs.B1br.B5eb.B1he.B1hf

Cladocopium
- C3.C3fc.C21.C3an.C3b.C3fd.C3s.C3bb
- C3.C3an.C21.C3bb.C3de.C3s
- C1.C1b.C1c.C42.2.C1bh.C1br.C72k.C1cb

Durusdinium
- D1.D4.D4c.D1c.D1k.D2
- D1.D4.D4c.D1hg.D1c.D2.D5ad
- D1.D4.D4c.D17d.D1c.D1r.D17c.D17e.D17j
- D1.D4.D4c.D17ao.D17ap.D17ar.D17aq.D1c.D1l

Montastraea cavernosa



- 18% loss after 2023 bleaching
- *Cladocopium r*etained from initial RTT outplanting through 2024 in R1 and R2
- Significant shifts to *Durusdinium* in Miami and Florida Keys

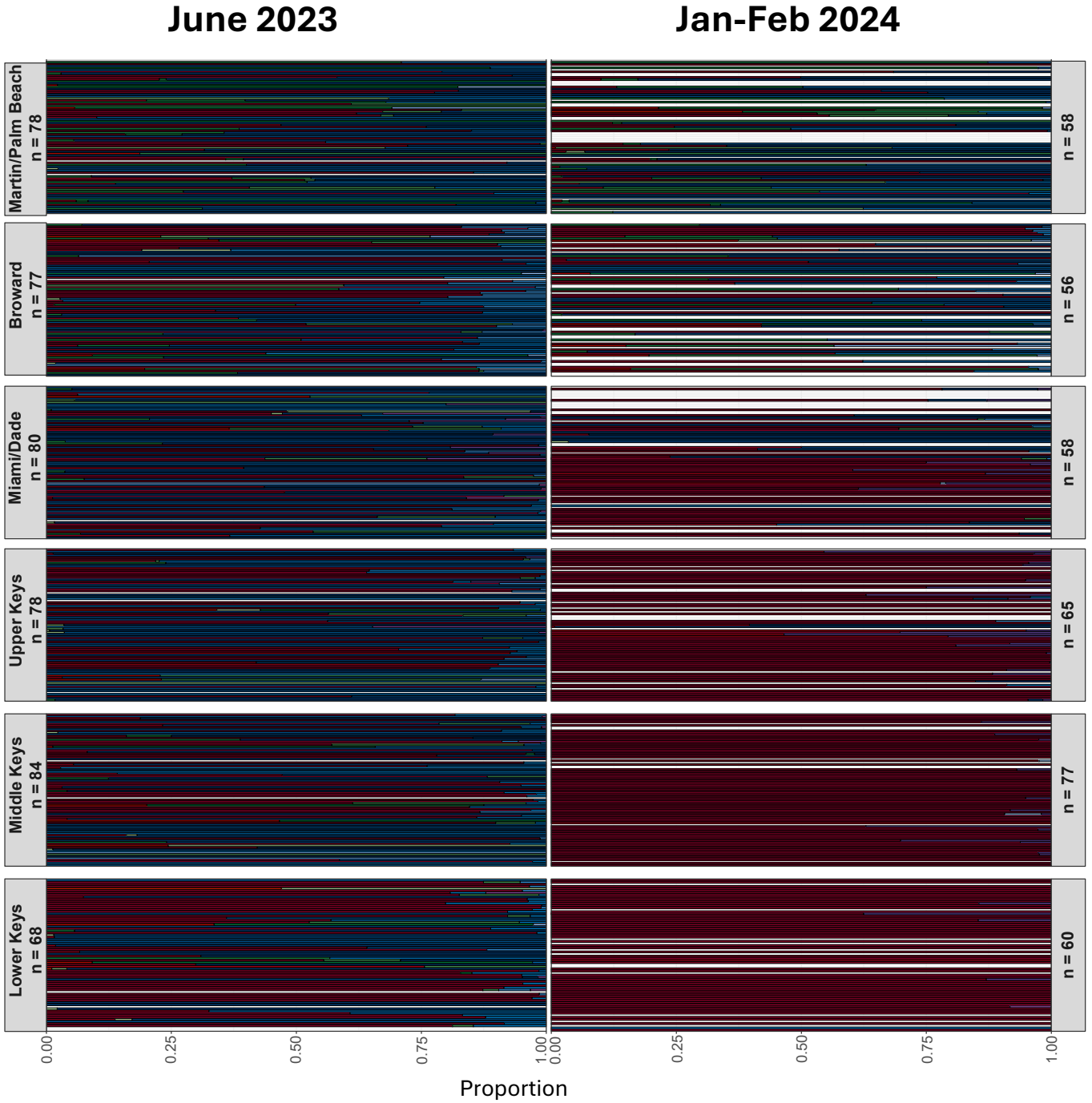
Symbiodinium
- A13
- A13.A1pt
- A13.A1pu.A1pv
- A13.A1pu
- A13.A3
- A13.A1py.A13m.A1px.A13p
- A4.A4.3.A4a.A4o.A4s.A4bg

Breviolum
- B1.B14e.B1ai.B1x.B1j.B1ao.B14c.B1am.B14b.
- B1.B1co.B1ai.B1x.B14d.B1t.B1az.B14c
- B1.B1x.B1ai.B1j.B1ao.B14e.B1am.B1eh.B14c
- B1.B1co.B14d.B1x.B1hg.B1be.B1hh
- B1.B14d.B1x.B1ao.B14b.B1co.B1dn.B5dc
- B1.B1by.B1bw.B1dm.B1au.B14h.B1x.B1bx
- B1.B1by.B1au.B1bw.B14h.B1dm.B20b
- B1.B1gy.B1br
- B1.B5dx.B1gs.B1br.B5eb.B1he.B1hf

Cladocopium
- C3.C3fc.C21.C3an.C3b.C3fd.C3s.C3bb
- C3.C3an.C21.C3bb.C3de.C3s
- C1.C1b.C1c.C42.2.C1bh.C1br.C72k.C1cb

Durusdinium
- D1.D4.D4c.D1c.D1k.D2
- D1.D4.D4c.D1hg.D1c.D2.D5ad
- D1.D4.D4c.D17d.D1c.D1r.D17c.D17e.D17j
- D1.D4.D4c.D17ao.D17ap.D17ar.D17aq.D1c.D1l

Orbicella faveolata



- 18% loss after 2023 bleaching
- Shifts to more cosmopolitan assemblages from 2021 to 2023
- After 2023 bleaching event *Durusdinium* dominate in Miami and FL Keys regions
- Will they survive? Shift back?

Symbiodinium
- A13
- A13.A1pt
- A13.A1pu.A1pv
- A13.A1pu
- A13.A3
- A13.A1py.A13m.A1px.A13p
- A4.A4.3.A4a.A4o.A4s.A4bg

Breviolum
- B1.B14e.B1ai.B1x.B1j.B1ao.B14c.B1am.B14b.
- B1.B1co.B1ai.B1x.B14d.B1t.B1az.B14c
- B1.B1x.B1ai.B1j.B1ao.B14e.B1am.B1eh.B14c
- B1.B1co.B14d.B1x.B1hg.B1be.B1hh
- B1.B14d.B1x.B1ao.B14b.B1co.B1dn.B5dc
- B1.B1by.B1bw.B1dm.B1au.B14h.B1x.B1bx
- B1.B1by.B1au.B1bw.B14h.B1dm.B20b
- B1.B1gy.B1br
- B1.B5dx.B1gs.B1br.B5eb.B1he.B1hf

Cladocopium
- C3.C3fc.C21.C3an.C3b.C3fd.C3s.C3bb
- C3.C3an.C21.C3bb.C3de.C3s
- C1.C1b.C1c.C42.2.C1bh.C1br.C72k.C1cb

Durusdinium
- D1.D4.D4c.D1c.D1k.D2
- D1.D4.D4c.D1hg.D1c.D2.D5ad
- D1.D4.D4c.D17d.D1c.D1r.D17c.D17e.D17j
- D1.D4.D4c.D17ao.D17ap.D17ar.D17aq.D1c.D1l

Nesic et al. in prep

Take Aways

- FL Keys mesophotic reefs are major contributors to reef genetic biodiversity → further characterization, monitoring, and protections needed
- Expanding genetic sequencing technologies provide unique opportunities
  - Uncover cryptic lineages
  - Assess connectivity
  - Identify clones
  - Resolve and track symbionts
  - Guide management and conservation strategies
  - Improve restoration designs
- Restoration/recovery of boulder corals appears feasible in Florida, despite intense disease and thermal stress
- Protecting and enhancing genetic diversity best supports the adaptive potential of corals
- Revive FKNMS expansion, management plan revision!