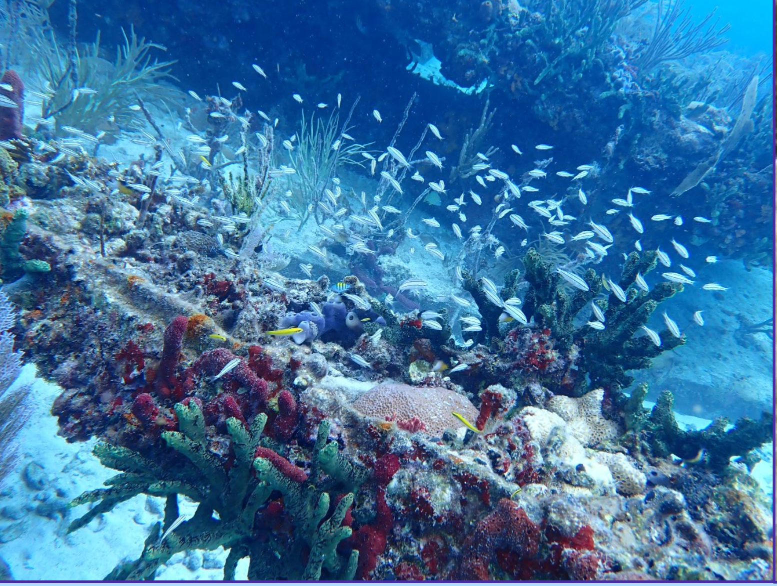
Using Habitat Support Structures to Address Habitat Deficits within the Florida Keys National Marine Sanctuary

Hanna Koch, William Sharp, Andy Bruckner, Carolyn Kalinowski, Keith Mille, & John Hunt

National Marine Sanctuaries

Florida Keys

Florida Keys Marine Ecosystem

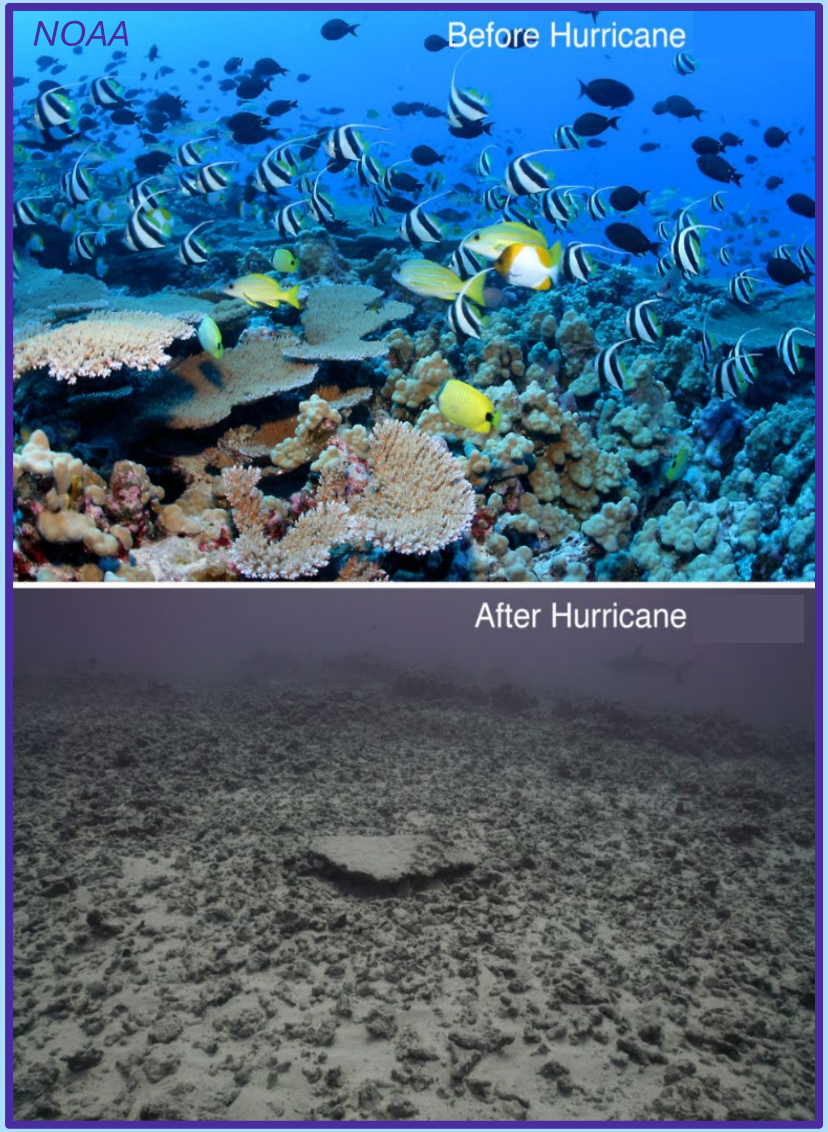
[Habitat]

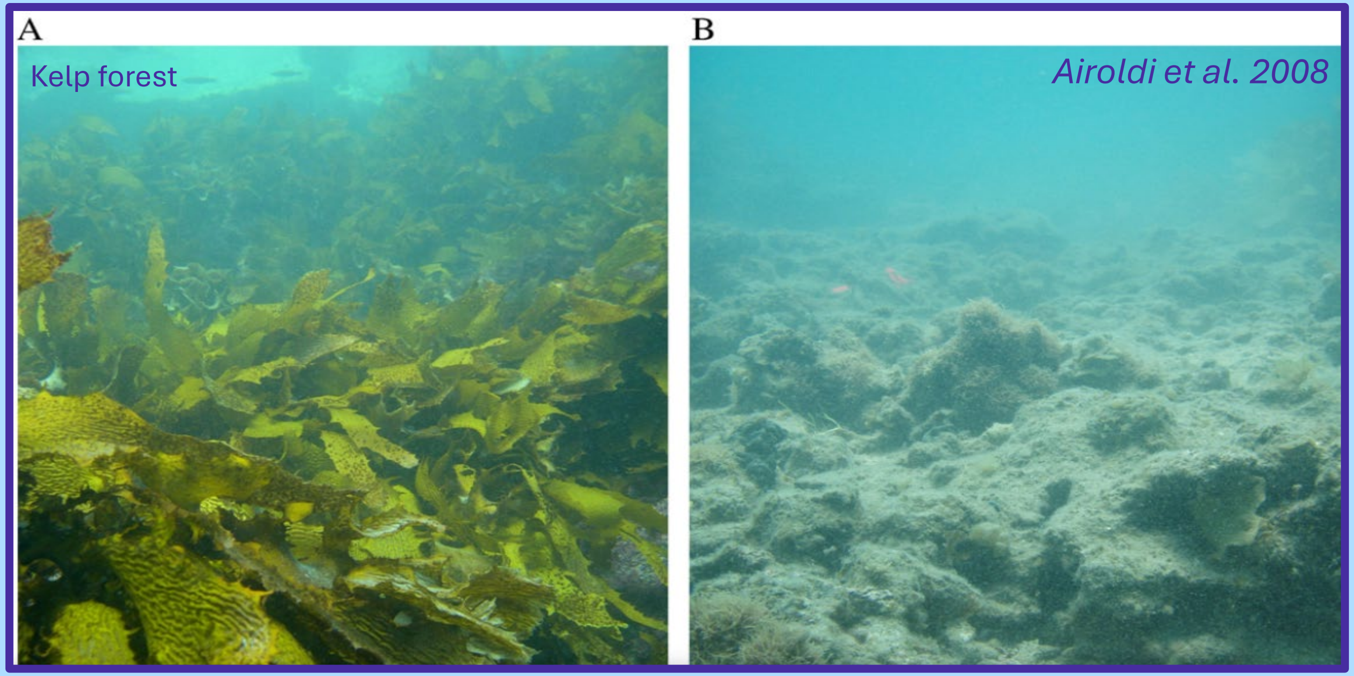
The resources and conditions present in an area that produce occupancy, which may include survival and reproduction, by a given organism *Hall et al. 1997*

Structurally Complex Habitats = Greater Species Abundance & Diversity

Chabanet et al. 1997
Gratwicke & Speight 2005a, 2005b
Kuffner et al. 2007
Alvarez-Filip et al. 2009
Graham & Nash 2013

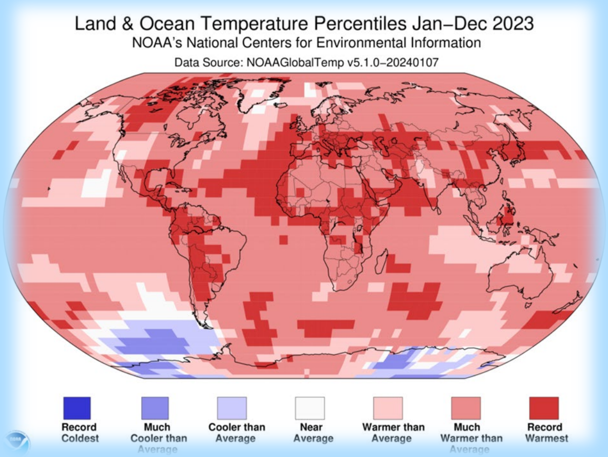
Habitat Loss & Degradation = Reductions in Abundance & Diversity





Drivers of Marine Habitat Loss and Degradation

Ocean warming

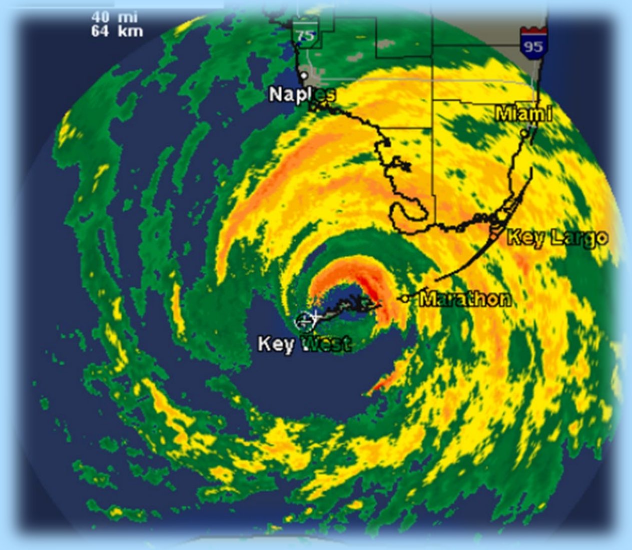


Coastal development

Declining water quality

Direct human impacts

Storms

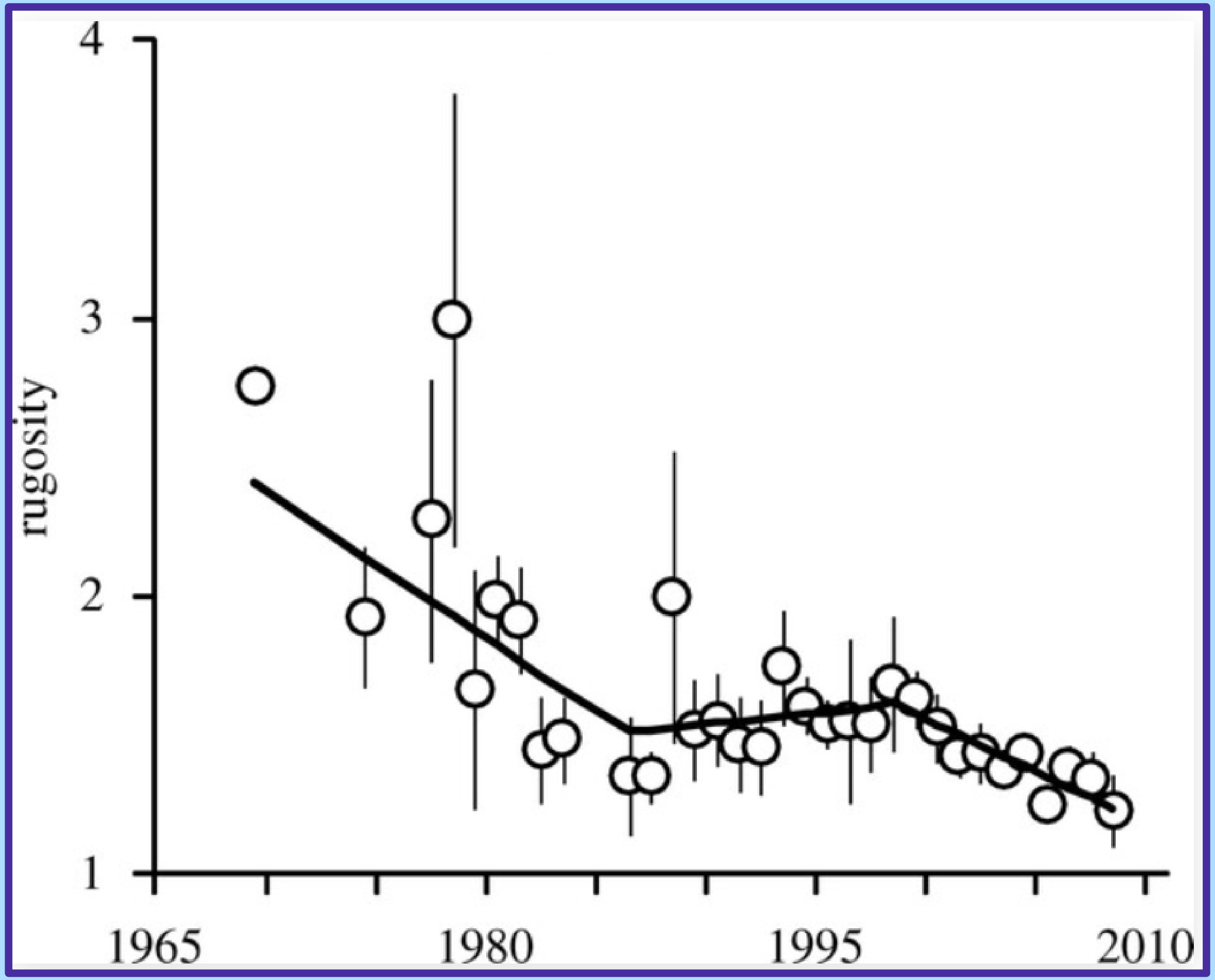


Butler et al. 1995
Fourqurean & Rutten 2004
Finkl, Charlier & Krupa 2005
Chiappone et al. 2005
Uhrin, Matthews & Lewis 2014
Kuffner et al. 2015

Examples of Habitat Loss & Degradation in the Florida Keys

Coral Reefs

Caribbean Reefs are Flattening



Alvarez-Filip et al. 2009

Reef Flattening Threatens Ecosystem Services & Functions

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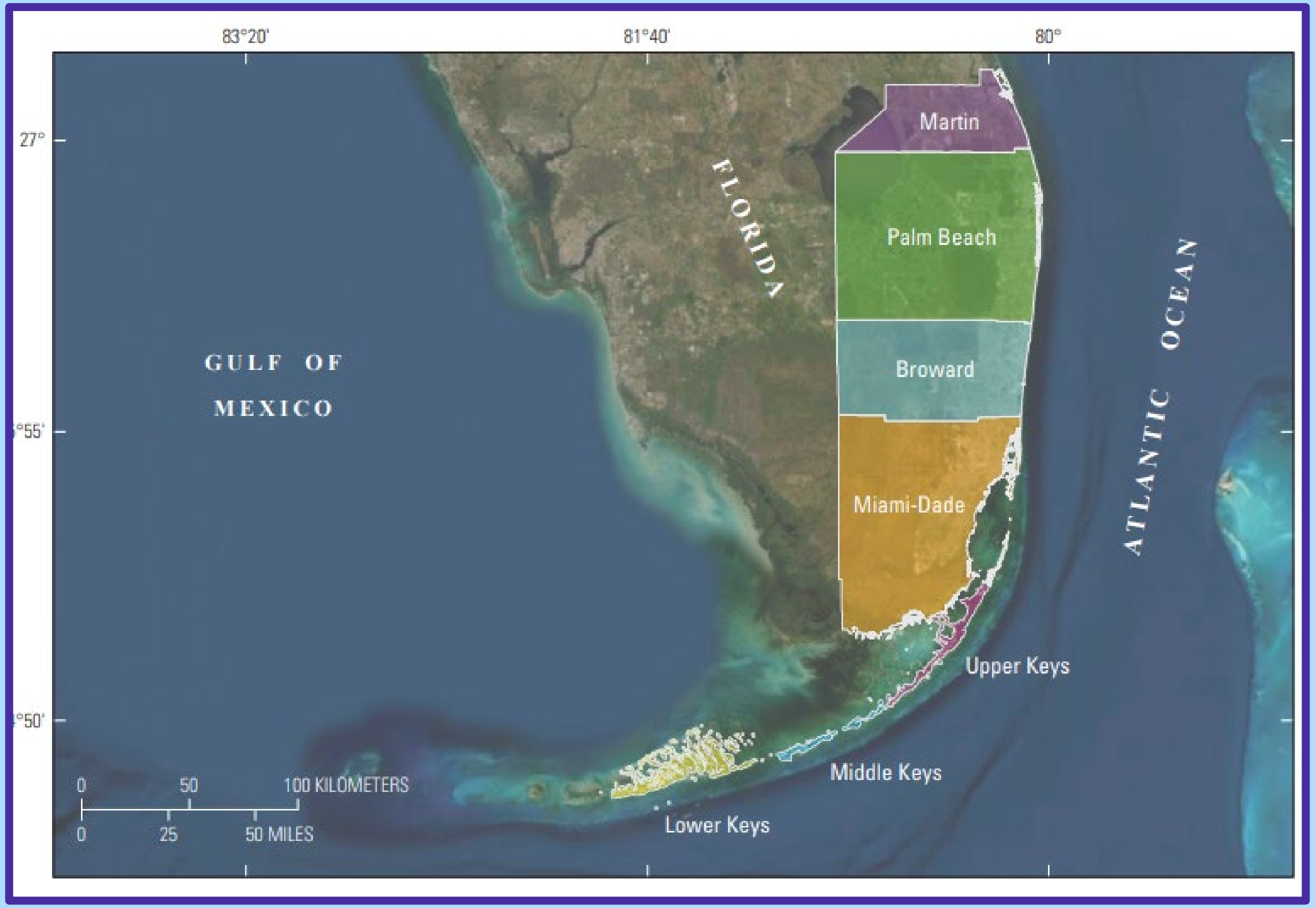
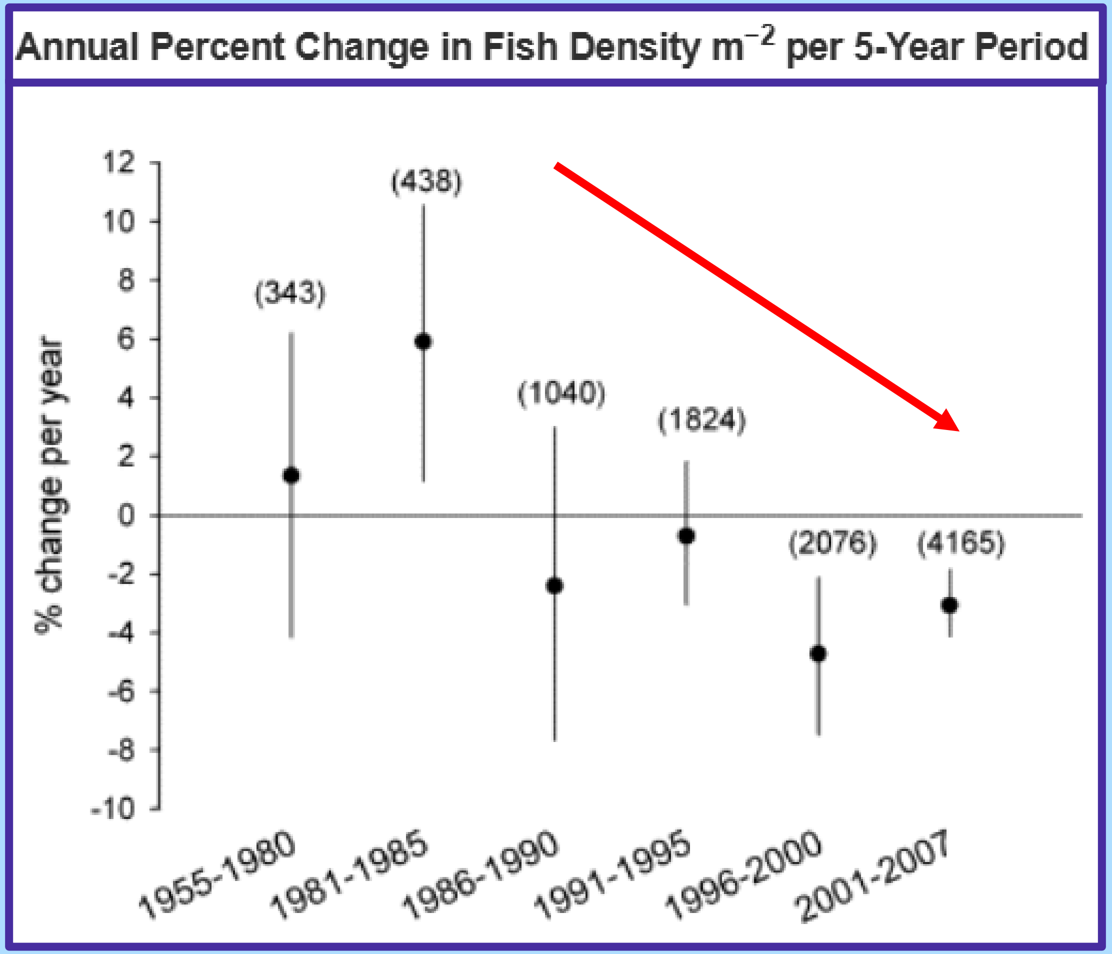


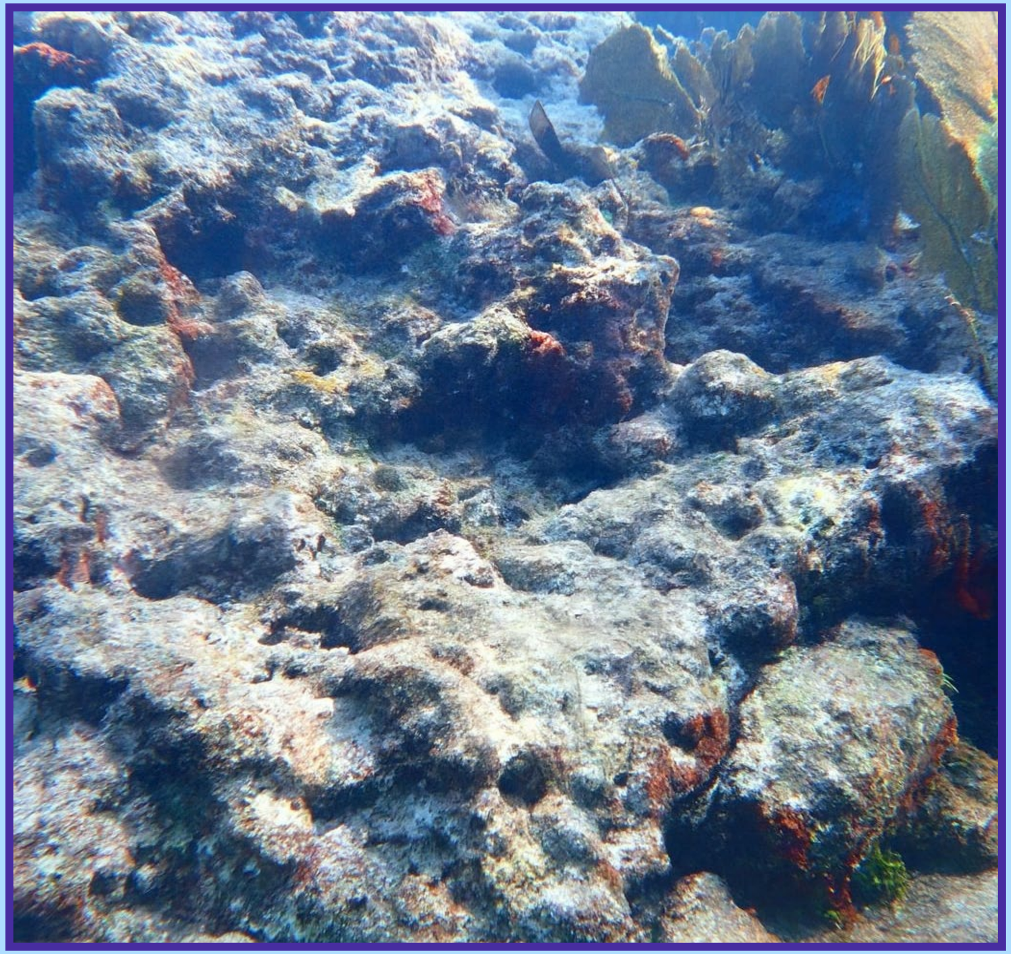
Projected coral reef degradation in Florida could increase the coastal flood risk to more than 7,300 people at the cost of $824 million annually

Storlazzi et al. 2021

Reef Flattening Threatens Ecosystem Services & Functions

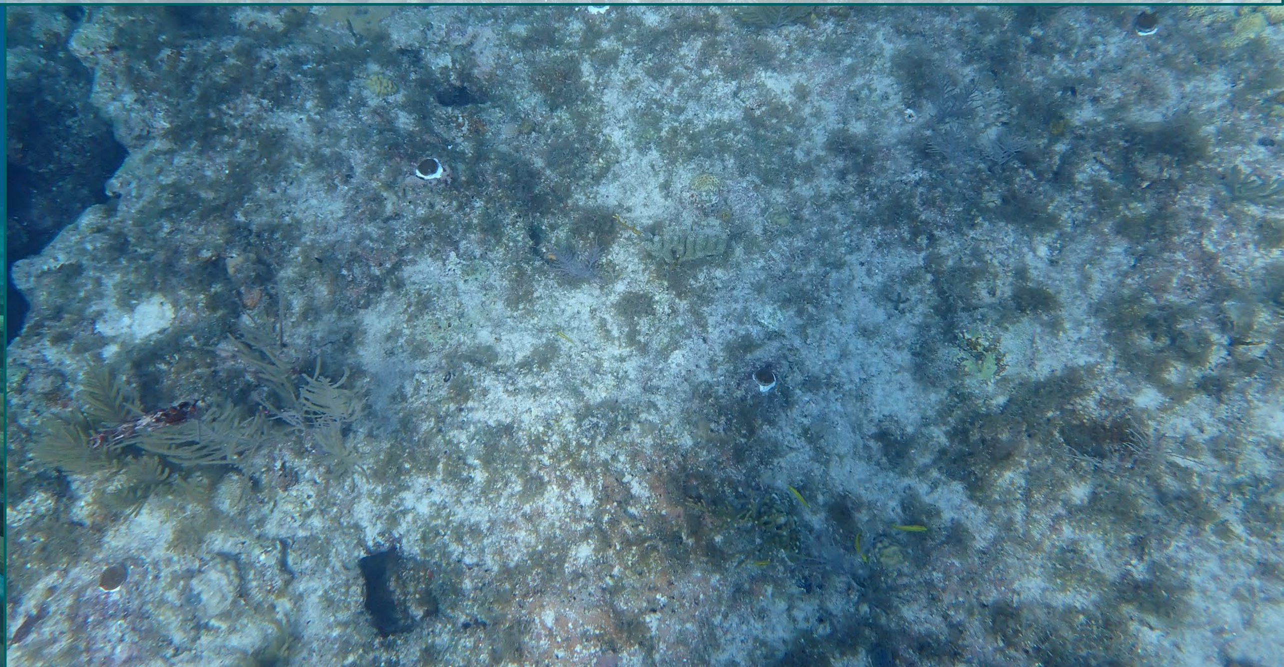


Paddack et al. 2009

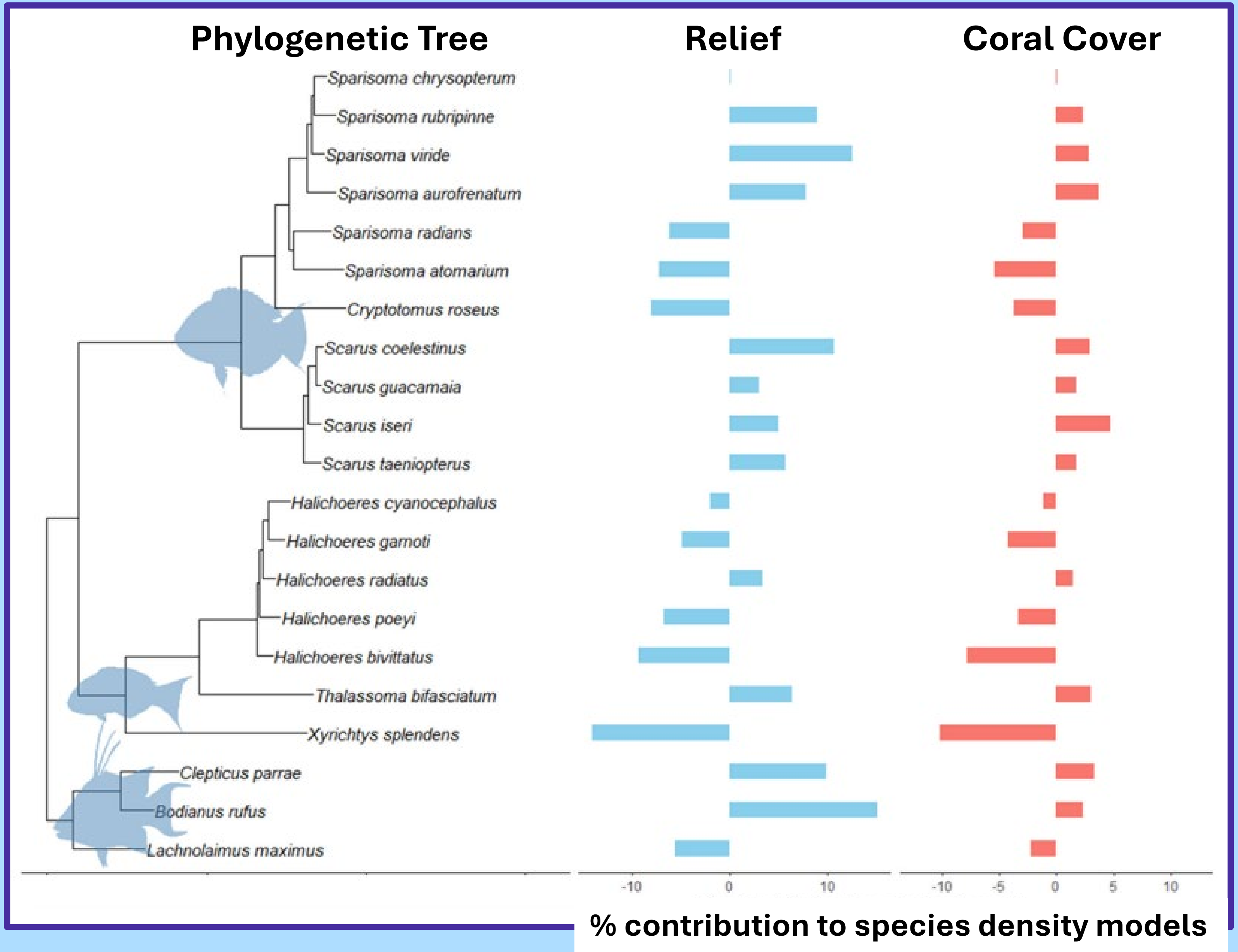


Helder, Burns & Green 2022
Burman et al. 2012
Alvarez-Filip et al. 2009
Alvarez-Filip et al. 2015
Rogers, Blanchard & Mumby 2014

Consider New Synergistic Management Strategies

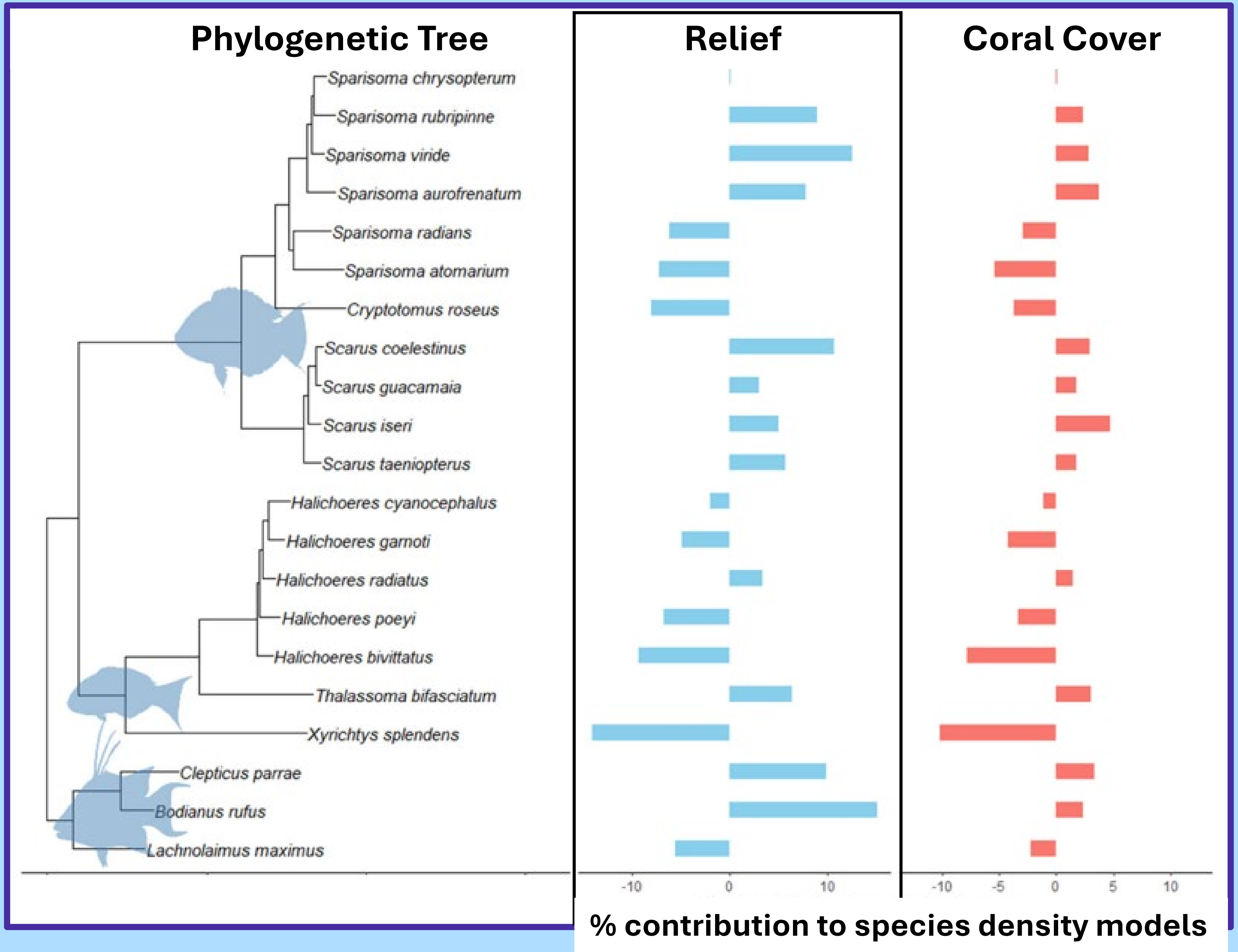


Coral Cover ≠ Structural Complexity on Low Coral Cover Reefs



Kochan et al. 2023, Oikos

Coral Cover ≠ Structural Complexity on Low Coral Cover Reefs

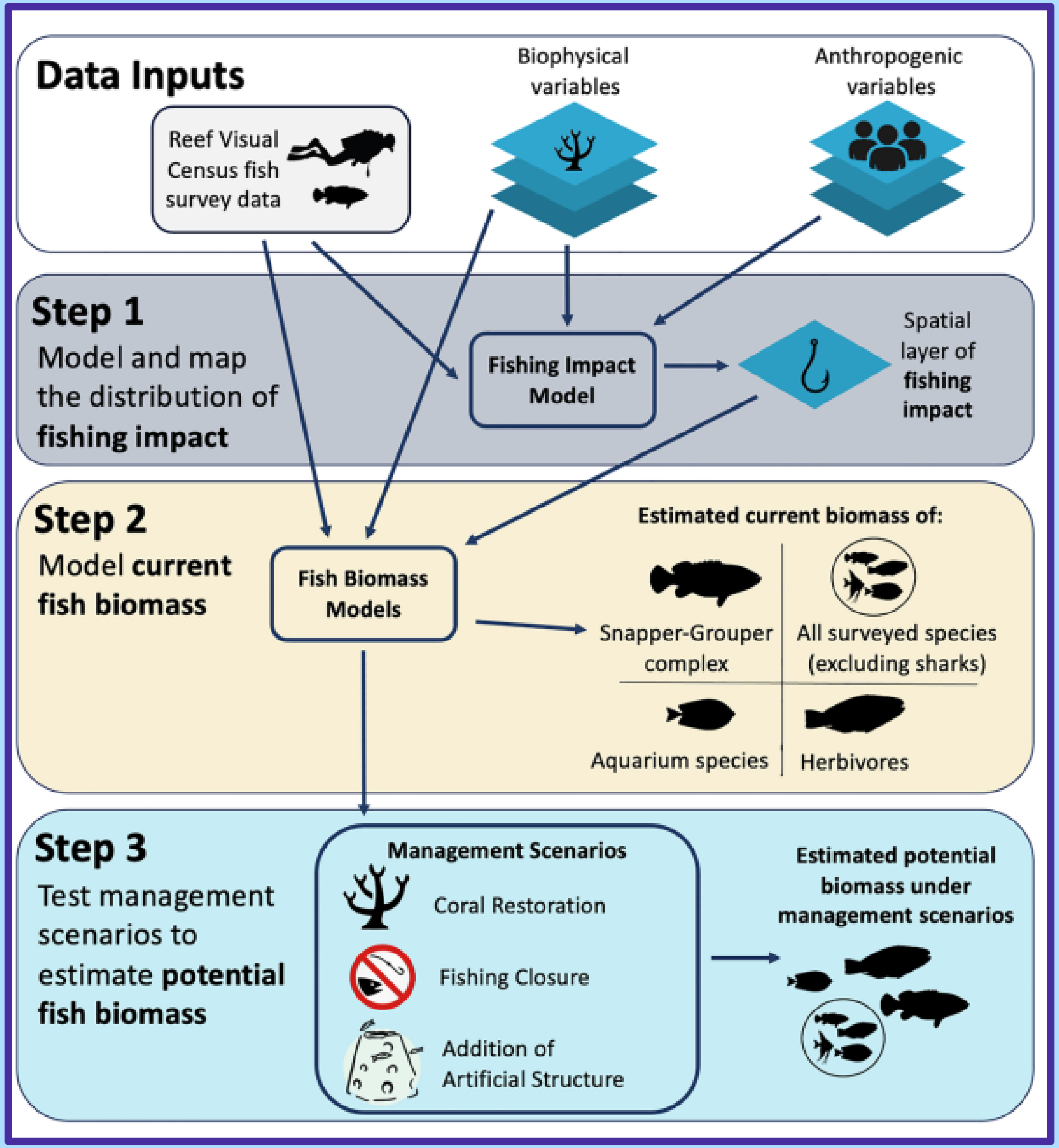


Maximum hard relief

- Explained more variation in species densities across Florida's Coral Reef
- Linked to larger # of species than coral cover

Kochan et al. 2023, Oikos

Estimating Potential Fish Biomass under Different Management Scenarios



Zuercher et al. 2023, Aquatic Conserv

The most effective <u>single</u> management measure for increasing predicted fish biomass → substantial increase in reef complexity

Management scenario	All species kg ha^{-1} (SD)	All species %Δ	Snapper–grouper kg ha^{-1} (SD)	Snapper–grouper %Δ	Grazing species kg ha^{-1} (SD)	Grazing species %Δ	Aquarium species kg ha^{-1} (SD)	Aquarium species %Δ
Current	657 (252)	–	218 (137)	–	98 (35)	–	189 (52)	–
I: Reef restoration – phase 1a (moderate)	689 (242)	5%	237 (159)	8%	94 (33)	-4%	198 (52)	5%
II: Reef restoration – phase 2 (extensive)	996 (508)	52%	285 (191)	31%	103 (41)	5%	225 (69)	19%
III: Artificial structure	1,132 (482)	72%	314 (208)	44%	121 (42)	23%	258 (70)	37%
IV: Fishing closure	698 (204)	6%	269 (110)	23%	112 (42)	14%	201 (52)	6%
V: Reef restoration + fishing closure	1,094 (520)	67%	369 (150)	69%	117 (48)	19%	240 (72)	27%
VI: Artificial structure + fishing closure	1,241 (477)	89%	411 (160)	89%	136 (49)	39%	274 (73)	45%

Zuercher et al. 2023, Aquatic Conserv
Rogers et al. 2015, Glob Change Biol

But Beneficial Synergies have Greater Potential for Greater Impacts

	All species		Snapper–grouper		Grazing species		Aquarium species	
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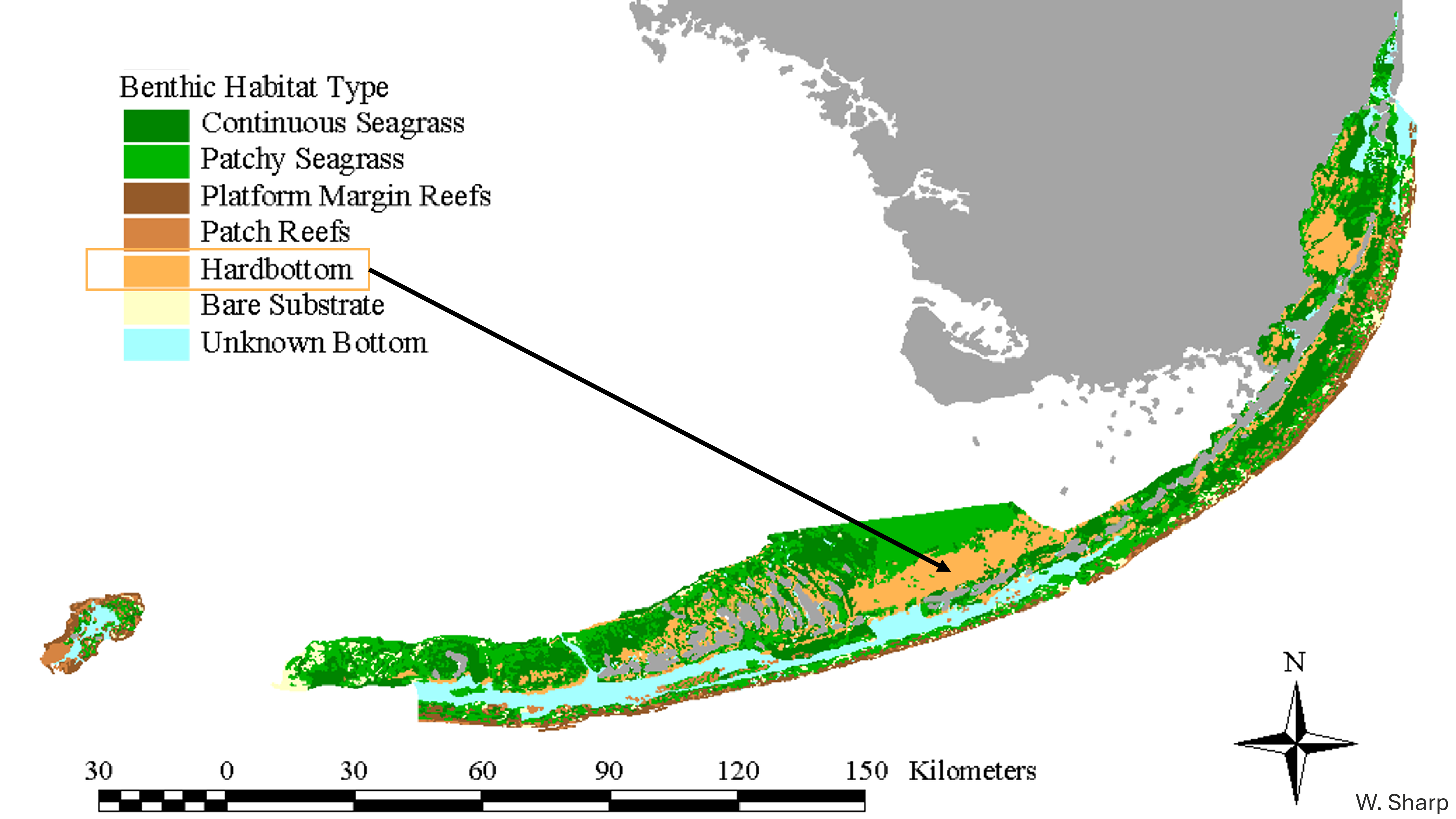
?? Artificial structure + reef restoration (hybrid reefs)

Zuercher et al. 2023, Aquatic Conserv
Rogers et al. 2015, Glob Change Biol


Shallow
Nearshore
Hardbottom
W. Sharp


Benthic Habitat Type
Continuous Seagrass
Patchy Seagrass
Platform Margin Reefs
Patch Reefs
Hardbottom
Bare Substrate
Unknown Bottom
N
30
0
30
60
90
120
150
Kilometers
W. Sharp



Shallow Nearshore Hardbottom (Bayside)



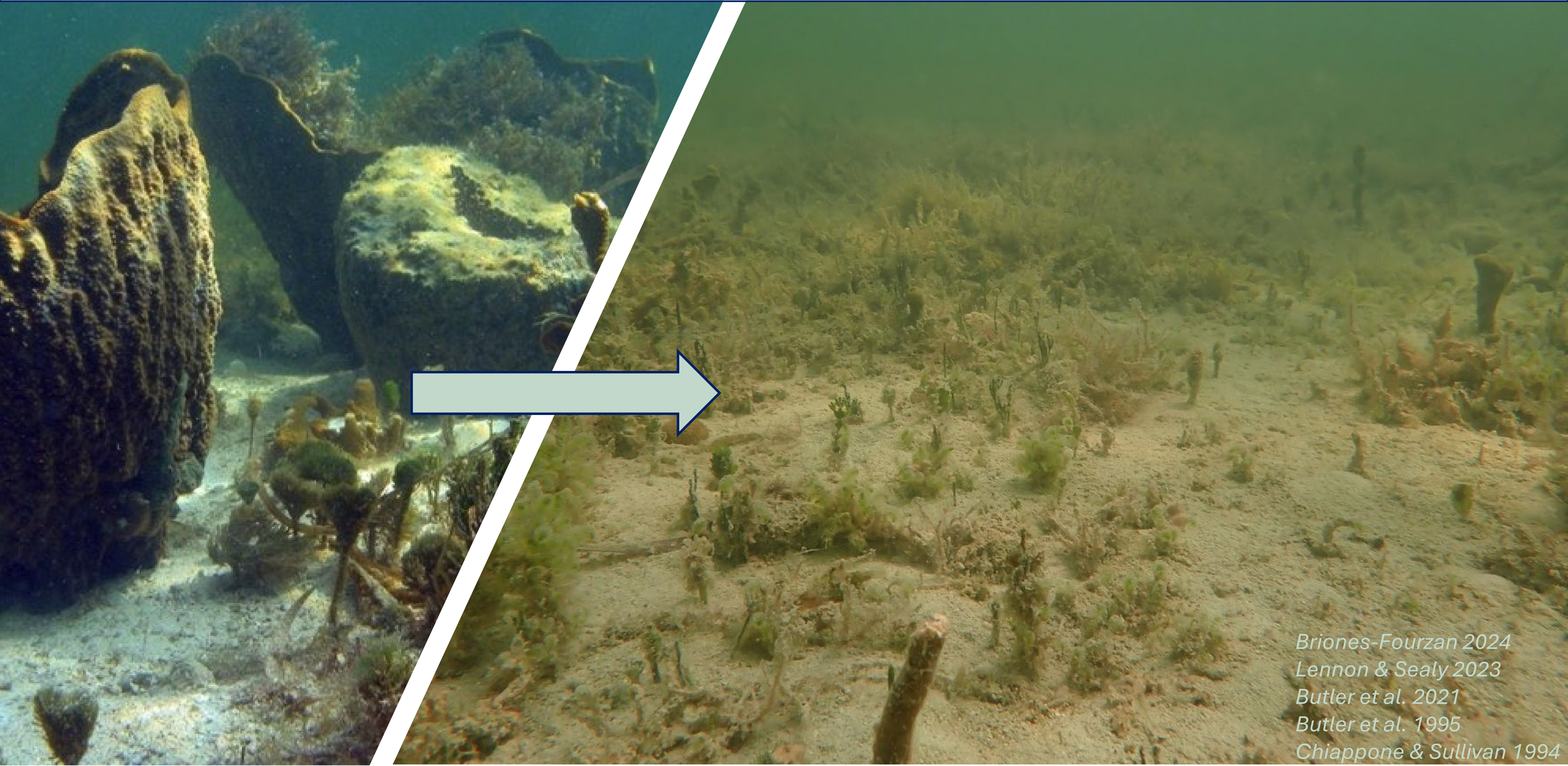
Field & Butler 1994
Chiappone & Sullivan 1994

W. Sharp

Essential Fish & Invertebrate Habitat (Shelter, Refuge, Foraging, Nursery)

Hunt 1994
Davis & Dodrill 1989
Herrnkind et al. 1994

Reductions in Habitat & Structural Complexity



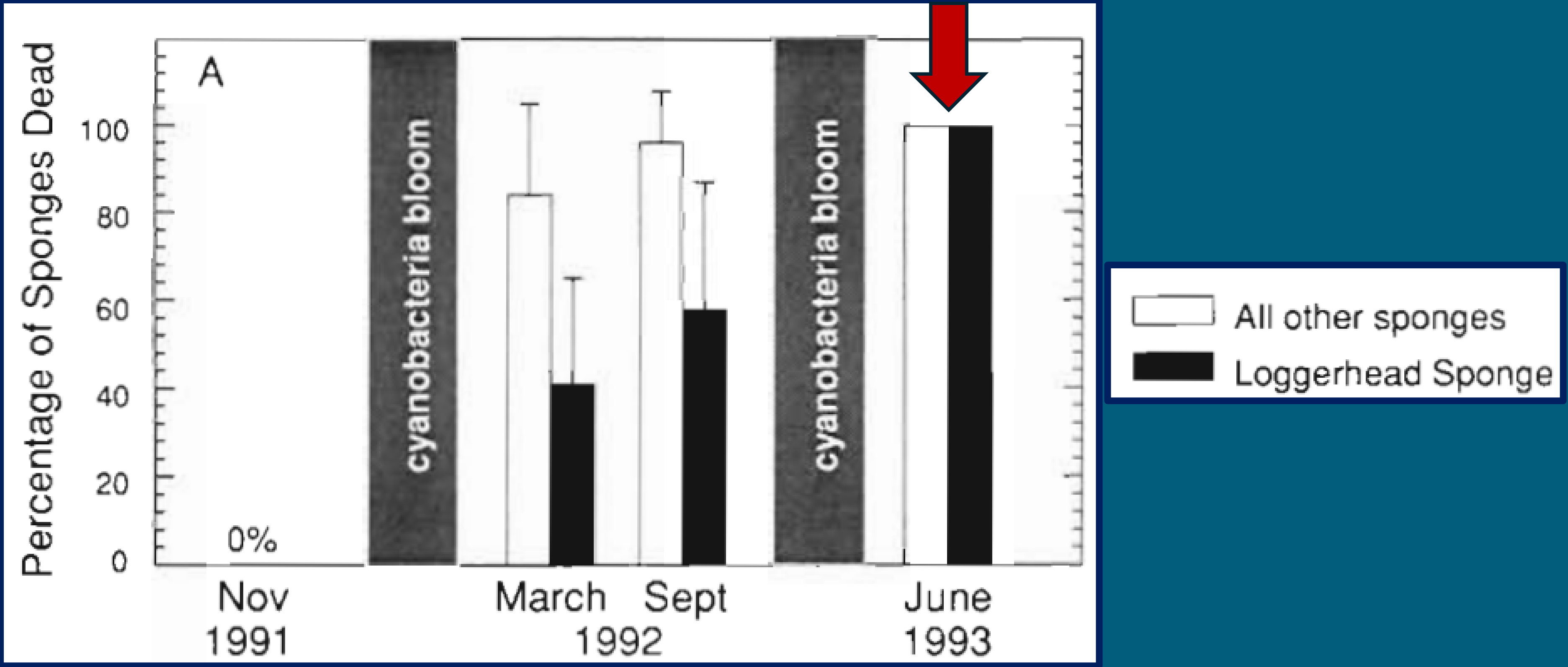
Briones-Fourzan 2024
Lennon & Sealy 2023
Butler et al. 2021
Butler et al. 1995
Chiappone & Sullivan 1994

Substantial Changes in Habitat Landscape, Community Composition, & Ecology

Briones-Fourzan 2024
Lennon & Sealy 2023
Butler et al. 2021
Butler et al. 1995
Boesch et al. 1993

Cascading disturbances in Florida Bay, USA: cyanobacteria blooms, sponge mortality, and implications for juvenile spiny lobsters *Panulirus argus*

Butler et al. 1995 MEPS



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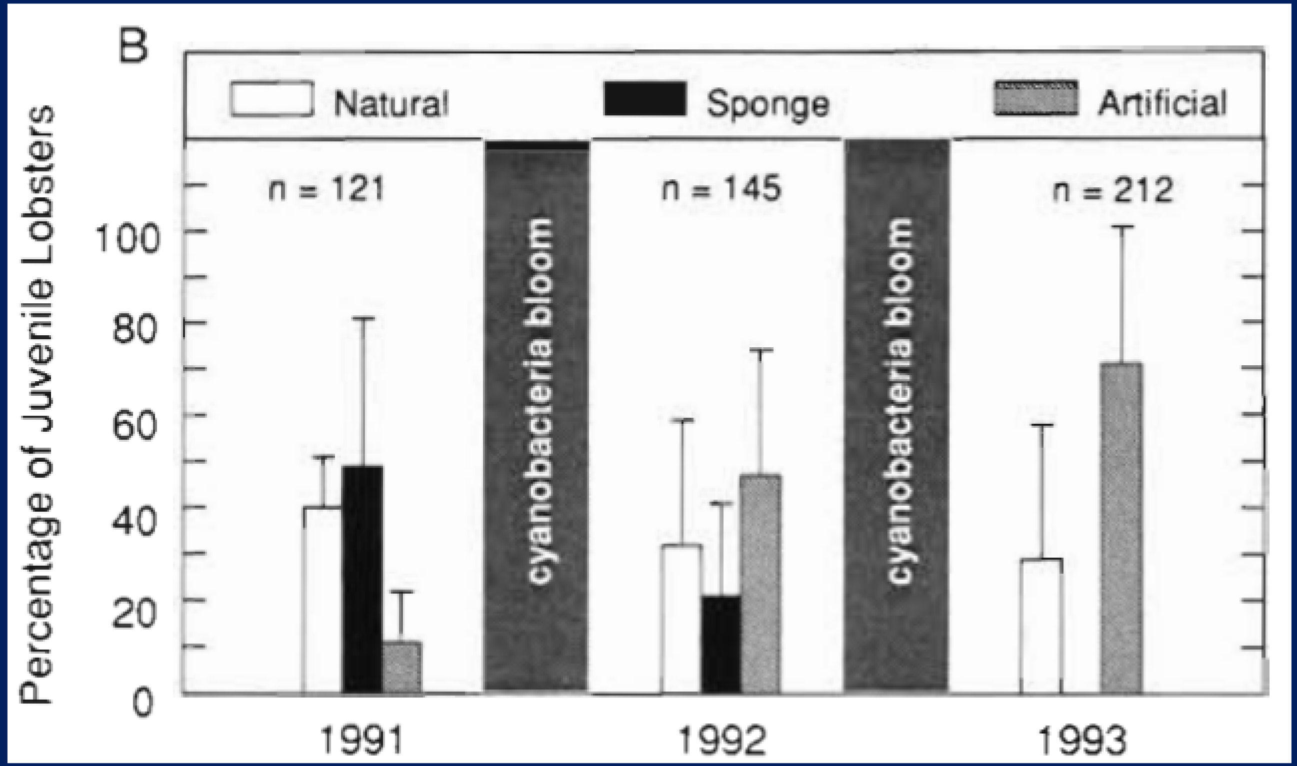
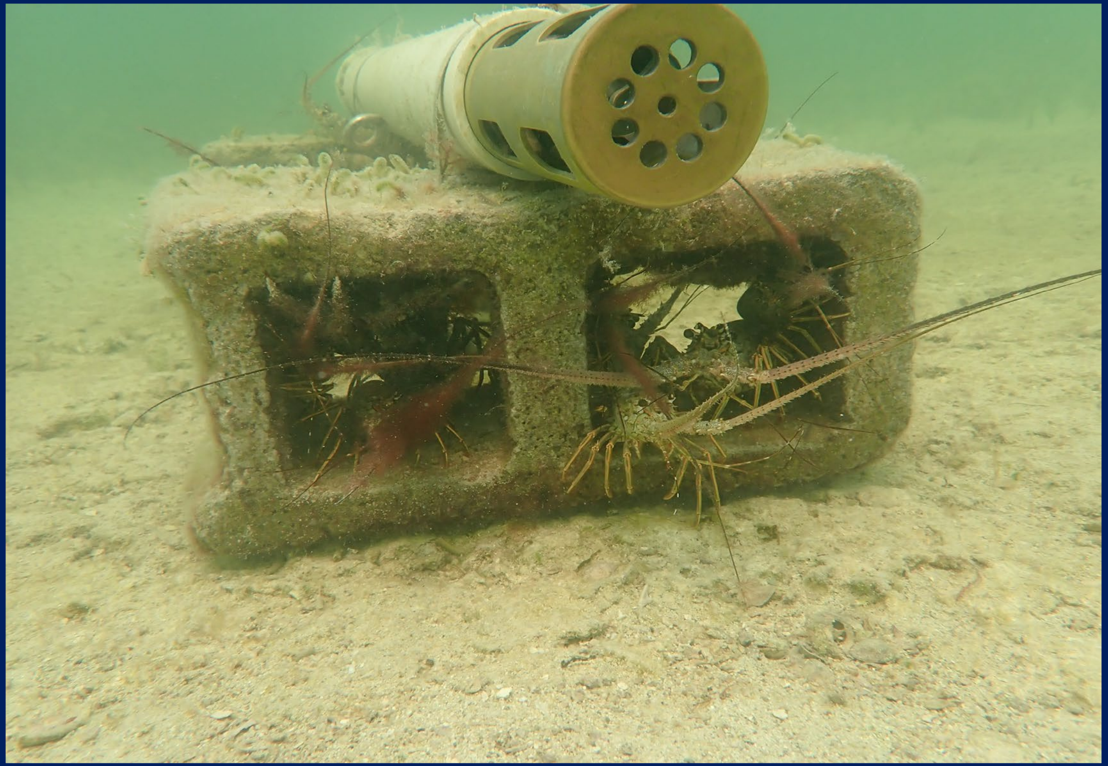
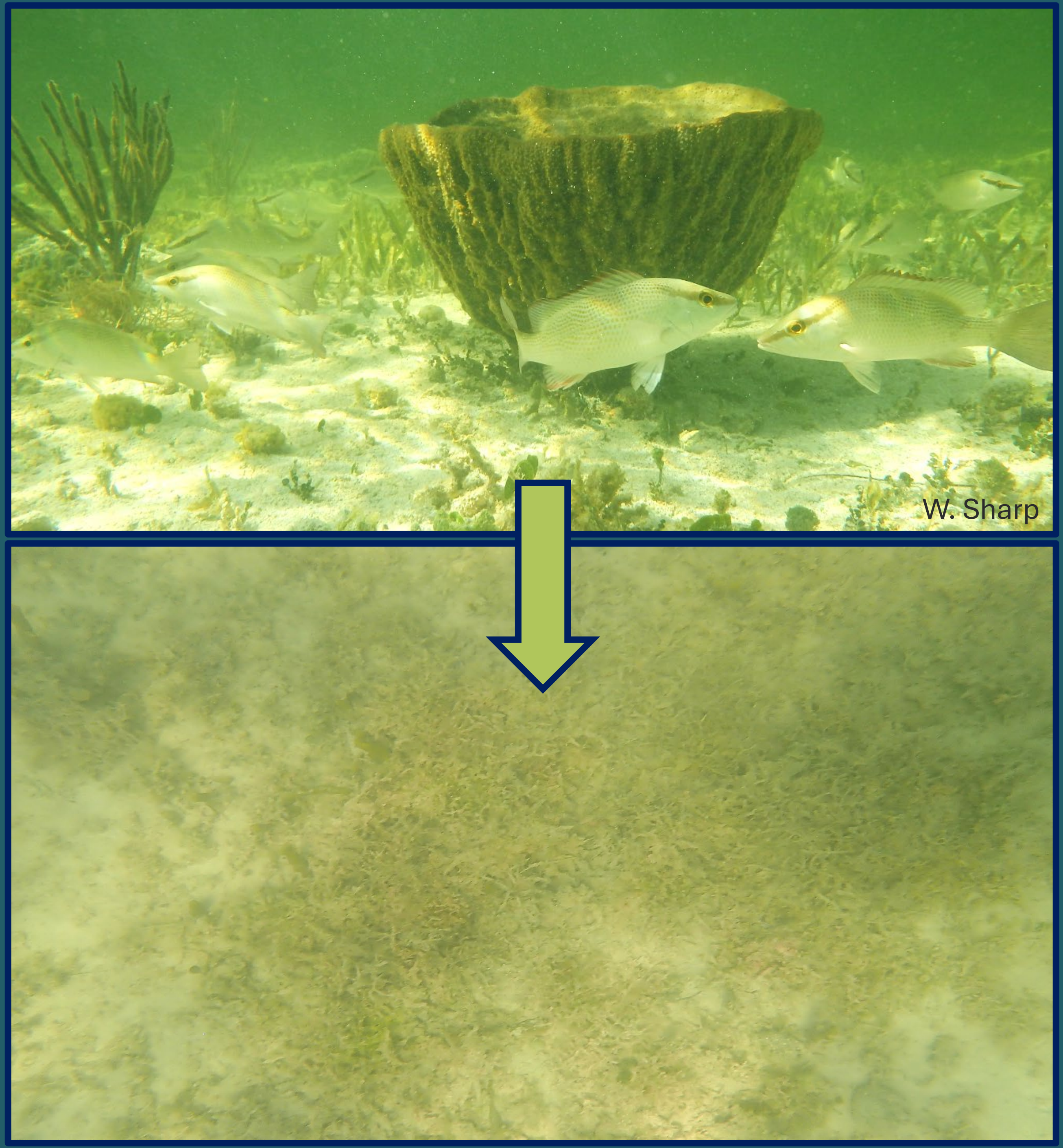
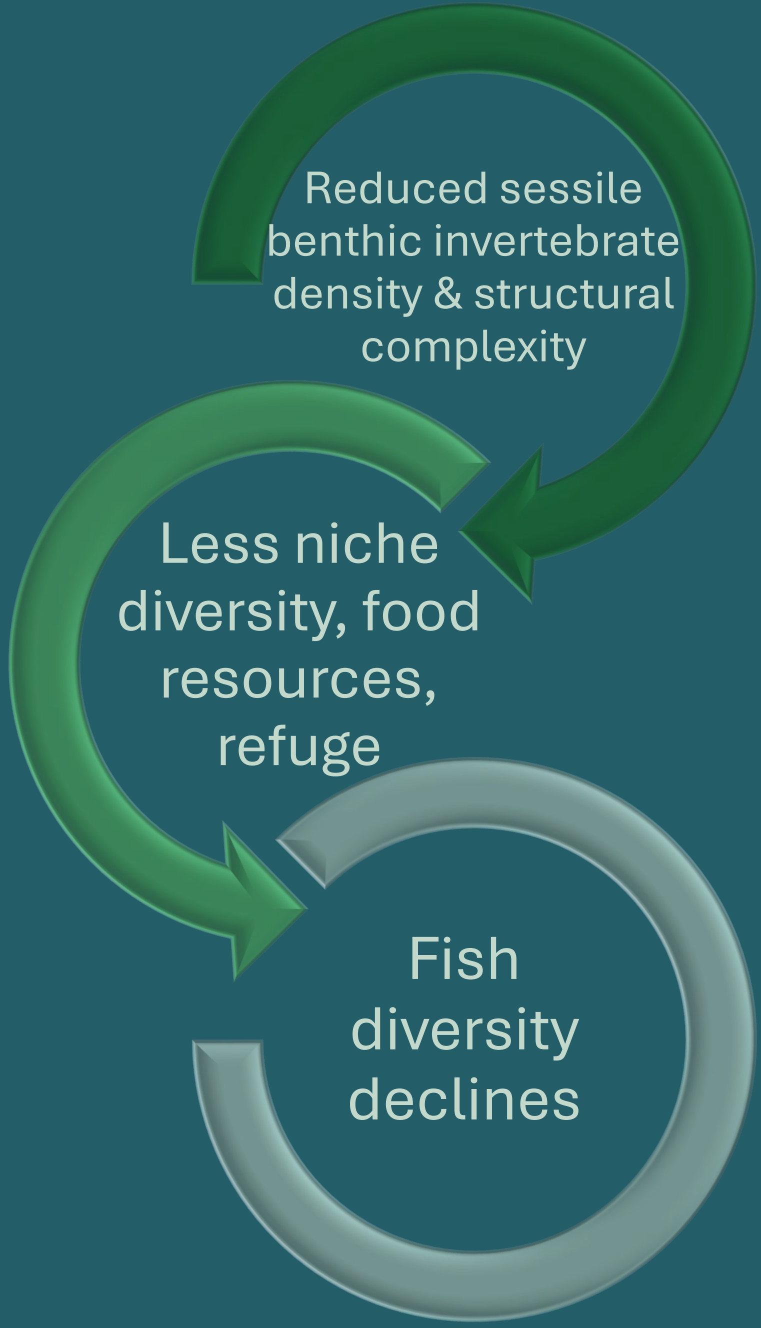








Briones-Fourzan 2024
Lennon & Sealy 2023
Butler et al. 2021
Butler et al. 1995
Chiappone & Sullivan 1994

Habitat Support Structures

Pilot Program

NATIONAL MARINE SANCTUARIES

FLORIDA KEYS

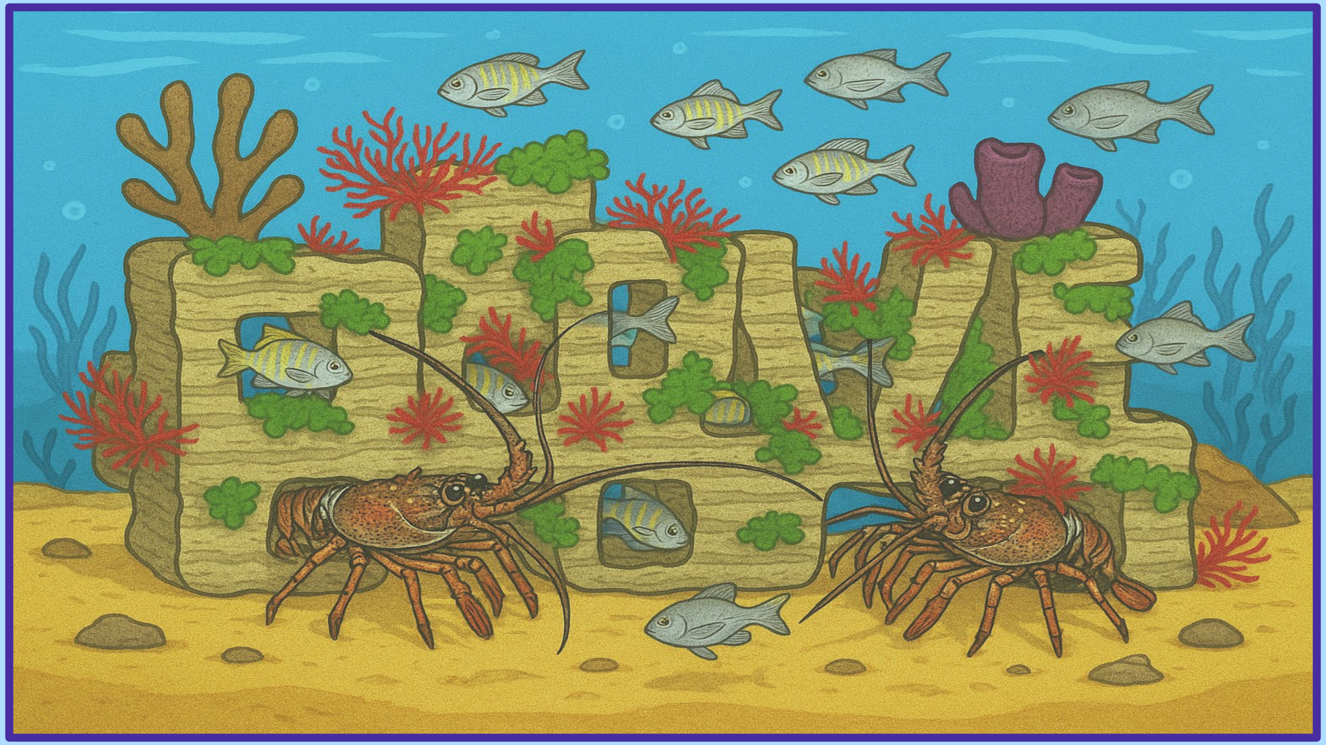
Objective:

Establish framework for the design, placement, & monitoring of HSS that:

1. Address habitat deficits as related to fish and invertebrate life histories

2. Promote 3D complexity, biodiversity, & diverse fish assemblages

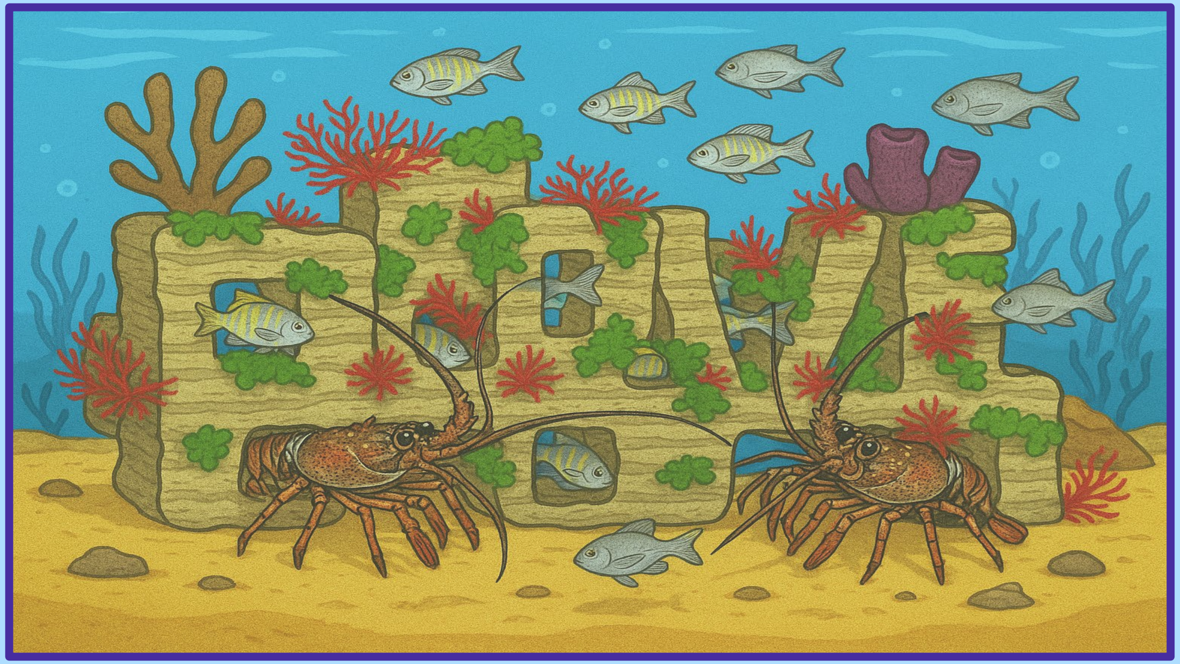
3. Provide ecological support and improve ecosystem function



Basis of Approach:

Characterize habitats and their (structural) deficits as related to fish and invertebrate life histories

Lack of specific habitat (from loss) & quality habitat (from degradation)



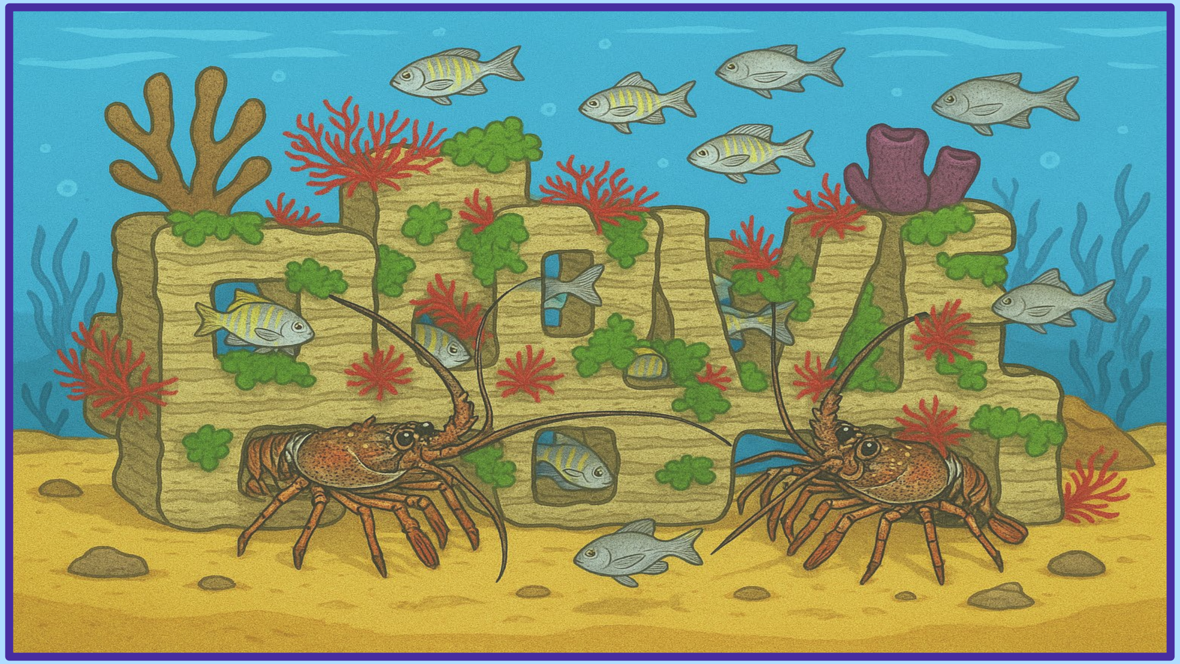
<u>Basis of Approach:</u>

Characterize habitats and their (structural) deficits as related to fish and invertebrate life histories

Lack of specific habitat (from loss) & quality habitat (from degradation)

Test HSS that functionally mimic and/or enhance the structural components that historically provided complexity

Treatments: material type, structure style, size, scale (benthic footprint), restoration component (hybrid reefs)



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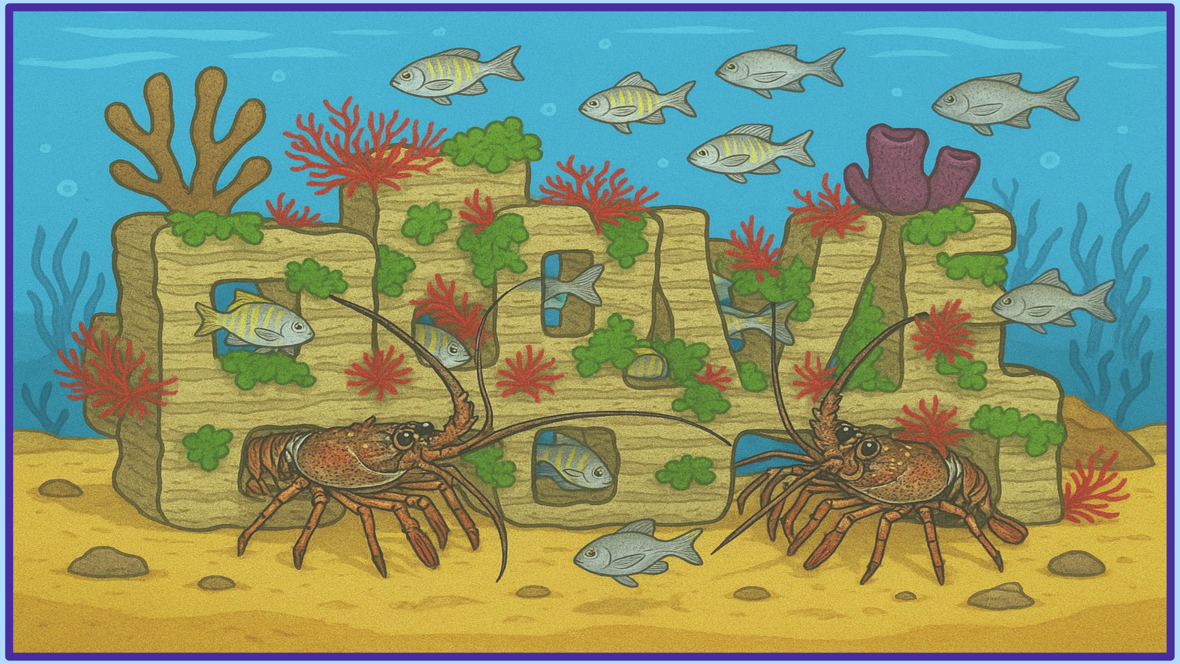
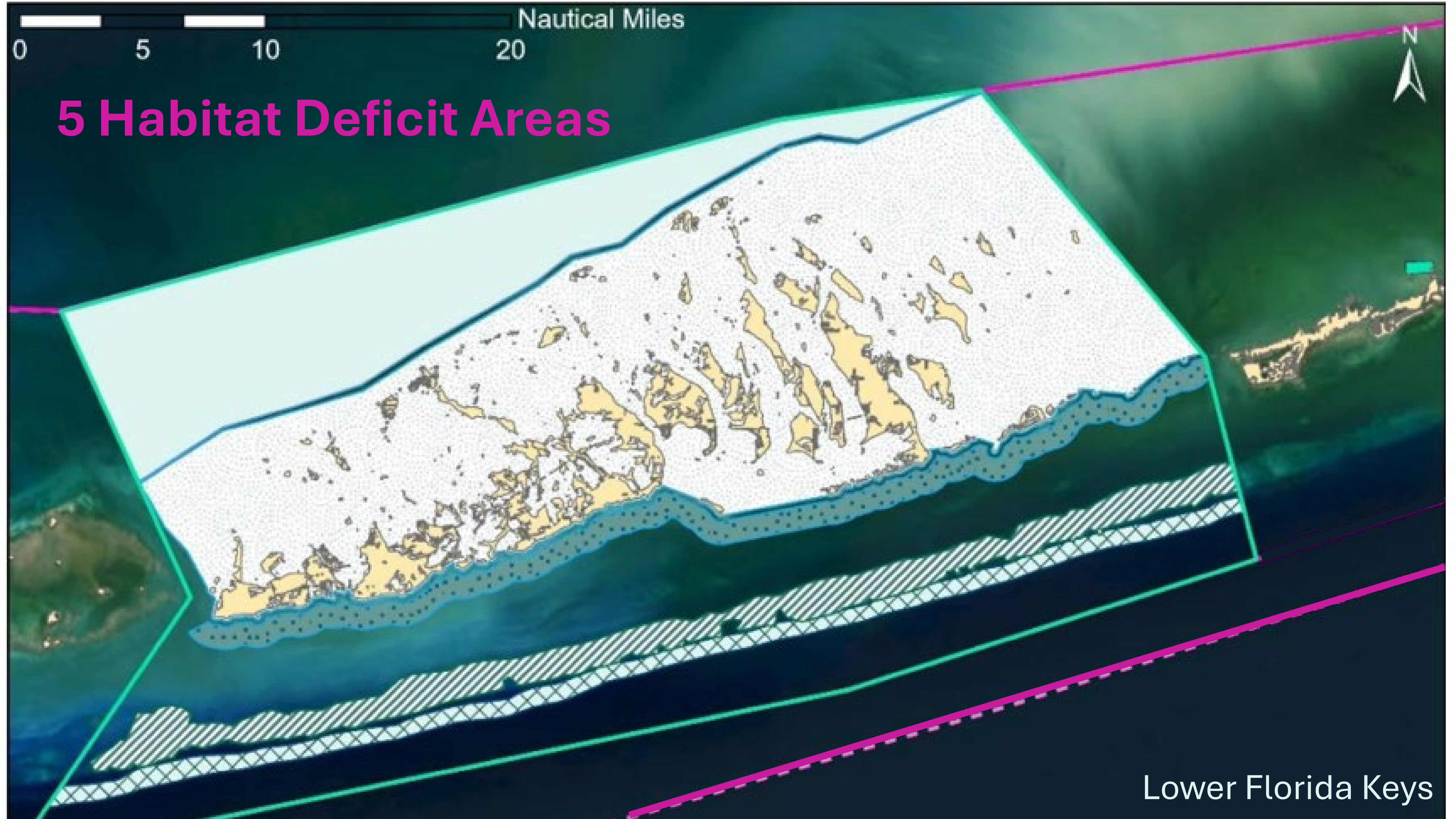
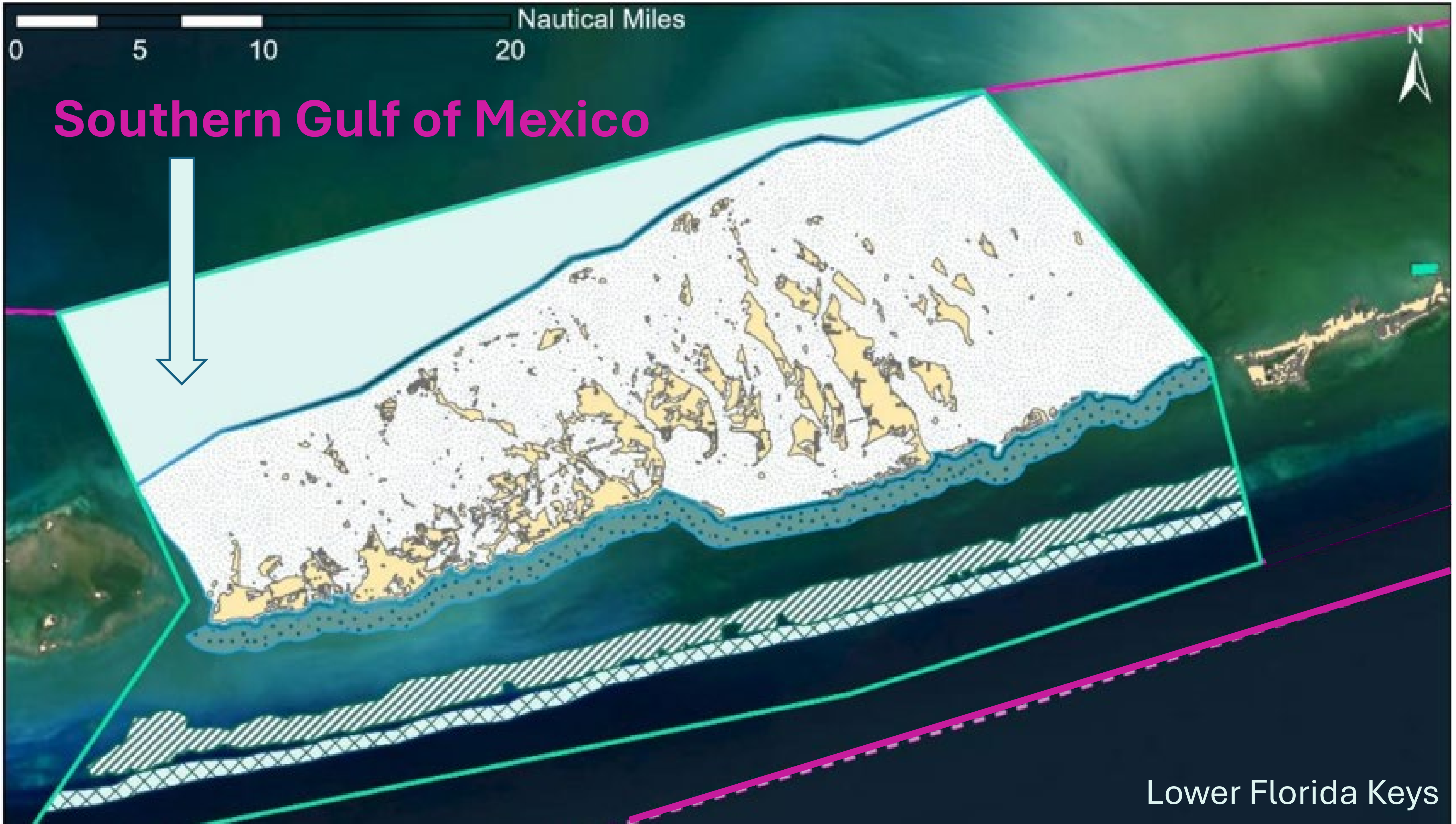
Treatments: material type, structure style, size, scale (benthic footprint), restoration component (hybrid reefs)

Evaluate net ecological outcomes (negative, neutral, positive) based on comprehensive monitoring plan

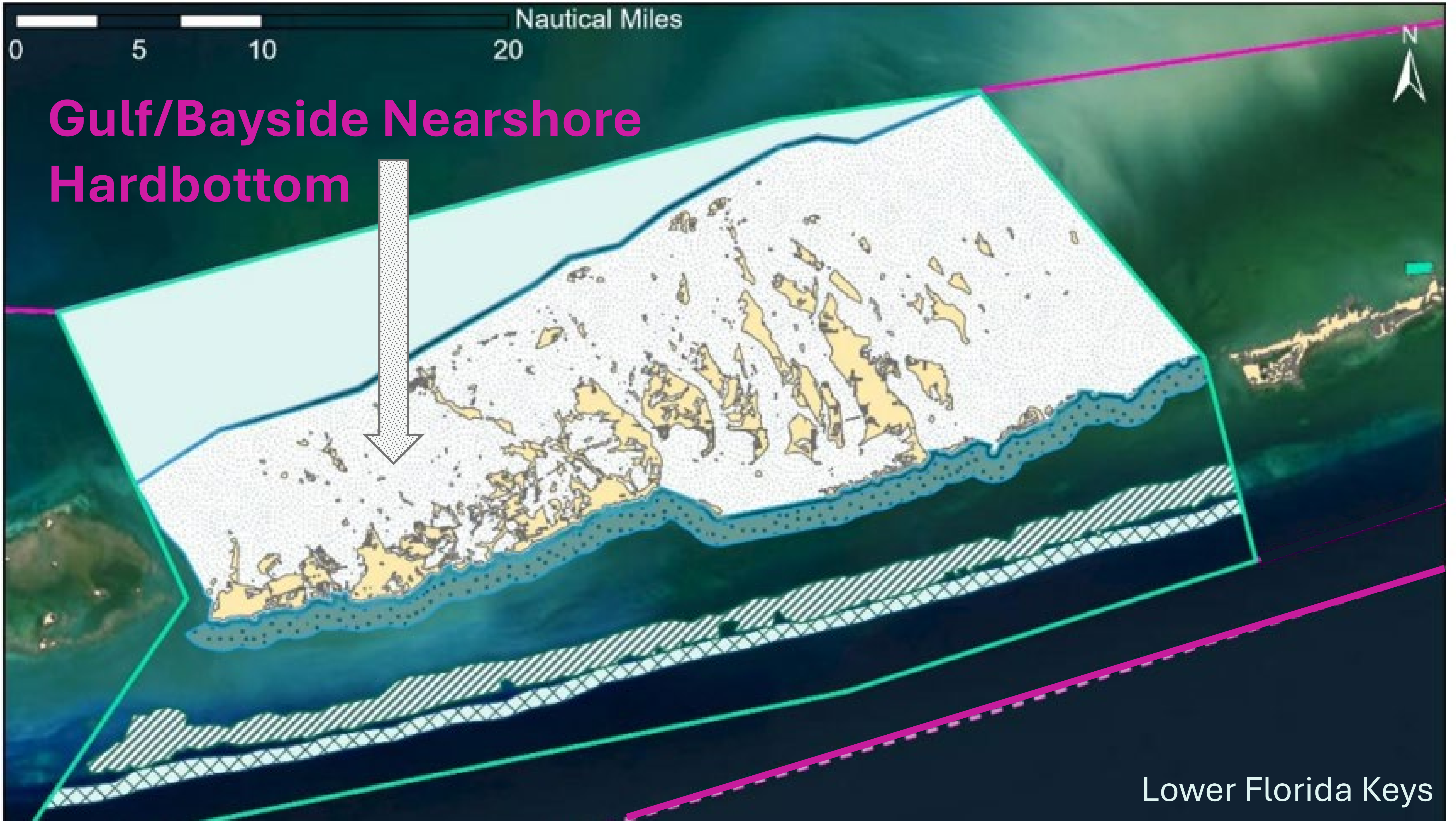
Executed by a team of local experts & scientists

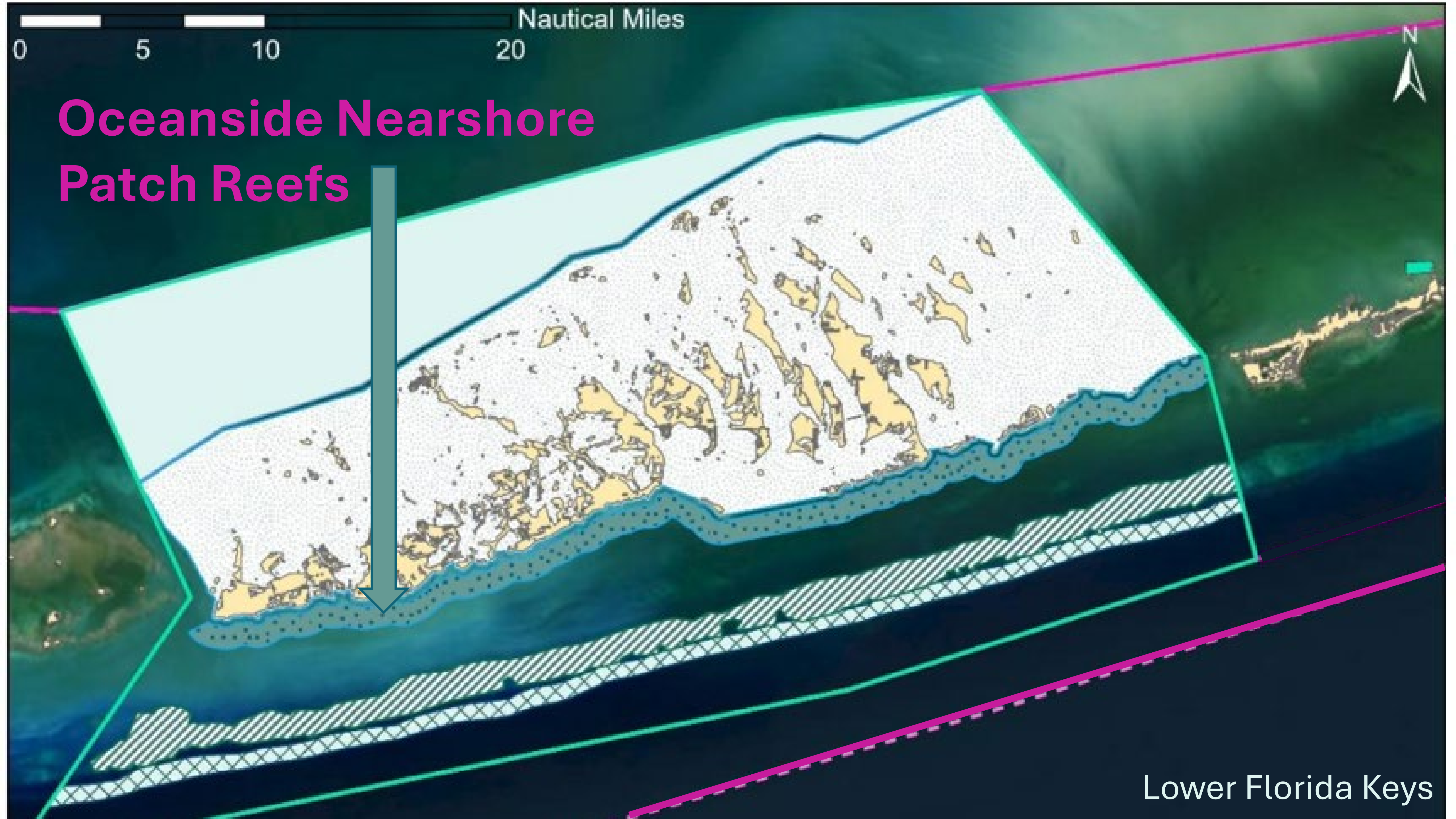


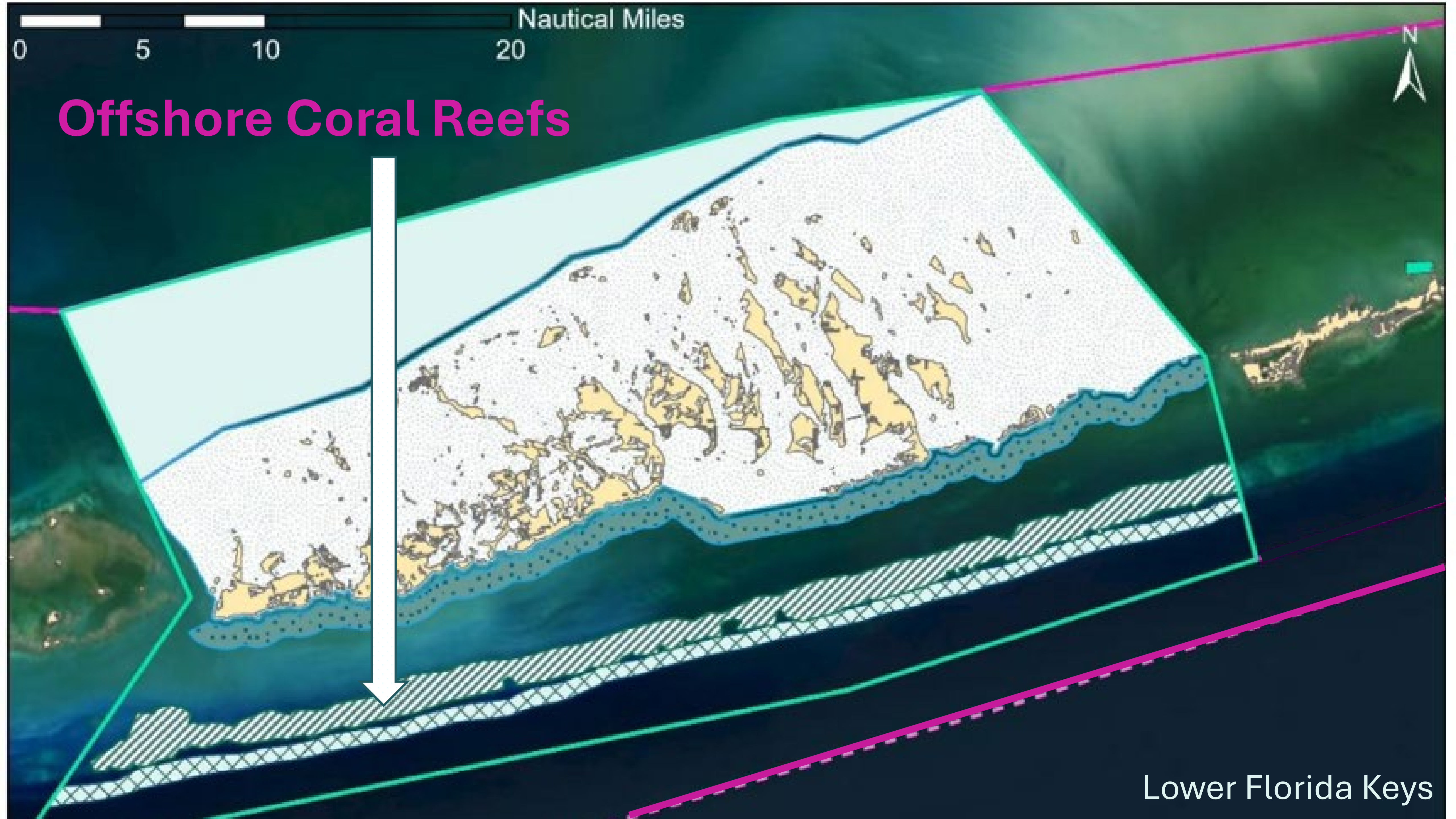

Nautical Miles
0
5
10
20
5 Habitat Deficit Areas
N
Lower Florida Keys

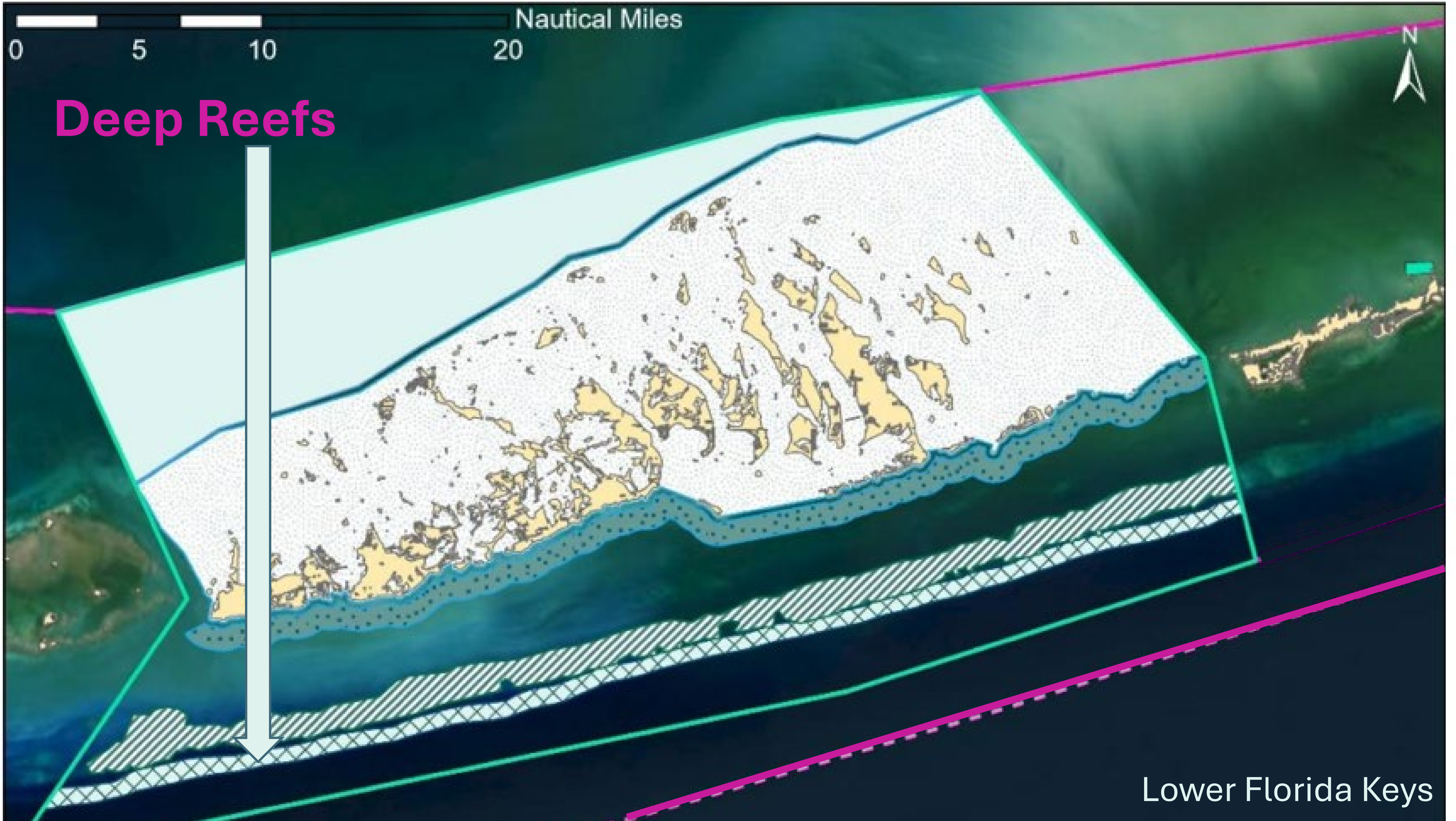


Nautical Miles
0
5
10
20
N
Southern Gulf of Mexico
Lower Florida Keys


Nautical Miles
0
5
10
20
N
Gulf/Bayside Nearshore Hardbottom
Lower Florida Keys


Nautical Miles
0
5
10
20
N
Oceanside Nearshore
Patch Reefs
Lower Florida Keys


Nautical Miles
0
5
10
20
N
Offshore Coral Reefs
Lower Florida Keys



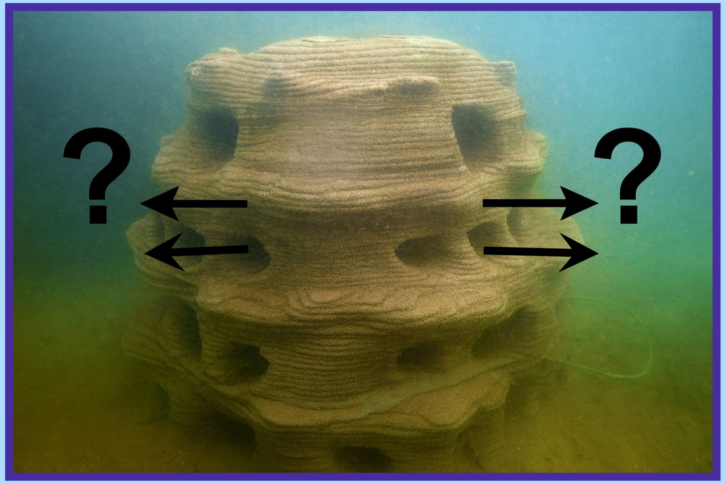
Nautical Miles
0
5
10
20
N
Deep Reefs
Lower Florida Keys

Materials | Innovative 3DP Tech

Methods | Comprehensive Monitoring

Physical

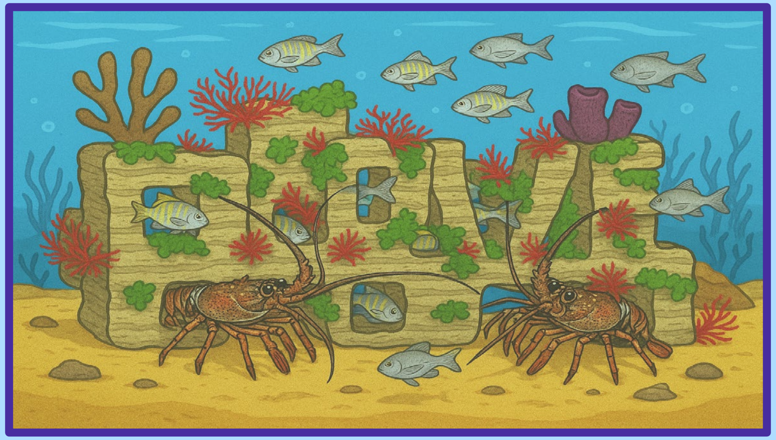
Stability (storms)
Subsidence
Scouring



Biological

Biodiversity
Fish
Motile + Sessile Inverts
Algae/Seagrass

Processes
Colonization
Settlement/Recruitment
Restoration Success
Seasonal Patterns



Social

Understanding
Attitudes
Usage

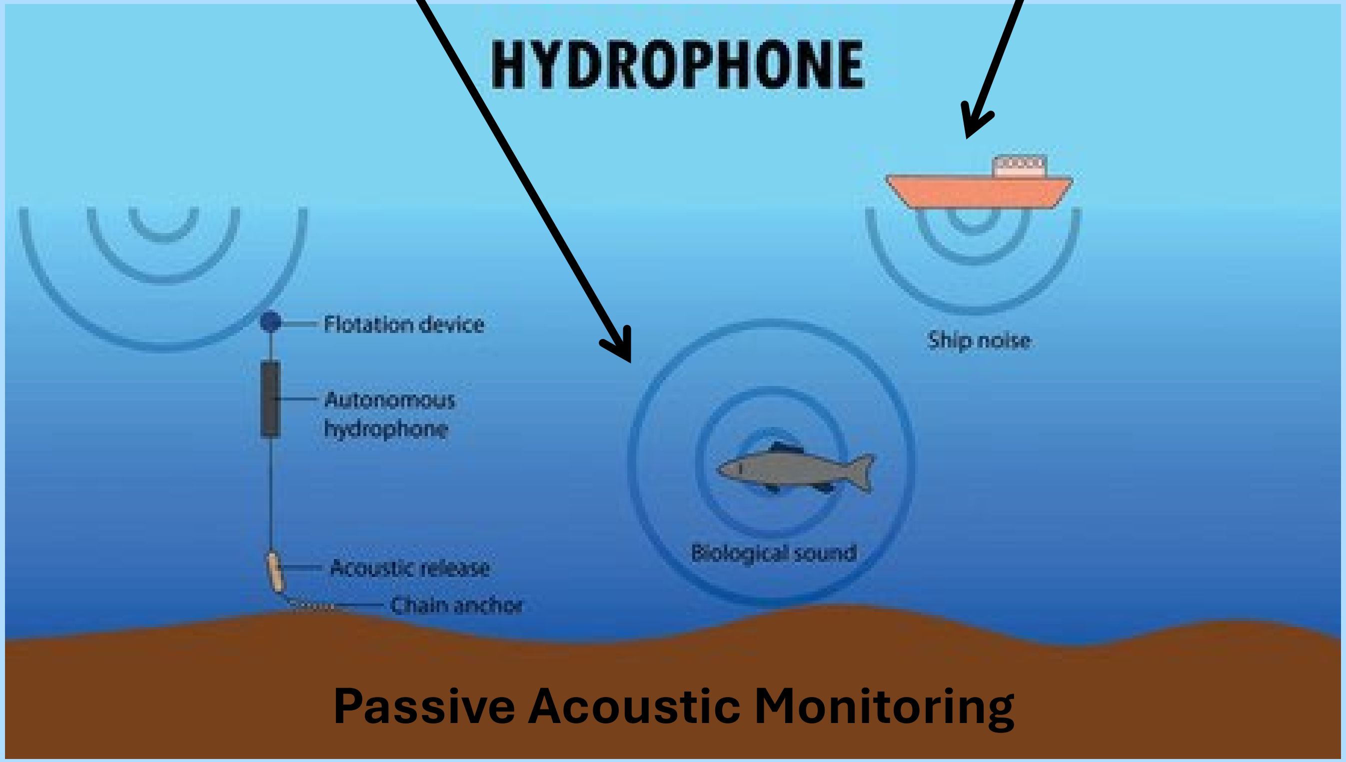
Methods | Comprehensive Monitoring

Biological

Social

Fish

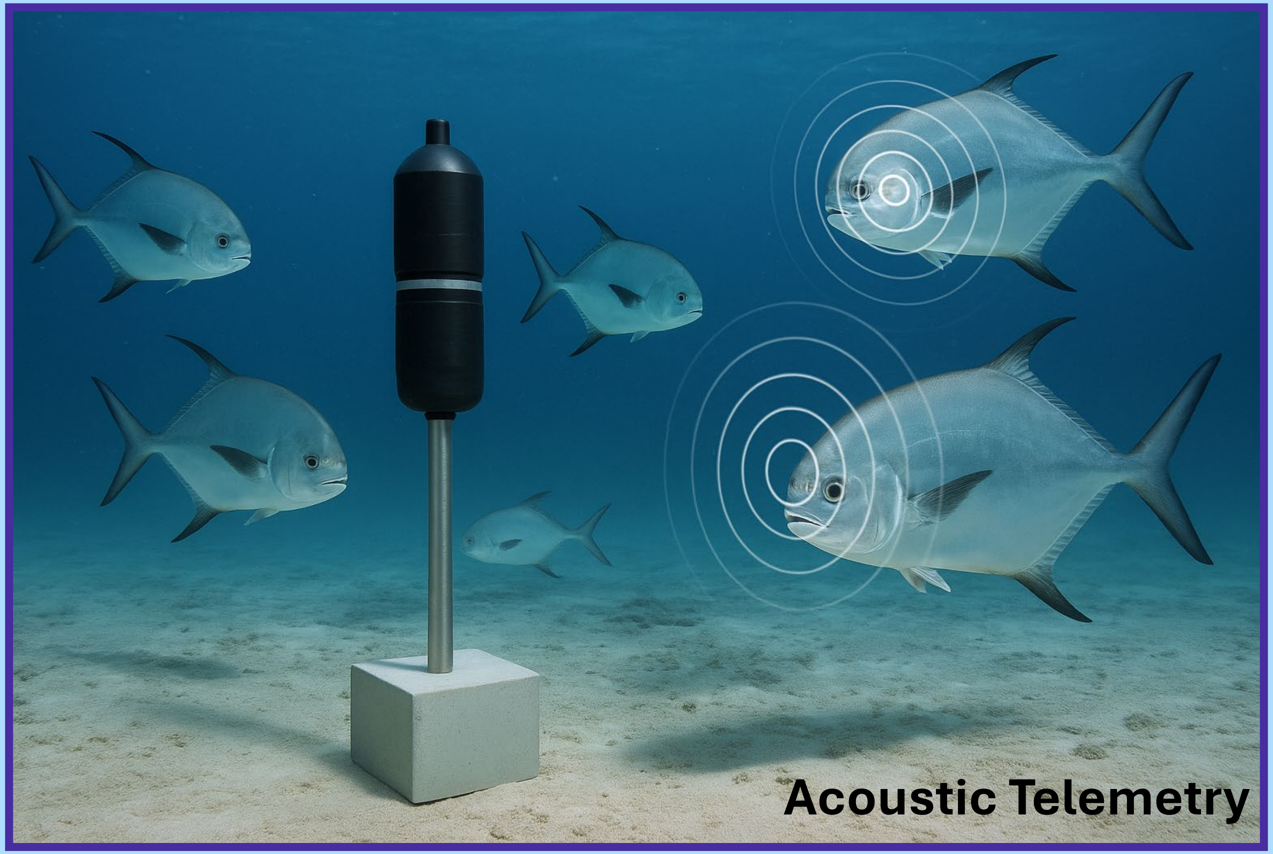
Usage



Methods | Comprehensive Monitoring

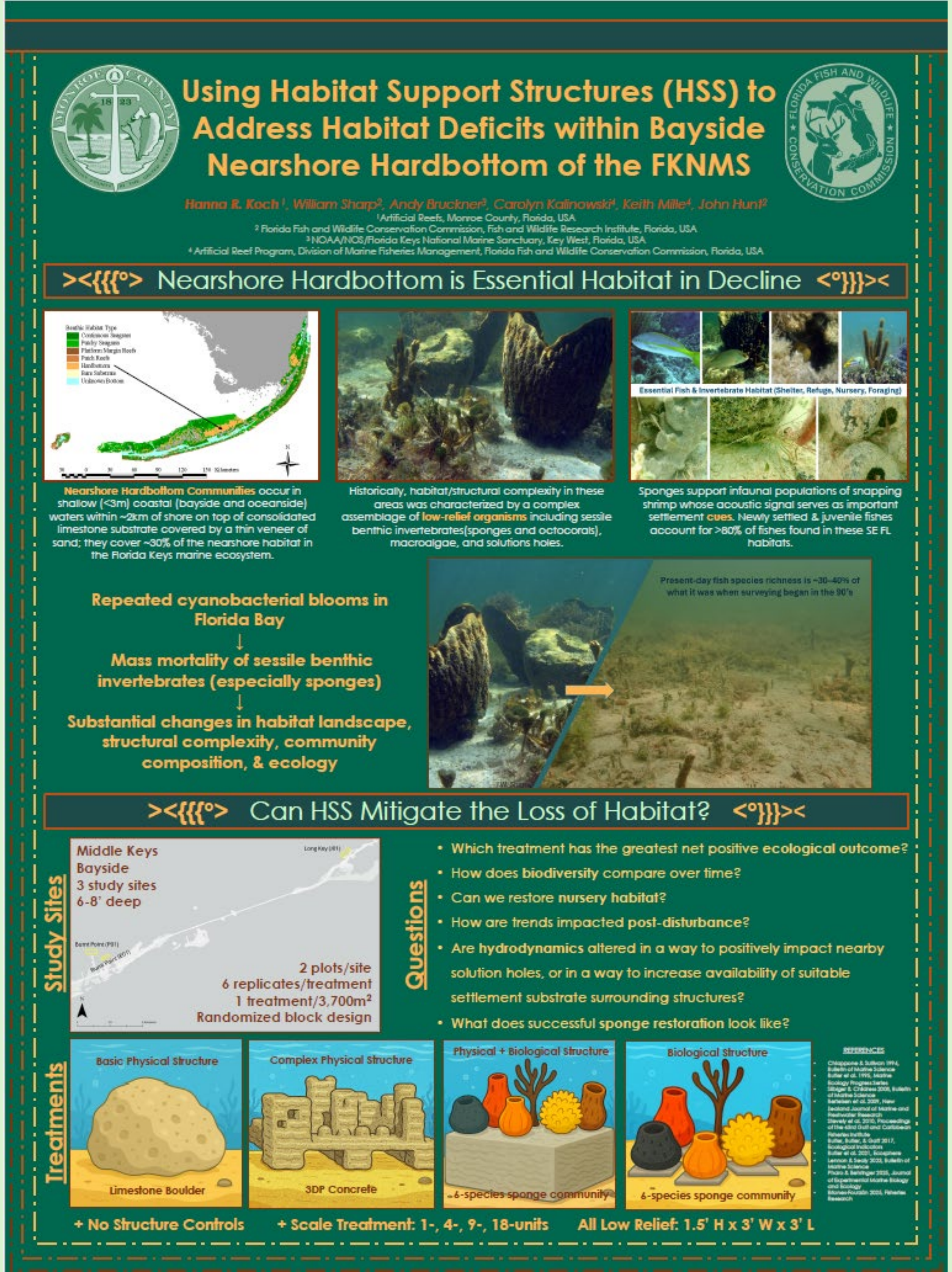
Biological

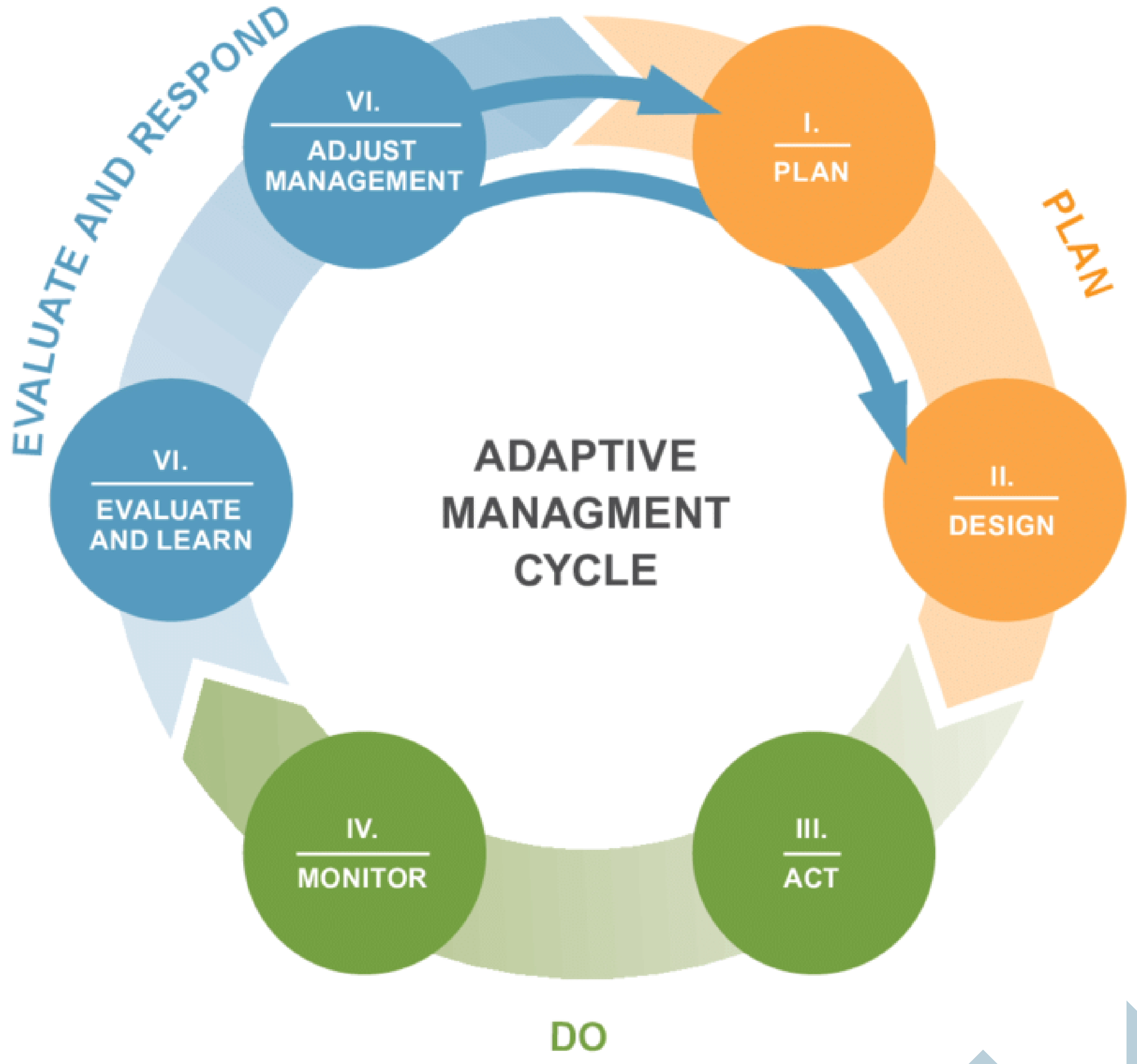
Fish

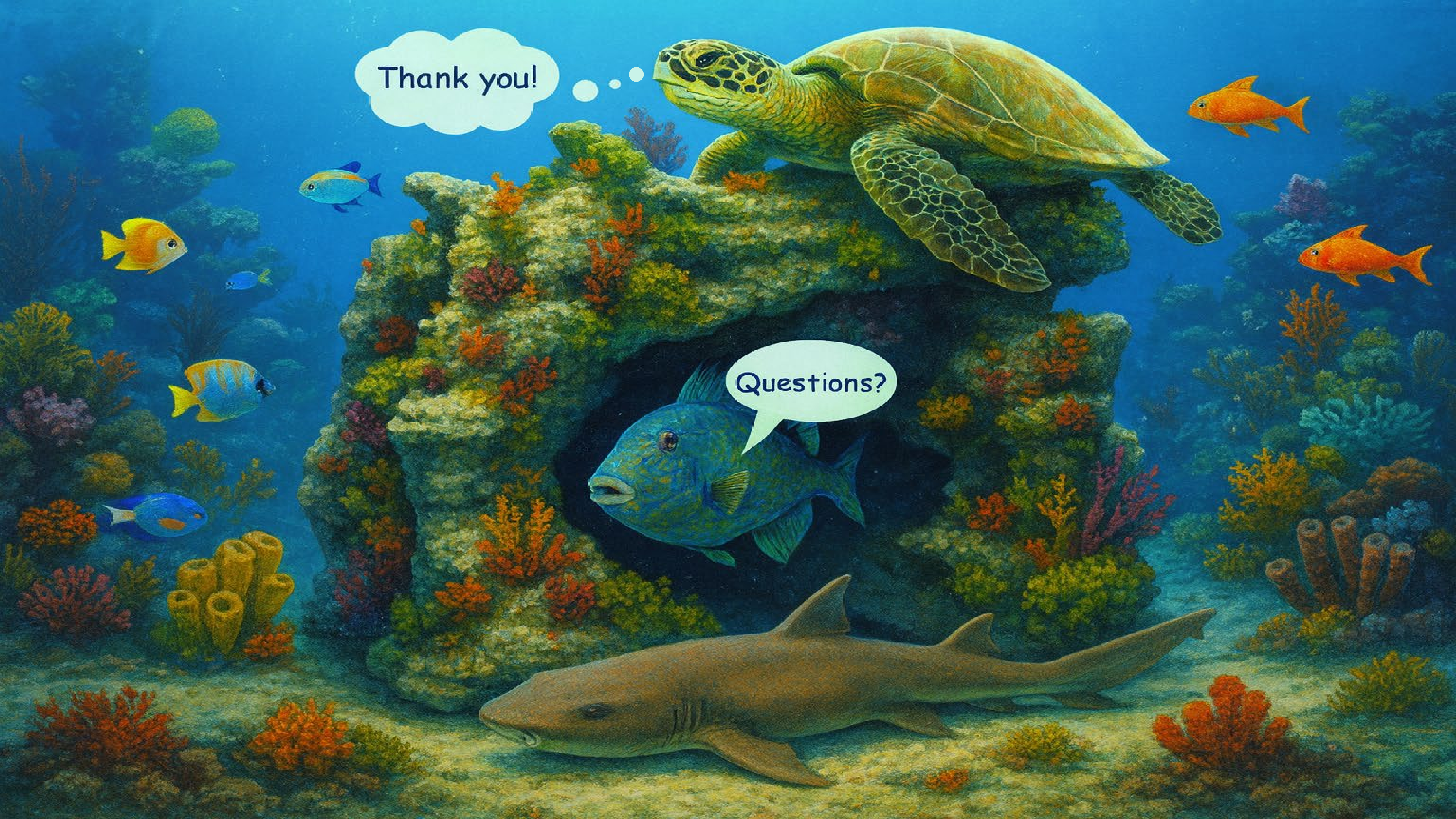


First Pilot Study:

Bayside Nearshore Hardbottom




EVALUATE AND RESPOND
PLAN
DO
ADAPTIVE MANAGMENT CYCLE
VI. ADJUST MANAGEMENT
I. PLAN
II. DESIGN
III. ACT
IV. MONITOR
VI. EVALUATE AND LEARN


Thank you!
Questions?

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