Research Theme 7:
Coral Reef Resilience

The Virgin Islands
Reef Resilience Study

Collaborations

Meet The Team - VIRRS

Tyler B. Smith, Ph.D.

Lauren K. Olinger, Ph.D.

Marilyn E. Brandt, Ph.D.

Peter J. Edmunds, Ph.D.

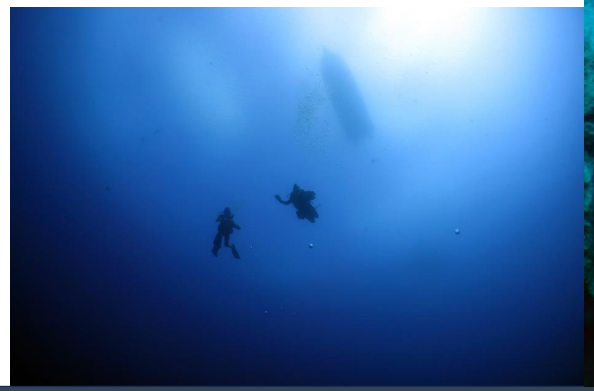
And 38 more!

Virgin Islands Reef Resilience Study

Goal 1

Determine the internal and external drivers most critical to coral reef ecosystem resilience in the USVI and identify targets for restoration of resilience.

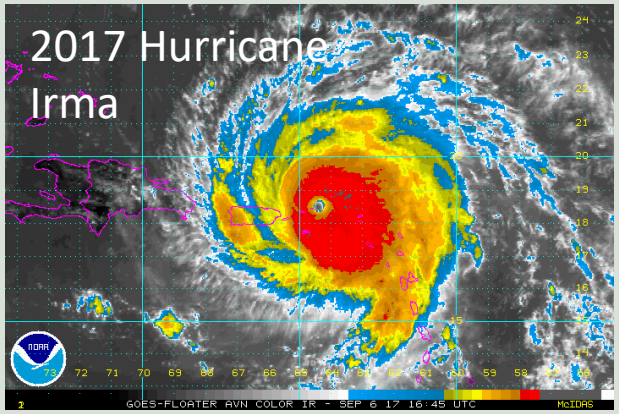
Hypothesis I (H I): The resilience of USVI's marine ecosystems is reduced through interacting stress drivers but may be modulated through increased genetic and species diversity.

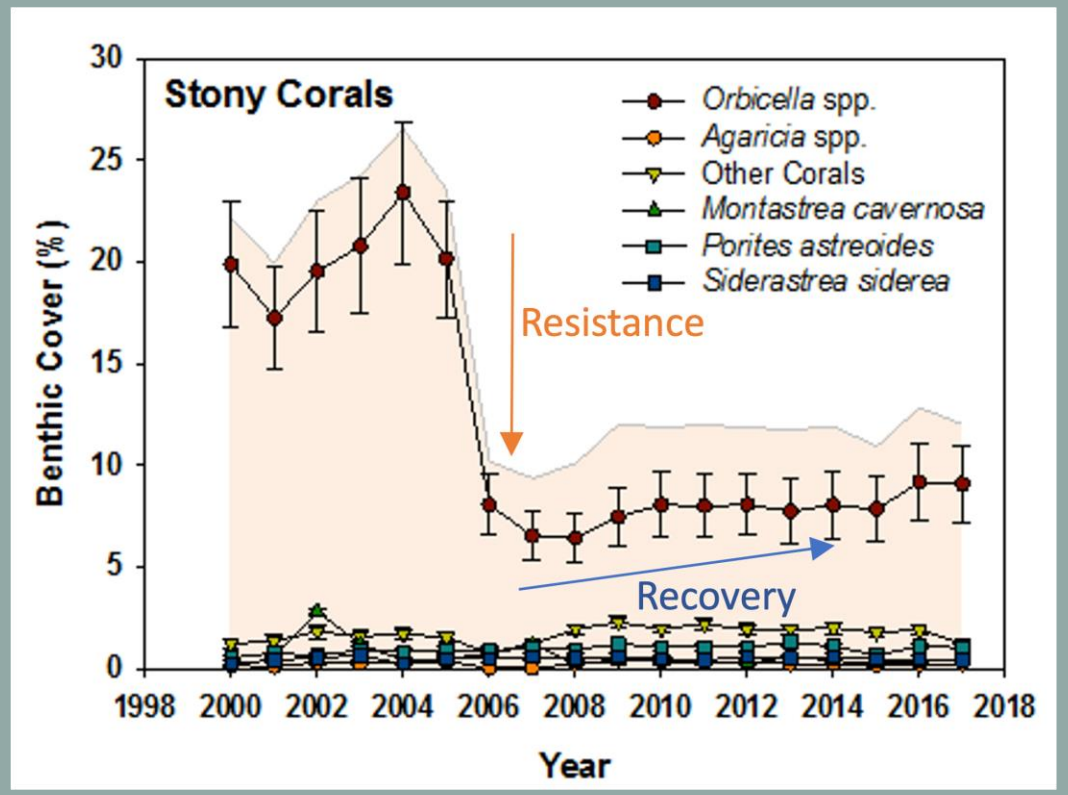


Sonora Meiling

Approach

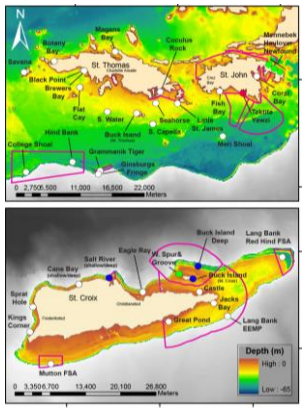
Virgin Islands Reef Resilience Study



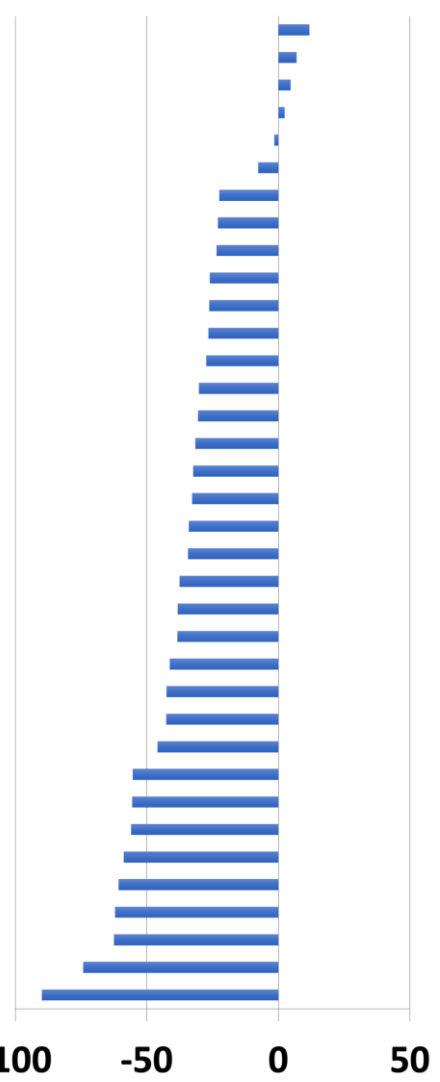


Mennebeck Reef, St. John. Data courtesy of the National Park Service

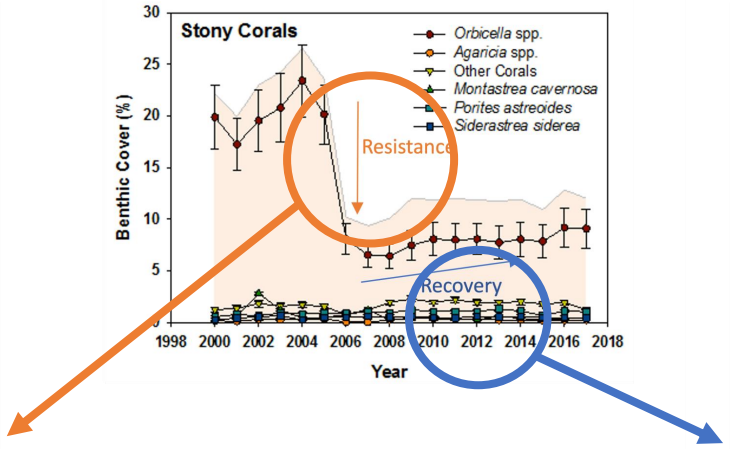
Resistance
2005



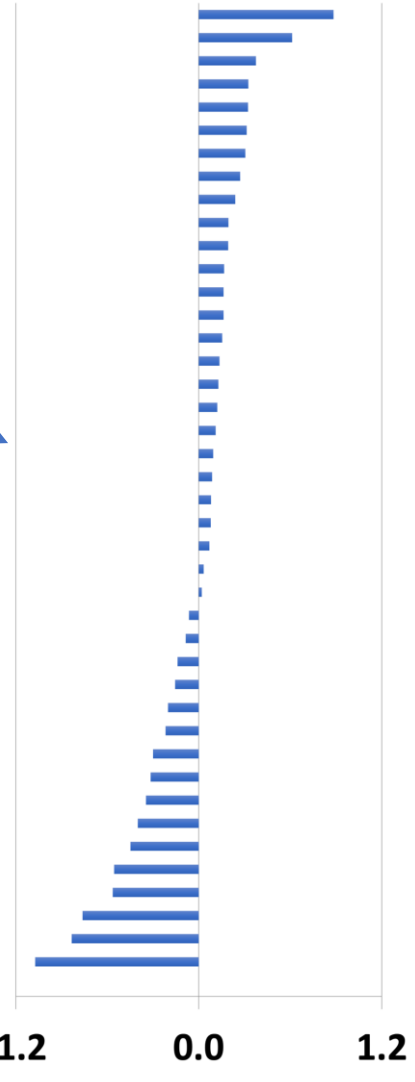
Study Sites →



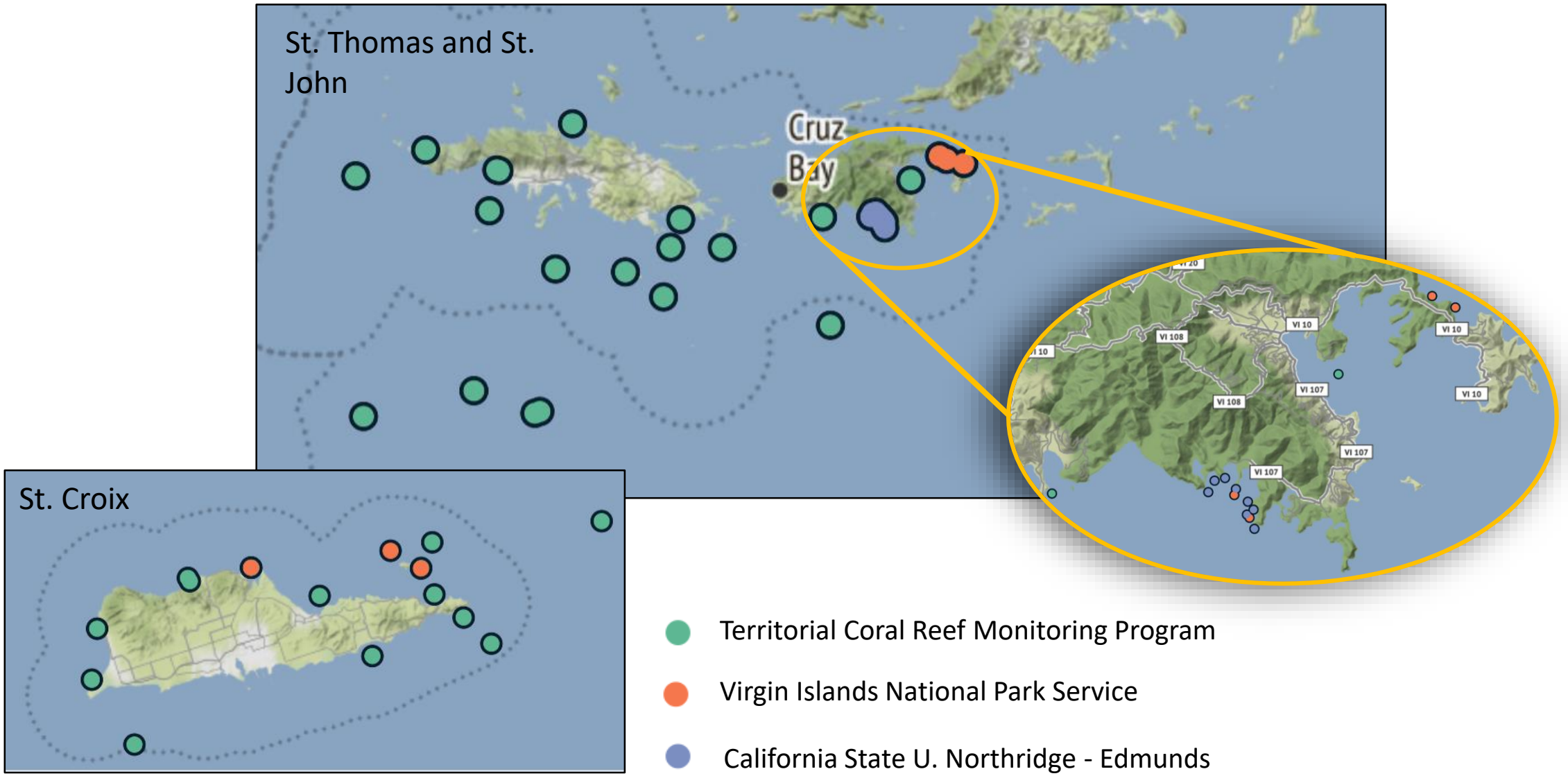
Relative change in coral cover (%)



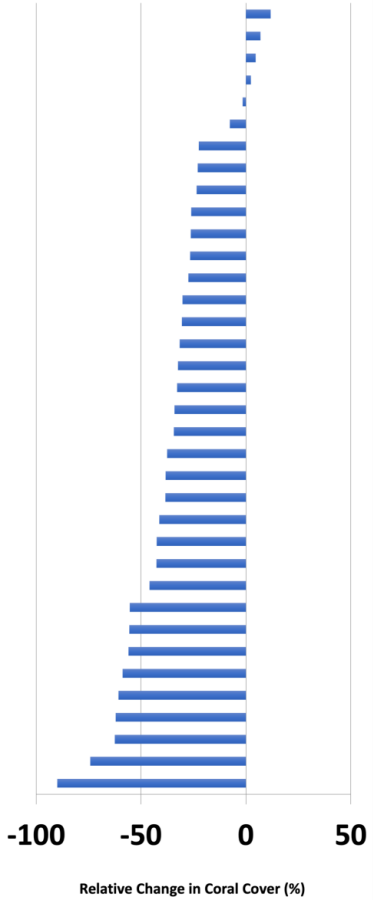
Recovery
2007-2017



Absolute change in coral cover (% per year)


St. Thomas and St. John
Cruz Bay
St. Croix
VI 10
VI 108
VI 107
Territorial Coral Reef Monitoring Program
Virgin Islands National Park Service
California State U. Northridge - Edmunds

Resistance

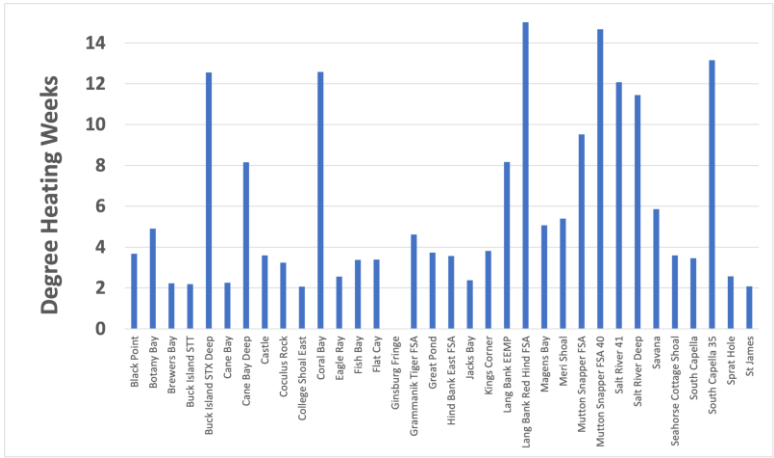


Community Susceptibility

+

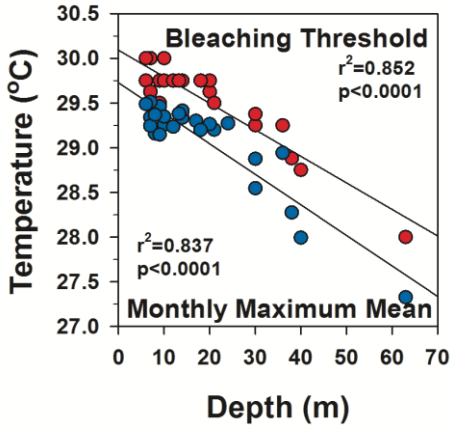
Realized environmental stress

Genetic Susceptibility



Degree Heating Weeks Calculated from TCRMP sites in bleaching year 2019

Acclimation



Smith et al. 2016

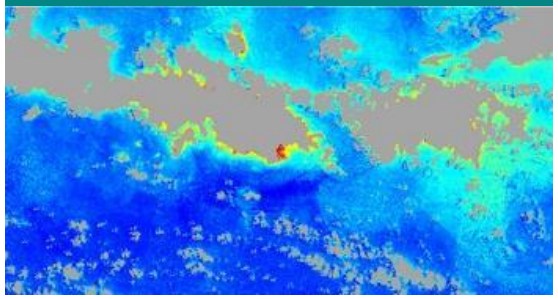
Some examples of potential drivers of recovery

Internal

External

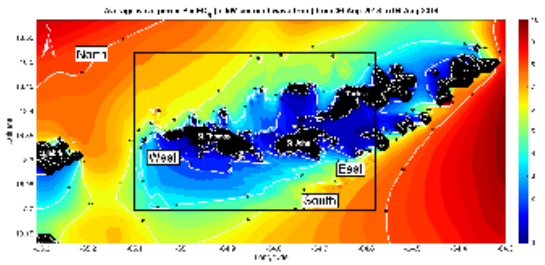
Herbivory

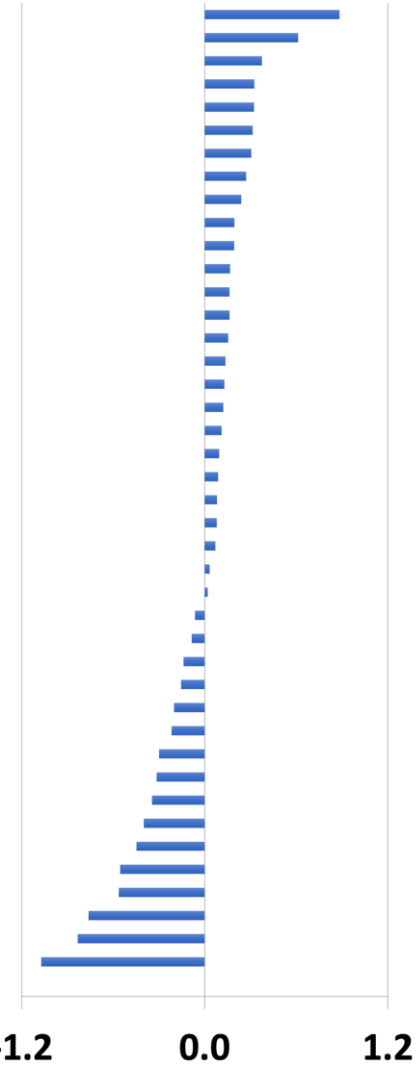
Satellite Chlorophyll a



Coral Competition

Modeled Wave Power





Recovery 2007-2017

Absolute change in coral cover (% per year)

Article

Coral reefs benefit from reduced land–sea impacts under ocean warming

https://doi.org/10.1038/s41586-023-06394-w
Received: 21 July 2022
Accepted: 30 June 2023

Jamison M. Gove[1,17], Gareth J. Williams[2,17], Joey Lecky[3], Eric Brown[4], Eric Conklin[5], Chelsie Counsell[6], Gerald Davis[3], Mary K. Donovan[7,8], Kim Falinski[3], Lindsey Kramer[9], Kelly Kozar[10], Ning Li[11], Jeffrey A. Maynard[12], Amanda McCutcheon[10], Sheila A. McKenna[10], Brian J. Neilson[13], Aryan Safaie[14], Christopher Teague[15], Robert Whittier[16] & Gregory P. Asner[2,16]

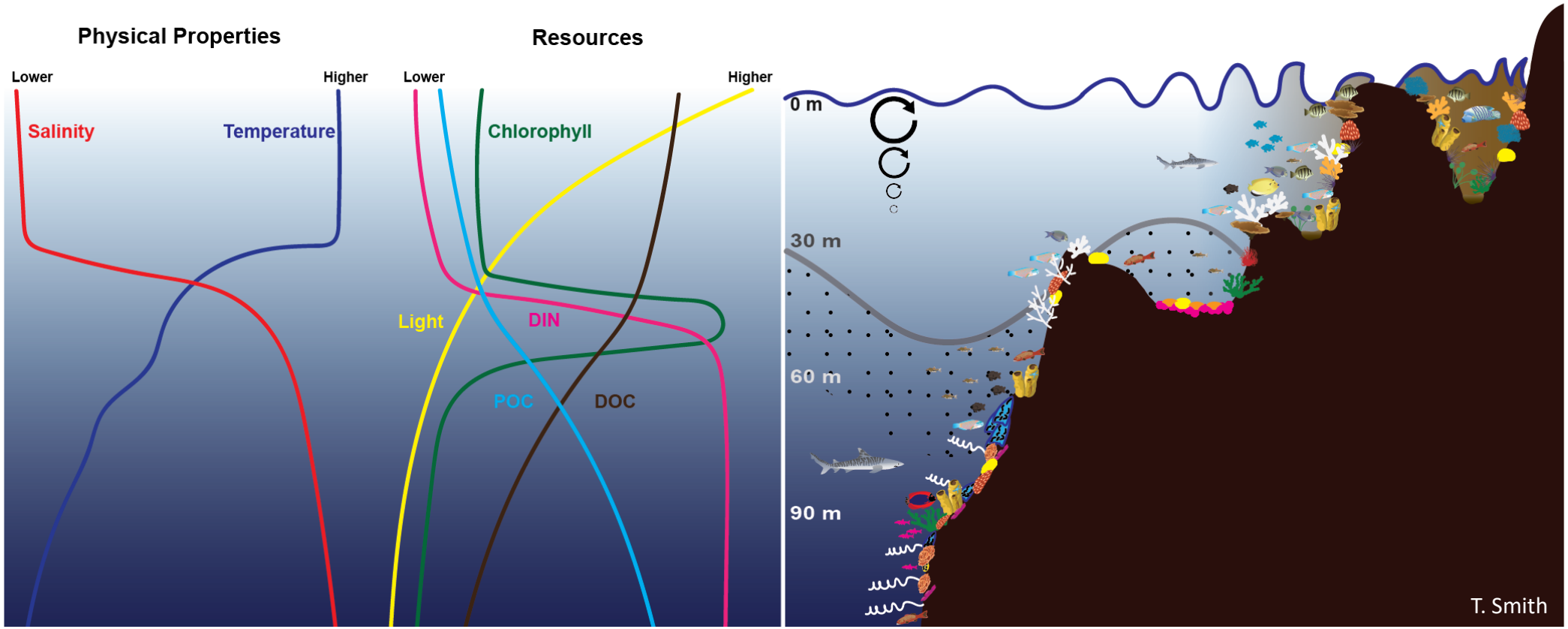
ARTICLES
https://doi.org/10.1038/s41559-019-0832-3
nature ecology & evolution

Water quality mediates resilience on the Great Barrier Reef

M. Aaron MacNeil[1*], Camille Mellin[2,3], Sam Matthews[2,4], Nicholas H. Wolff[5], Timothy R. McClanahan[6,7], Michelle Devlin[8], Christopher Drovandi[9,10], Kerrie Mengersen[9,10] and Nicholas A. J. Graham[11]

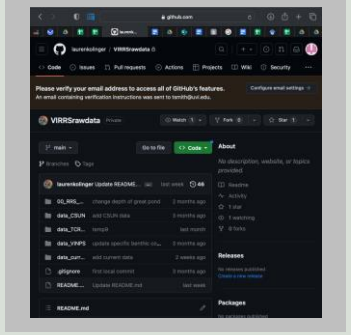
Spatial resilience of the Great Barrier Reef under cumulative disturbance impacts

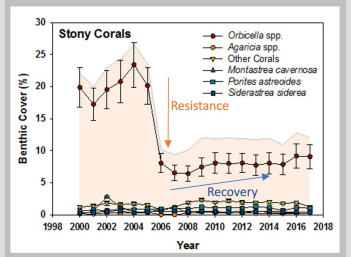
Camille Mellin[1,2] | Samuel Matthews[1,3] | Kenneth R.N. Anthony[1,4] | Stuart C. Brown[2] | M. Julian Caley[5,6] | Kerryn A. Johns[1] | Kate Osborne[1] | Marjetta Puotinen[7] | Angus Thompson[1] | Nicholas H. Wolff[8,9] | Damien A. Fordham[2,10] | M. Aaron MacNeil[1,11]

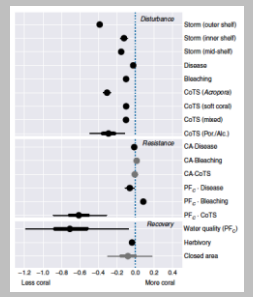


Year 4 Goal 1

- Objectives →







MacNeil et al. 2019

Objective 1: Database Development

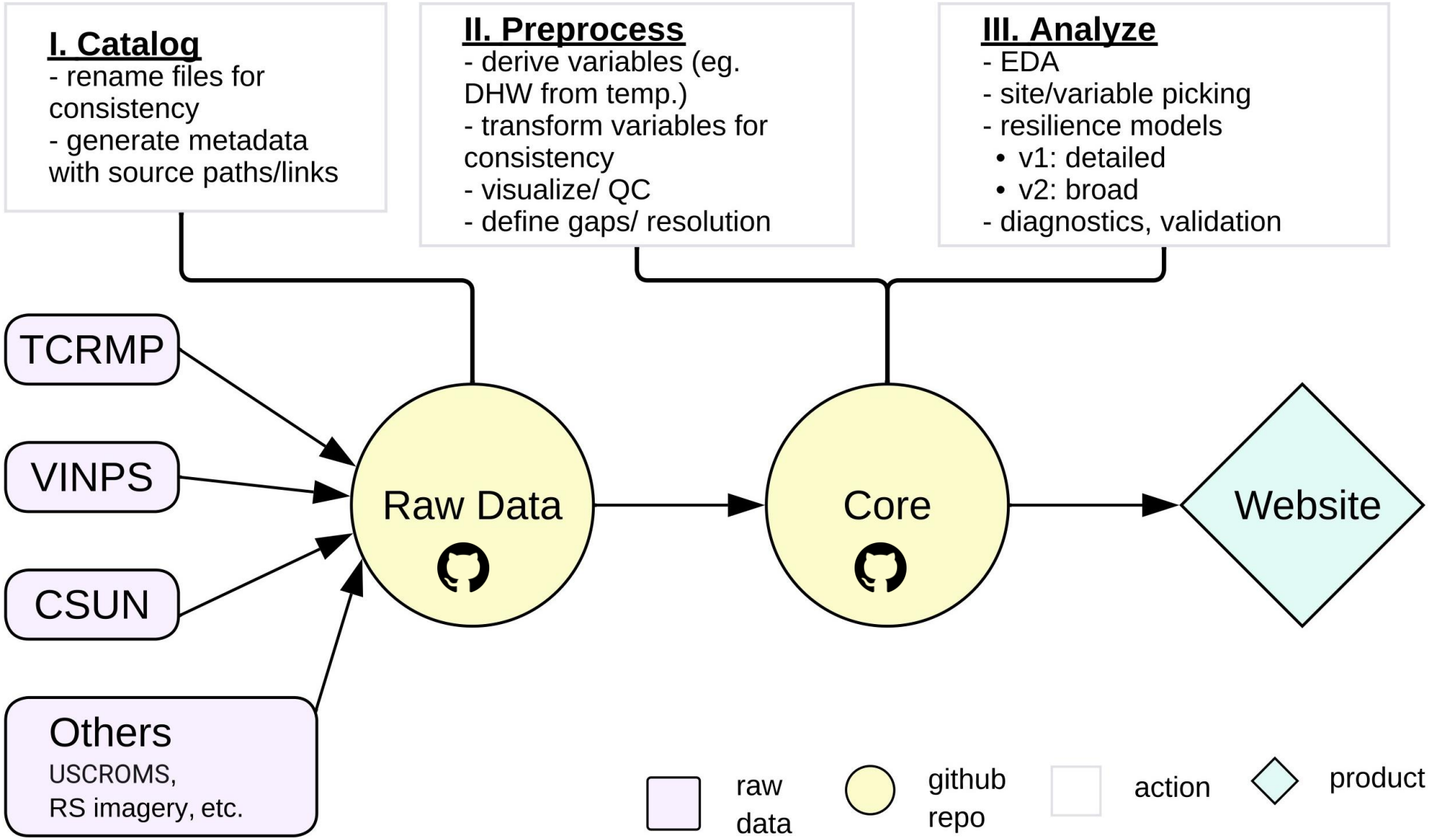
✓ **Create a comprehensive database (50 long-term coral reef monitoring sites) and identify gaps**

Objective 2: Metric Development

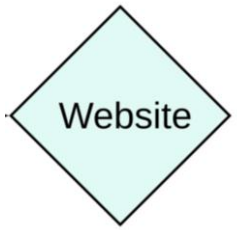
✓ **Develop metrics of resilience**

Objective 3: Analyses

✓ **Analyses of long-term coral reef data to uncover drivers of resilience**


I. Catalog
- rename files for consistency
- generate metadata with source paths/links
II. Preprocess
- derive variables (eg. DHW from temp.)
- transform variables for consistency
- visualize/ QC
- define gaps/ resolution
III. Analyze
- EDA
- site/variable picking
- resilience models
• v1: detailed
• v2: broad
- diagnostics, validation
TCRMP
VINPS
CSUN
Others
USCROMS,
RS imagery, etc.
Raw Data
Core
Website
raw data
github repo
action
product

Website homepage of core data repository



website homepage of core data repository

- 1.1 OVERVIEW
- 1.2 LIST OF STUDY SITES
- 1.3 MAP OF STUDY SITES
- 1.4 DATA GAPS AND RESOLUTION
- 1.5 LITERATURE MAP
- 1.6 CONCEPTUAL MODEL

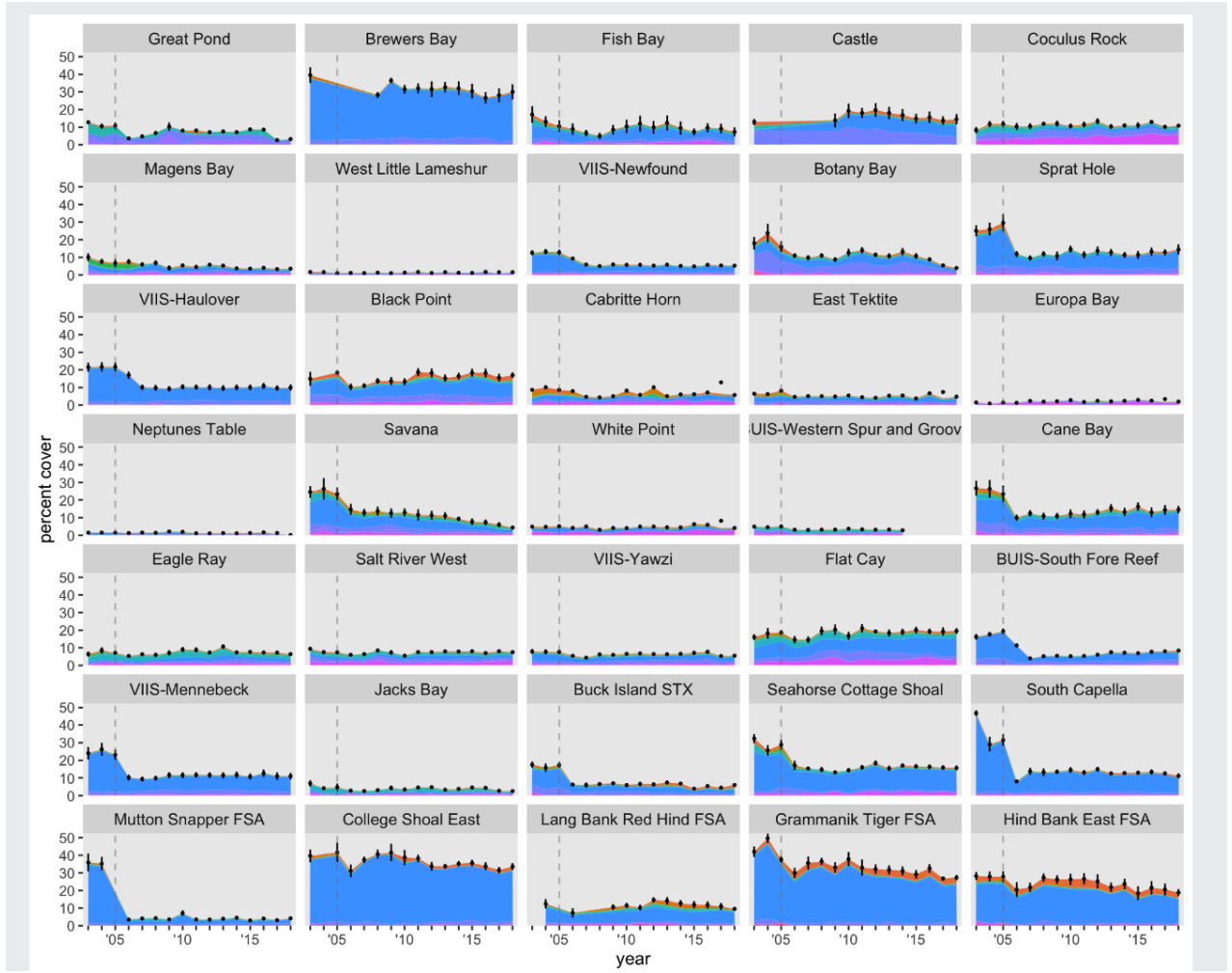
- 3.1 SITE RUGOSITY
- 3.2 SITE DEPTH
- 3.3 SITE DISTANCES FROM SHORE
- 3.4 REFORMAT RAW TEMPERATURE DATA
- 3.5 MONTHLY AND ANNUAL TEMPERATURE
- 3.6 WAVES (DATA MISSING)
- 3.7 CURRENTS
- 3.8 WATER QUALITY (DATA MISSING)
- 3.9 MANAGEMENT STATUS (COMING SOON)
- 3.10 CONNECTIVITY (DATA MISSING)

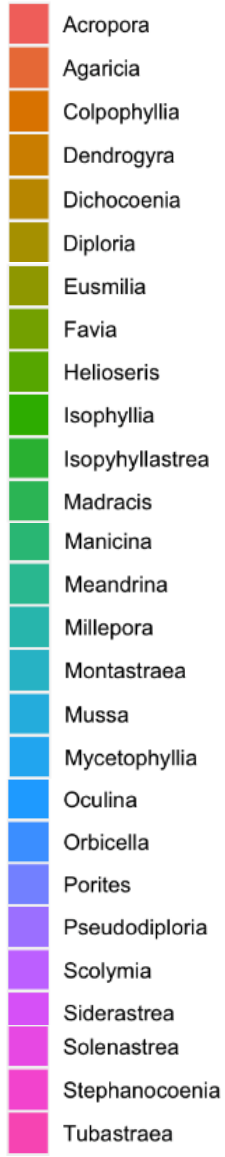
1. ABOUT ▾ 2. BENTHIC COVER ▾ 3. EXTERNAL DRIVERS ▾ 4. INTERNAL DRIVERS ▾ 5. ANALYSES ▾

- 2.1 REFORMAT RAW BENTHIC COVER DATA
- 2.2 CROSS REFERENCE BENTHIC CODES
- 2.3 PERCENTAGE COVER OF MAIN BENTHIC CATEGORIES
- 2.4 PERCENTAGE COVER OF CORAL GENERA
- 2.5 PERCENTAGE COVER OF CORAL TRAIT GROUPS
- 2.6 PERCENTAGE COVER OF ALGAE TAXA
- 2.7 PERCENTAGE COVER OF SPONGE MORPHS

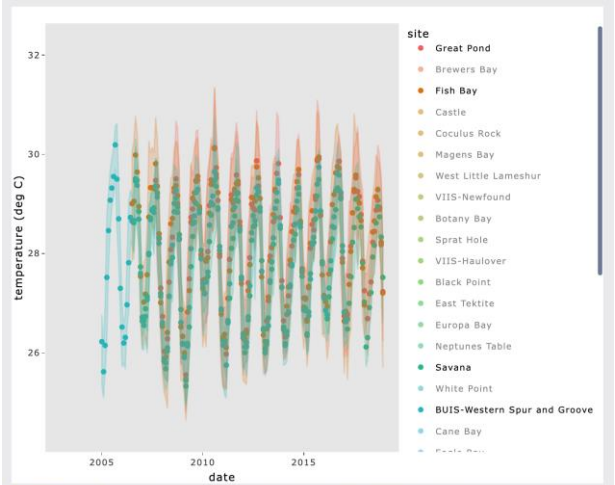
- 4.1 CORAL HEALTH
- 4.2 NUISANCE SPECIES (COMING SOON)
- 4.3 INVERTEBRATE BIODIVERSITY (COMING SOON)
- 4.4 FISH BIODIVERSITY
- 4.5 HERBIVORY
- 4.6 CORAL INTERACTIONS
- 4.7 CORAL BIODIVERSITY (COMING SOON)

2.4 PERCENTAGE COVER OF CORAL GENERA

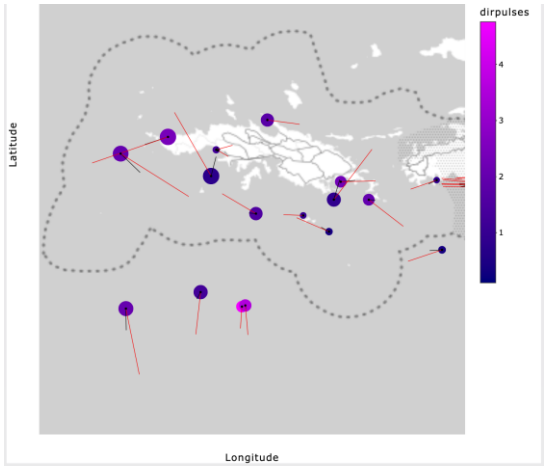




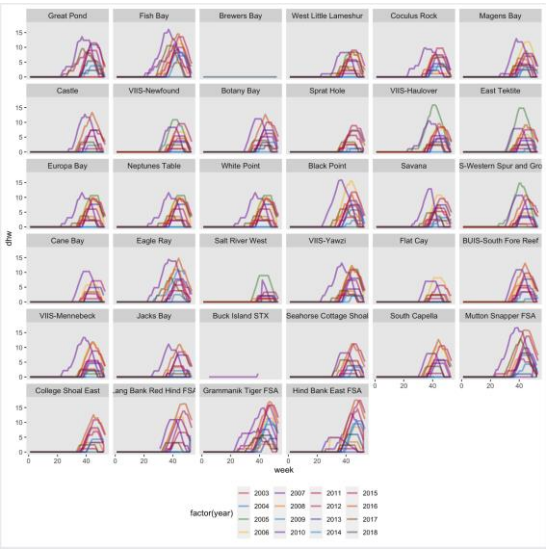
35 sites, 27 genera, 15 years (link)

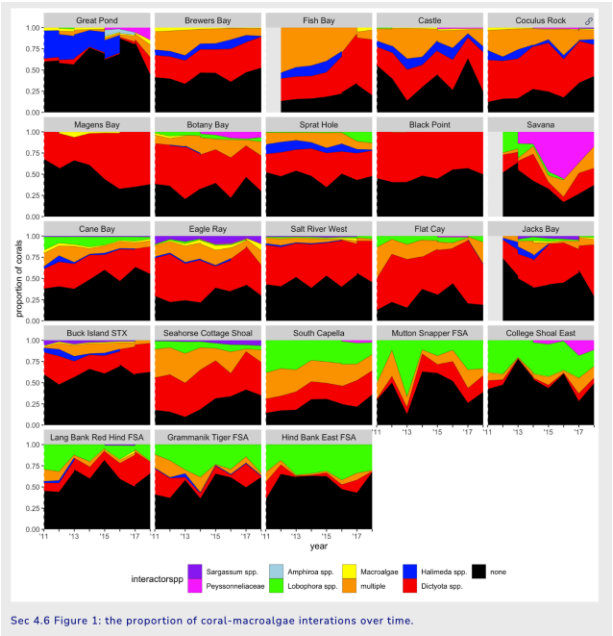


Sec 3.5 Figure 3: Monthly mean temperatures at each site, with individual monthly means and minimum and maximum temperatures colored by site. Sites are superimposed for comparisons in the interactive legend.

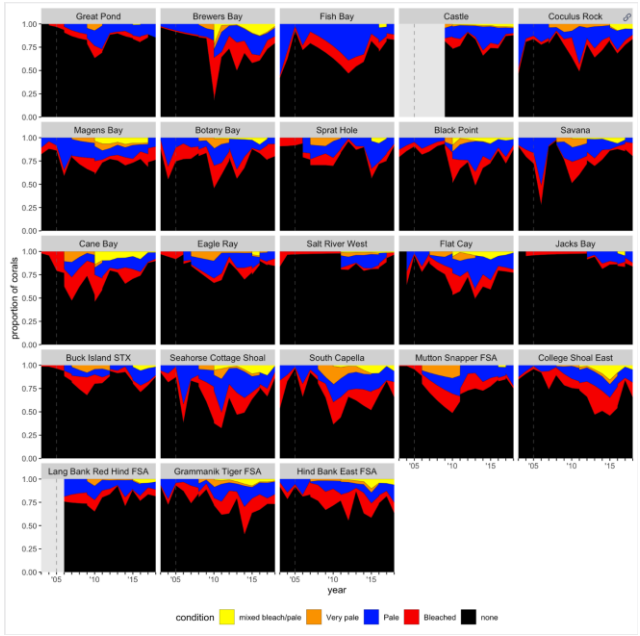


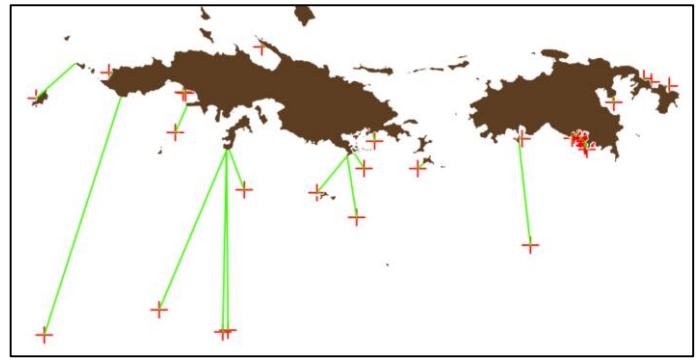
Sec 3.7 Figure 2: current speeds (lengths of arrow) and directions (orientation of arrow) at all sites, black arrows represent mean currents and red arrows represent maximum currents between January and April 2019 (verify dates)

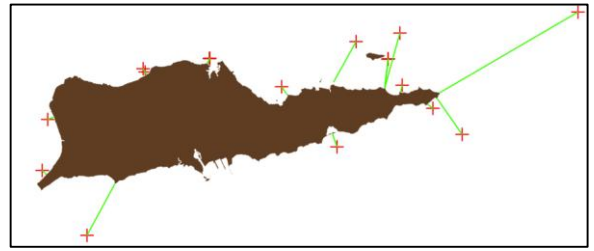




Sec 4.6 Figure 1: the proportion of coral-macroalgae interations over time.







Goal	Type	Category	Data Collected	Data QA/QC'ed	Data Analyzed	Reported/ Published	Ready for Analysis	Workshop	Planned Outputs
CR1	External	Rugosity							*
		Depth							*
		Distance from Shore							*
		Temperature							Manuscript : x-shelf thermal regimes
		Waves							Manuscript: hurricane disturbances
		Currents							Manuscript: hurricane disturbances
		Water quality							Ali et al. (2023) Frontiers in Remote Sensing 4
		Disease							Manuscript: multiple published/in prep (Disease)
		Management							*
		Connectivity							Manuscript: multiple
	Internal	Coral Health							Manuscript: multiple, thermal stress/disease
		Nuisance species							Manuscript: multiple published/in prep
		Biodiversity - Invertebrates							*
		Biodiversity - Fishes							Manuscript: Heidmann et al. (in revision)
		Herbivory							Manuscript: MMES capstone
		Coral Interactions							Manuscript: Masters thesis
		Biodiversity - Coral							*
		Coral Abundance							*

Completed **Near Complete** **In Progress**

Results, Outcomes & Accomplishments

The VIRRS workshop held November 3 & 4, 2023 at UVI

~34 participants from within and outside the USVI

VIRGIN ISLANDS EPSCoR

Virgin Islands Established Program to Stimulate Competitive Research

August 16, 2023

Dear Colleagues,

We are pleased to invite you to the Virgin Islands Reef Resilience Study (VIRRS) Workshop on November 3-4, 2023! The VIRRS workshop is hosted by the Virgin Islands Established Program to Stimulate Competitive Research (VI-EPSCoR) and will be held at the University of the Virgin Islands on the St. Thomas campus. Continue reading for more details about the workshop, and please **RSVP to indicate your availability by Wednesday August 30** by replying to the invite email or by sending a separate email to lauren.olinger@uvi.edu.

The primary goal of the workshop is to discuss the core VIRRS study. This study integrates benthic survey and biophysical data that comprise external (physical oceanography) and internal (coral reef health and biodiversity) drivers of reef resilience. Data sources include three long-term monitoring programs and recent models of oceanographic circulation, connectivity, and satellite-based water quality, spanning ~40 sites and two decades. The goal of this study is a unified analysis of these datasets to determine the internal and external drivers that are most critical to coral reef ecosystem resilience and identify targets for restoration in the region.

Workshop discussion topics will include overview of the findings, validity of the analyses and underlying data, management implications, and timeline for publication. Participants may divide into working groups to (1) discuss follow-up research questions and approaches to answering those with either existing data or new experiments and (2) develop driver- or site-specific metrics for resistance and recovery after disturbances. This research is timely given the current unprecedented SST and likely bleaching in the next few months.

We will host two zoom meetings, one before the workshop (mid-October) to orient everyone to the data and analyses, and the second after the workshop to share progress on the core study and any follow-up research. We may offer short virtual sessions during the in-person workshop for those who cannot travel, but we highly recommend attending in person to get the full experience.

Travel and lodging costs for participants will be covered by VI-EPSCoR, and we will provide more details about coordinating travel plans in the coming weeks. Please let us know if you have any questions. We look forward to hearing back and working with you all on this exciting project!

Regards,

Lauren Olinger
Tyler Smith
VIRRS Workshop Organizers

2 John Brewers Bay | St. Thomas, USVI 00802 | www.viepscor.org

Meet The Team – Connectivity & Biodiversity

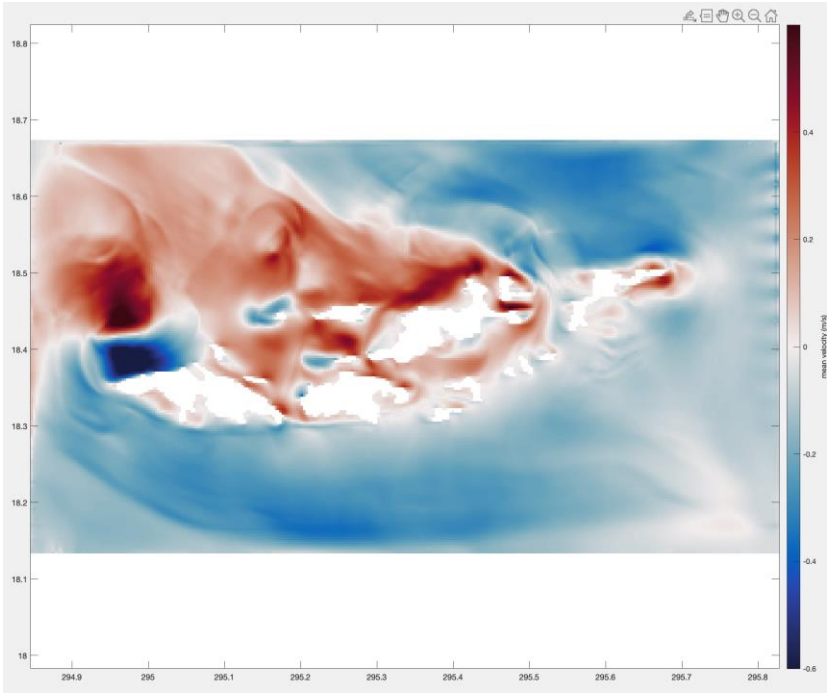
Tyler B. Smith, Ph.D.

Lauren K. Olinger, Ph.D.

Sonaljit Mukherjee, Ph.D.

Daniel M. Holstein, Ph.D.

Benjamin Farmer

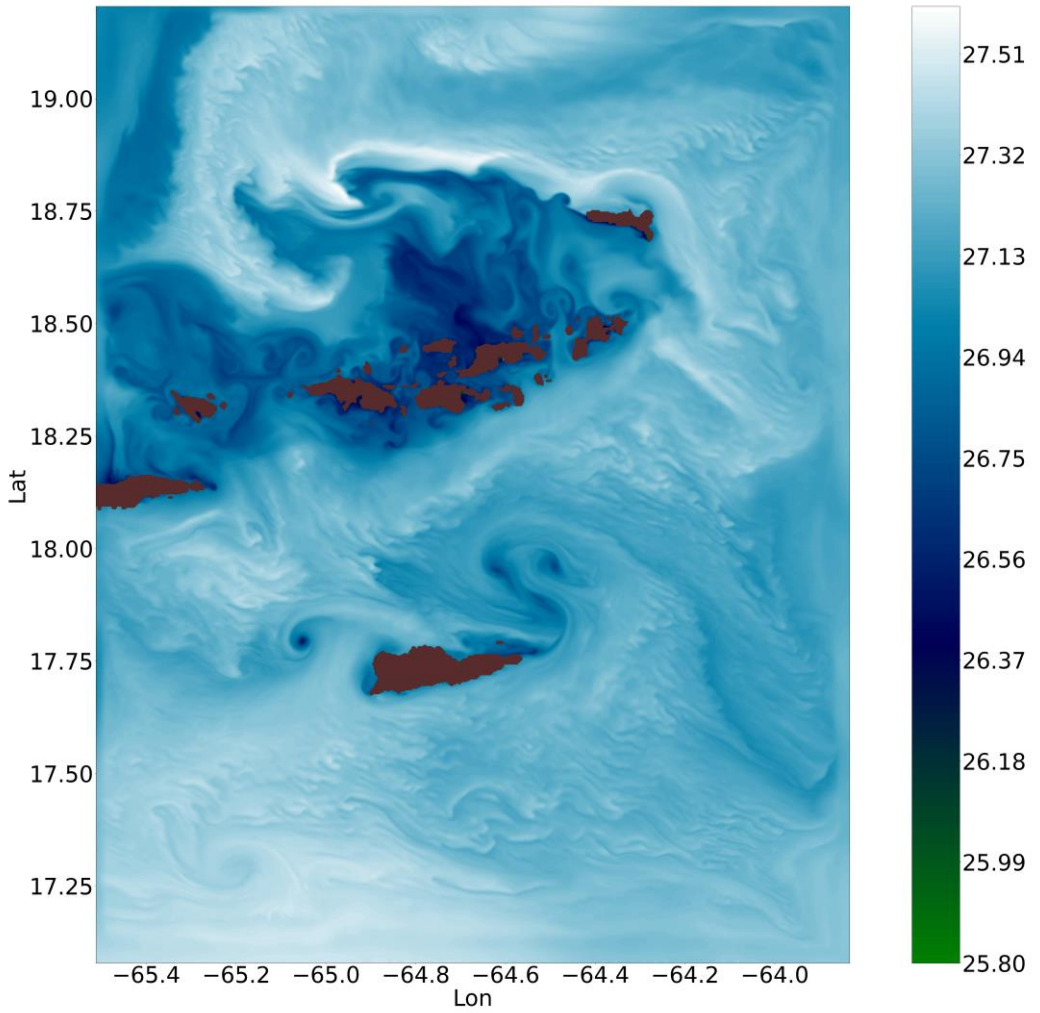


Connectivity and Biodiversity Study

Goal 2.

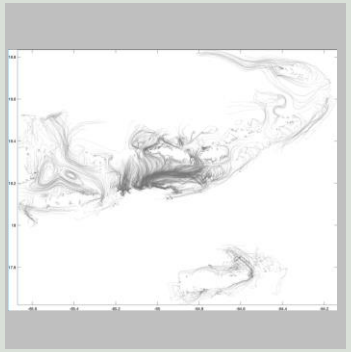
Understand the impact of regional larval connectivity patterns on biodiversity patterns.

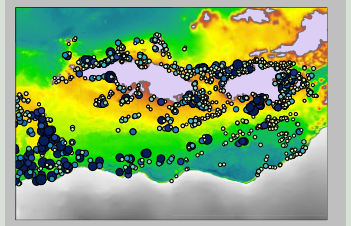
Hypothesis: Stronger larval sink locations, or high centrality habitats, that receive coral larval input from diverse upstream habitats are areas of increased species diversity and, hence, resilience

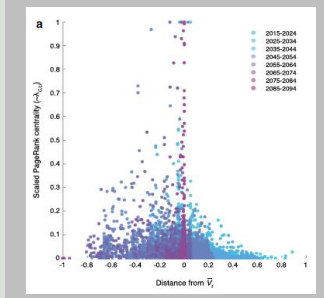


Year 4 Goal 1

- Objectives →







Objective 1: **Database Development**	**Develop regional connectivity model for coral reef organisms**
Objective 2: **Metric Development**	**Determine network and habitat connectivity metrics and corresponding estimates of biodiversity**
Objective 3: **Analyses**	Analyze the relationship between realized diversity and connectivity, stress, and past disturbances

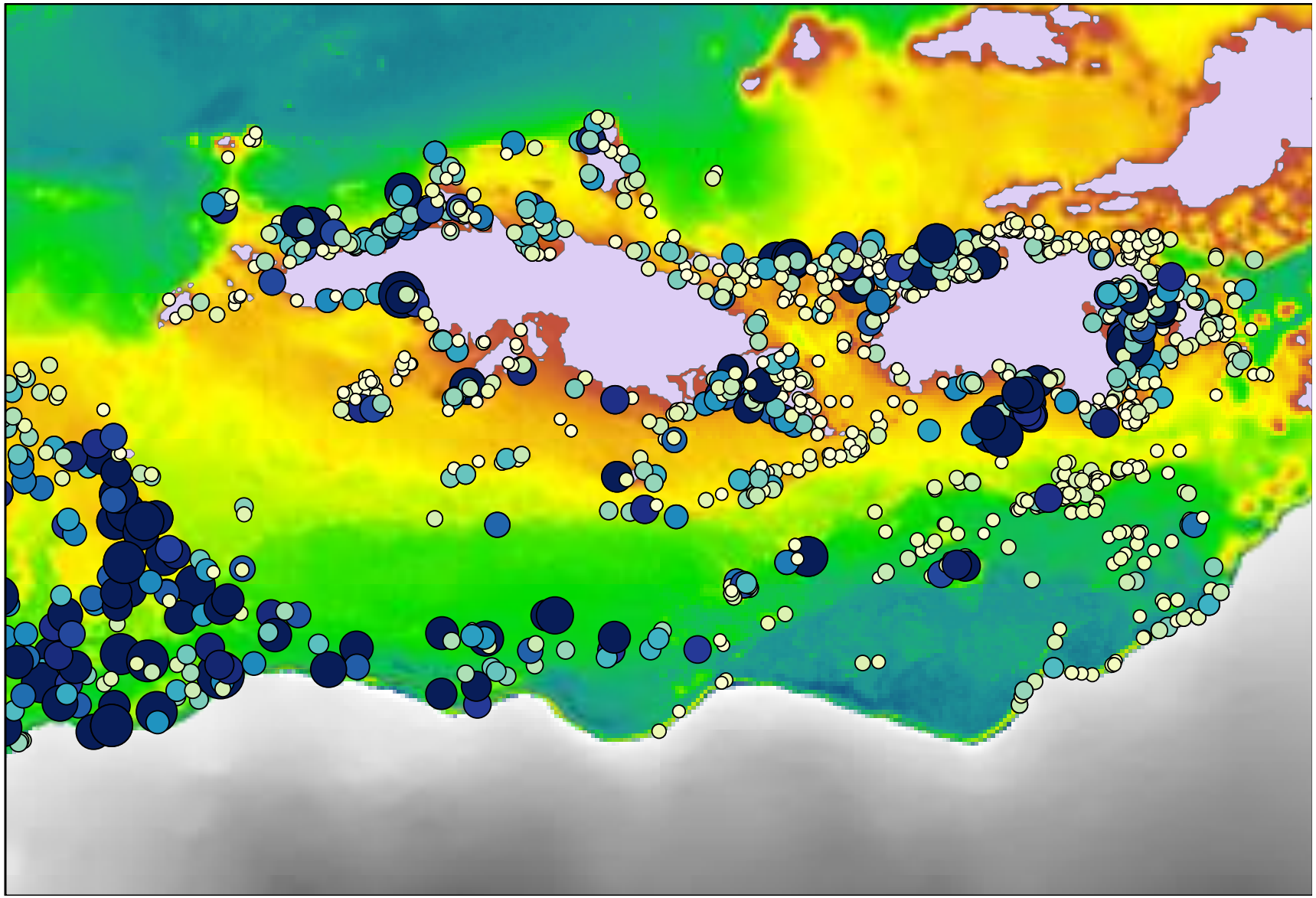
Example biological data:

The National Coral Reef Monitoring Program

Coral Cover Legend

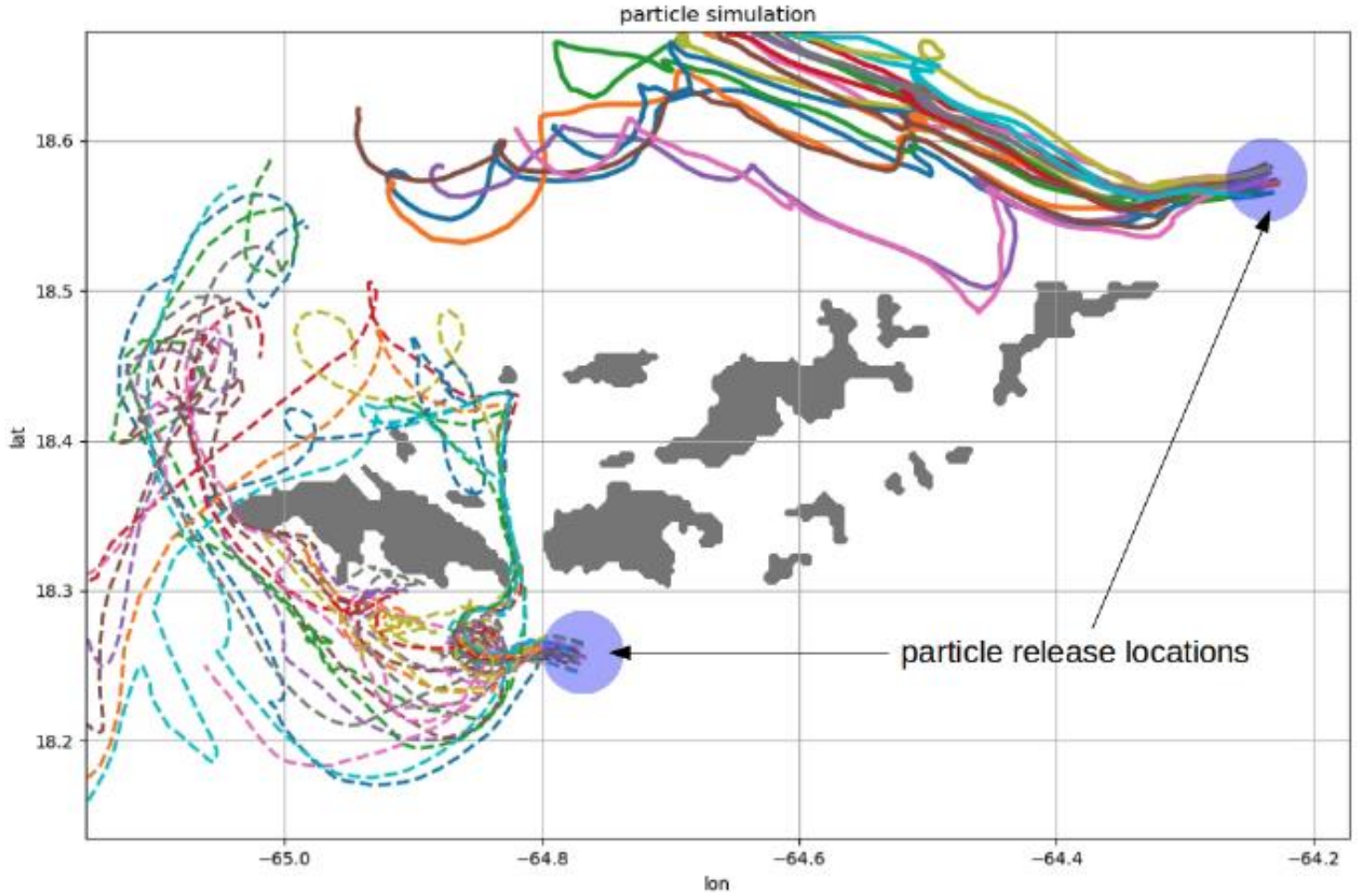
0 23 46%

1272 surveys total
264 > 30 m depth



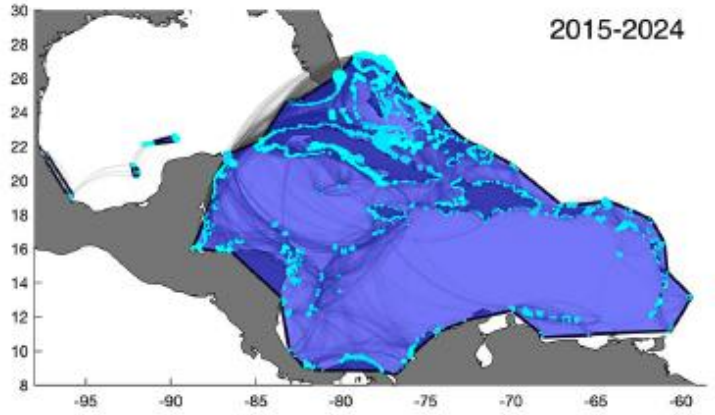
Connectivity

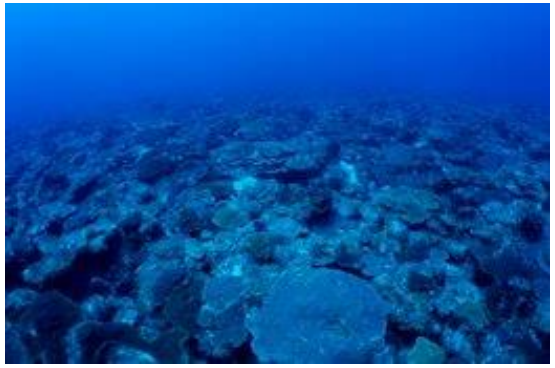
- US Caribbean Regional Ocean Model allows the tracking of virtual particles with the Connectivity Modeling System



Paris CB, Helgers J, van Sebille E, Srinivasan A (2013) Connectivity Modeling System: A probabilistic modeling tool for the multi-scale tracking of biotic and abiotic variability in the ocean. Environmental Modelling & Software 42:47-54

Research, Outcomes & Accomplishments





Coral Reefs
https://doi.org/10.1007/s00338-022-02252-9

REPORT

Predicting coral metapopulation decline in a changing thermal environment

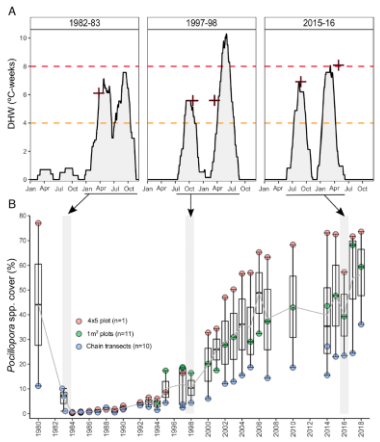
Daniel M. Holstein[1] · Tyler B. Smith[2] · Ruben van Hooidonk[3,4] · Claire B. Paris[5]

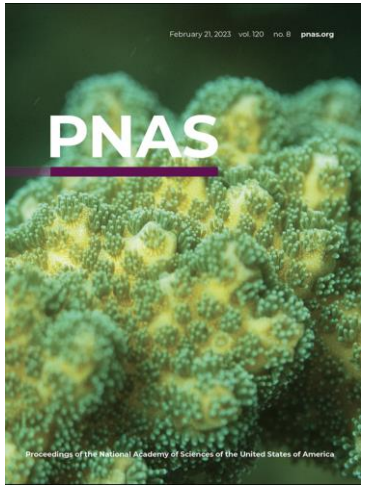
41:961–972

PNAS RESEARCH ARTICLE | ECOLOGY

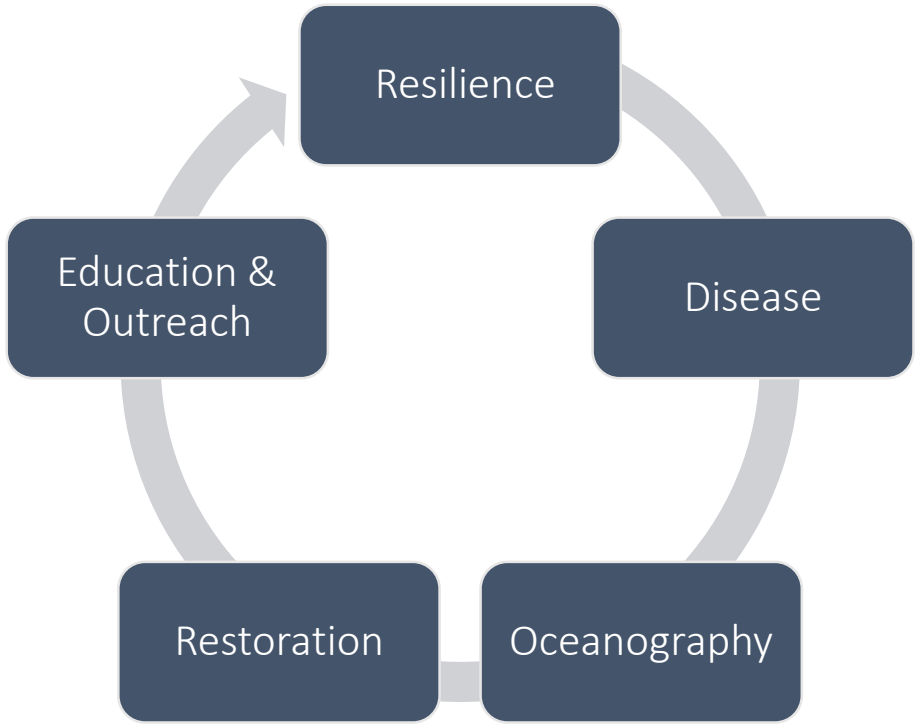
Increased dominance of heat-tolerant symbionts creates resilient coral reefs in near-term ocean warming

Ana M. Palacio-Castro[a,b,c,1], Tyler B. Smith[d], Viktor Brandtneris[d], Grace A. Snyder[a], Ruben van Hooidonk[b,c], Juan L. Maté[e], Derek Manzello[f], Peter W. Glynn[a], Peggy Fong[g], and Andrew C. Baker[a]





Research Interdependencies



The marine resilience theme is strongly dependent on past and current research investments and will feed directly into management (e.g., restoration) and education and outreach

Broader Impacts, Intellectual Merit, & Diversity

Data for the masses!	Engagement	Management & Restoration	What is Possible with Investment	Training Tomorrow's Scientists
A quality-controlled database of multiple coral reef and oceanographic data sets for the territory.	Engagement of multiple professionals on a central project of high importance for understanding coral reef resilience	Evidence-based directions for more effective resource management and restoration	Highlights the utility of multiple investments in ecosystem data collection and will be an attractor for more funding	Contributes to the training of students and post-doctoral researchers






Thank you!

Dr. Tyler Smith

EMAIL: tsmith@uvi.edu

PHONE: 786-564-4090