NOAA Coral Reef Conservation Program Ecosystem Science Evaluation

Ecological Status and Recovery

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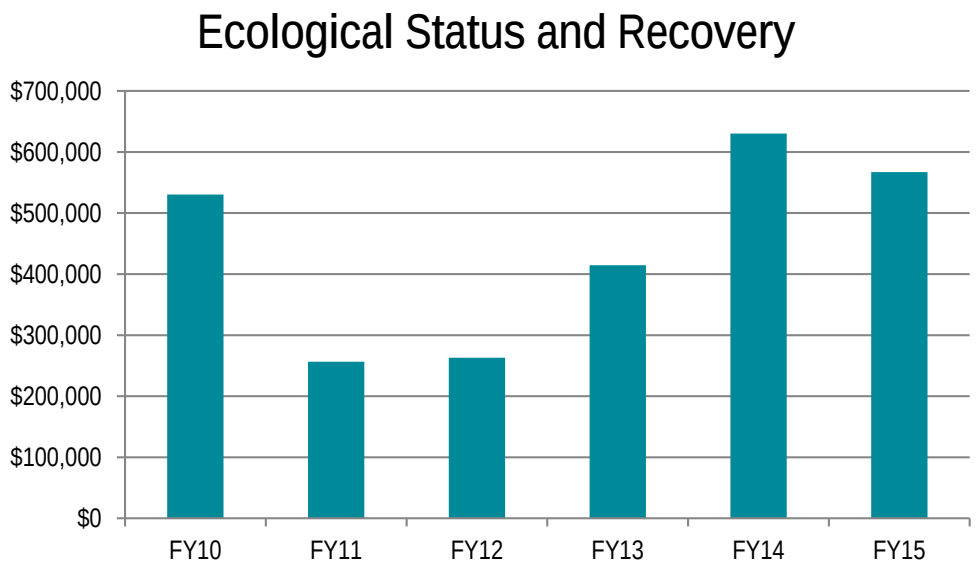
Overview

- Corals are foundation of coral reef ecosystems
  - Basic population declines
    - ‘Biotic threats’ such as disease
  - Recruitment failure
  - Community shifts
- Requires an ecological (i.e., more integrated, organismal and community) approach

Funding: FY10-15



TOTAL $2,661,995

Leveraged Resources

- NMFS/SERO Protected Resources
- FKNMS, SEFSC, local partners
- External grants/agreements (Mote 'Protect Our Reefs'; Biscayne National Park)

Objectives

- Hypothesis-driven and/or species-focal monitoring and assessment
  - Demography, population genetics, and population modeling for ESA spp
  - Monitoring effects of NoTake reserves, and capacity building
- Coral reproduction, early life history, recruitment
- Disease and corallivore ecology
  - Dynamics in local populations
  - Potential mitigation measures
- Restoration science: ESA-listed species
  - Improve implementation and success of population enhancement

Information, products, tools

- Peer-reviewed publications (>20)
- Technical Reports
- Presentations at scientific and management fora
- Direct verbal communication with managers
- Direct communication in public planning fora (e.g. FKNMS)
- NCEI archived data sets

Users:

-Managers

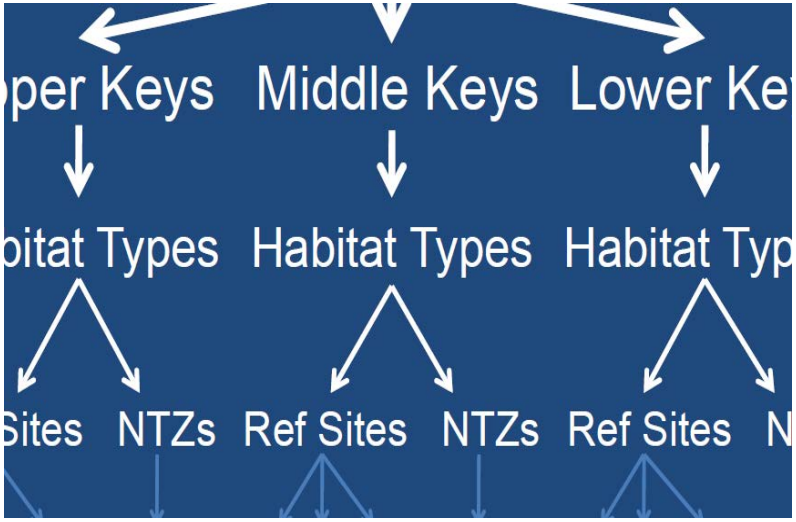
-Researchers

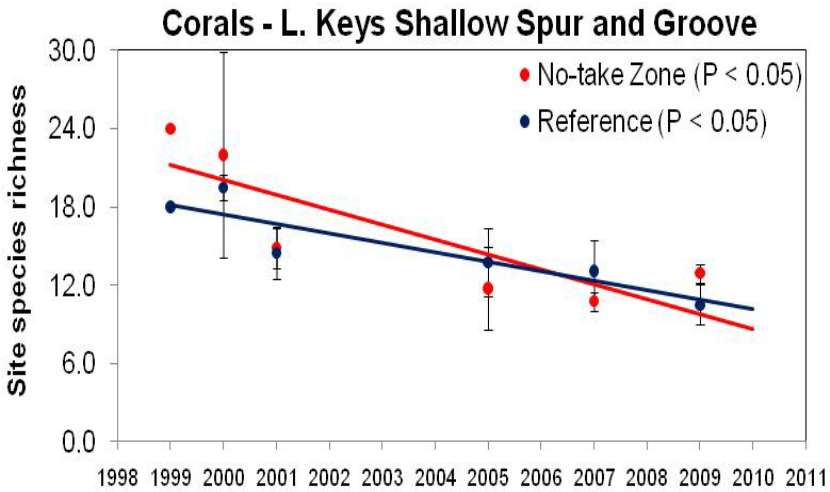
-Restoration Practioners

-Public

Monitoring no-take zones in FKNMS

- Monitoring stratified by region and habitat type and WIDE range of parameters (urchins, gorgonian and sponge species richness, debris, rugosity)
- Estimate proportion of spp. abundance within protected zones
  - Currently: 4.3% of *A.cervicornis*, 33% of *A.palmata* in no take zones
  - Can be 'tweaked'





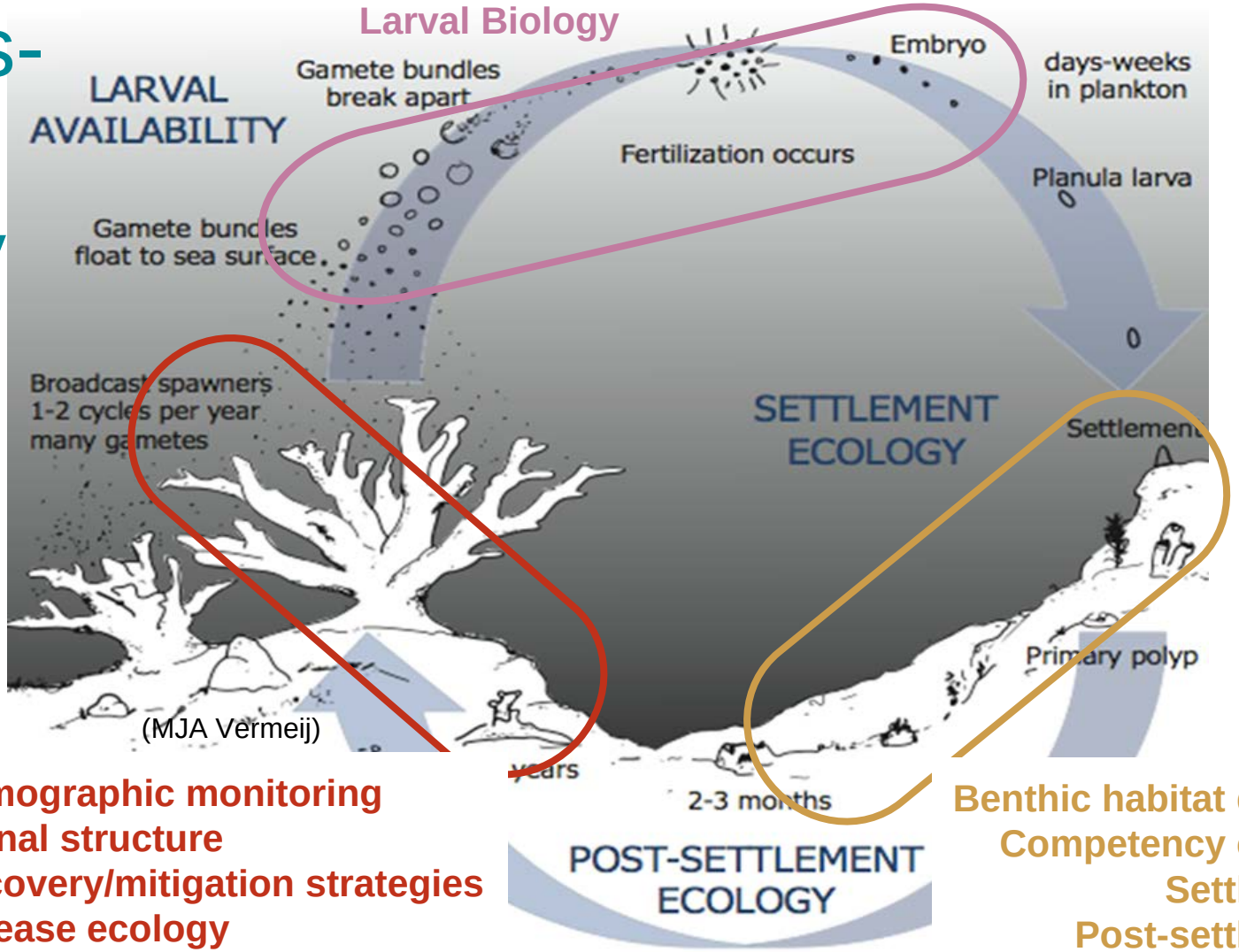
How is this information useful?

- Targeted monitoring provides baselines to detect trends in reef processes
  - Are levels of coral recruitment changing over time?
  - Recruitment ‘hot spots’?
- Targeted monitoring enable evaluation of management actions
  - Zoning or other conservation regulations
  - Zone ‘tweaking’ (e.g.,FKNMS) to balance or target protection of different components

Project 1079: underway

Species-focal ecology

Population genetics/connectivity
Larval Biology



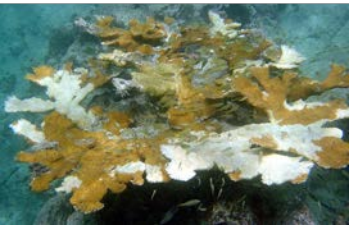
(MJA Vermeij)

Demographic monitoring
Clonal structure
Recovery/mitigation strategies
Disease ecology

Benthic habitat quality
Competency curves
Settlement
Post-settlement survivorship

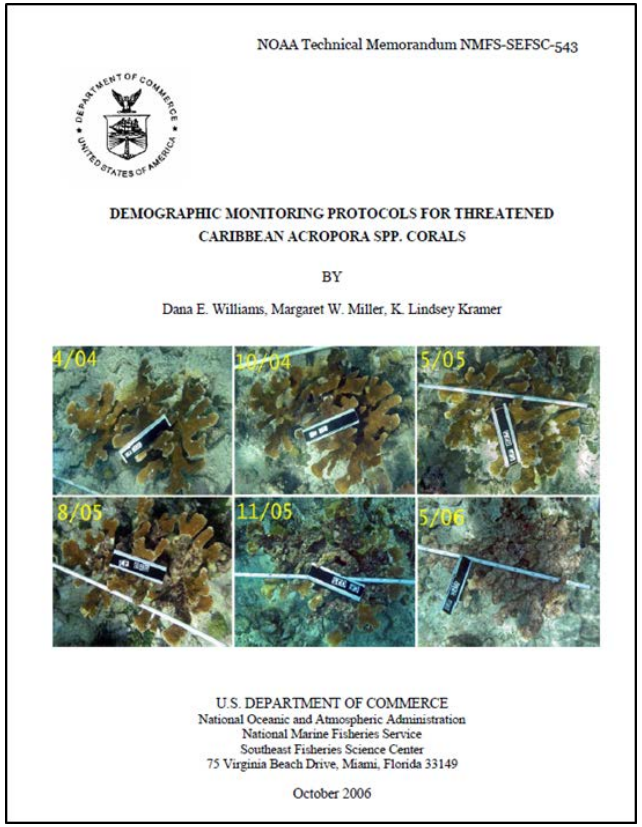
Acropora Recovery Actions

(Drafted 2009, Published 2015)



1. **Improve understanding of population** abundance, trends, and structure through monitoring and experimental research.
2. **Curb ocean warming and acidification** impacts to health, reproduction, and growth, and possibly curb disease threats, by reducing atmospheric greenhouse gas concentrations.
3. Determine coral **health risk factors** and their inter-relationships and implement **mitigation or control** strategies to minimize or prevent impacts to coral health.
4. **Reduce locally-manageable stress and mortality** sources (e.g., predation, anthropogenic physical damage, acute sedimentation, nutrients, contaminants).
5. **Population enhancement**, through restocking and active management to increase the likelihood of successful sexual reproduction and to increase wild populations.
6. Implement ecosystem-level actions to improve **habitat quality** and restore keystone species and functional processes such as herbivory to sustain adult colonies and enable successful natural recruitment in the long term

Acropora palmata status: Upper Florida Keys


NOAA Technical Memorandum NMFS-SEFSC-543

DEMOGRAPHIC MONITORING PROTOCOLS FOR THREATENED CARIBBEAN ACROPORA SPP. CORALS

BY

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National Oceanic and Atmospheric Administration
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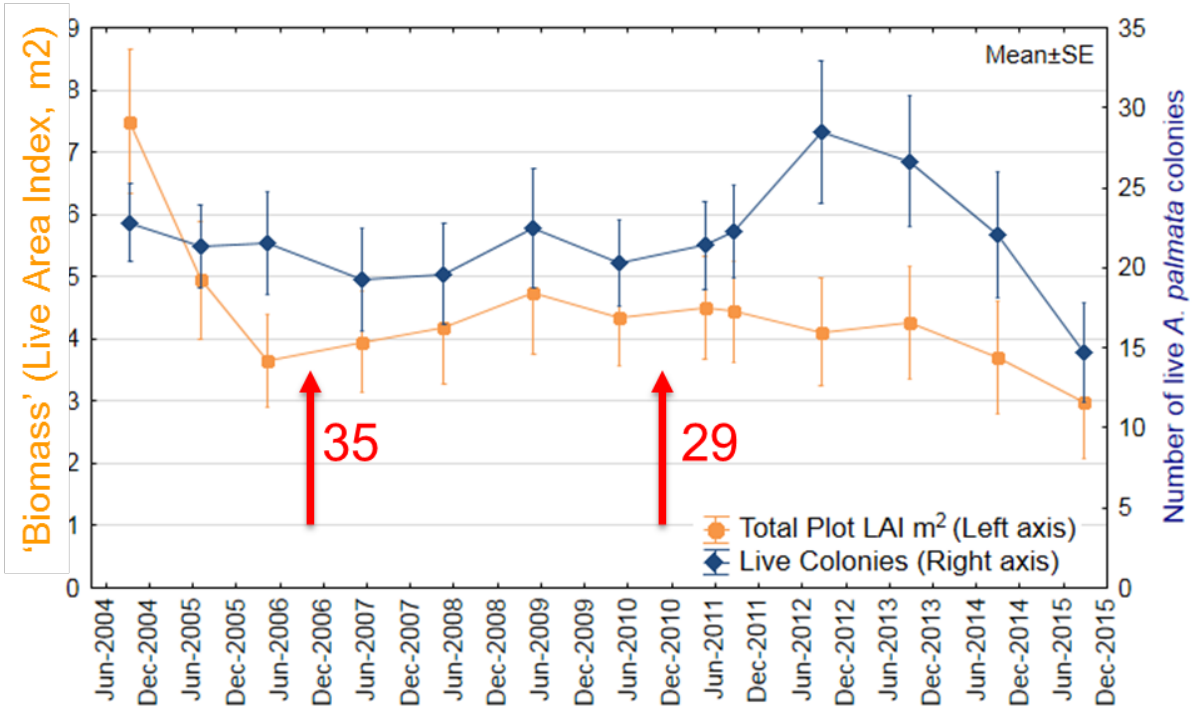
October 2006



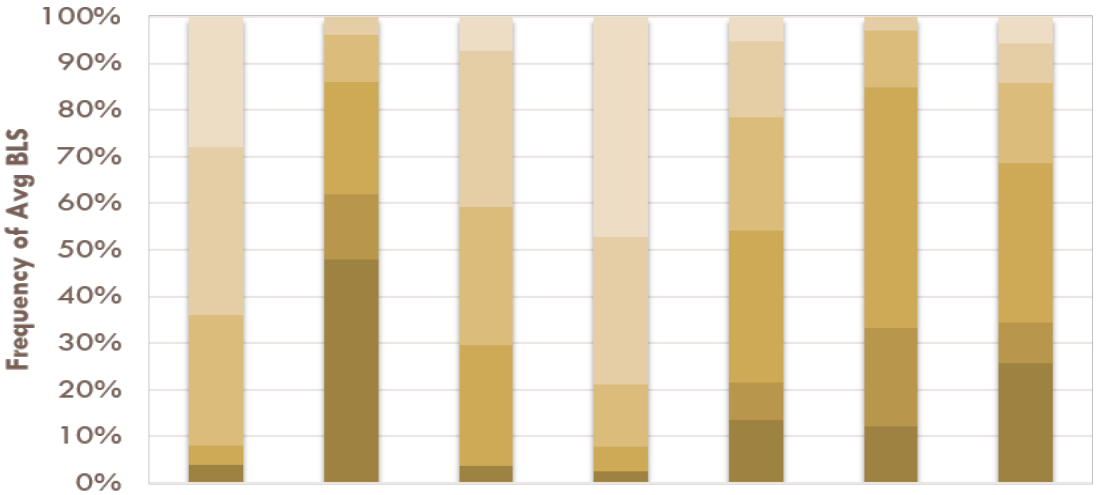
Genotypic abundance/structure (2010):

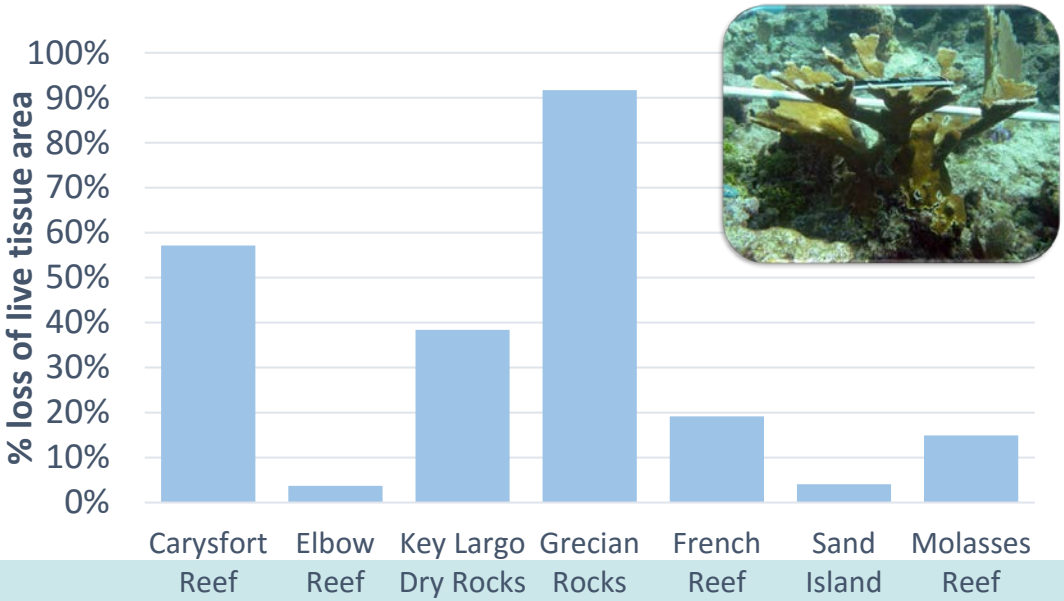
- LOW abundance/diversity (mean Ng/N = 0.1)
- 17% loss from 2006-10
- 7 of 23 plots monoclonal

Williams & Miller 2012
Williams et al. 2014a

Thermal stress and Bleaching 2014-15

- Strong relationship of bleaching severity with death
- Average 1/3 loss of live tissue
- Average ¼ loss of whole colonies
- Bleaching prevalence best correlates with days > 31oC





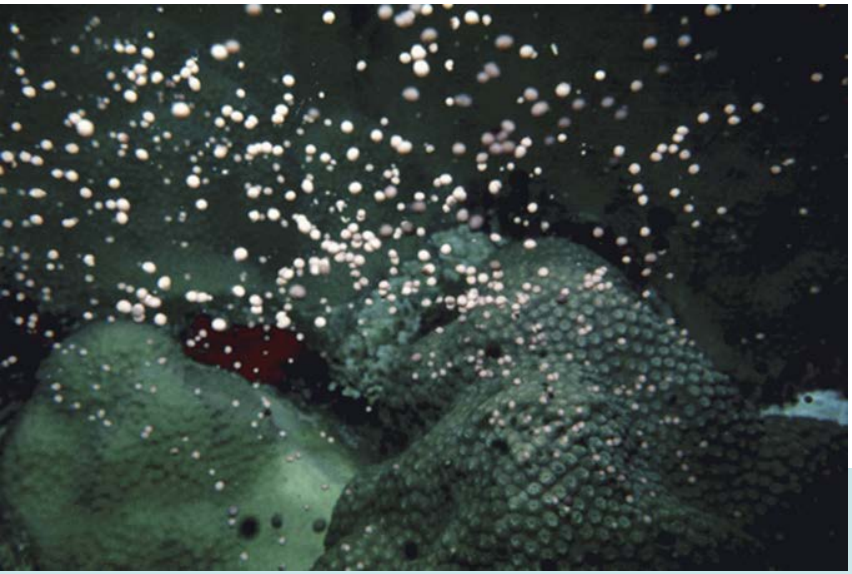
How is this information useful?

- Baseline for evaluating status, effects of recovery actions and disturbances
- Vulnerability of Florida Keys *A.palmata* to and consequences of thermal stress now well-defined
- Despite repeated thermal stress exposure, the hope for acclimatization has not been evident

		2015							
		normal color	slightly pale	pale	very pale	bleached	dead	better	same or worse
2014	normal color (62)	48%	24%	0%	0%	0%	27%		
	slightly pale (103)	14%	51%	11%	2%	1%	21%	14%	65%
	pale (19)	0%	16%	16%	21%	0%	47%	16%	37%
	very pale (33)	3%	12%	9%	15%	12%	48%	24%	27%
	bleached (14)	0%	0%	0%	7%	7%	86%	7%	7%

Coral reproduction and early life history-

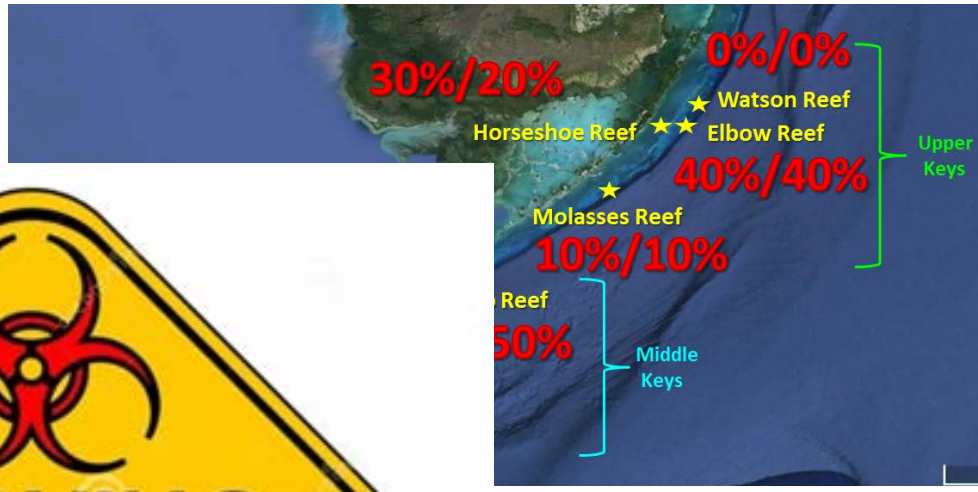
- Gametogenic effort
- Genet-specific spawning performance
- Parental compatibility for fertilization
- Survivorship and competency curves
  few months not weeks
- Advancing methods for larval-based population enhancement

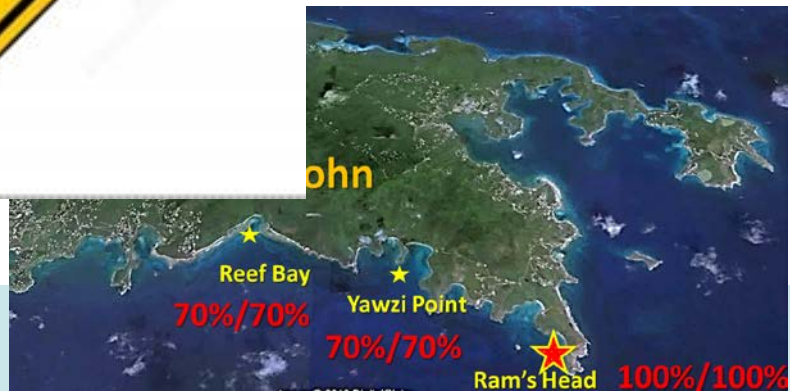


Reproductive effort in *A.palmata* (Woodley et al)

% colonies with ova/% colonies with spermaries (n=10)

- Highly inconsis
- Some variabilit
  with water qual





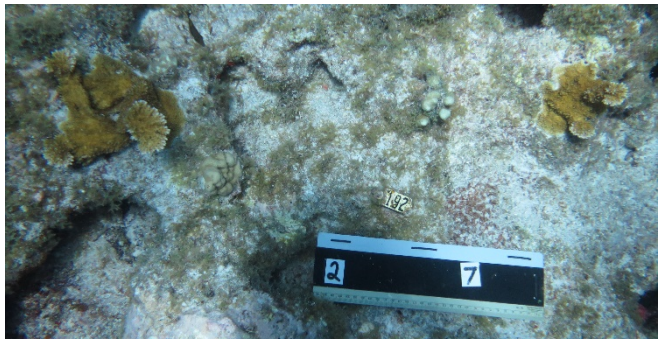
Gonadal pathologies

Location	% Polyps w/ Ova		
FLORIDA– Elbow Reef	15.75		
PUERTO RICO Rincon	47.78		
ST. JOHN USVI Ram's Head	45.52		
ST. JOHN USVI Hawksnest	7.24		
ST. CROIX Buck Is (Underwater Trail)	1.88	0.03	0.01
ST. CROIX Buck Is (Site 5)	22.63	0.62	0.52

How is this information useful?

- *A.palmata* is worse off than it appears
  - Punctuated, significant declines in biomass
  - Cryptic loss of genotypic diversity
    - 17% over 5 years WITHOUT disturbance
  - Inconsistent reproductive effort
    - Both gametogenesis and spawning
    - Water quality contributing factor
  - Fertilization success highly dependent on parental identity – and there are not enough parents

➔ Consider genotypic enhancement with reproductively compatible genotypes



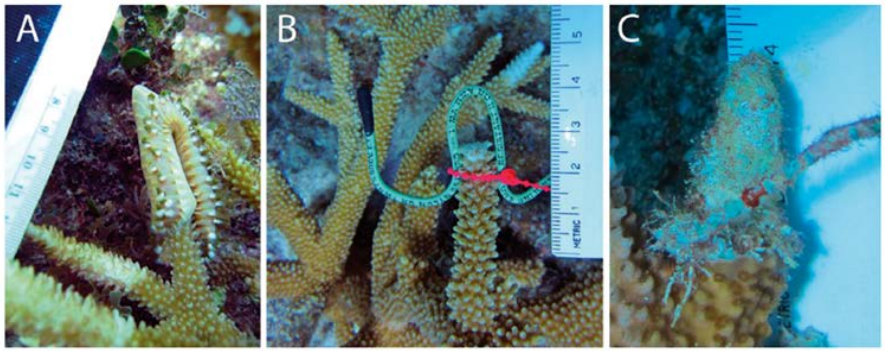
How is this information useful?

- Larval duration and competency better defined for two primary reef building species
  - Improved understanding of connectivity
  - Substantial contrasts between *A.palmata* and *O.faveolata* in longevity, onset of competency
- Dismal survivorship of settlers on the reef (Miller 2014)
- Lab grow-out to larger sizes enables further propagation and improves survival on the reef

Born: Aug 14
Outplanted: Nov 15

Acropora Recovery Actions

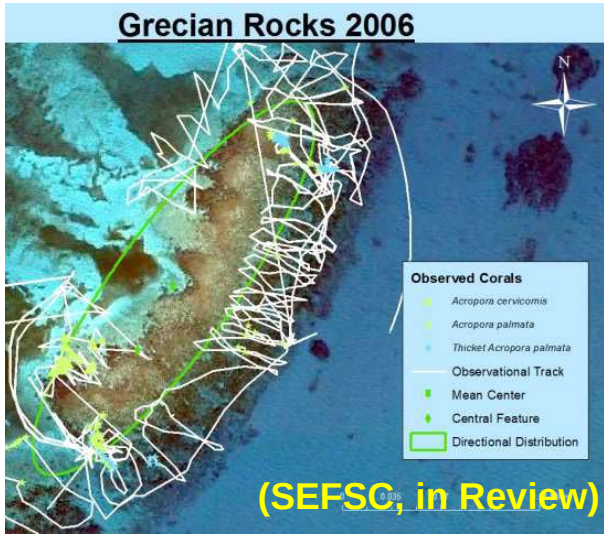
- Population Enhancement
  - Fragment propagation in field nurseries
  - Via larval culture
- Health/disease
  - research and intervention
- Predator Control

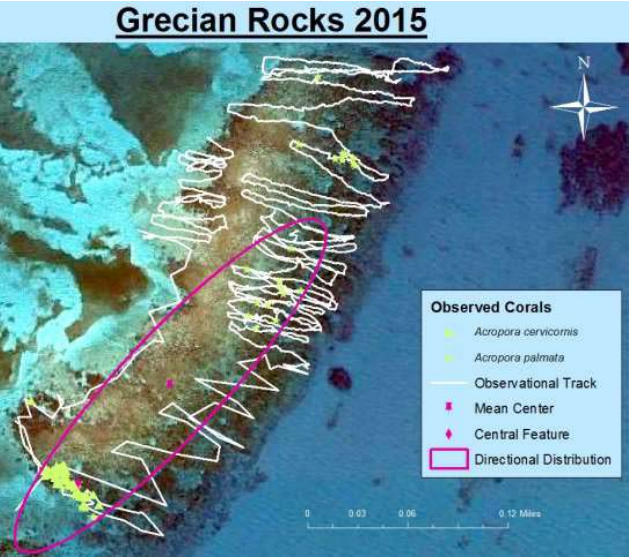


'Coral Recovery Science'

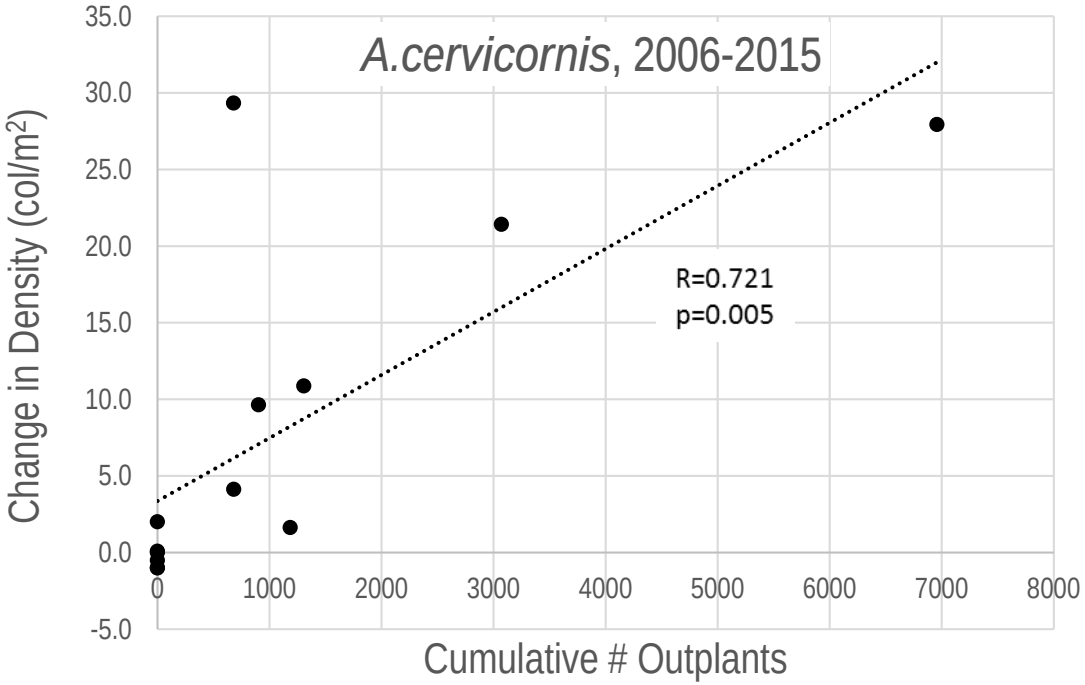
- Health and genetics of enhanced populations
- Basic evaluation of outplant performance
  - Genet
  - Size
  - Spacing
  - Habitat
- Disease risk evaluation
- Evaluating resistance traits
- How and cost/benefit of predator control
- Practical mitigation for disease and/or predation

Does fragment outplanting matter?



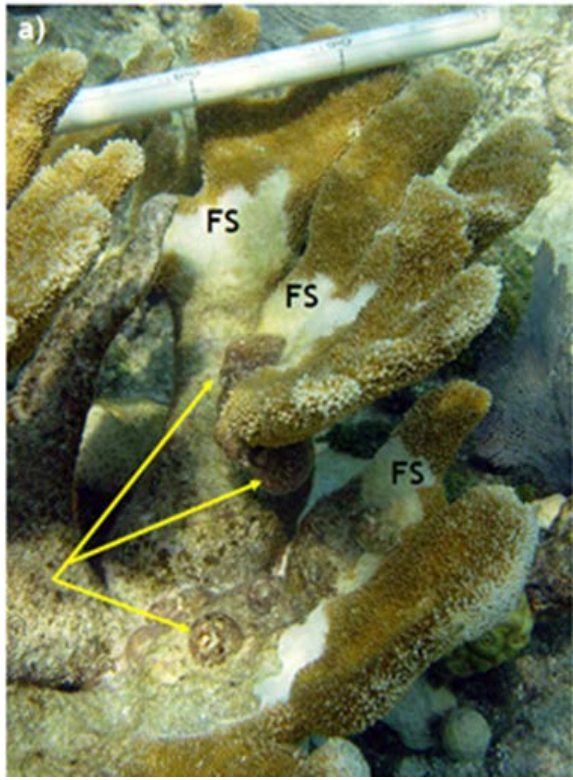


Year	# palmata	# cervicornis	# Ac outplants
2006	429	39	-
2014	264	39	300
2015	50	351	605



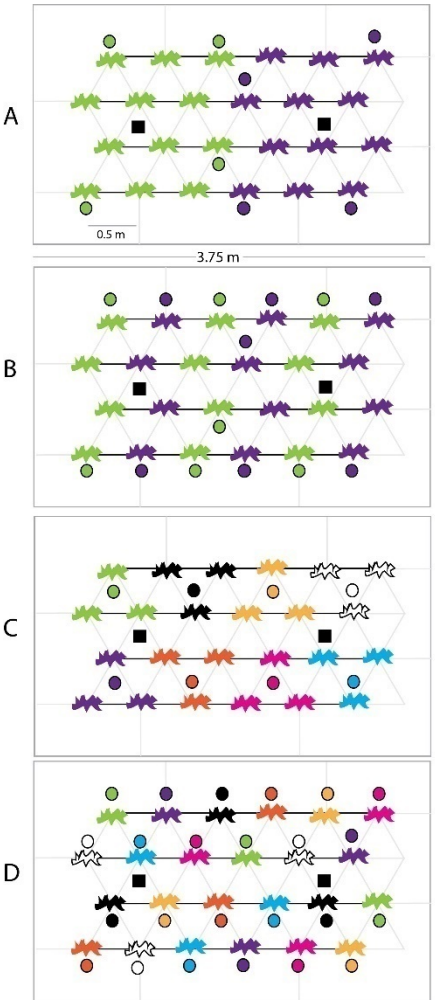
How is this information useful?

- Population enhancement is making a difference at the reef scale!
- Disease dynamics of outplants does not differ from wild populations
  - ➔Distinct health management policies (e.g., culling) are not warranted
- Predator control and/or mitigation can provide benefits, some at tractable cost, for vulnerable populations



Ongoing contributions (FY16-17)

- Evaluating different designs and configurations for outplanting *A.palmata*
  - 'Thicket' development
  - Community-level effects of diversity and interspersion of foundation spp.
- Continue *A.palmata* demographic monitoring
- Continue spawning and larval studies
  - Substrate enhancements for post-settlement
  - Lab grow-out to improve survivorship
- Experimental quantification of disease resistance traits in nursery stocks of *Acropora* spp. (collaborators determining complementary traits)

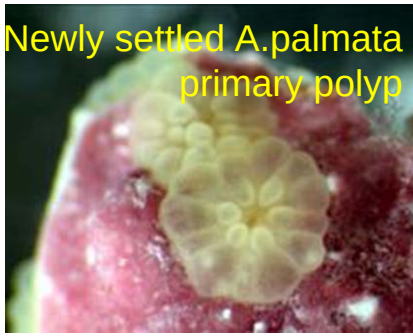


Challenges

- Threats to corals are intractable
  - Short time frame for solutions
  - Effective strategies are few
  - Bad news is unpopular
- Capacity for field science relative to scope of need
- How to communicate results most effectively to managers?
- Timeliness
  - Management needs
  - Moving funds
  - Data availability

Future Research Needs

- Understand mechanisms of reproductive failure
  - Senescence, water quality, reversibility
- Develop/evaluate more proactive and novel tools for enhancing/ assisting coral resilience and coral reef ecosystem function (van Oppen et al. 2015)
  - Tweaking more tolerant symbiotic partnerships
  - Identify disease and thermal stress resistance traits (and tradeoffs)
  - Translocation of resilient genotypes or species
  - Enhance recruitment success
- MANAGEMENT PLANNING



Citations

- Miller MW, Kerr KA, Williams DE (In Revision) Reef-scale trends in *Acropora* spp. abundance and effects of population enhancement. PeerJ.

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