

TRAINING

Climate-Smart Management



Goals

- Explore threats associated with climate change
- Understand social-ecological resilience
- Discuss climate-smart management solutions



Climate change and Uncertainties



How does climate change differ from other threats?



3 key differences



Uncertainty

Uncertainty at every step

- How much and how quickly climate change will advance (e.g. low/high emissions scenarios)
- How major Earth systems will cope
- How atmospheric climate changes will impact complex regional systems
- How resilient/adaptable species and habitats will be
- How humans will respond (policies, social impacts, values)



3 key differences



Uncertainty



No control over the
threat

3 key differences



Uncertainty



No control over the
threat



Even in the best
scenarios, the
threat will persist
beyond our lifetime

As a manager you can influence:

Cause: fisher



Threat: dynamite fishing



Stress: loss of live coral cover



What we are trying to protect: coral reef



Lack of:

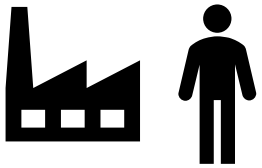
- Education
- Alternative livelihood
- Regulations
- Policy
- Etc...



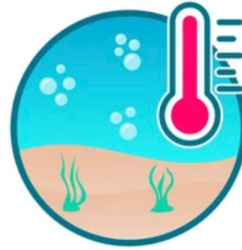
Strategies –
in 5 to 10 years

As a manager you can't influence:

Cause:
humans/CO2
emissions



Threat: increased
SST / bleaching



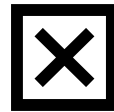
Stress: loss of live
coral cover



What we are trying
to protect: coral



No control over
the threat



Threat persists
beyond our lifetime

Strategies –

- Enhance recovery
- Accelerate adaptation
- Increase resilience

BUT Strategies –
will only slow
down the
trajectory

What will the impacts of climate change be on management?



Climate change will impact



The ecological systems we manage



The human systems associated with those resources



Infrastructure we manage



Our ability to carry out operations (budgets and capacity)



The way in which we manage (management approach)



The relevance and achievability of management goals

Changes in management

- Stresses on reefs are increasing or changing
- New threats are predicted



New/novel interventions will be increasingly necessary

- Management baselines are shifting
- Ecosystems are changing in character and function
- Timing and impacts are fundamentally uncertain



We require adaptive and flexible approaches to planning and management

- Pressures (and impacts) are complex and largely outside our direct control



Collaborative and participatory approaches will be fundamental

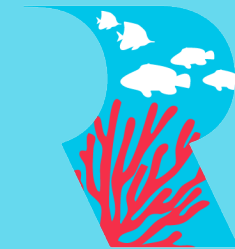
Uncertainty is a
fundamental property
of climate change.

We need to find ways
to plan and manage
around climate change
without waiting for
certainty...



ACTIVITY #1

**How has climate change
already impacted your work
and/or personal life?**



**Reef
Resilience
Network**

Threats to Coral Reef Resilience



Social-Ecological Resilience

3 dimensions

Ecosystem

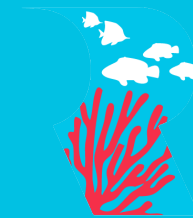
Community

Governance



1. Ecological Resilience

What are the threats to ecological resilience on coral reefs?



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Attributes of ecological resilience

- **Habitat condition**
 - Structural complexity
 - Water quality
 - Suitable recruitment habitat
- **Diversity and functional redundancy**
- **Herbivory**
- **Connectivity**
- **Seascape diversity**



Threats to ecological resilience

KEY THREATS:

- Coral bleaching
- Land-based pollution
- Overfishing
- Destructive fishing practices
- Tropical storms
- Coral disease and predator outbreaks

+ non-resilient social and institutional frameworks



2. Social Resilience

What are the threats to social resilience on coral reefs?



Attributes of social resilience

- Knowledge and Stewardship
- Resources and Livelihoods
- Networks and Relationships
- Health and Culture



Threats to social resilience

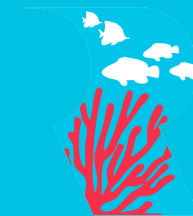
KEY THREATS:

- Dependence on coral reef resources
 - Limited access to alternative livelihood opportunities
 - Barriers to education and healthcare, and social support systems
 - Weak community networks
 - Loss of traditional ecological knowledge
 - Misinformation and poor risk communication
 - Competition over declining reef resources
 - Loss of agency and optimism for the future
- ✦ non-resilient ecological and institutional frameworks



3. Institutional Resilience

What are the threats to governance systems that support resilience on coral reefs?



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Attributes of institutional resilience

- Rules and Regulations
- Representation and Inclusion
- Leadership and Management
- Accountability and Equity



Threats to institutional resilience

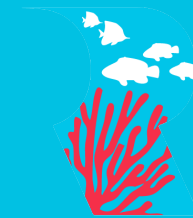
KEY THREATS:

- Inadequate policies
- Governance systems that are too rigid
- Inadequate funding for reef management
- Lack of effective resource planning and coastal management
- Insufficient resource preparedness and response capacity
- Limited participation of local communities in decision-making

+ non-resilient ecological and social frameworks



ACTIVITY #2



**Reef
Resilience
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CASE STUDY: NIAVOU

A single-island nation of about 2,800 people in the Pacific, built around a fringing reef and a sheltered lagoon locals call the Vasa Channel. Most households fish the reef flats and lagoon, grow root crops, and increasingly host small-scale tourism. The reef has been through two significant coral bleaching events in the past five years, most recently in 2025, leaving large sections of the outer reef pale and slow to recover. A single inter-island ferry connects Niavou to the regional capital twice a week.

Coral Cover	Visitors / Year	Avg. Reef Catch / Fisher / Day
50% (2017) → 22% (2025)	600 (2019) → 2,300 (2025)	18 kg (2015) → 9 kg (2025)

Ecological	Social	Governance
Unconfirmed reports of coral disease on the eastern reef Increased coral rubble and reduced reef structure in places Seagrass beds in the lagoon are thinning Saltwater intrusion into a coastal taro patch after a recent storm surge	Fishers travel farther from shore as nearshore catches decline More households are buying store food as reef catches drop Young people increasingly seek work via the ferry route rather than fishing Tourism operators aren't coordinated with the village council on reef-use guidelines	No formal marine protected area yet; a community proposal has sat for three years Village council hasn't reviewed the latest reef health survey No designated authority enforces reef-use rules; disputes handled informally A commercial fishing fleet has been seen working just outside the lagoon mouth

Report Out

1. Share the top 2 priorities included in your plan and management actions

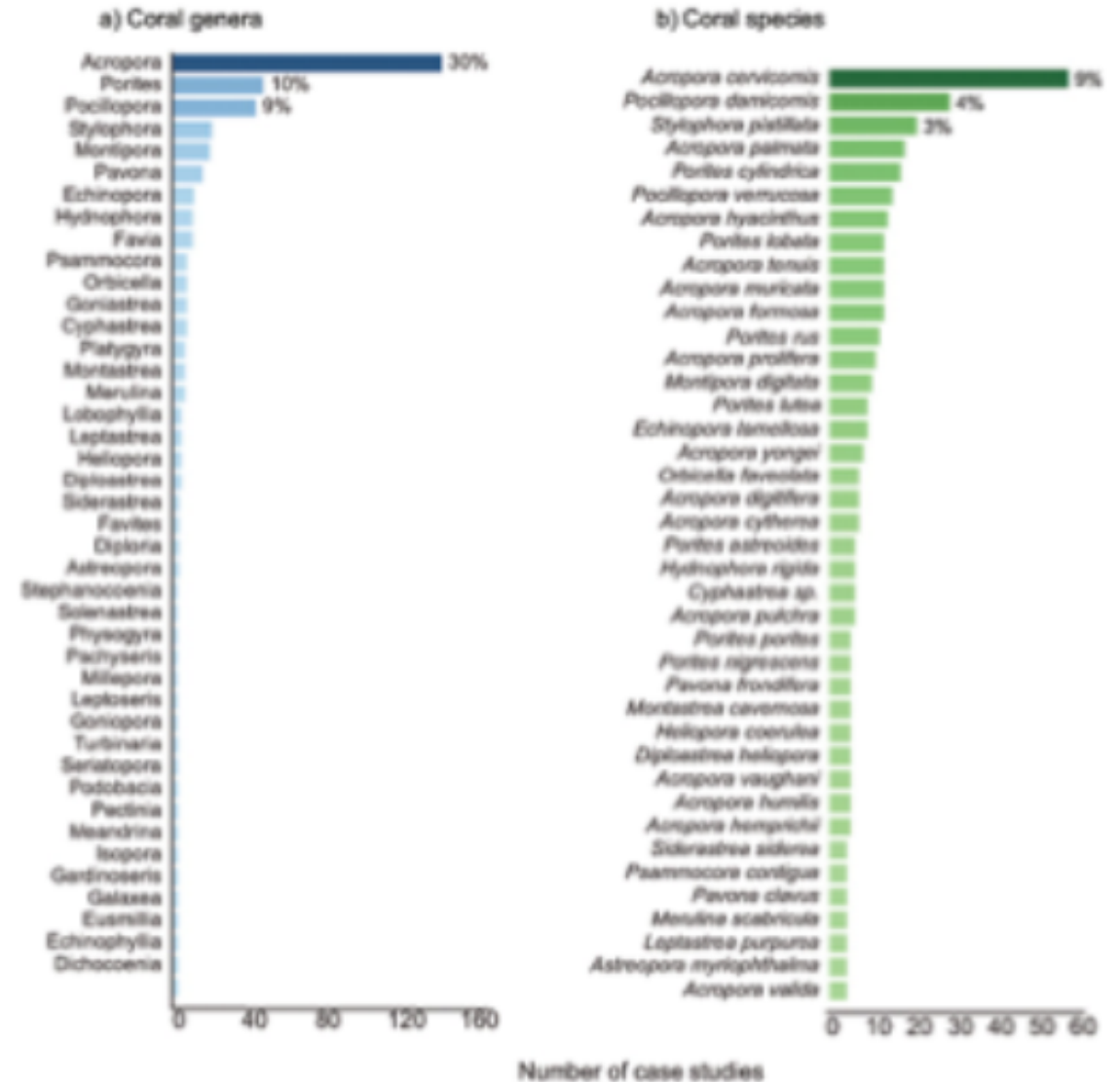
What tools do we have to “climate-smart” coral reef management?

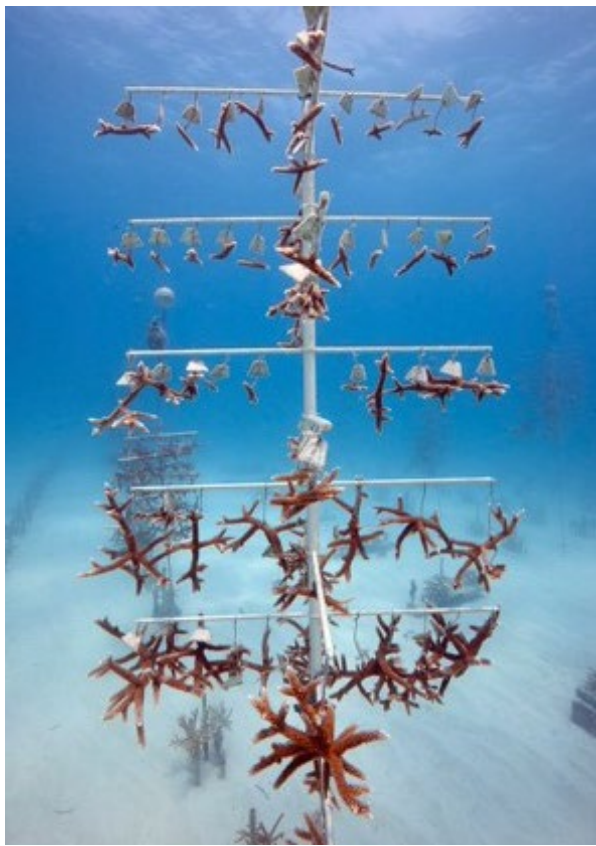


Coral restoration – A systematic review of current methods, successes, failures and future directions

Lisa Boström-Einarsson^{1*}, Russell C. Babcock², Elisa Bayraktarov³, Daniela Ceccarelli⁴, Nathan Cook⁵, Sebastian C. A. Ferse^{6,7}, Boze Hancock⁸, Peter Harrison⁹, Margaux Hein¹, Elizabeth Shaver⁸, Adam Smith⁵, David Suggett¹⁰, Phoebe J. Stewart-Sinclair³, Tali Vardi¹¹, Ian M. McLeod¹

- Only 5 out of over 350 projects included the word “climate” in the project description or goals
- A third of all projects focusing on acroporids





A roadmap to integrating resilience into the practice of coral reef restoration

Elizabeth C. Shaver¹ | Elizabeth McLeod¹ | Margaux Y. Hein² | Stephen R. Palumbi³ | Kate Quigley⁴ | Tali Vardi⁵ | Peter J. Mumby⁶ | David Smith^{7,8} | Phanor Montoya-Maya⁹ | Erinn M. Muller¹⁰ | Anastazia T. Banaszak¹¹ | Ian M. McLeod¹² | David Wachenfeld¹³



Restoration Recommendations to Enhance Coral Reef Resilience

Design coral reef restoration projects:

- 1 To integrate climate change adaptation
- 2 While including and engaging local communities
- 3 Utilizing techniques that promote coral resilience and recovery

Prioritize coral colonies that are:

- 4 Sourced from at least 10 colonies spaced 5 meters apart
- 5 Sourced from a variety of reef habitats and conditions
- 6 Represent a diversity of growth forms and functions
- 7 Thermal or disease resistant genotypes and species

Prioritize conducting restoration in sites that:

- 8 Represent a variety of reef habitats and conditions
- 9 Have high diversity and redundancy of herbivores
- 10 Are more resilient or less likely to experience environmental change
- 11 Supply coral and fish larvae to other areas

Conduct coral reef restoration:

- 12 As part of effective management and threat reduction
- 13 Alongside protection and restoration of other marine habitats
- 14 Focusing on ecological processes and species that support corals

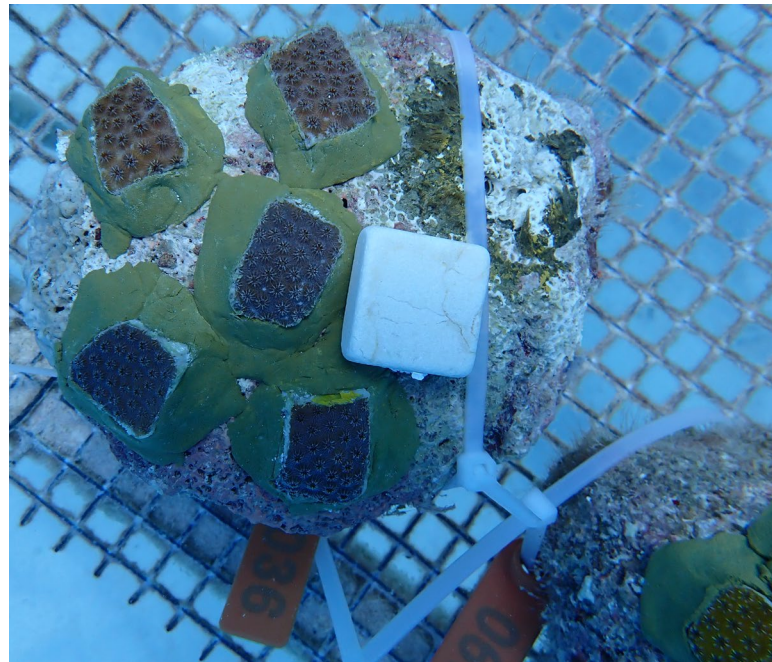
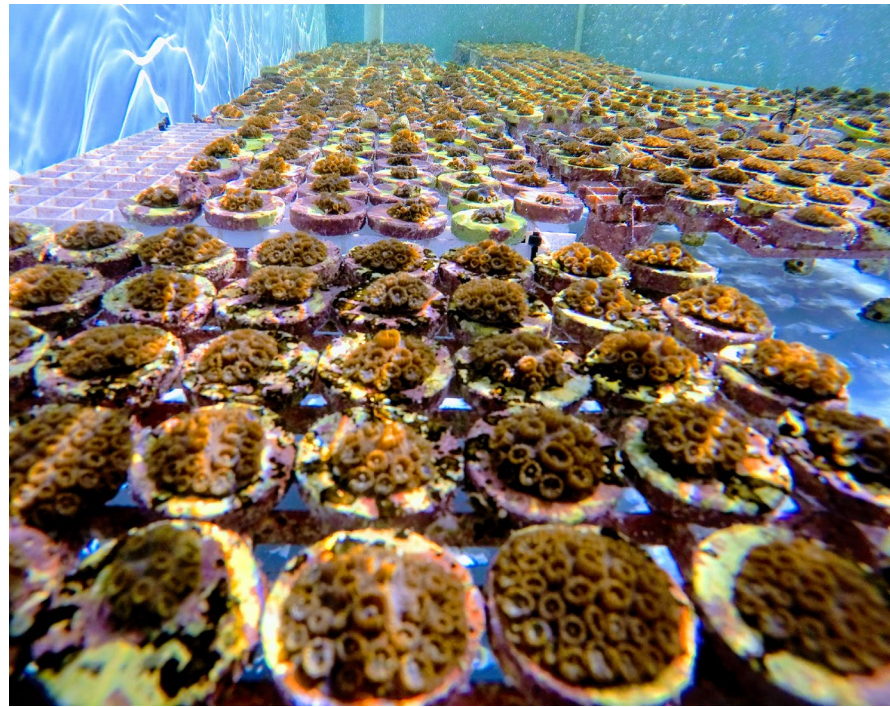
Designing restoration projects

- 1** Integrate environmental change and climate adaptation into restoration planning
- 2** Include local communities and traditional and local knowledge in restoration projects to support social-ecological resilience
- 3** Utilize techniques that promote genetic diversity, increased thermal tolerance, and rapid coral recovery (such as: assisted sexual reproduction, micro-fragmentation, stress hardening, selective breeding for tolerance traits)





Micro-fragmentation



Macro-fragmentation



Prioritizing & selecting corals

- 1 Restore a diversity of coral species, growth forms, and functional roles
- 2 Source corals from a diversity of genotypes by collecting corals from at least 10 unique genets spaced no less than 5 meters apart
- 3 Source corals from a variety of reef habitats including diverse environments and conditions
- 4 Use thermal or disease-resistant species and genotypes, but when not known increase genotypic and morphological diversity to incorporate varying tolerances and promote redundancy



Prioritizing restoration sites

- 1** Conduct restoration in multiple sites that represent a variety of reef habitats, such as depths, oceanographic conditions, and thermal regimes
- 2** Select sites with high diversity and functional redundancy of reef herbivores
- 3** Conduct restoration in areas that show higher resilience to, or are less likely to experience, environmental or climate change impacts
- 4** Prioritize sites that are well connected and provide high larval output to other areas, accommodating dispersal distances of coral species of interest



Restoring in a broader context

- 1** Ensure coral reef restoration is integrated within a broader resilience-based management strategy, focused on reducing local threats to reefs that weaken corals
- 2** Restore or protect multiple ecologically connected marine habitats and ecosystems
- 3** Restore populations of non-coral species that support coral reef functional processes and recovery



Case study: TNC USVI

Bleaching monitoring

Assisted sexual reproduction

Land-based rearing

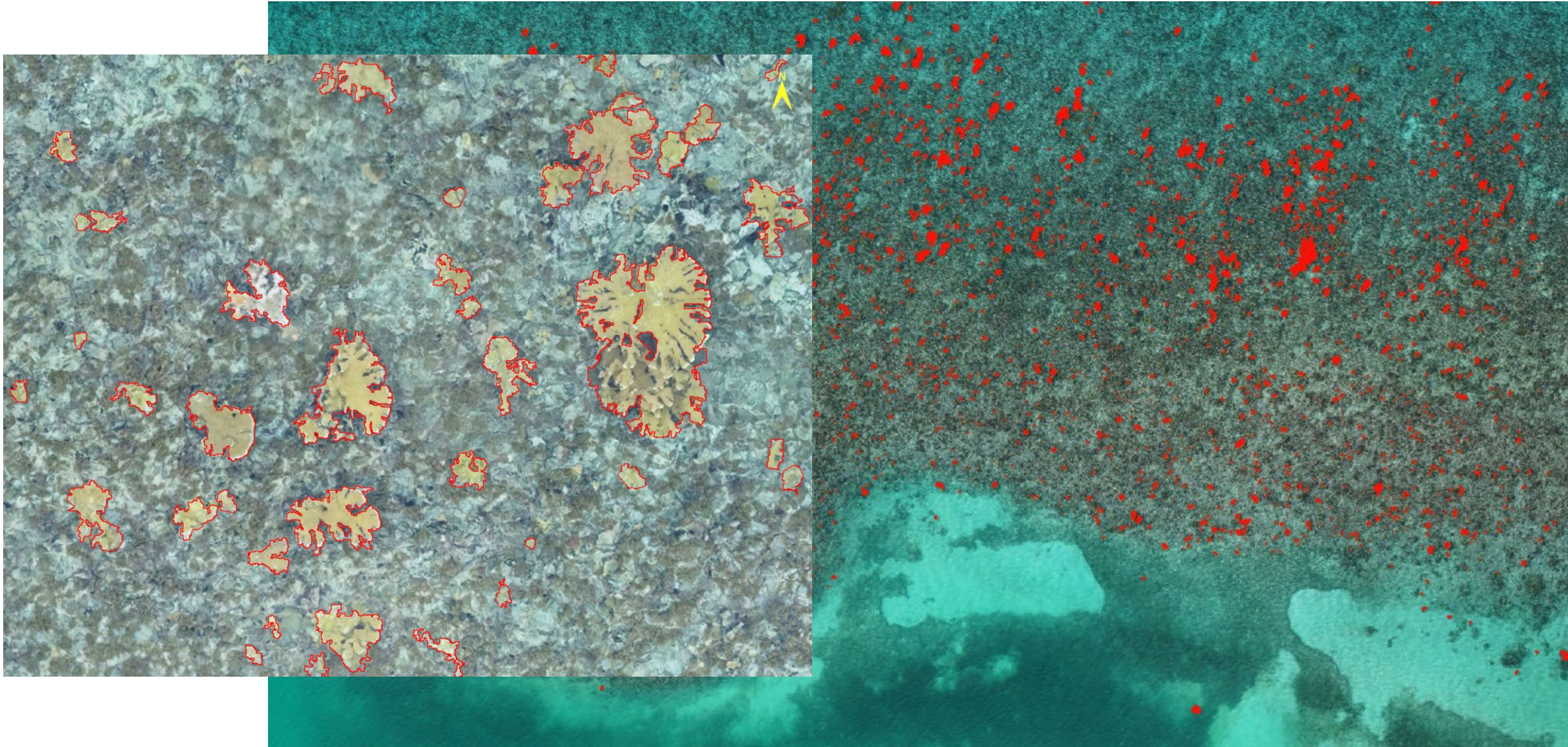
Assisted gene flow (AGF)



Bleaching Monitoring – in situ



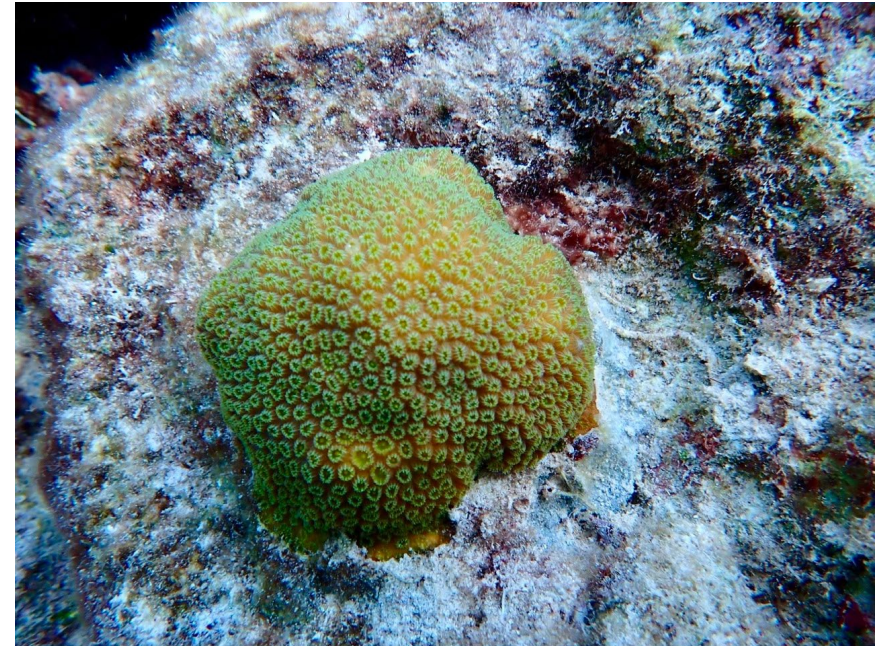
Bleaching Monitoring - drones



Assisted sexual reproduction

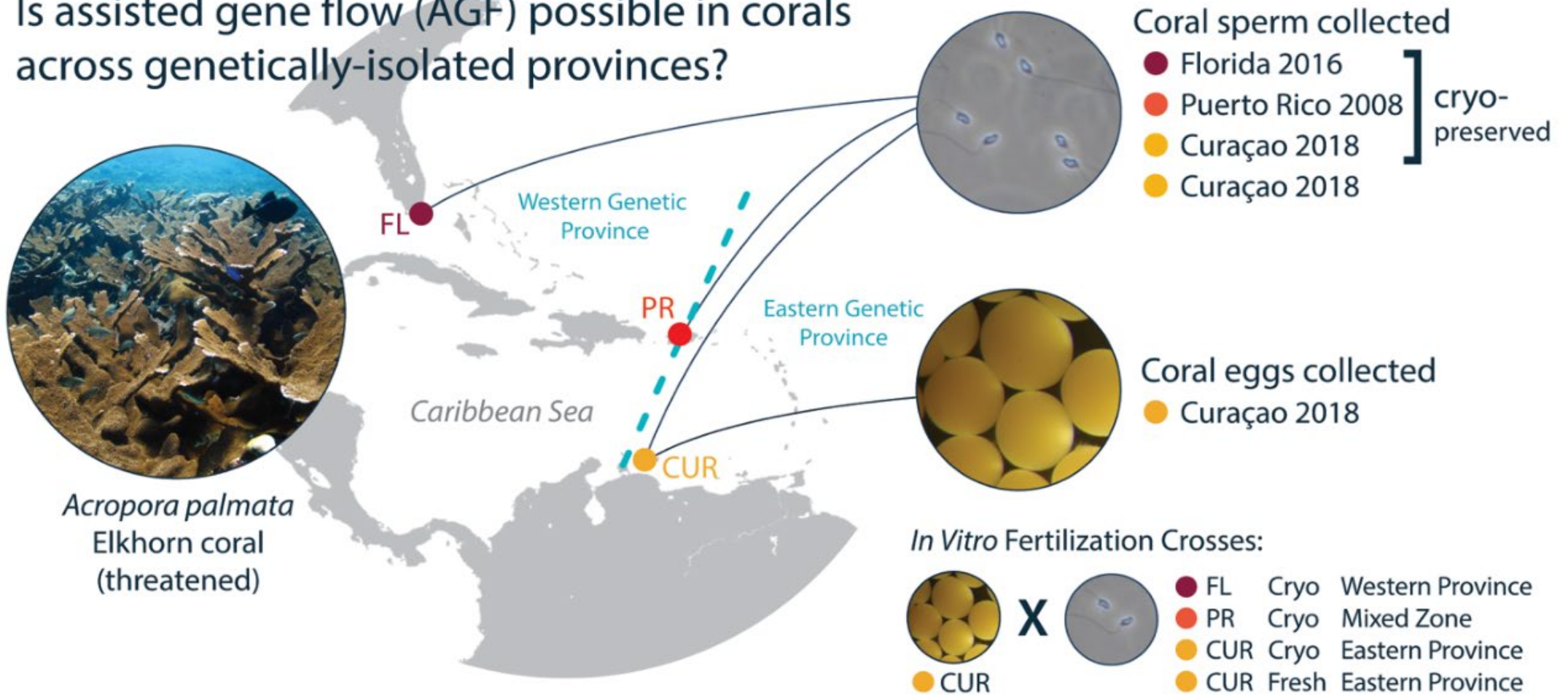


Land-based rearing



Assisted gene flow (AGF)

Is assisted gene flow (AGF) possible in corals across genetically-isolated provinces?



Emergency Response Plans

1. Response Coordination

Planning & Organization

Preparation

2. Response Execution

Early
warning

Immediate
response

Post
response

- ➔ Effectiveness requires:
- Appropriate and detailed planning
 - Clearly defining roles and responsibility

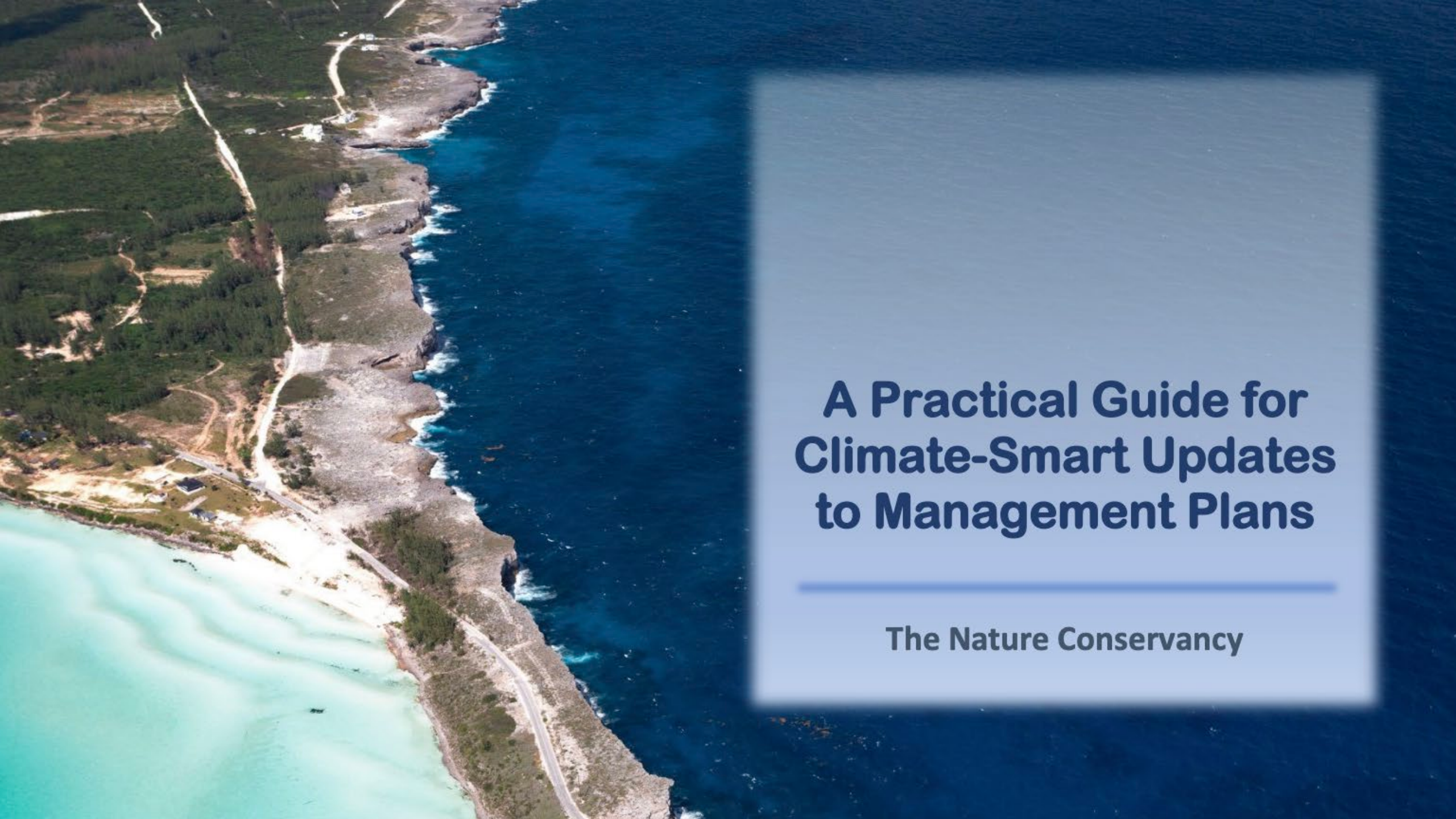


Marine Protected Areas

1. Manage unsustainable fishing practices
2. Manage general overuse of area
3. Support the control of other local threats (e.g., disease, predation)

- ➔ Effectiveness requires:
- Collaboration for water quality/pollution
 - Clear goals that are attainable under climate change
 - Effective design for goals



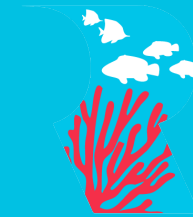
An aerial photograph of a tropical coastline. A paved road runs along the edge of a lush green forested area. The forest meets a light-colored sandy beach, which then meets the turquoise water of a lagoon. Further out, the water turns a deep blue, and the coastline continues with more forest and rocky outcrops. The overall scene is a beautiful example of a tropical environment.

A Practical Guide for Climate-Smart Updates to Management Plans

The Nature Conservancy

Activity

What are your programs or partners doing to make management actions/strategies climate smart?



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