Assessing the status and trends of coral reefs (and other coastal ecosystems)

Dr. Stuart Sandin

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I. Mapping coastal habitats of Sri Lanka

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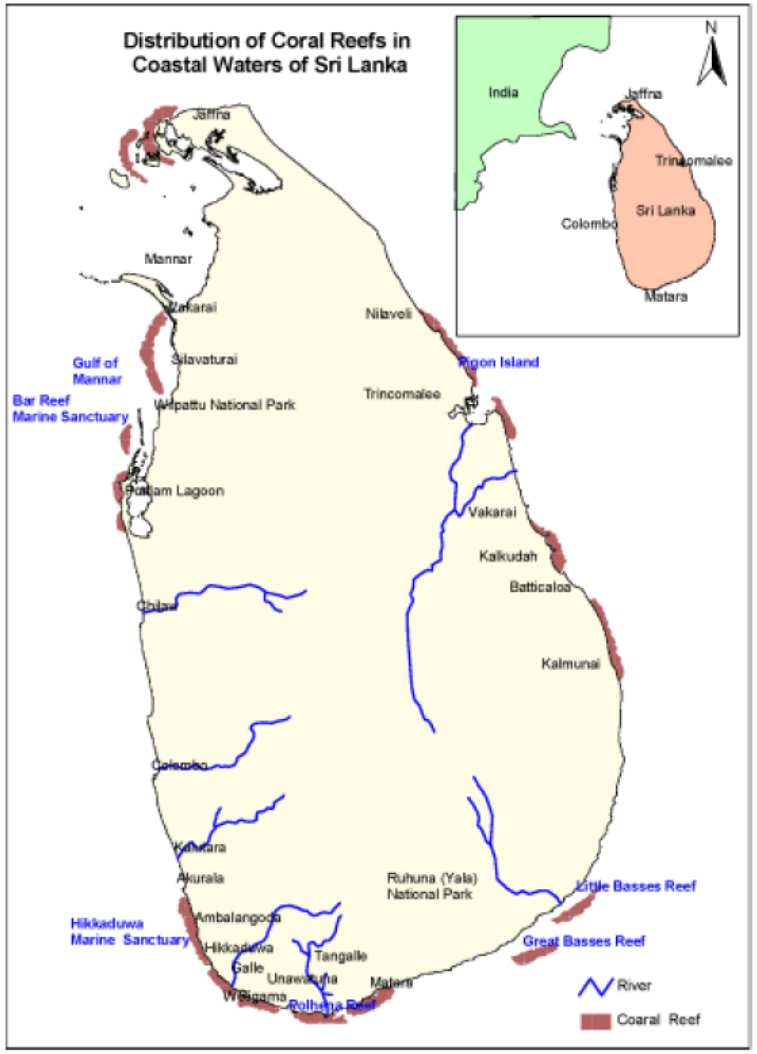
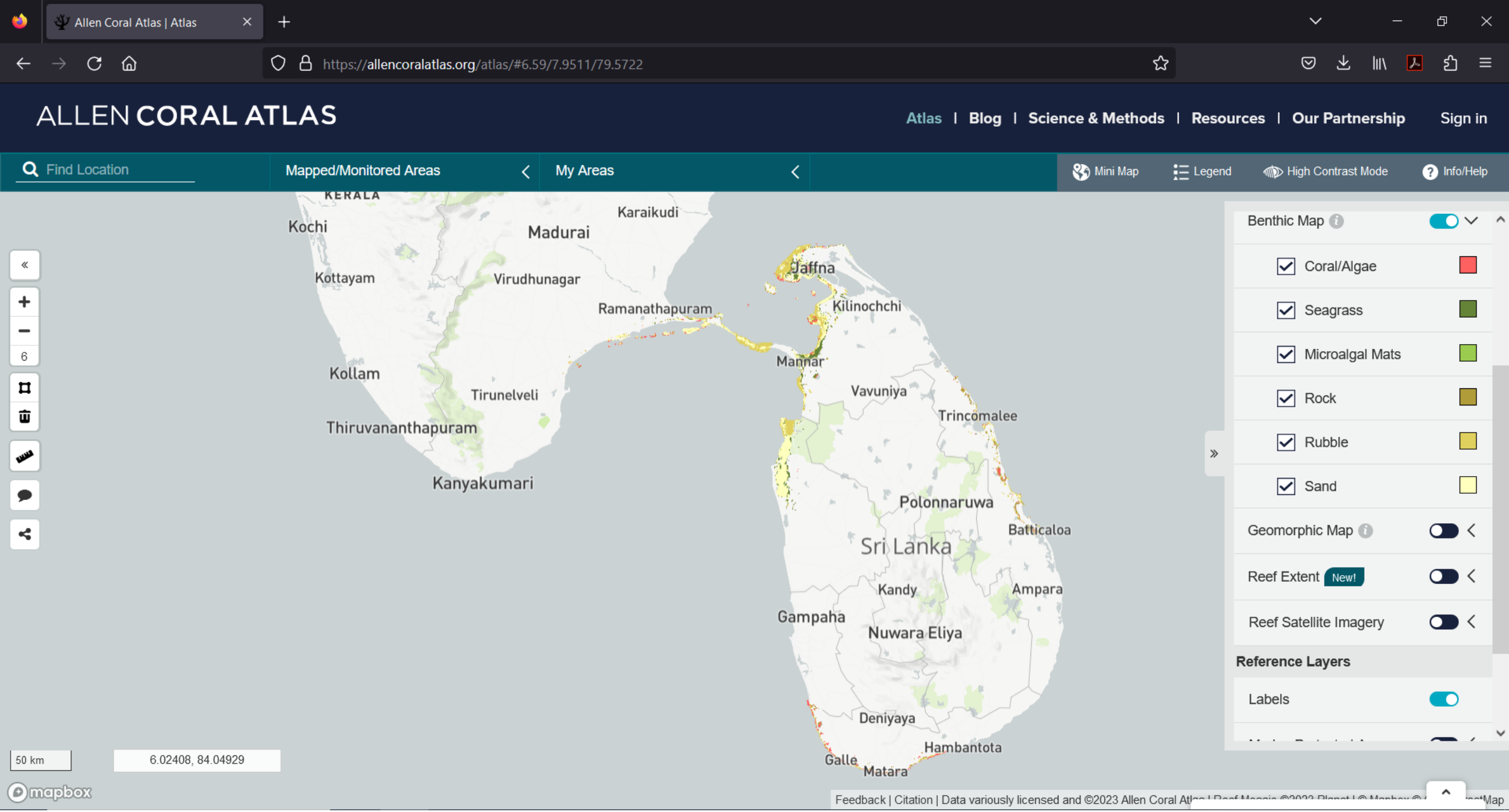


Figure 1: Map of Sri Lanka showing major reef areas (*Image Source: FAO*).

A preliminary report on the status of Kayankerni coral reef, Sri Lanka (Nishan Perera; 2019). <<link here>>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Benthic Map
Coral/Algae
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Microalgal Mats
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Geomorphic Map
Reef Extent
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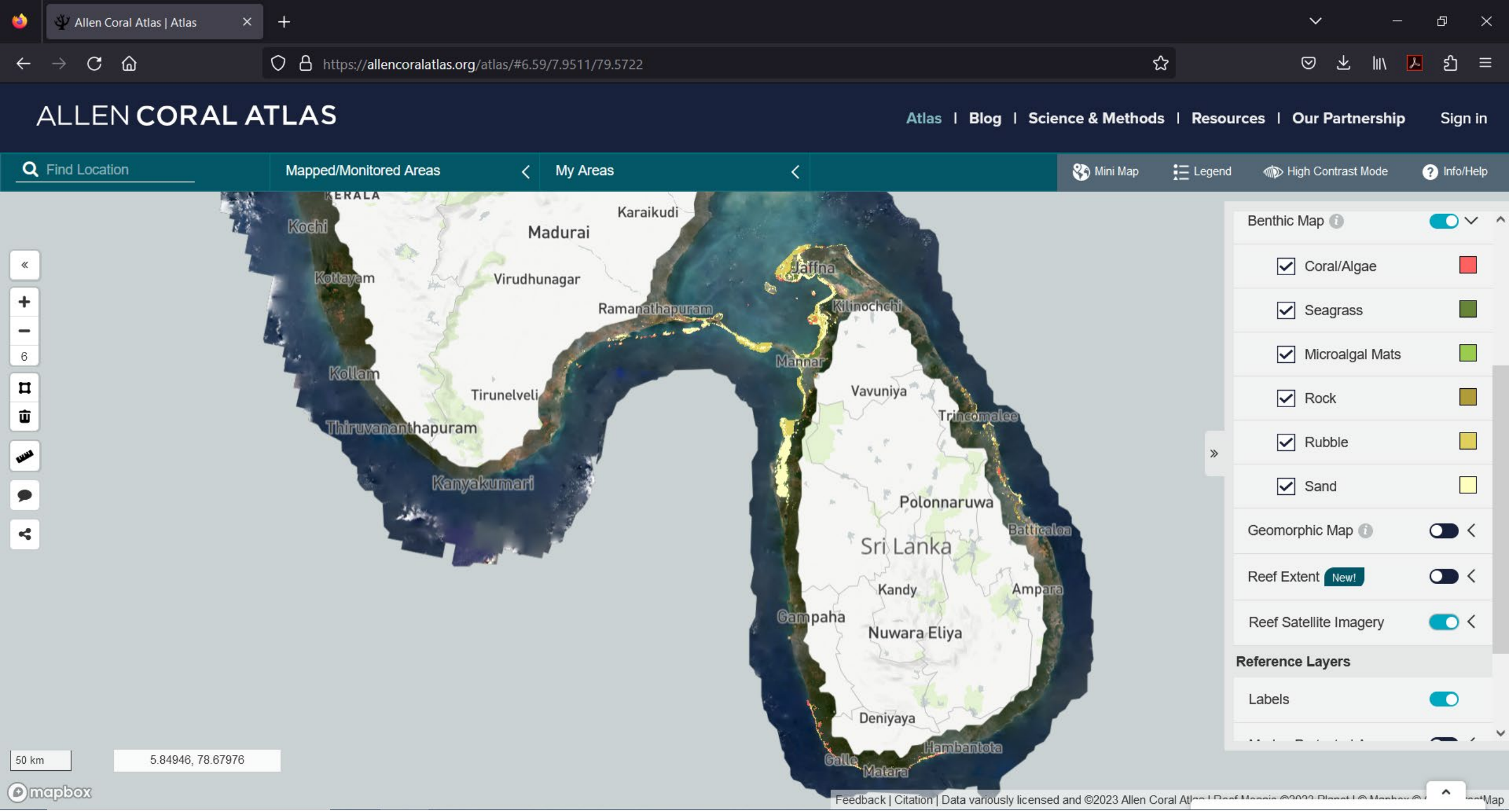
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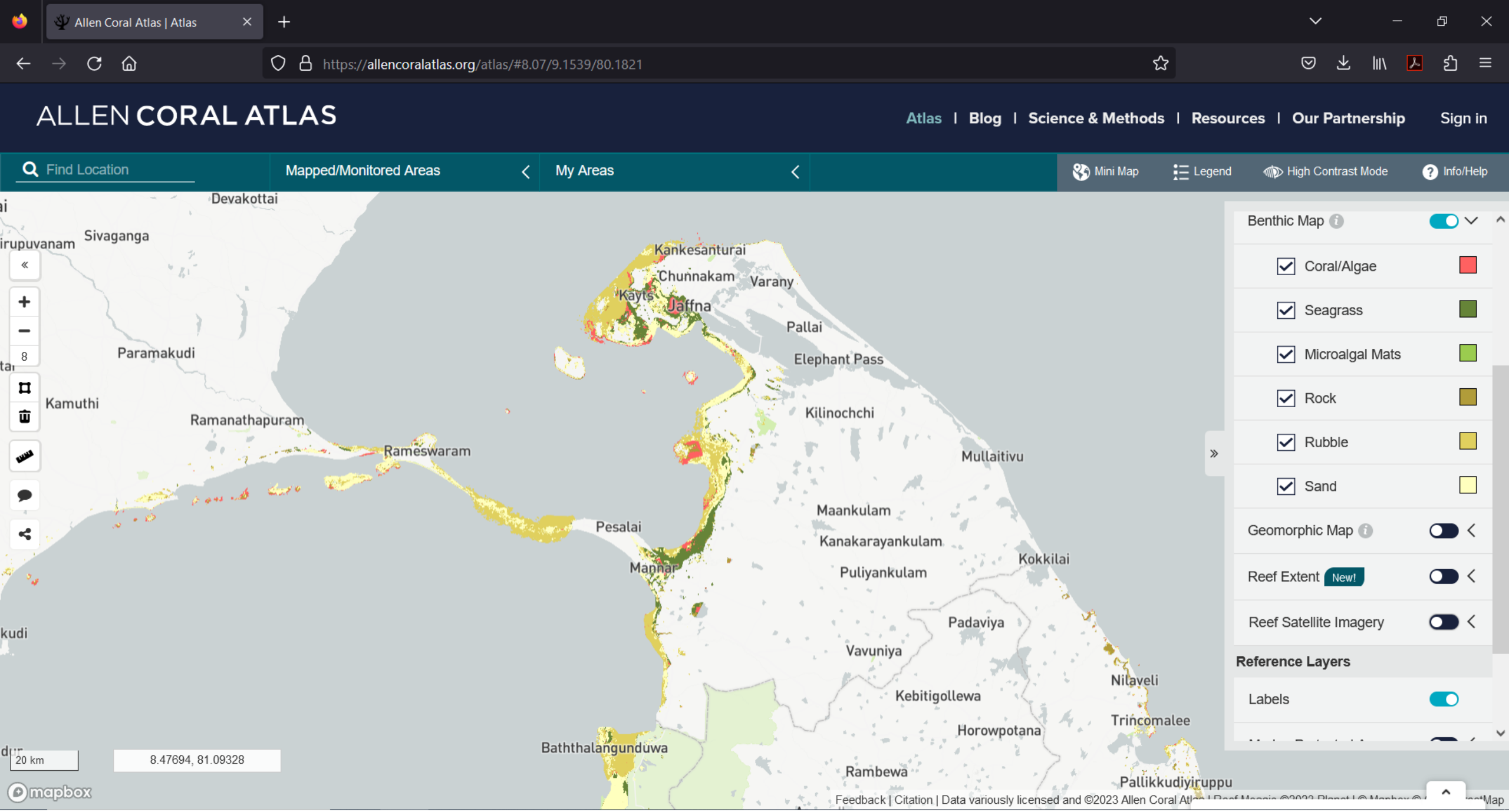
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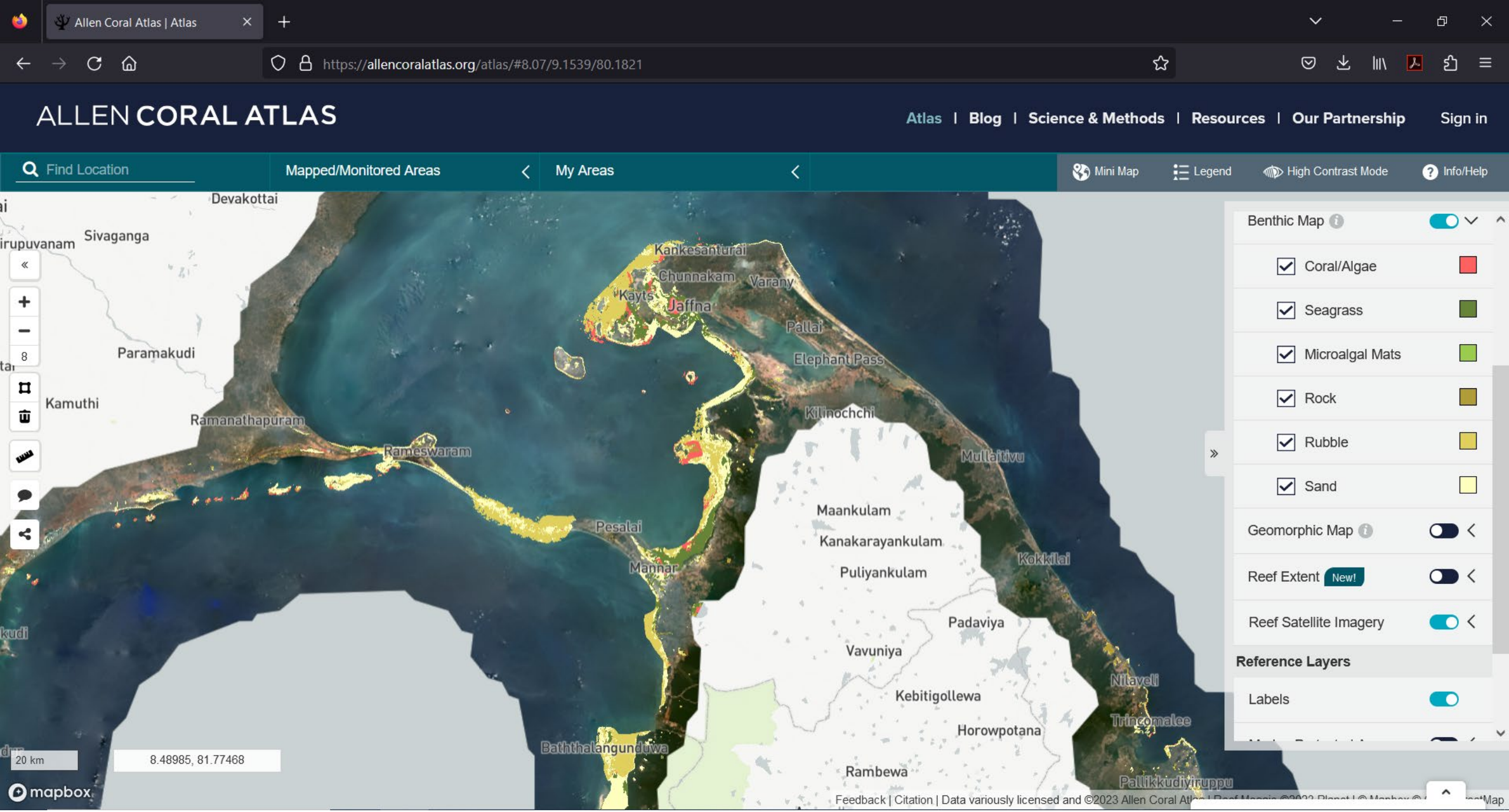
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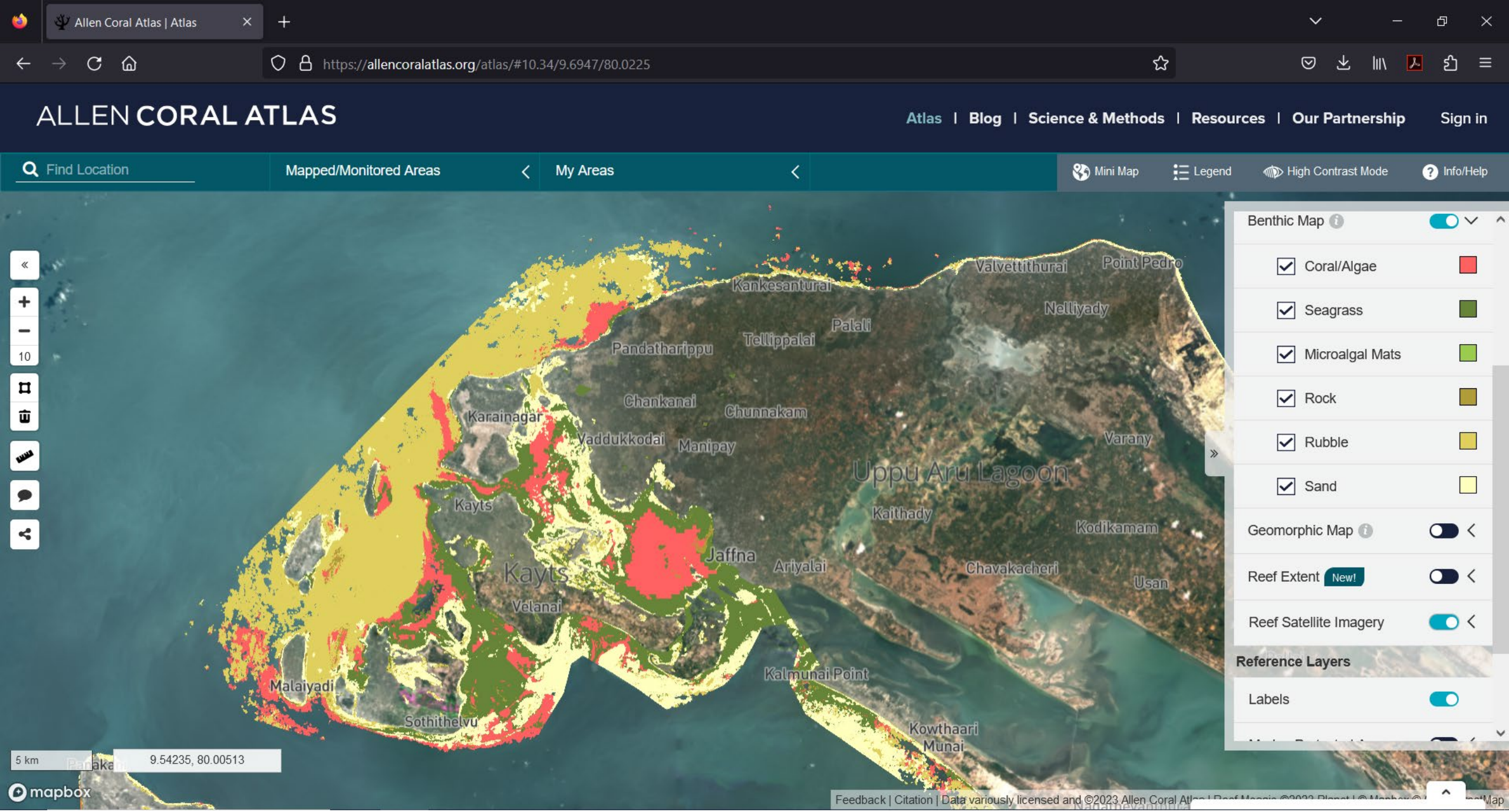
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Manipay
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Kodikamam
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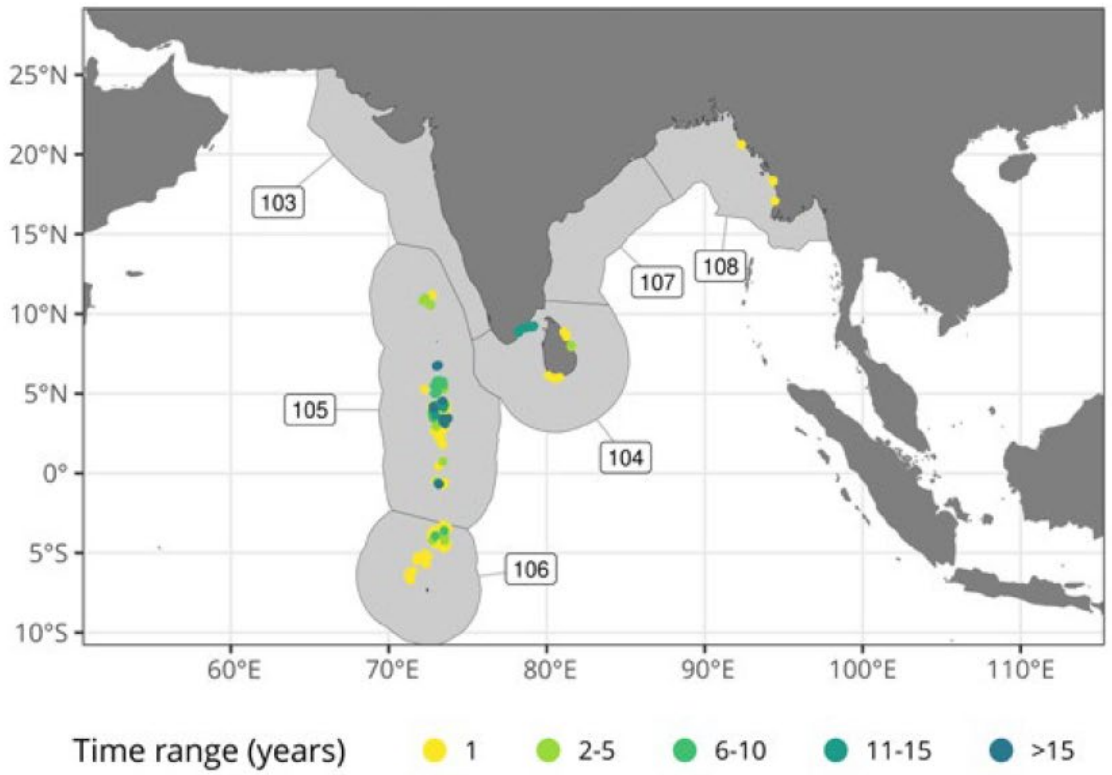
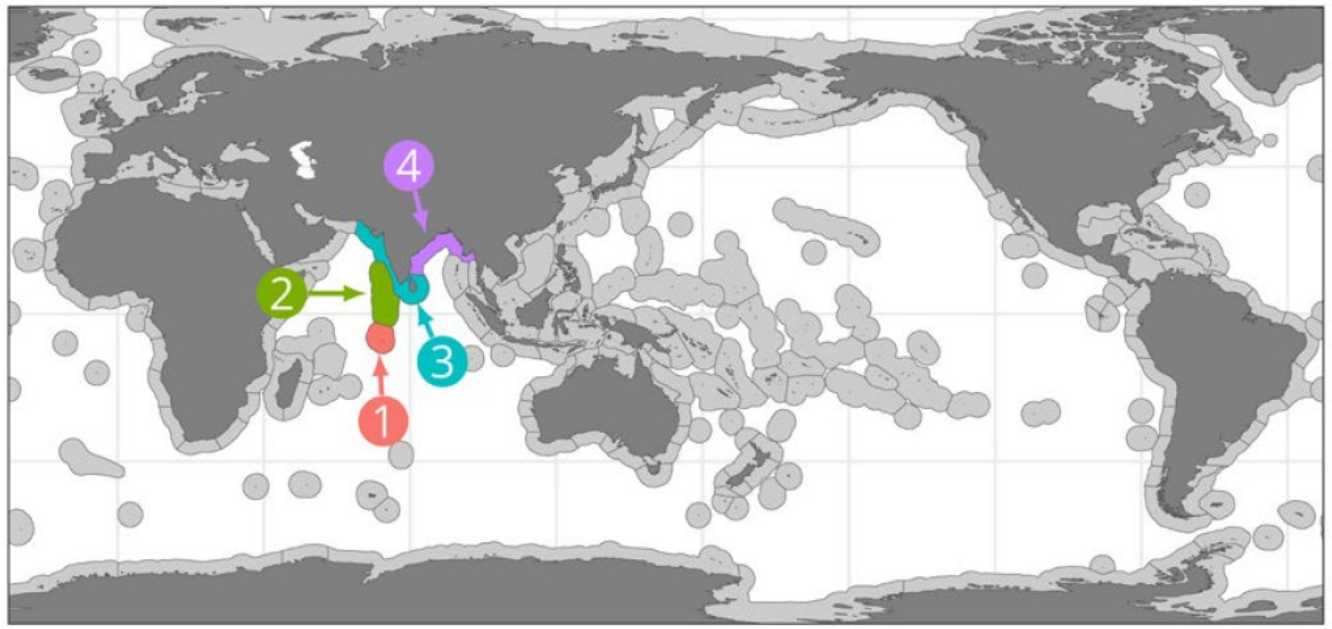


Figure 6.2. The distribution and duration of monitoring at sites across the South Asia region. The colours of dots represent the time span between the first survey and the most recent survey at each site. Numbers refer to the MEOW ecoregions listed in Table 6.1.

Status of coral reefs of the world: 2020 report. Global Coral Reef Monitoring Network (GCRMN) and Interntaional Coral Reef Initiative. https://gcrmn.net/2020-report



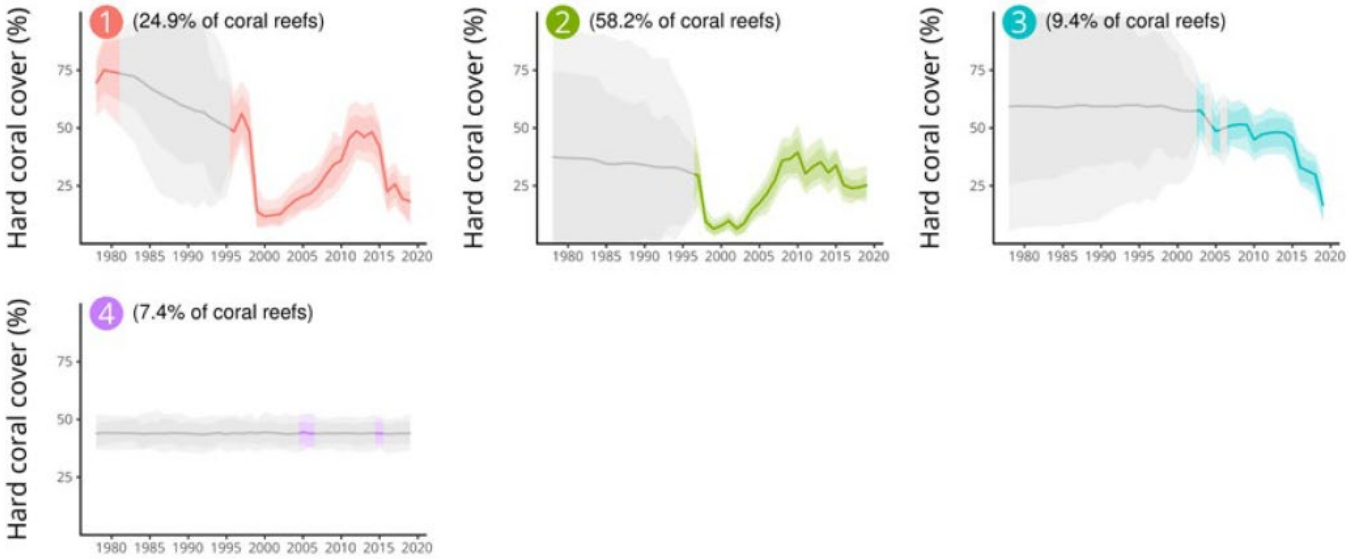
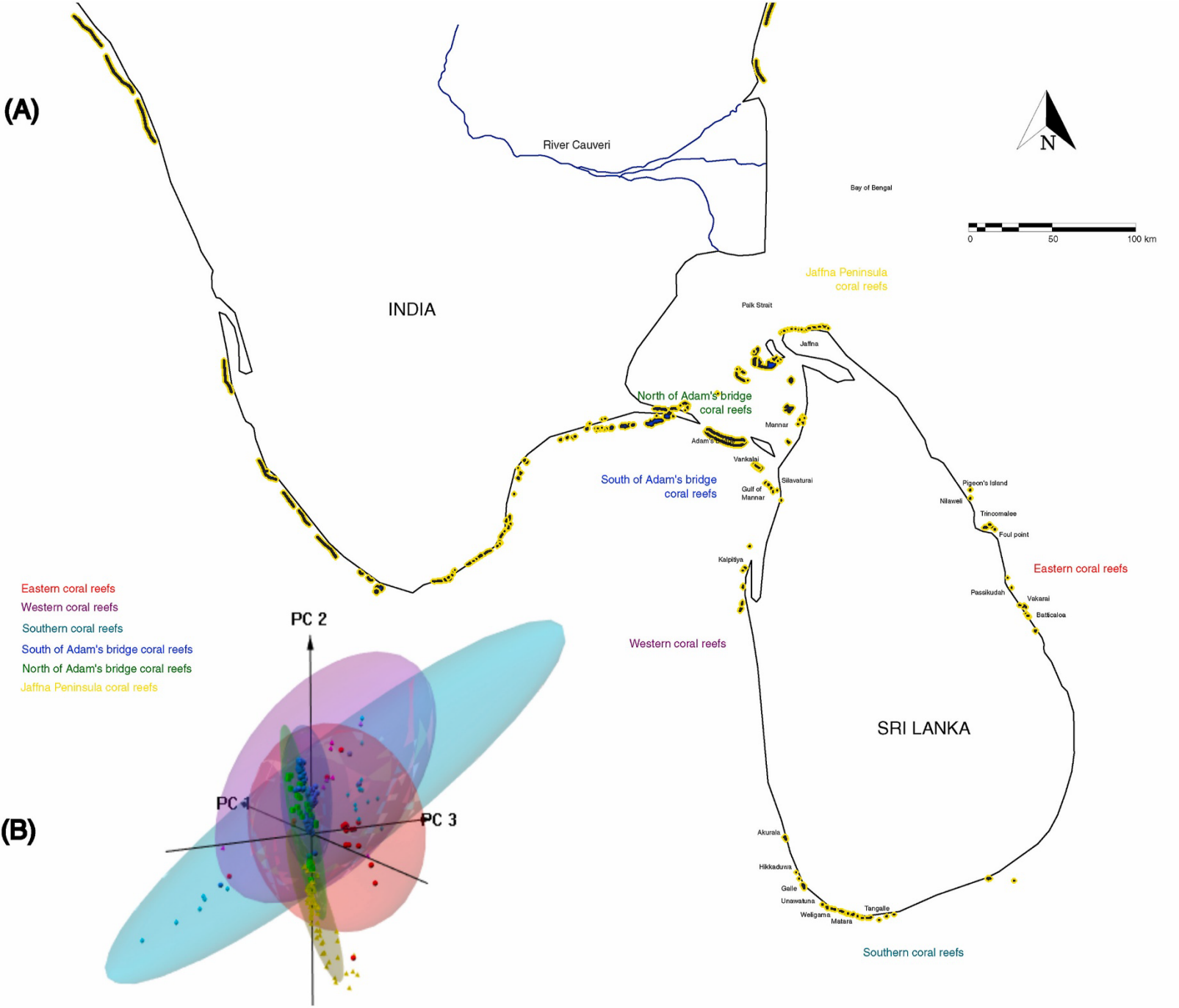
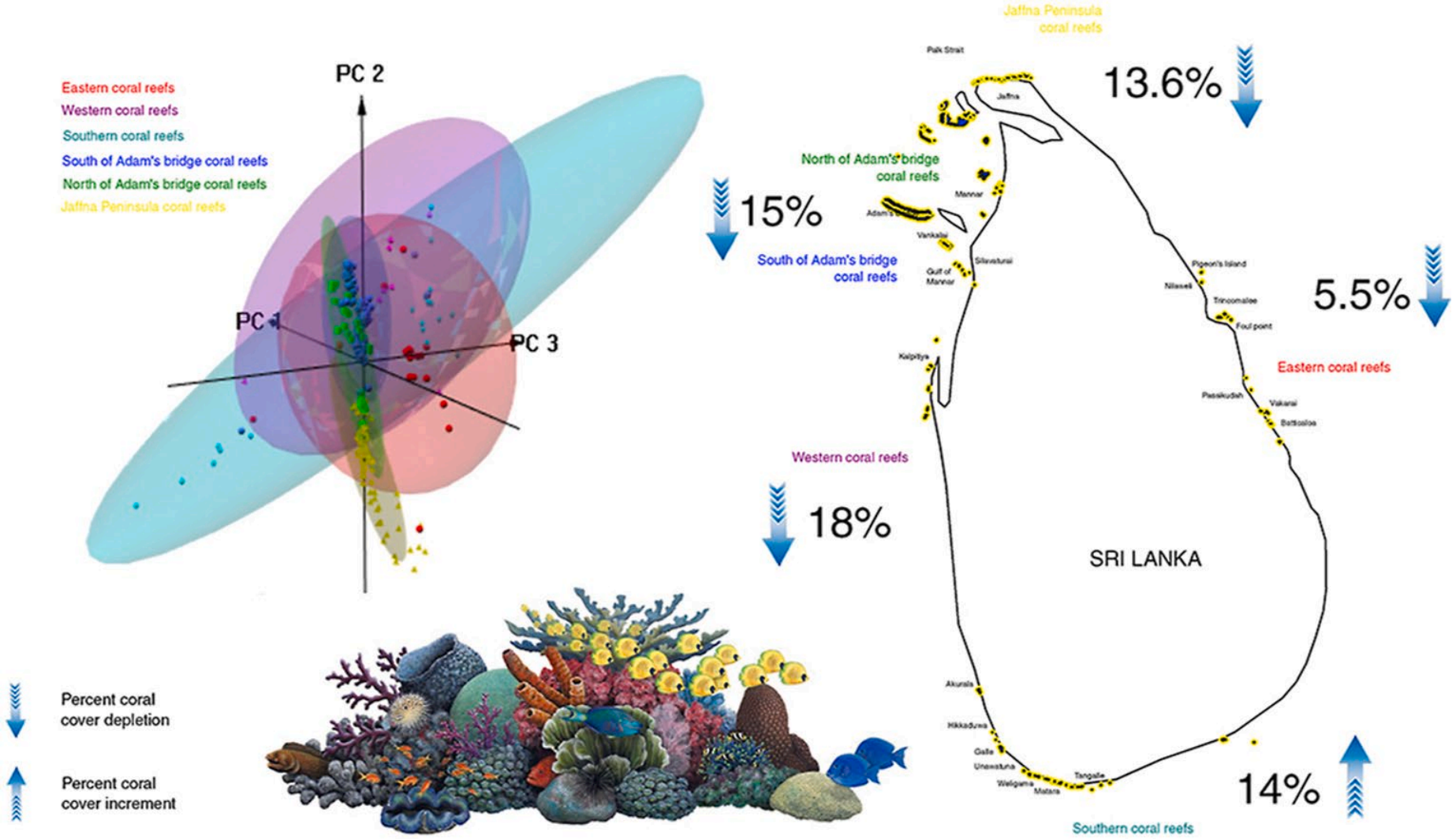


Figure 6.6. Estimated average cover of live hard coral within each subregion comprising the South Asia region. The solid line represents the estimated mean and associated 80% (darker shade) and 95% (lighter shade) credible intervals, which represent levels of uncertainty. Grey areas represent periods during which no field data were available. The proportion of all coral reefs in the South Asia region within each subregion is indicated by the % of coral reefs.

Status of coral reefs of the world: 2020 report. Global Coral Reef Monitoring Network (GCRMN) and Interntaional Coral Reef Initiative. https://gcrmn.net/2020-report



Ellepola, Harischandra, Ranawana (2021) *Ocean & Coastal Management*. https://doi.org/10.1016/j.ocecoaman.2021.105667



Ellepola, Harischandra, Ranawana (2021) *Ocean & Coastal Management*. https://doi.org/10.1016/j.ocecoaman.2021.105667

5. Conclusion

The current research update the knowledge on coral reef ecology of Sri Lanka, highlights the importance of conserving these unique reef habitats and aids in understanding the reef ecology around the island. It further, emphasizes on the unique and vulnerable coral reefs in the Gulf of Mannar as well as the coral reefs in the southern Sri Lanka which are adaptable to varying environmental conditions. Further we consider east coast as a future refuge for coral reefs as it will be less affected by future environmental changes. In addition we recommend more empirical studies to be conducted on unique biotic assemblages inhabiting these coral reefs which will aid in deeper understanding of these ecosytems. The current findings can be useful for future predictions, marine ecosystem management and ultimately coral reef conservation in Sri Lanka.

Ellepola, Harischandra, Ranawana (2021) *Ocean & Coastal Management*.
https://doi.org/10.1016/j.ocecoaman.2021.105667

II. Describing (in more detail) coastal habitats

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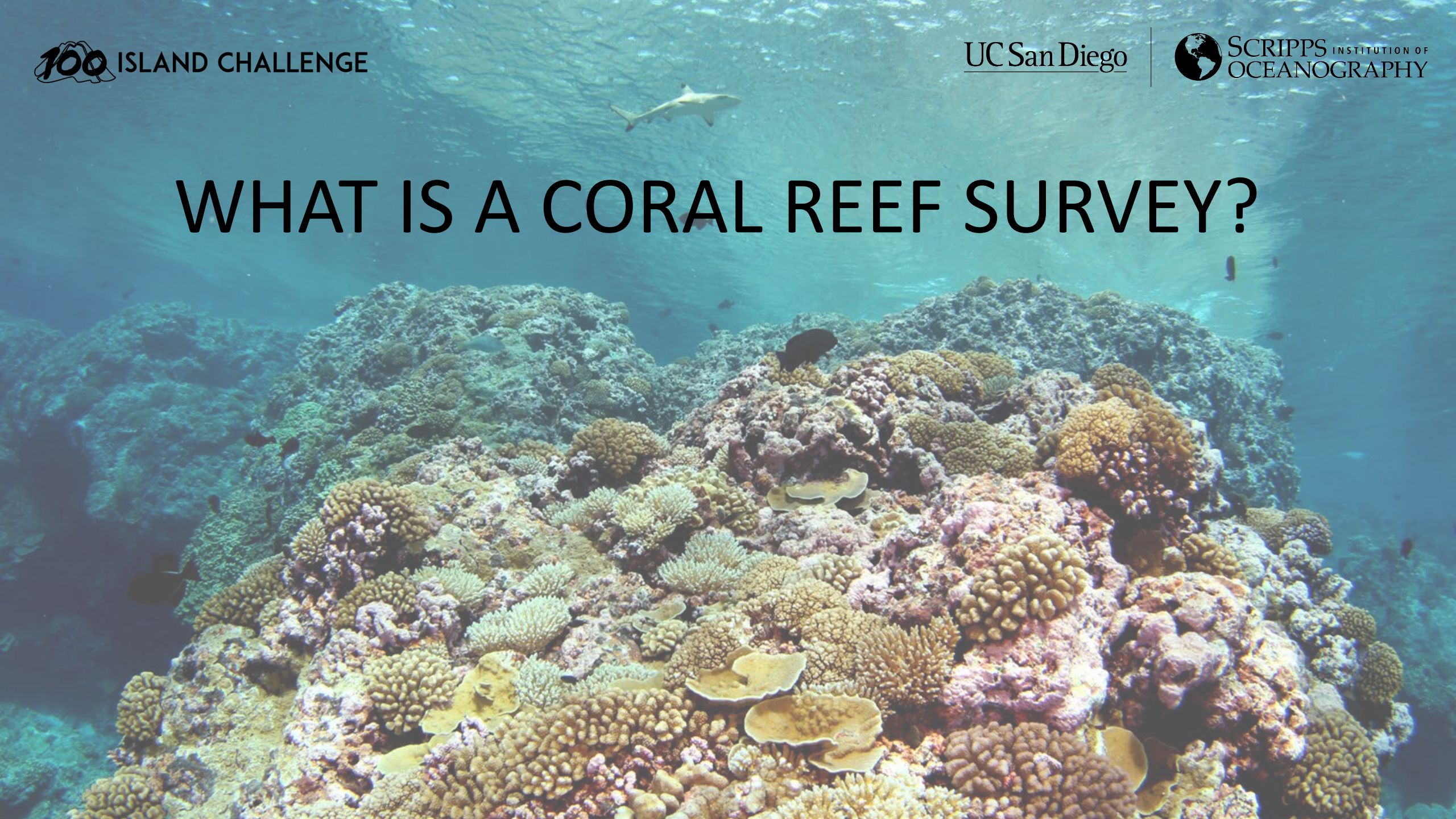
WHAT IS A CORAL REEF SURVEY?



Coral Reef Surveys

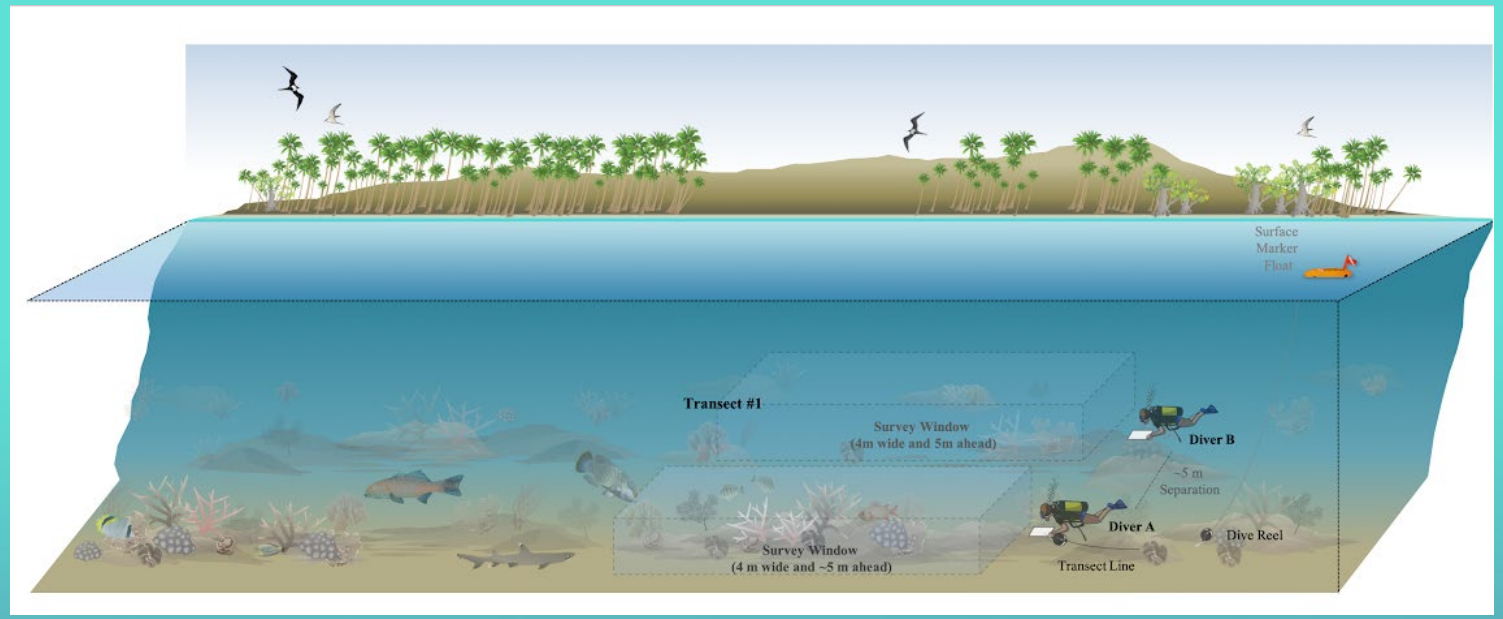
A way to collect information about the current state of a coral reef ecosystem

- "Snapshot"
- Environment is not manipulated
  - Not an "experiment"
- Many different types
  - Fish surveys
  - Benthic surveys
  - Macroinvertebrate surveys

Coral Reef Surveys

Not every organism at a given site can be counted

- Representative sample
  - Defined survey area
  - Replication



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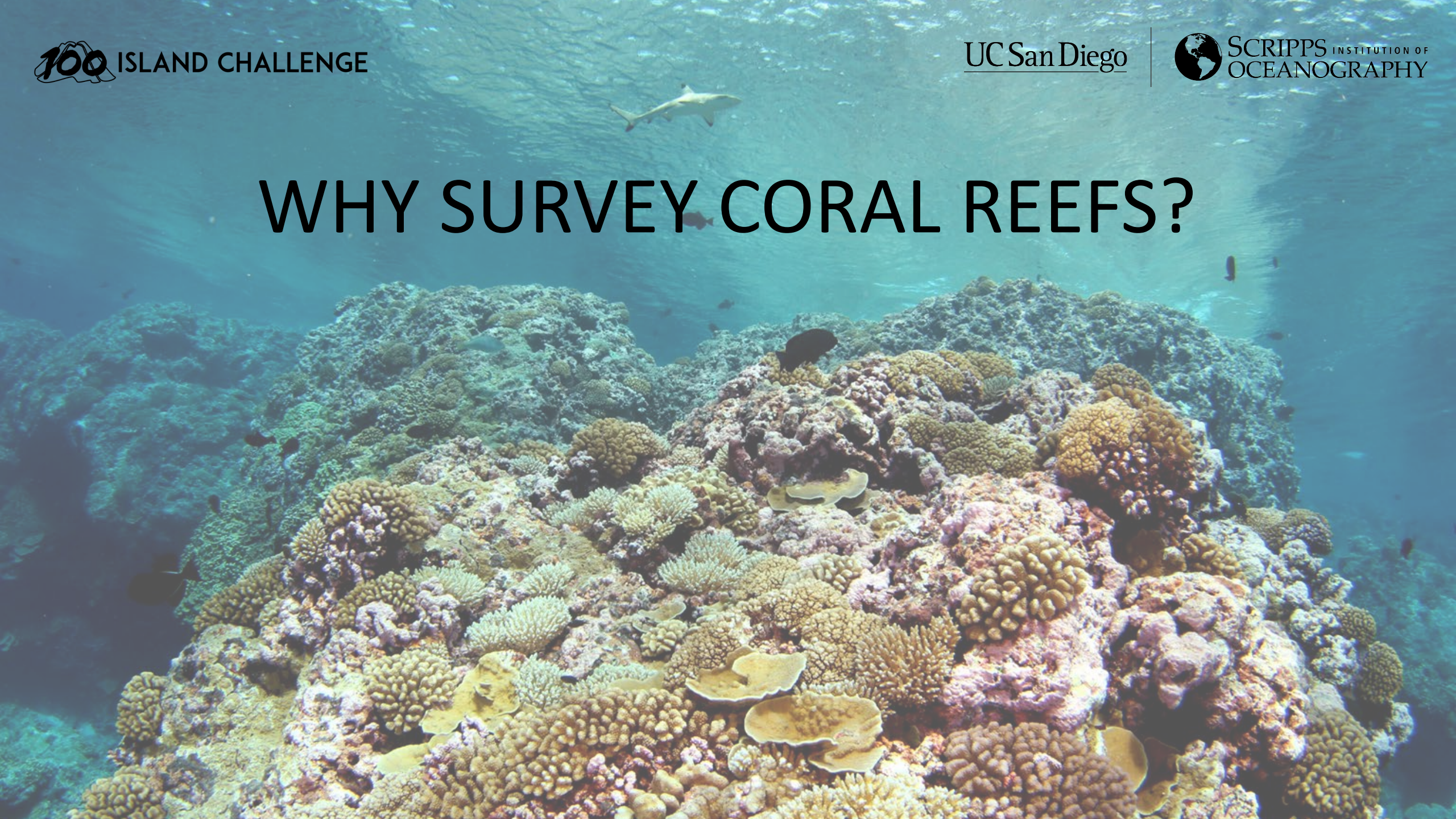
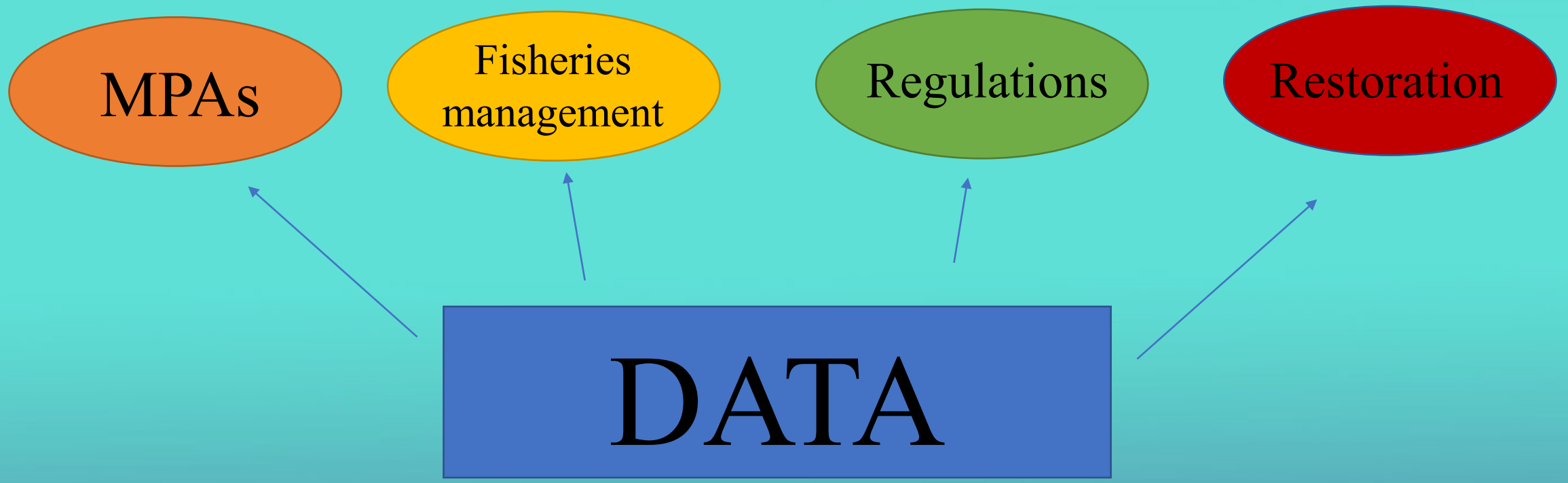
WHY SURVEY CORAL REEFS?



Management & Conservation



Variability over space

Surveying reefs in different locations allows us to compare reef health in sites with different conditions

- Human impacts (e.g., marine disasters)
- Pollution, runoff
- Coastal development
- Current, water motion
- Management regimes, protection status

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Variability over time

Surveying the same reefs over time allow us to understand how reefs change in response to various forces

- Hot water events (bleaching)
- Marine disasters
- Change in protection status
- Predator outbreaks
- Growth/recovery

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Define your survey motivation

What do you want to learn from your surveys?

What data products do you need to answer that question?

Survey motivation

Monitoring

- Change over time
- Not hypothesis-driven

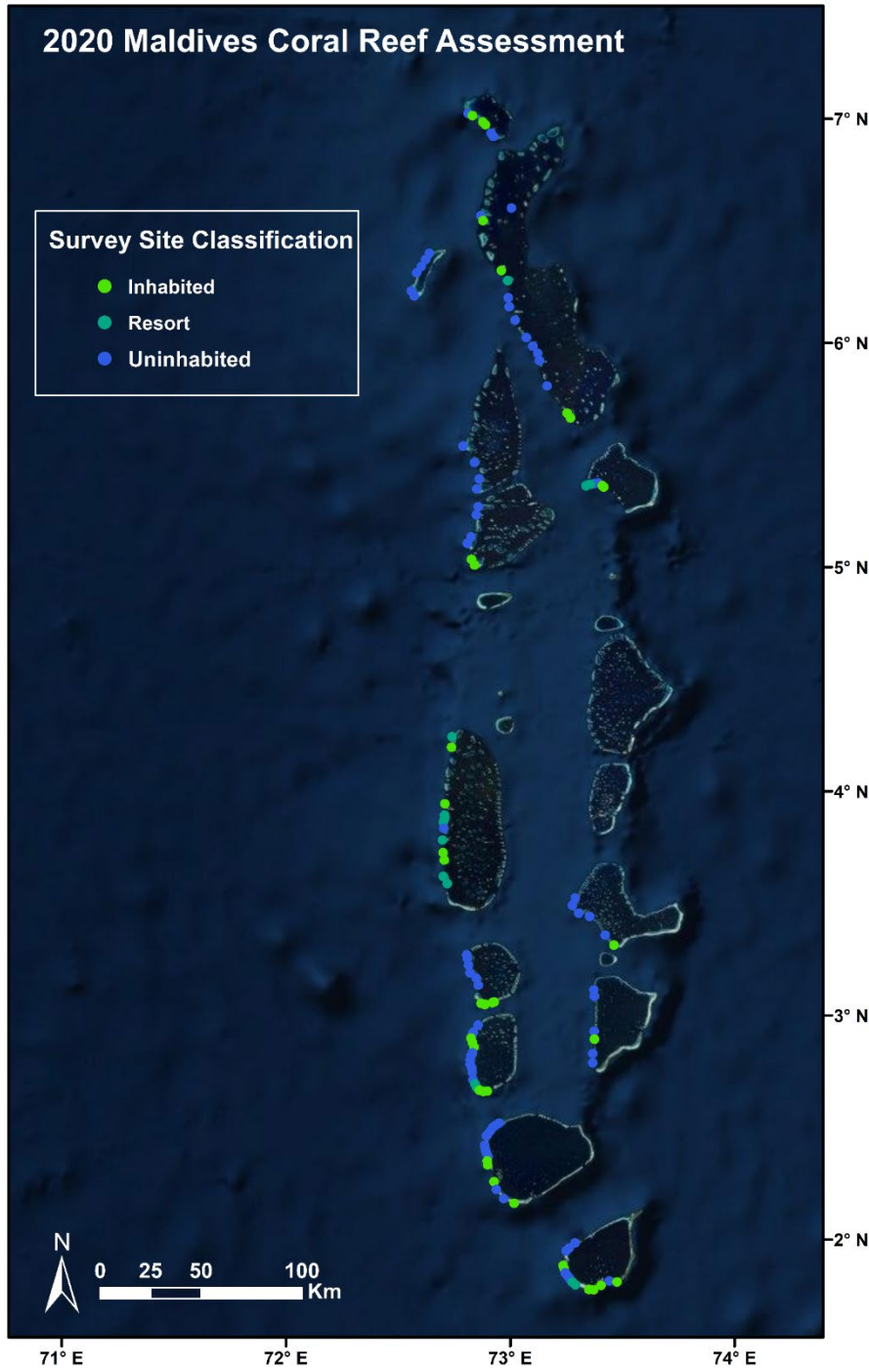
Research

- Questions should be:
  - Specific
  - Testable
  - Hypothesis-driven

100 ISLAND CHALLENGE

Choose the appropriate survey design

- Large-scale
- Small-scale
- Time series
- Before/after



Consider data type & resolution

Species → **Genus** → **Family** → **Functional Group**

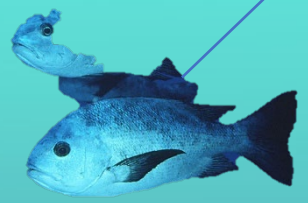
L. bohar

Lutjanus

Lutjanidae (Snappers)

Carnivores

L. kasmira



M. niger

C. amblyrhynchos

Variable of interest

Try to keep everything constant except for the variable you want to test

Example: What is the effect of island use type on benthic percent cover?

Keep constant	Vary
Depth	Island use type (resort, community, uninhabited)
Reef type (forereef, lagoon, patch reef)	
Exposure (windward, leeward)	

Successful surveys

- Data are representative of site
- Data collected to appropriate resolution
- Repeatable
- Clearly defined methodologies
- Not overly complicated
- Organized
- Only vary variable of interest
- Conducted safely
- Surveyors appropriately trained
- Data & metadata diligently collected, organized, & backed up

Unsuccessful surveys

- Disorganized
- Poorly defined or overly complex methodologies
- Data collected to wrong resolution
- Sites vary in too many ways
- Surveyors not properly trained
- Unsafe diving, snorkeling, or boating practices
- Data are disorganized and/or not backed up
- Metadata are poor or not collected

Coral Reef Surveys – Planning, Execution, and Analysis Syllabus

Student Learning Outcomes

By the end of this course, students will:

- Learn about motivation and common goals of marine resource assessment efforts
- Be able to undertake logistical and safety planning for marine field survey expeditions
- Gain skills to contribute to field operations of a marine resource assessment effort
- Be familiar with various marine field survey methods (e.g., NCRMF and 100 Island Challenge protocols), including fish belt transect surveys, benthic photoquadrats, and macroinvertebrate transect surveys
- Develop techniques in data management, including skills of recording and organizing expedition metadata and field-collected data
- Be prepared to continue training in intermediate to advanced skills of survey design and data analysis

Coral Survey Science II – Data Summaries and Reporting

Student Learning Outcomes

By the end of this course, students will:

- Understand basic statistical concepts, such as sample size, independent replicates, mean, and measures of variability (i.e. variance, standard deviation, standard error)
- Know the hallmarks of a good data summary
- Be aware of and understand how to calculate common data metrics for fish, benthic and macroinvertebrate reef surveys
- Gain practical experience in calculating common data metrics using real datasets
- Understand different types of graphs, their uses, and how to use them to effectively communicate results to different audiences
- Be exposed to advanced analysis methods for other types of reef survey data.

Techniques in large-area imaging for coral reef science and monitoring

Student Learning Outcomes

By the end of this course, students will:

- Understand LAI and SfM terminology, concepts, and applications
- Have the ability to plan and safely collect imagery for an LAI project
- Be comfortable with the basics of 3D model generation using Agisoft Metashape
- Gain knowledge in proper data management (imagery and models)
- Have experience with multiple platforms for viewing and sharing 3D models.

III. Goals of coastal monitoring

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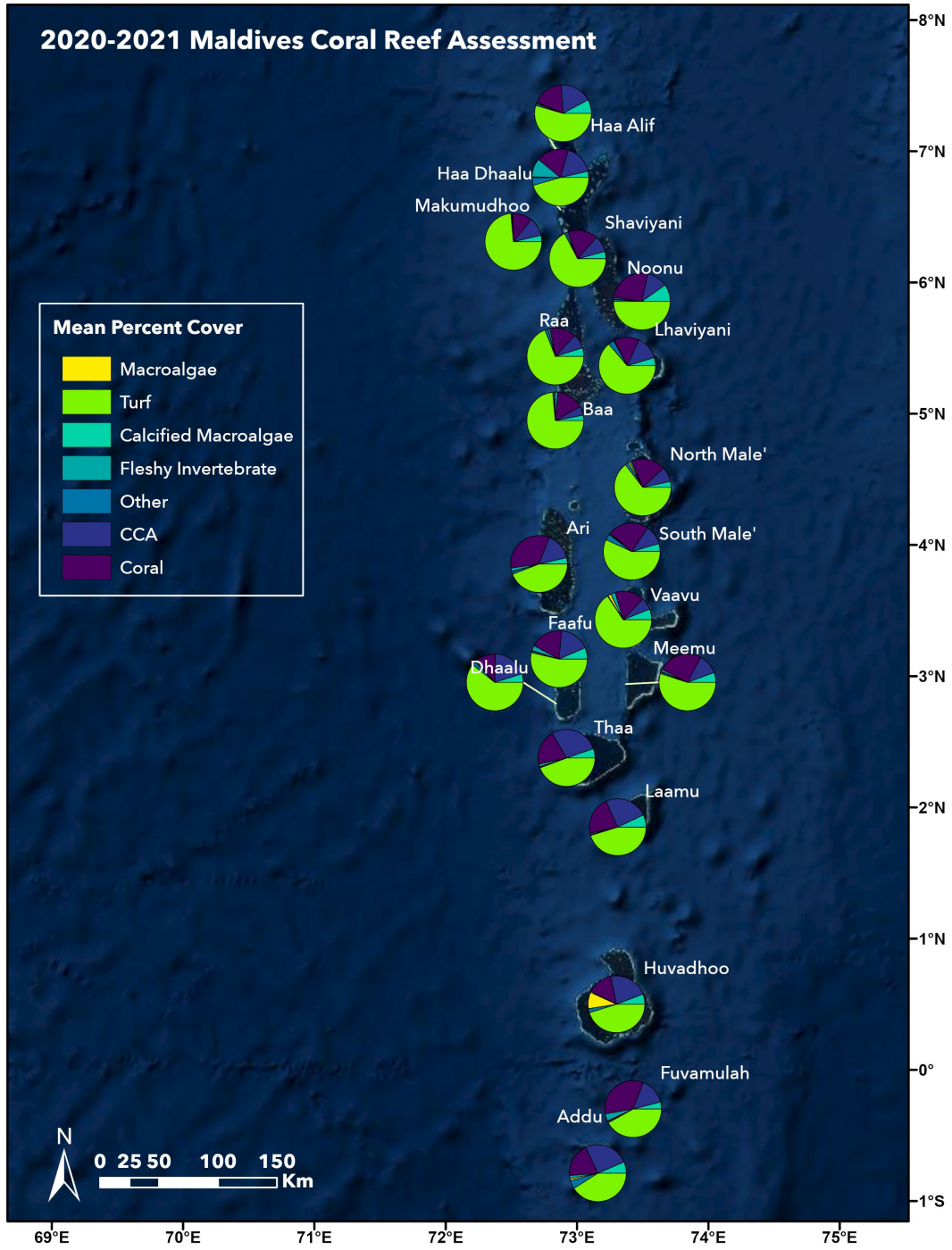
2020-2021 Maldives Coral Reef Assessment
Mean Percent Cover
Macroalgae
Turf
Calcified Macroalgae
Fleshy Invertebrate
Other
CCA
Coral
Haa Alif
Haa Dhaalu
Makumudhoo
Shaviyani
Noonu
Raa
Lhaviyani
Baa
North Male'
Ari
South Male'
Vaavu
Faafu
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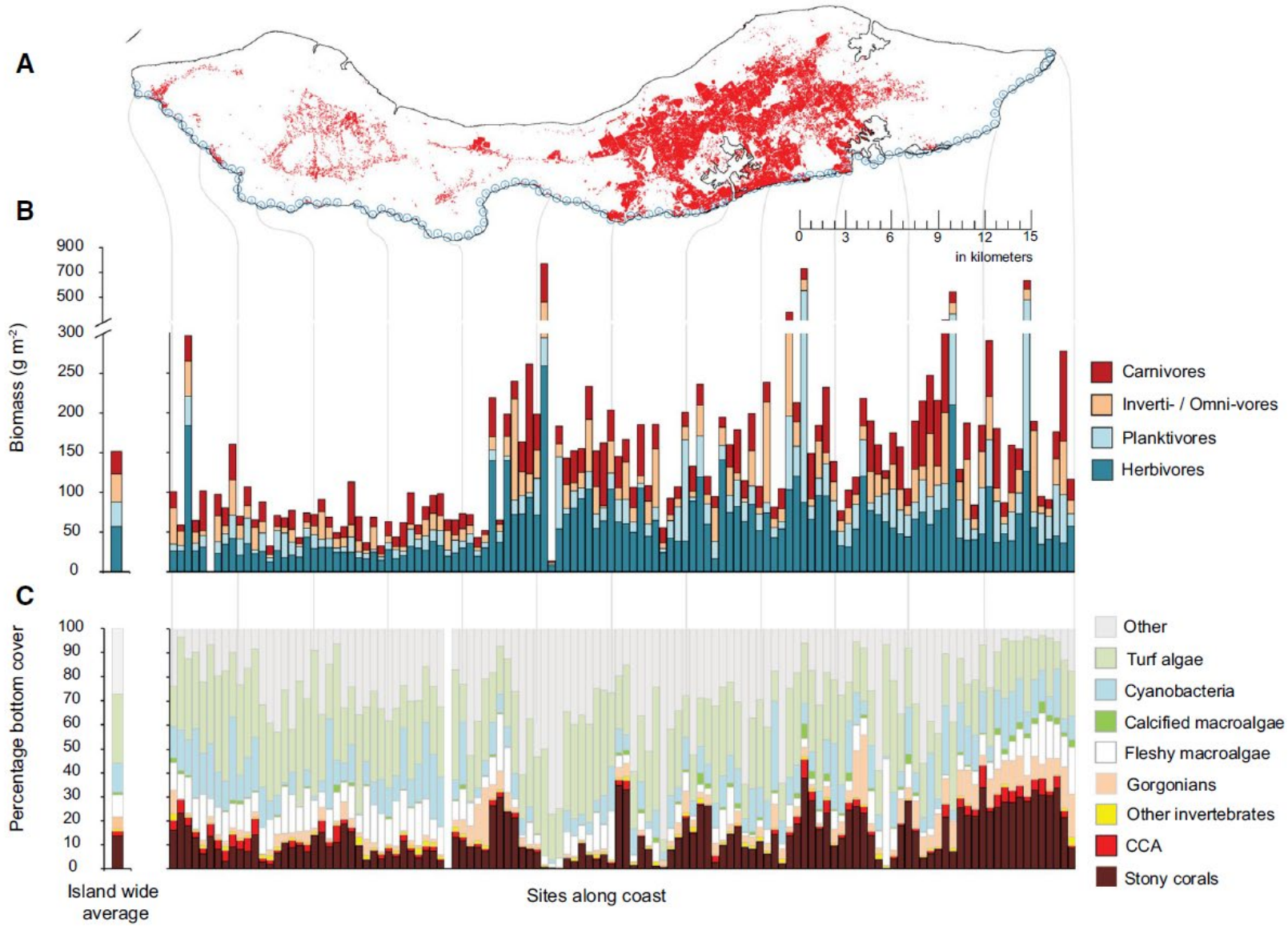
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Carnivores
Inverti- / Omni-vores
Planktivores
Herbivores
100
90
80
70
60
50
40
30
20
10
0
Percentage bottom cover
Other
Turf algae
Cyanobacteria
Calcified macroalgae
Fleshy macroalgae
Gorgonians
Other invertebrates
CCA
Stony corals
Island wide average
Sites along coast

The GCRMN – Caribbean biophysical methods describe six elements of the coral reef ecosystem:

1) *Abundance and biomass of key reef fish taxa,*
2) *Relative cover of reef-building organisms (corals, coralline algae) and their dominant competitors,*
3) *Assessment of coral health,*
4) *Recruitment of reef-building corals,*
5) *Abundance of key macroinvertebrate species, and*
6) *Water quality.*

These elements provide an overview of the current condition of the coral reef ecosystem as well as an indication of likely future trajectories. The GCRMN-Caribbean recognizes that by collecting information about these elements across multiple locations, with regular re-sampling through time, it will be possible to more knowingly describe the status of coral reef health in the Caribbean and to assess the effectiveness of local and regional management efforts.

United Nations Environment Programme (2016). GCRMN-Caribbean Guidelines For Coral Reef Biophysical Monitoring. https://wedocs.unep.org/20.500.11822/33574.

GCRMN
GLOBAL CORAL REEF MONITORING NETWORK

1) Abundance and biomass of key reef fish taxa

Core information to collect – The goal of data collection for the fish taxa is to characterize the key species of economic and ecological importance. In total, **the core data to collect are the density and size structure of all species of snappers (Lutjanidae), groupers (Serranidae), parrotfish (Labridae – Scarinae), and surgeonfish (Acanthuridae)**. Additionally, it is recommended to record the presence of sensitive species (e.g., sharks, rays) or important invasive species (e.g., lionfish).

Beyond the core information, it is highly recommended to provide estimates of the density and size structure of all fish species within the survey area. Such high resolution estimations of the fish assemblage provide the core information, while also providing fundamental information about other members of the fish assemblage that may serve important roles in fisheries or ecosystem maintenance (e.g., damselfish) that will be further considered or discovered in the years to come.

GCRMN
GLOBAL CORAL REEF MONITORING NETWORK

2) Relative cover of reef-building organisms (corals, coralline algae) and their dominant competitors

Core information to collect – The goal of data collection for the assessment of benthic environment (i.e., corals, algae) is to document the relative cover of reef-building, stony corals and their dominant competitors. As such, **the core data to collect is the percent of the reef bottom that is covered by stony corals, gorgonians, sponges, and various types of algae (turf algae, macroalgae, and crustose coralline algae)**. The stony corals and some of the calcifying algae are the dominant taxa that build the coral reef structure, while the turf, some macroalgae and benthic invertebrates can compete with reef-builders and thereby limit growth of the reef structure.

GCRMN
GLOBAL CORAL REEF MONITORING NETWORK

3) Assessment of coral health

Core information to collect – The goal of data collection for assessing coral health is to document **the prevalence of disease (not including bleaching) in stony corals**. Disease prevalence is a metric describing the proportion of coral colonies that exhibit signs or pathologies of any disease. Because of the challenges associated with defining the boundaries of individual coral colonies in photographs, the GCRMN core information reports coral disease as the proportion of replicated benthic areas (e.g., photoquadrats) that have diseased corals. Note that while this simplified method does not capture many elements of coral disease ecology, like species- or size-specificity of disease incidence, this is a useful approach for collecting standardized and inter-comparable data describing coral health.

GCRMN
GLOBAL CORAL REEF MONITORING NETWORK

4) Recruitment of reef-building corals

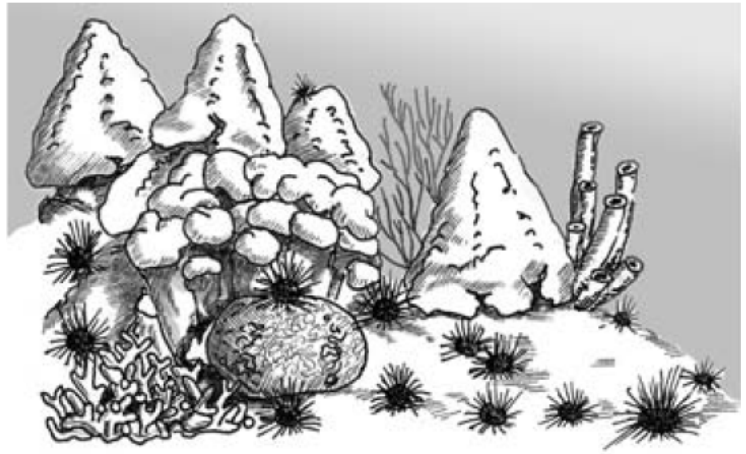
Core information to collect – The goal of data collection for coral recruitment is to estimate **the density of young corals that are likely to contribute to the next generation of adult corals** on the reef. Documenting the early life stages of corals is notoriously challenging, given that many of the smallest coral settlers (e.g., those that recently settled to the reef substrate) are very small and are found in cryptic habitats, such as in cracks or on the hidden surfaces of rocks. As such, this protocol employs an operational definition of coral recruits as those smallest individuals (0.5-4.0 cm diameter) that are visible to a diver in situ.

NOTE: In addition to the coral recruitment data, the observer should take a measurement to the nearest cm for the visually averaged macroalgal height within the quadrat; and to the nearest mm for the visually averaged turf algal height within each quadrant. These can be measured quickly with a small plastic ruler.

GCRMN
GLOBAL CORAL REEF MONITORING NETWORK

5) Abundance of key macroinvertebrate species

Core information to collect – The goal of data collection for key macro-invertebrate species is to provide an estimate of the density of biologically and economically important species on the reef. There are two principal groups of macro-invertebrates that are targets for data collection, the sea urchins and the sea cucumbers. **The core data to collect are the densities of the long-spined sea urchin (Diadema antillarum), other sea urchins, and all sea cucumbers**.



GCRMN
GLOBAL CORAL REEF MONITORING NETWORK

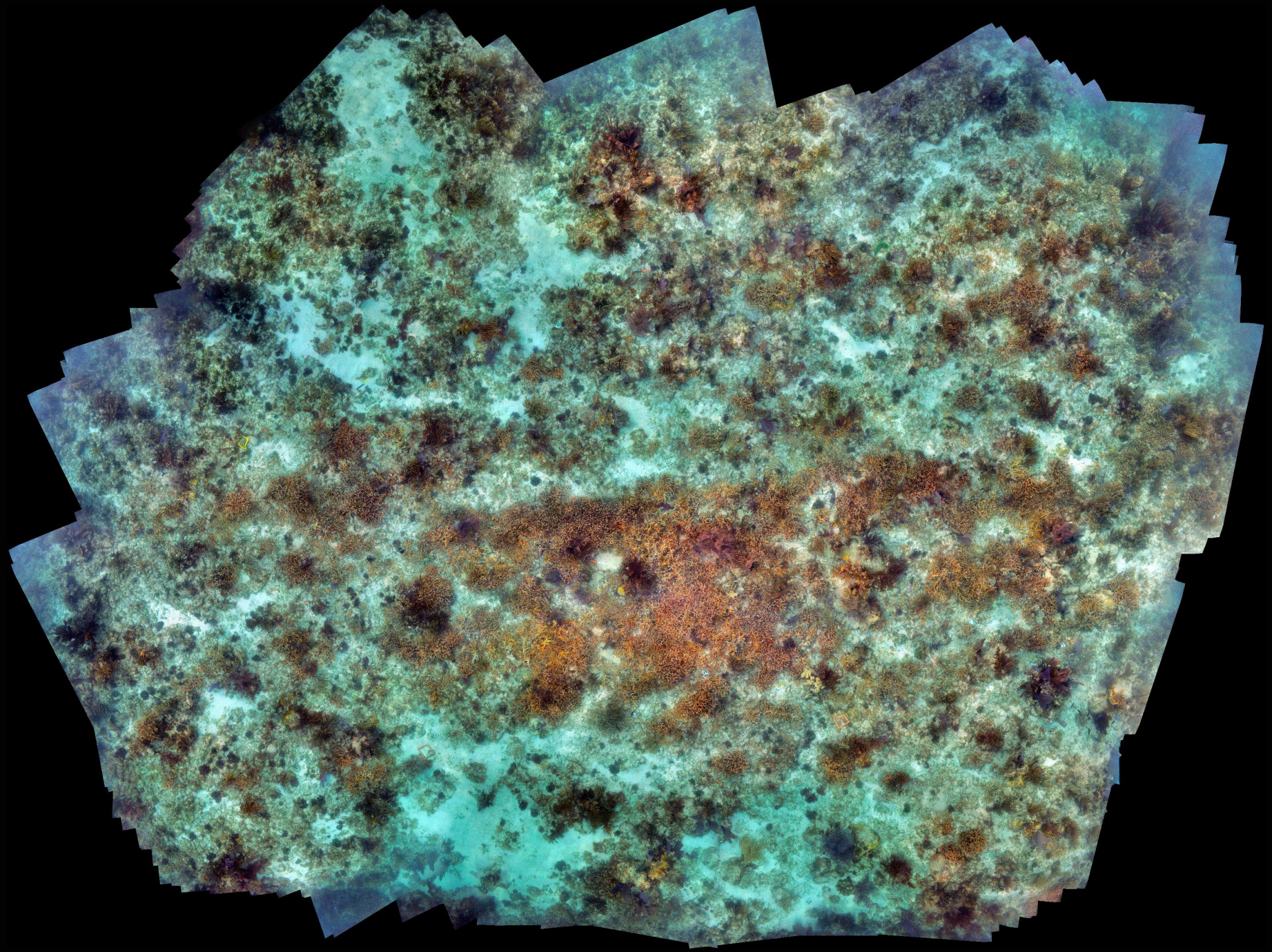
6) Water quality

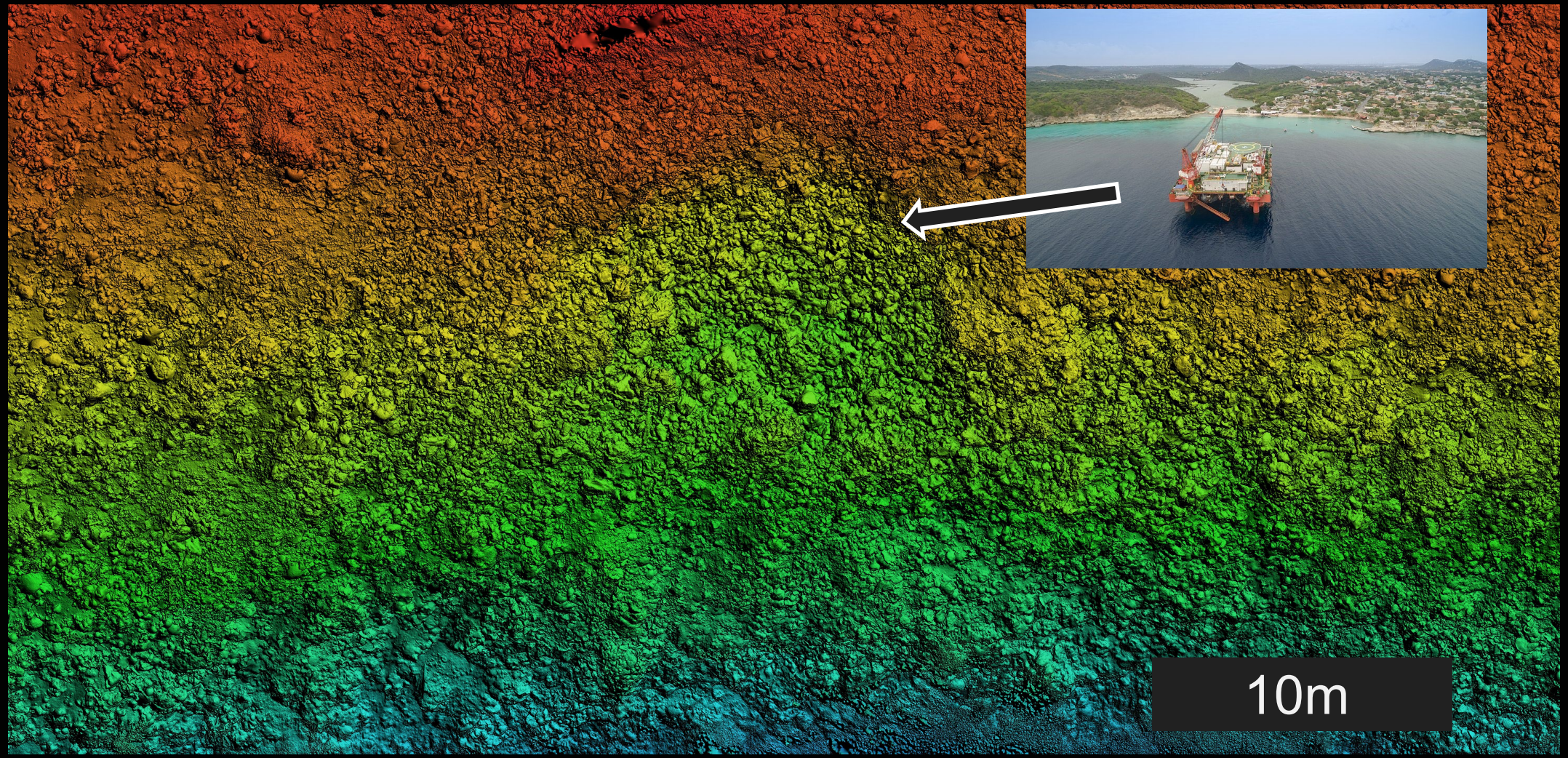
Core information to collect – The goal of data collection for water quality is to provide an estimate of the concentration of particulates in the water column. Water quality is influenced by many factors, ranging from oceanographic delivery of nutrients, algal growth in the water column, terrestrial contribution (e.g., mud and silt), and anthropogenic inputs. As an estimate of the integrated water quality, **the core data to collect are the depths at which standardized Secchi disks are visible in the surface waters of the reef**. Use of Secchi disks is a standardized and common metric that captures the basic elements of water quality and has a long history of application.

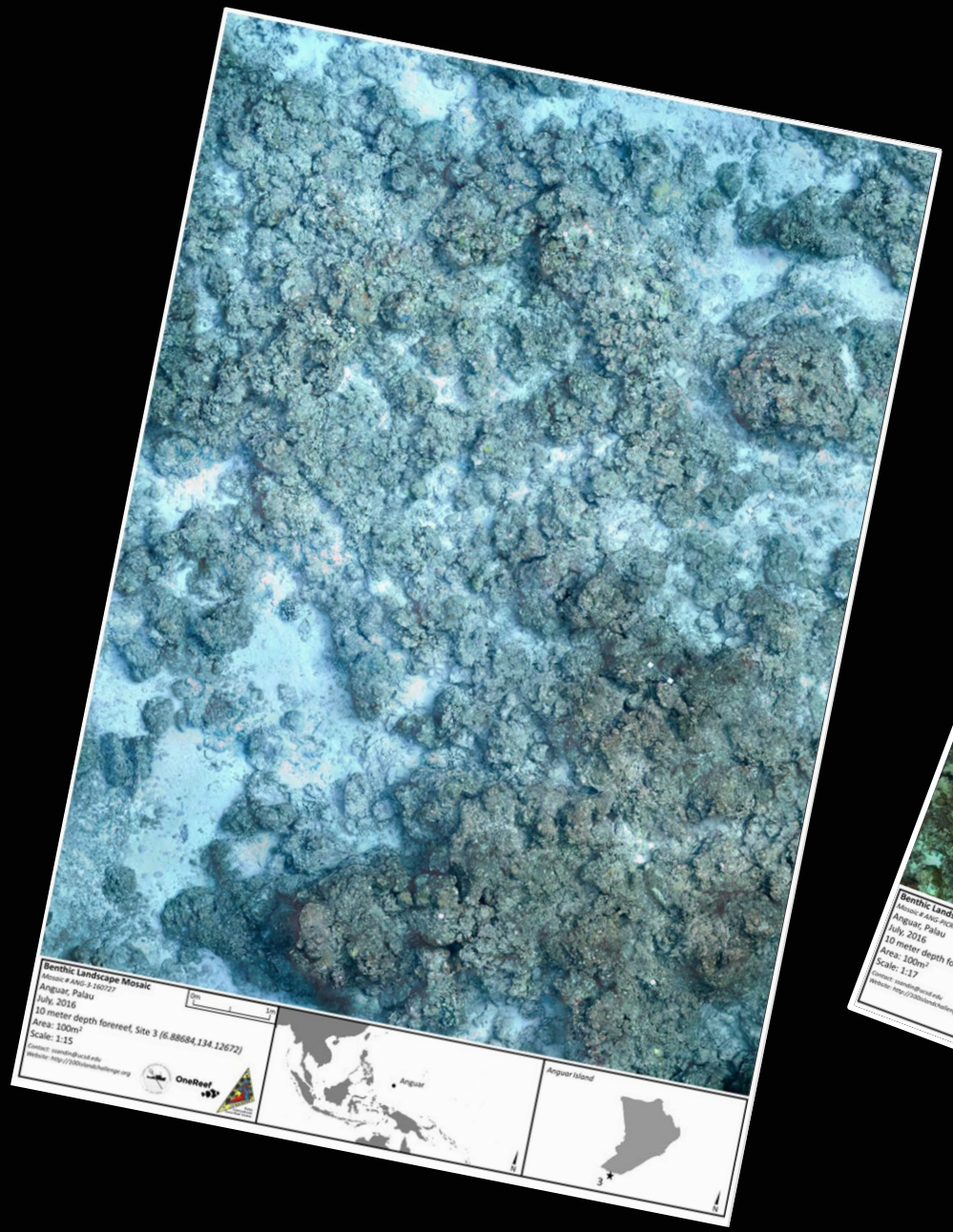
IV. Technology

SCRIPPS INSTITUTION OF OCEANOGRAPHY

UC San Diego

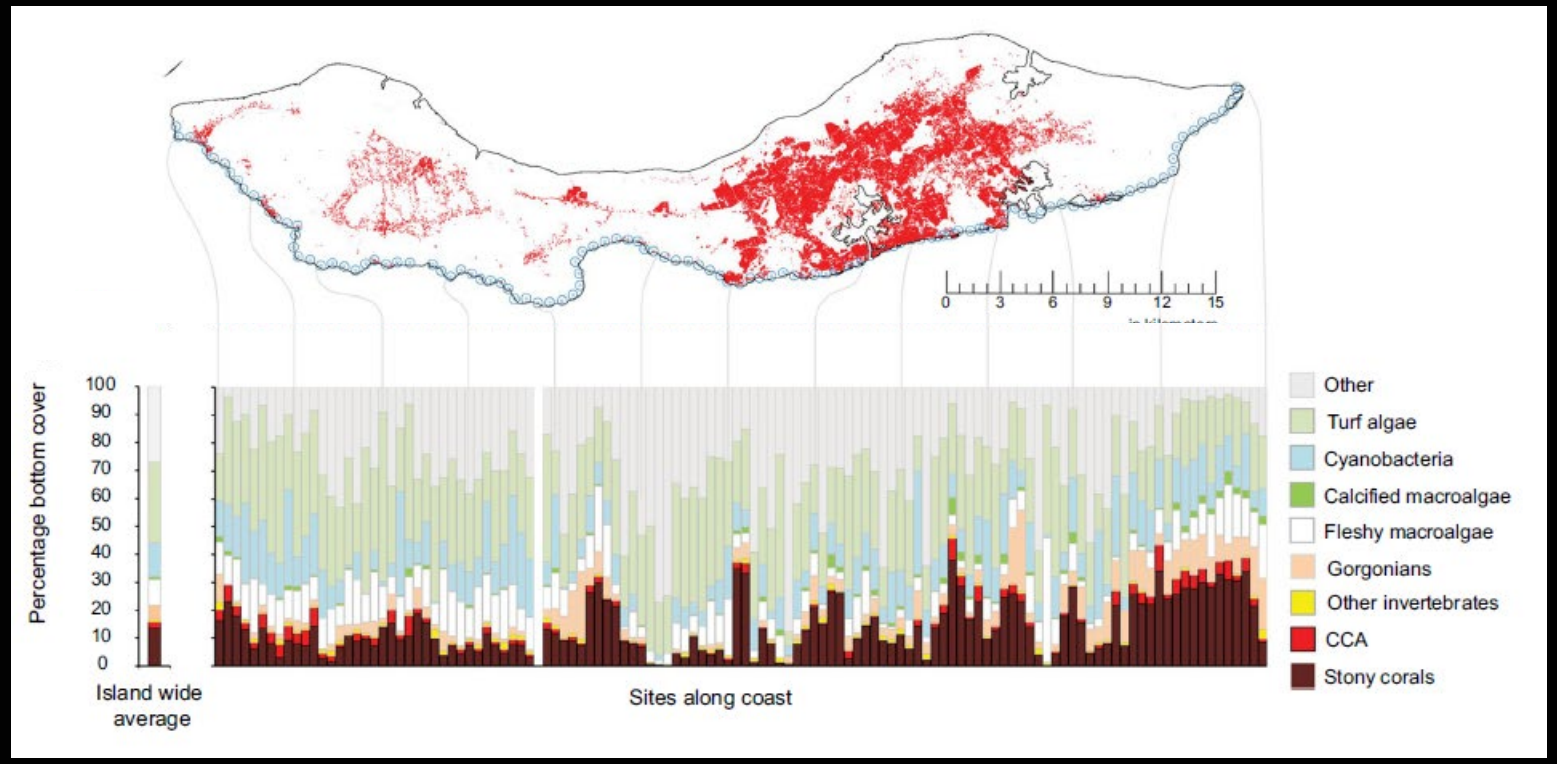



10m


Benthic Landscape Mosaic
Mosaic # ANG-9-160727
Anguar, Palau
July, 2016
10 meter depth forereef, Site 3 (6.88684,134.12672)
Area: 100m²
Scale: 1:15
OneReef
Anguar
Anguar Island
3

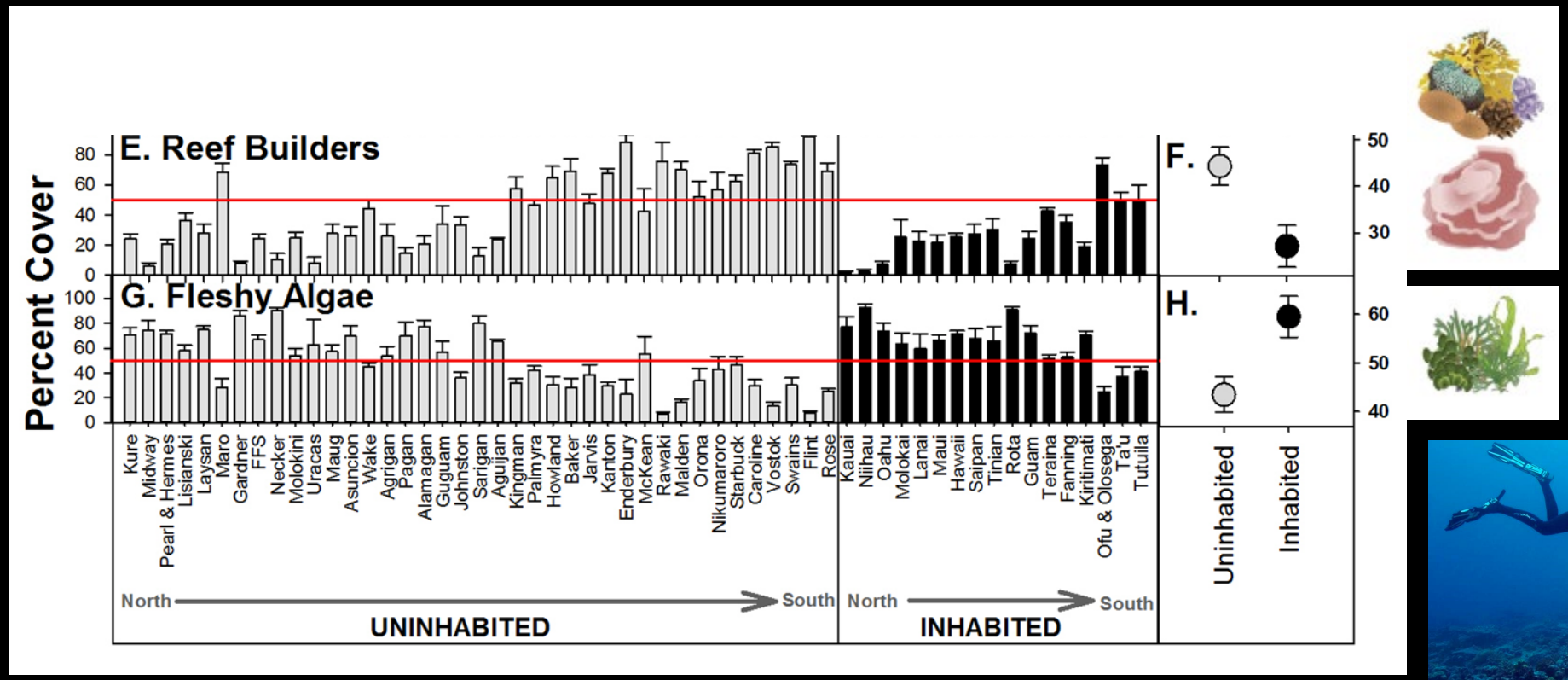

Benthic Landscape Mosaic
Anguar, Palau
July, 2016
10 meter depth forereef, Site PICRC (6.89809,134.12242)
Area: 100m²
Scale: 1:17
OneReef
Anguar
Anguar Island
PICRC

OFFICE OF THE GOVERNOR
OFFICIAL SEAL
MCMLXXIII
STATE OF PELELIU

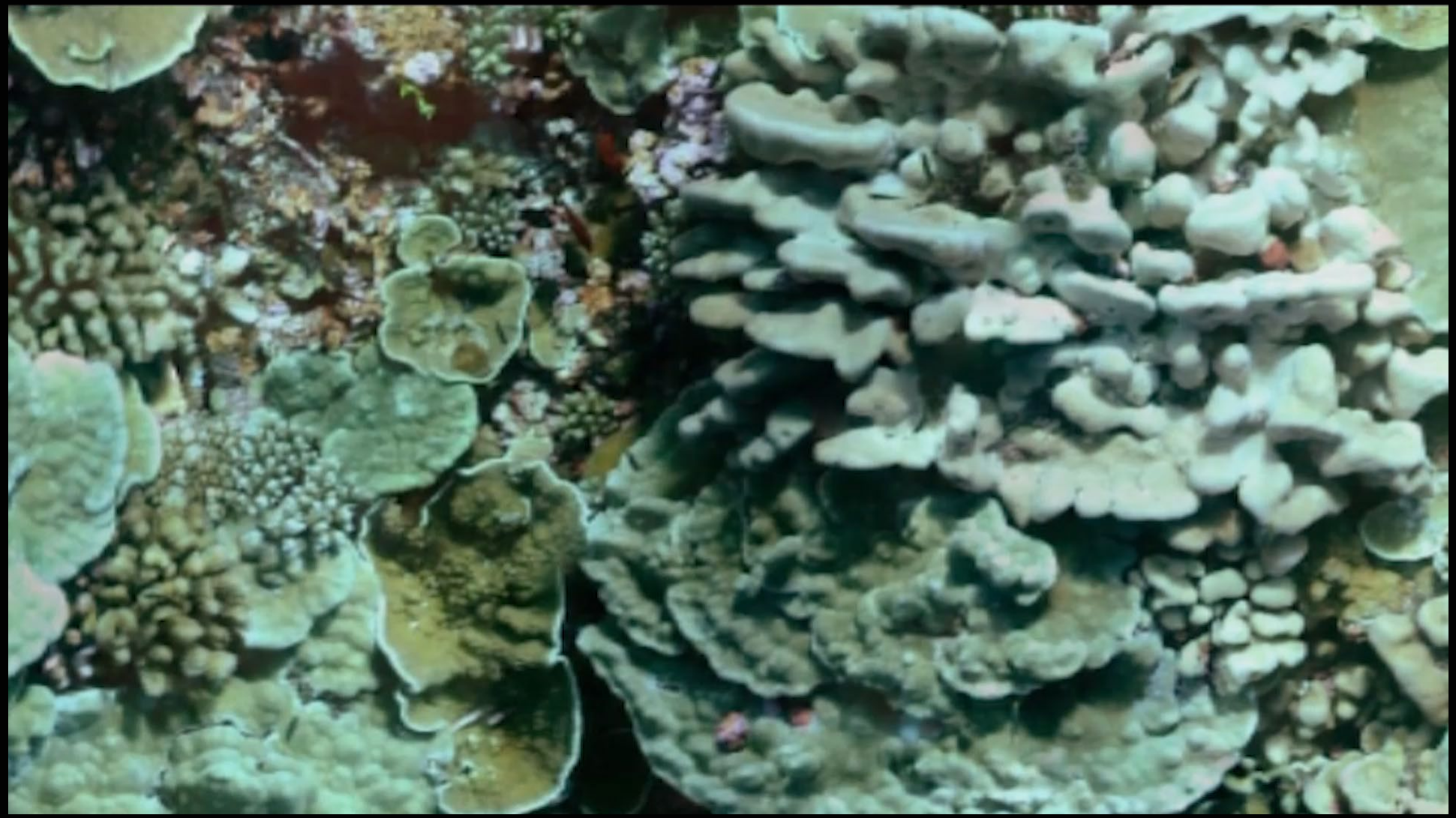


(Sandin et al. 2022 *Coral Reefs*)

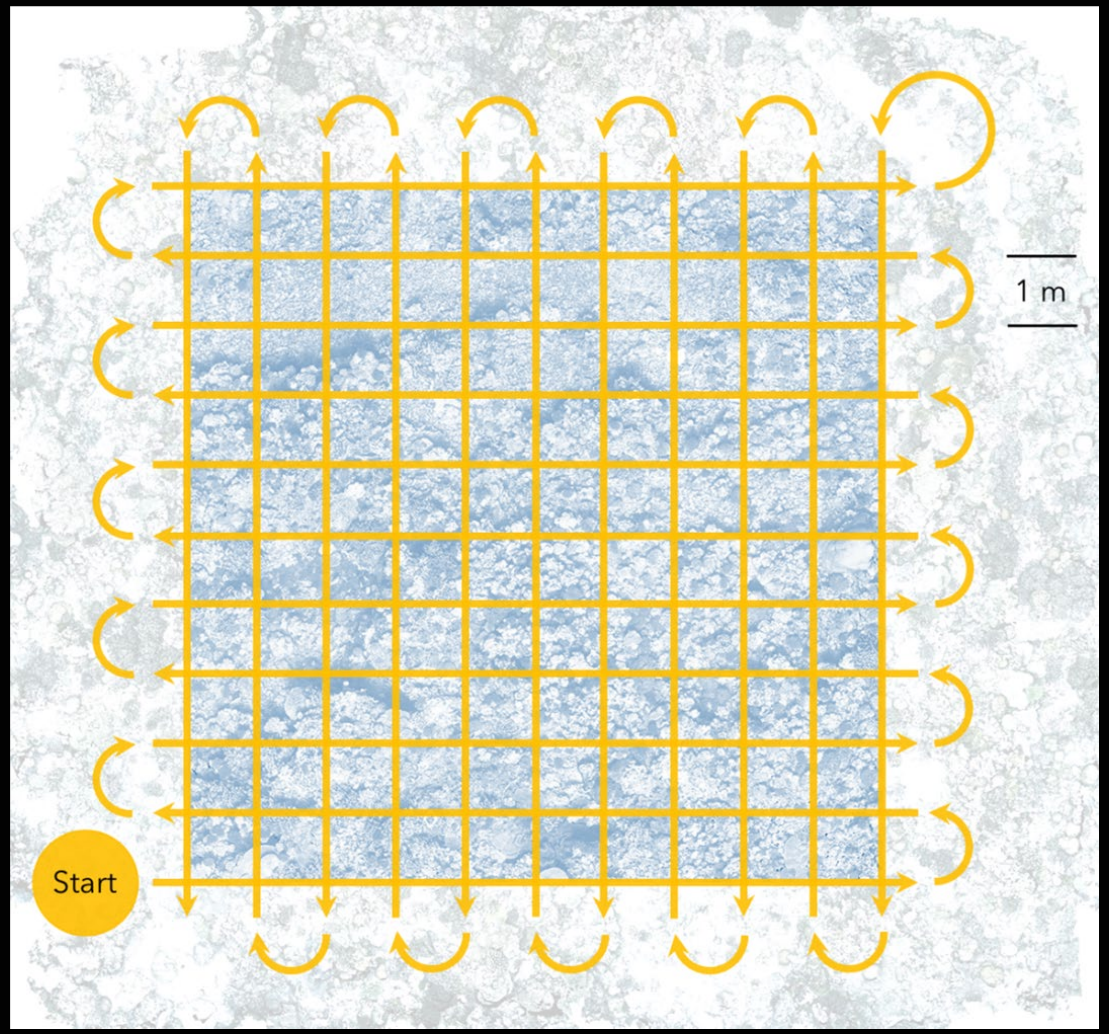
Regional surveys – benthic assemblages

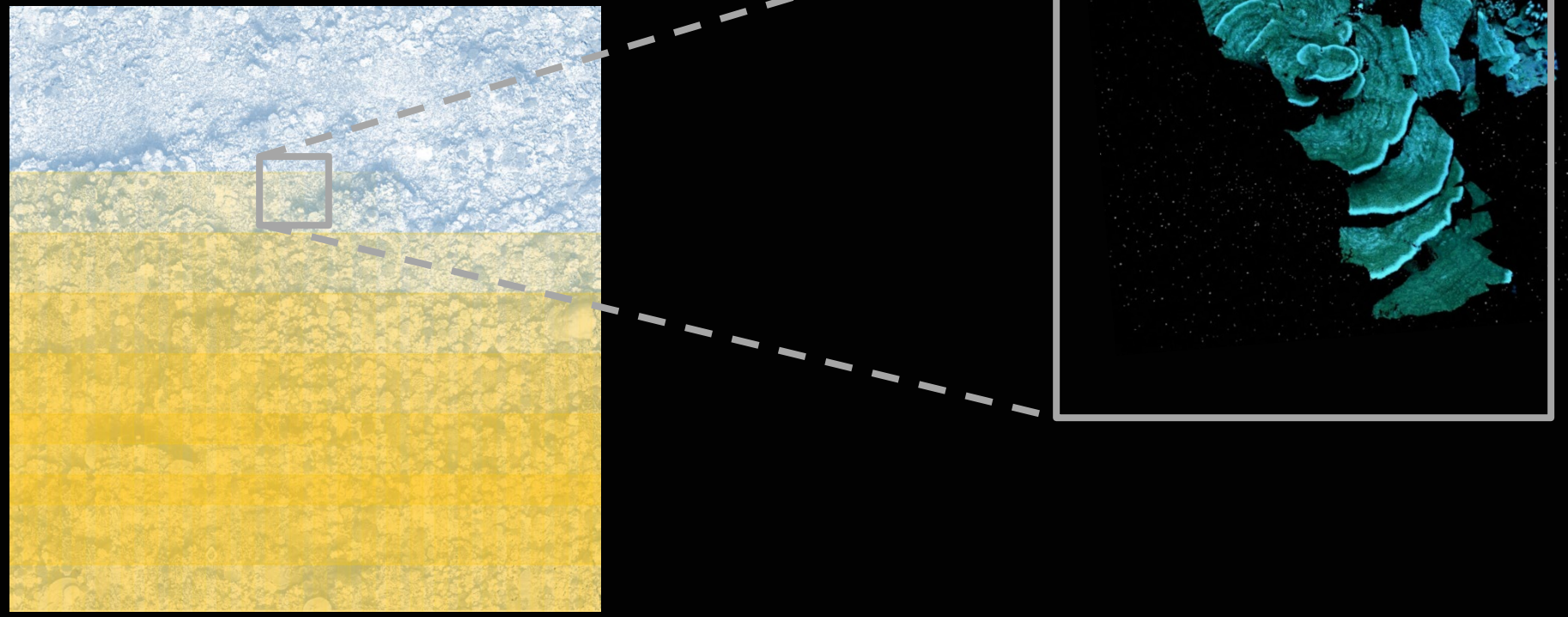


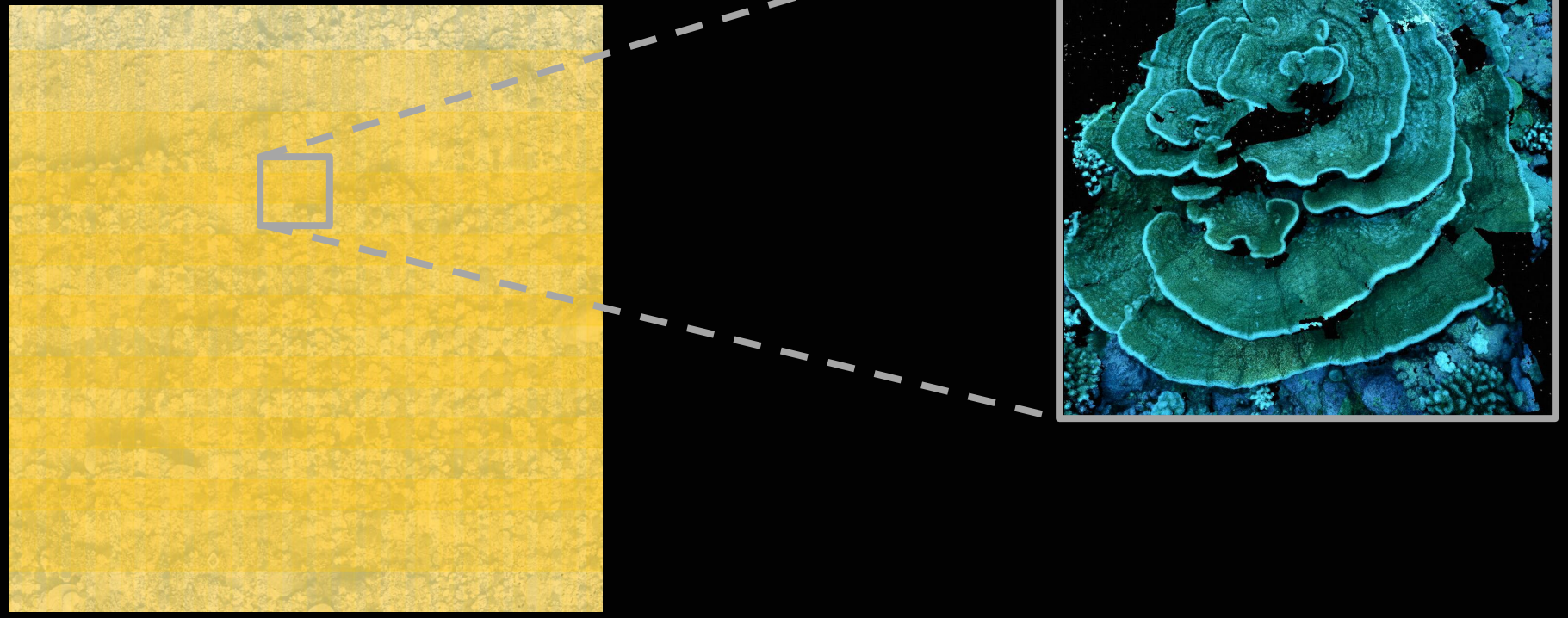
(Smith et al. 2016, *Proc Roy Soc B*)

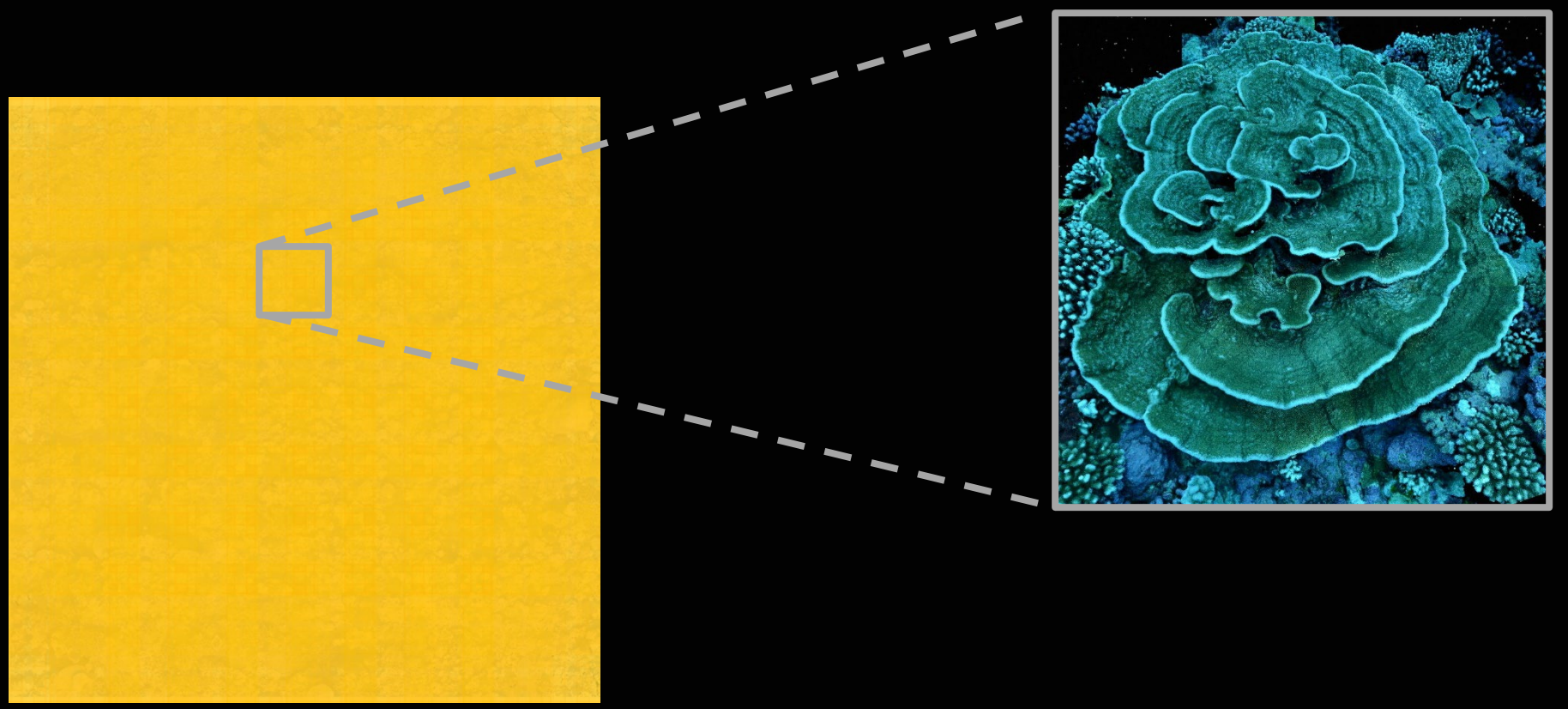



FLEET
OFFICE

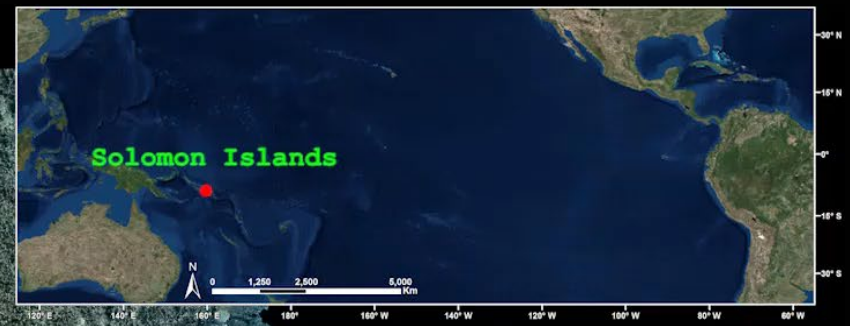

1 m
Start







100 ISLAND CHALLENGE



Environmental imaging pipeline

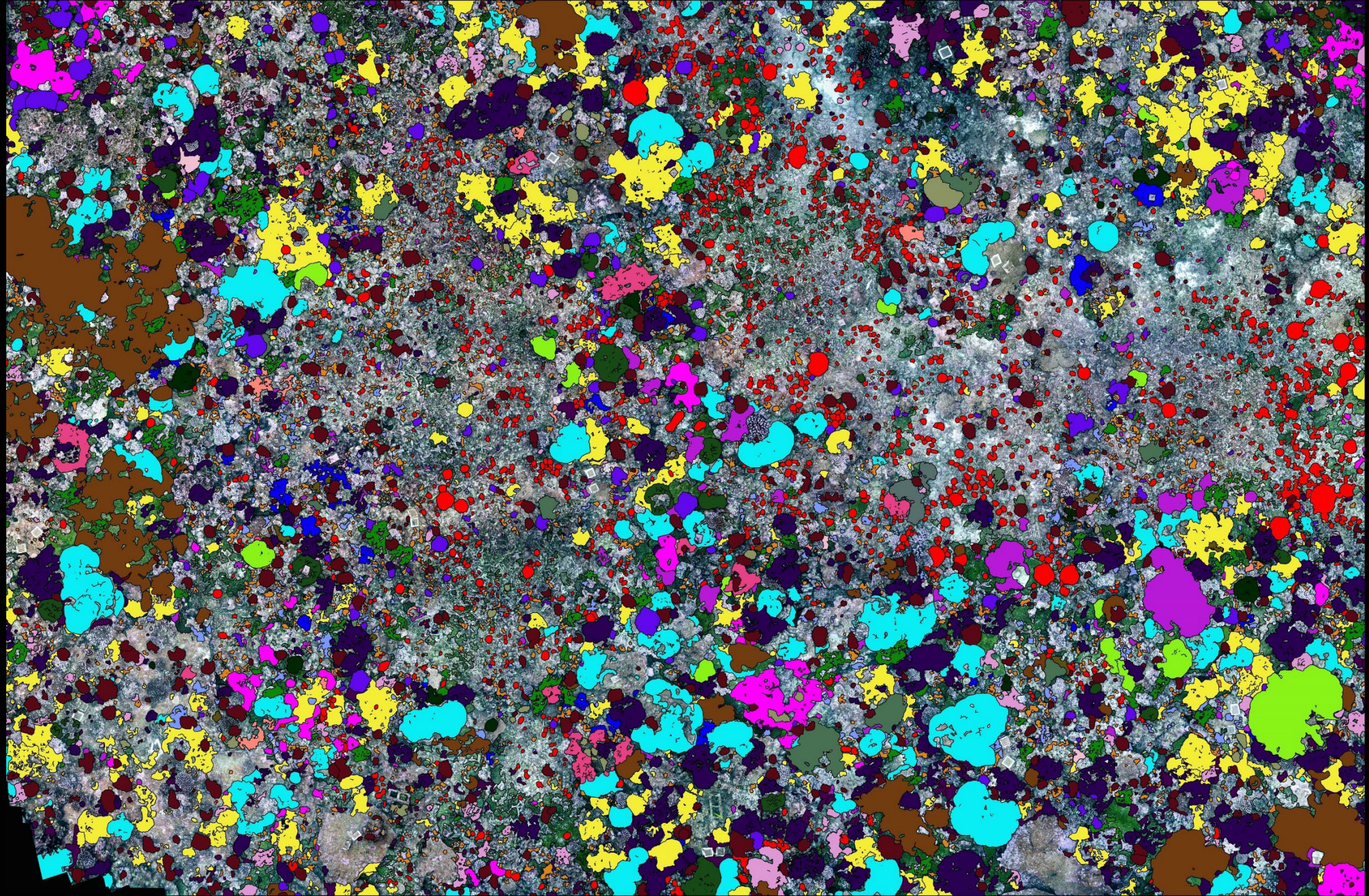
1) Image acquisition
2) Model construction (2D, 3D, or 4D)
3) Data extraction and visual analytics
4) Data curation and access


Palmyra, 2013
FR40
100
ISLAND
CHALLENGE


1 m


1 m


1 m




Palmyra
FR38
2013
2014
2015
2016
2017
100
ISLAND
CHALLENGE

Using Drones to Develop Regional Correction Factors for Mangrove Extent

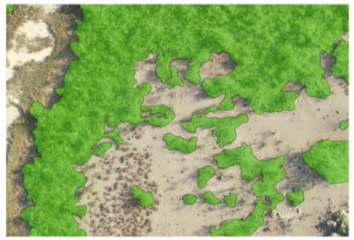
Collect Imagery

Satellites

+

Drones

Process Data



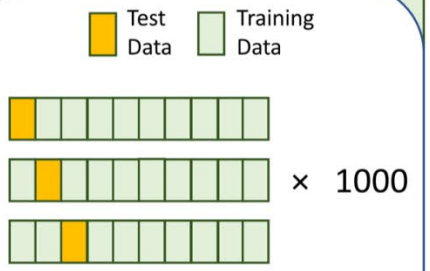
Mangrove Labeling

Convolution Analysis

Create Output

Drone-based Correction Factors for Satellite Extent

Validate Results



K-fold Cross-Validation
Accuracy = 98.3%±2.1%