BURT MARINE BIOLOGY LAB

جامعة نيويورك أبوظبي
NYU ABU DHABI

مركز مبادلة لعلوم مناخ وبيئة الخليج العربي
MUBADALA ACCESS CENTER

# Regional Coral Reef Monitoring Program

ROPME Sea Area

2024

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# Introduction

The **Regional Coral Reef Monitoring Program** aims to standardize and enhance coral reef monitoring across the ROPME Sea Area. Given the ecological importance of coral reefs and the increasing threats from climate change and human activities, consistent monitoring is essential for informed conservation actions.

This program brings together regional stakeholders to collect scientifically robust data, enabling long-term assessments of reef health. By implementing standardized protocols, we enable meaningful comparisons at both regional and global scales, offering critical insights to support the effective management and protection of these invaluable ecosystems.

Contributors who sign the **Data Sharing Agreement (DSA)** can choose to have their data published in summary format for the **GCRMN Status of Coral Reefs of the World: 2025** report, in a detailed format for the **Regional Data Paper**, or both, ensuring proper attribution and recognition.

# Program Objectives and Scope

The Regional Coral Reef Monitoring Program employs scientifically rigorous and standardized protocols to achieve the following key objectives:

1. **Assess the Current Status of Coral Reef Communities** Through the collection of comprehensive ecological data, this program aims to evaluate the health and composition of coral reef ecosystems within the region, providing a snapshot of current reef conditions.
2. **Monitor Temporal and Spatial Changes in Reef Communities** The program is designed to track changes in coral reef communities over time, identifying shifts in biodiversity, habitat complexity, and species composition. This includes detecting the impacts of natural and anthropogenic disturbances, such as bleaching events.
3. **Evaluate the Impact of Management Interventions** Monitoring efforts will assess the efficacy of various management actions aimed at conserving coral reef ecosystems.

The program's biological scope includes the following components:

1. **Benthic Communities**: Detailed analysis of the taxonomic composition, growth morphology, condition, and percent cover of benthic organisms, with a primary focus on Scleractinian corals (hard corals) as indicators of reef health.
2. **Habitat Complexity**: Measurement of the structural complexity of coral reef habitats, which serves as a critical factor influencing biodiversity, species interactions, and ecosystem resilience.

The geographical scope of this monitoring program encompasses the coral reefs within the **ROPME Sea Area**, involving the following member states: United Arab Emirates (UAE), Qatar, Saudi Arabia, Bahrain, Oman, Kuwait, Iran, and Iraq (Note: No current stakeholders from Iraq were represented at the 2024 workshop)

By focusing on coral reef ecosystems across these countries, the program facilitates a regional approach to understanding reef dynamics and fostering collaborative conservation efforts.

# Protocol overview

This protocol outlines the entire workflow for conducting coral reef monitoring, from pre-survey preparation to data submission. **Data can be submitted to us at any point after the photos are taken (Step 2).** Our team is here to support you at every stage, whether it's providing guidance on survey procedures or assisting with post-survey tasks such as data cleaning, annotation, or storage. The process includes the following key steps:

**1**

### PRE-SURVEY *Preparation*

Before conducting field surveys, dive teams should review the survey objectives, prepare equipment, and ensure that all necessary forms (e.g., **Site and Survey form**) and equipment are ready. Teams should also complete a **reconnaissance dive** to assess site suitability, if necessary.

**2**

### SURVEY

During the dive, surveyors will lay transects and collect data on **benthic cover** and **habitat complexity** using photoquadrat sampling and visual assessment methods. Data will be recorded following the outlined protocol.

**3.1**

### POST-SURVEY *Data Cleaning*

After the dive, photos should be organized, renamed, and backed up according to the file structure protocol. Ensure that no photos are blurry, and that all images are properly **renamed** before beginning analysis.

**3.2**

### POST-SURVEY *Annotations*

Photoquadrat images will later be analyzed for benthic composition. This can be done using automated tools like **ReefCloud** or **CoralNet.** These annotations will help quantify benthic cover and condition.

**3.3**

### POST-SURVEY *Data Storage*

Data should be stored in **MERMAID**, where each project has dedicated folders.

**Info**

If you need assistance at any stage—whether it's with survey procedures, data cleaning, annotation, or storage—you can reach out for help . For more information on how we can assist you, please refer to the "Next Steps" section.

# Methodology

The following chapter outlines the detailed methodologies used in the Regional Coral Reef Monitoring Program. These standardized procedures ensure consistency across all surveys, from pre-dive preparations to data collection and post-survey analysis. By adhering to these protocols, collaborators can collect high-quality data on benthic composition and habitat complexity, enabling accurate comparisons across sites and contributing to regional and global coral reef assessments.

## 1. Pre-survey Preparation

Conduct a reconnaissance dive at all survey sites as part of a pilot study if necessary. Record a site video to gather essential information on site layout and suitability.

During the reconnaissance dive, surveyors should take note of any significant features, such as coral bommies or reef ridges, that could influence transect positioning. Transect lines should follow the natural contours of the reef as much as possible, while maintaining adherence to the protocol.

**Note**
Surveyors should familiarize themselves with the site layout and determine transect placements beforehand. This can be achieved by taking a compass bearing from the site's GPS point or using site features (such as the coastline).

### 1.1 Metadata Recording

Prior to each dive, surveyors are required to complete as much as possible of the 'Site and Survey' forms that record key information such as date, time, GPS location, participants, and environmental observations. **The remaining information (e.g., depth, bearing) will be added after the survey is completed.** Metadata collection is critical for ensuring the accuracy and contextualization of the survey data, and for later input into MERMAID. For each survey, details of transect layout, equipment used, and any deviations from the protocol should also be recorded to ensure transparency and reproducibility.

**Annex**
See Annex 1 for complete Site and Survey form

## 2. Surveys

While fish surveys are an important aspect of coral reef monitoring, this document focuses exclusively on the protocols for collecting and analyzing data related to benthic cover and habitat complexity, both of which are essential for understanding coral reef ecosystems.

**Equipment Check**

- Quadrat frame: 50cm x 50cm
- Camera: GoPro Hero (version 9 to 12 / 20MP+), set to “wide view”
- Transect Tape: 30m x 6
- Habitat Complexity Benthic Survey Sheet
- Pencils: At least 2
- Compass
- GPS
- SCUBA Equipment

**Annex**

- See Annex 2 for a complete guide on How to Build a Frame
- See link for a downloadable 3D GoPro survey cradle
- See Annex 3 for Habitat Complexity Benthic Survey Sheet

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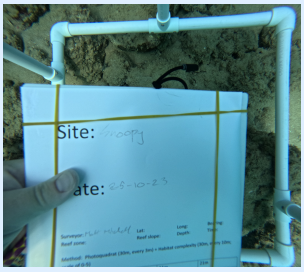
## 2.1 Benthic Survey

At each site, six 30-meter transects will be laid out in a haphazard manner. Ideally, transects should be placed parallel to one another, ensuring that they are positioned at a consistent depth and within the same reef zone. To minimize sampling overlap and disturbance, a minimum distance of 5 meters should be maintained between adjacent transects.

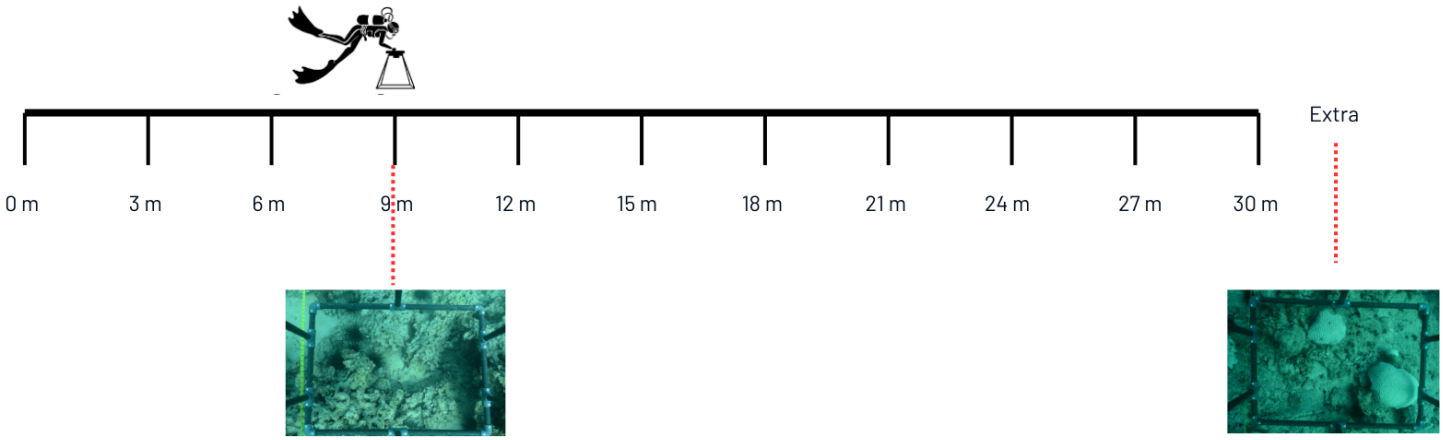
**Photo**

Before beginning the survey, take a picture of the habitat complexity benthic survey sheet with the site and date information clearly visible.



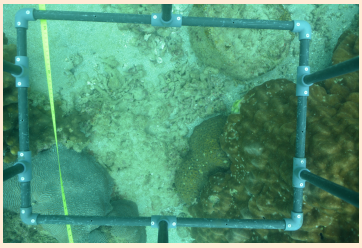

The benthic surveyor will be responsible for collecting data on the coral-associated benthic communities using **photoquadrat sampling.** This involves the use of a 50cm x 50cm quadrat frame placed at regular intervals along each transect. The bottom left corner of the quadrat frame should be aligned with the meter marks on the transect tape, ensuring consistency in the placement of the quadrants.

The first photo should be taken at the 0-meter mark, with subsequent photos captured every 3 meters along the transect line, including the 30 meters mark (e.g., at 0m, 3m, 6m, 9m, etc.). At the end of each transect, an additional “extra” photo will be taken to ensure sufficient coverage, resulting in 12 images per transect.




**Attention**

Ensure the transect line is NOT in the photo,

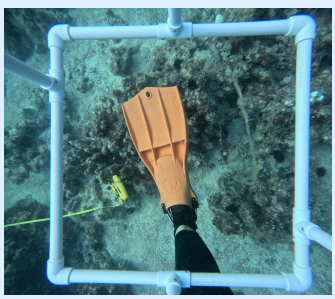


but on the left side of the frame like this:

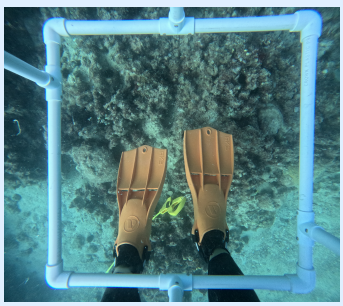
These images will later be analyzed to assess percent cover and composition of benthic organisms, with a primary focus on the health and condition of Scleractinian corals, as well as other important benthic components such as algae, sponges, and soft corals.

**Photo**

To clearly mark the conclusion of the transect, and survey, in the photo series, take a photo of ONE fin at the end of each transect



Take a photo of TWO fins at the end of the survey (after finishing the 6 transects)



## 2.2 Habitat Complexity

In addition to photoquadrat sampling, the benthic surveyor will assess habitat complexity at three designated points along each transect—at the 1m, 11m, and 21m marks. **Habitat complexity** is a measure of the structural relief of the reef, which influences biodiversity, species interactions, and ecosystem functioning. Rather than simply looking directly down at the transect mark, the surveyor should assess the overall complexity of the surrounding reef within a defined radius (e.g., 2-3 meter) around the transect point.

To quantify habitat complexity, the surveyor will assign a score between 0 and 5 based on the vertical relief and structural features observed in the surrounding area:

**0:** No vertical relief; flat or rubbly areas with no significant structures.

**1:** Low (<30 cm) and sparse relief, typically with small isolated structures.

**2:** Low, but widespread relief, with small but consistent features.

**3:** Moderate complexity (30–60 cm) with moderately sized and frequent structures, such as small coral bommies or reef ridges.

**4:** High complexity (60–100 cm), characterized by significant vertical structures with numerous fissures, crevices, and small caves.

**5:** Exceptional complexity (>1 m), with abundant large structures, overhangs, and deep caves.

**Annex**
See Annex 4 for a photo guide on Habitat Complexity Scores

**Info**
At each assessment point, the surveyor should also record a short video to document the habitat's vertical relief and provide a visual confirmation of the complexity rating. This video footage is not mandatory but will be used to support the subjective visual assessment and allows for post-dive review if necessary.

# 3. Post-Survey Protocol

Once the survey of all six transects has been completed, all equipment, including transect tapes, must be retrieved, and any additional notes or observations made during the dive should be recorded on the 'Site and Survey' form. Surveyors should then back up their data immediately after the dive, including transferring photographs and video footage from the GoPro camera to an external hard drive and cloud storage.

**Note**
Always remember to rinse all survey gear, especially transect tapes and cameras, with fresh water after each survey to prevent saltwater corrosion and ensure the longevity of your equipment.

**Post-survey steps overview**

| Procedure | Software | Outcome |
|---|---|---|
| 3.1 Photo cleaning | PhotoScapeX | All photos renamed and organized. |
| 3.2 Annotations | CoralNet or ReefCloud | All photoquadrats annotated with 50 random points per photo. |
| 3.3 Data standardization | MERMAID | All data standardized, saved in the cloud, and ready to be analyzed. |

# 3.1 Photo Storage and Cleaning

To ensure data security and easy retrieval, all survey photos must be stored in at least two of these three secure locations:

- **External hard drive** dedicated to the monitoring project.
- **Cloud storage platform** (e.g., Google Drive, Dropbox) for easy access and added security.
- **Local server** (if available) for an additional backup.

At each storage location, maintain the following folder structure to organize your data efficiently:

- **Raw Folder**: This folder should contain unprocessed, original photos.
- **Processed Folder**: This folder is for photos that have been cleaned, renamed, and are ready for analysis.

**Warning**
Never modify or work directly on the photos stored in the raw folder; always work on a copy.

#### FOLDER ORGANIZATION

Proper folder organization is essential for managing a large number of images and ensuring efficient data processing. Here is a suggested folder structure to be used across both your external hard drive and cloud storage:

1. **Root Folder**: Create a root folder for the project, clearly named, such as: Regional_Coral_Reef_Monitoring_Project
2. **Survey subfolders**: Inside the root folder, create subfolders for each survey region and site. These subfolders will contain all data related to that specific location (e.g., Abu Dhabi > Western Region > Delma)

1. **Survey date folder:** Within each site folder, create subfolders for each survey date, formatted as YYYY-MM-DD (e.g., 2024-09-30). This ensures that the data is organized chronologically and is easy to trace to a specific survey.
2. **Transect folder:** Inside each date folder, create subfolders for each transect (e.g., Transect_A, Transect_B, etc.). This ensures that photos from each transect are organized separately, making data retrieval easier and preparing the data for import into platforms like **ReefCloud**.

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#### CLEANING AND RENAMING

Photos can be cleaned and organized using **PhotoScapeX** (free software). Carefully review each photoquadrat image to verify that none are blurry or poorly captured. If any images are blurry, discard them and replace them with the extra image taken at the end of each transect.

The processes of reviewing, cleaning, cutting, and renaming photos can all be done simultaneously in **PhotoScapeX**. Using a standardized naming convention ensures consistency across surveys and makes each image uniquely identifiable and traceable to its corresponding site, transect, quadrat, and date. Follow this naming format: **Site_Transect_Quadrat_YYYY-MM-DD.jpg.**

**Example**

**Delma_A_01_2024-09-30.jpg**

- **Site**: The site name where the survey was conducted (e.g., Delma).
- **Transect**: The transect identifier (6 transects, so from A through F)
- **Quadrat**: The quadrat number, ranging from 1 to 11 for each transect (e.g., 01, 02, etc.).
- **Date**: The survey date in the format YYYY-MM-DD (e.g., 2024-09-30).

**Video**

Please refer to the attached video for instructions on cutting and renaming photos using PhotoScape X. Keep in mind that the software is frequently updated, so the features and interface shown in the video may change over time.

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## 3.2. Annotations

In our coral reef monitoring work, we utilize both **CoralNet** and **ReefCloud** to efficiently process and analyze photoquadrat images. These platforms are invaluable for automating image analysis, enhancing data accuracy, classifying benthic cover, and tracking changes in coral reef ecosystems over time.

We continue to rely on CoralNet, a trusted platform in our workflow, while gradually integrating ReefCloud for larger-scale projects such as the **Regional Coral Reef Monitoring Program**. ReefCloud offers notable advantages for handling high volumes of data, and we are currently in a trial phase, working closely with the ReefCloud team to refine its application for our needs.

By using both ReefCloud and CoralNet, we optimize the annotation process, ensuring both efficiency and accuracy. This dual-platform approach allows us to manage large datasets while maintaining consistent data quality. Since we use the same label set across both platforms, our data remains standardized, enhancing cross-comparability.

While CoralNet provides reliable machine learning-based image annotation, ReefCloud's evolving AI features are particularly promising for large-scale projects, offering greater flexibility and faster processing for extensive datasets.

**Warning**

To ensure faster ReefCloud AI training and accurate results, we recommend that all photos be processed through the Regional Coral Reef Monitoring Program. **ReefCloud** is optimized for projects with a large volume of photos, which may make it less efficient to use for smaller-scale projects. For this reason, we strongly encourage you to share your raw images with us, so we can handle the processing on your behalf. Rest assured, you will be involved in every step of the process, and we will provide updates and results as we progress through the analysis.

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#### BENEFITS OF AI FOR IMAGE ANNOTATIONS

The key advantage of using AI-driven platforms like **ReefCloud** and **CoralNet** is their ability to efficiently process large sets of photoquadrat images by automating much of the annotation process, while still allowing for manual review to ensure accuracy. This significantly reduces both workload and processing time, especially when managing the high volume of images generated by our program.

- Both platforms use standardized label sets to categorize benthic components. For our surveys in the region, we employ the **NortheasternArabiaMonitoring** label set, which ensures consistent classification across sites. This label set includes broad categories such as *hard coral*, *sand*, and *algae*, as well as more detailed classifications like *genus*, *morphology*, and *status* for all hard corals identified in the region. If you'd like to use this label set for your projects, please contact us.
- To optimize the annotation process, it's crucial that image naming conventions (e.g., Delma_A_01_2024-09-30.jpg) are followed accurately, as platforms like ReefCloud and CoralNet link metadata to images for efficient bulk uploads.
- In ReefCloud we recommend manually reviewing 30% of the images for quality assurance. Adjusting the automated annotations where necessary ensures that the results align with expert judgment, which improves the model's accuracy for future surveys.
- Once annotations are complete, ReefCloud offers visual summaries and statistical breakdowns of the data. These can be used to assess benthic cover percentages and identify patterns in coral health and habitat composition.
- For both CoralNet and ReefCloud results can be downloaded in multiple formats, such as .csv files, for integration into other data analysis tools or platforms.

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## 3.3 Data Standardization and Management

Once the annotations are finalized, we recommend exporting your classified data to **MERMAID** for long-term storage and integration into broader regional monitoring initiatives. Data can be sent to our team at any point in the process for review, integration, or further analysis.

The **MERMAID** platform is an essential tool for managing and analyzing coral reef monitoring data. We highly recommend the use of MERMIAD for all your coral reef monitoring projects. Below is a step-by-step guide to ensure your data is entered, organized, and accessed efficiently within MERMAID.

### SETTING UP A NEW PROJECT

Log in to MERMAID at https://datamermaid.org and create a new project for your survey. Use a clear, standardized naming convention that includes at least the country/region and survey year (e.g., *Musandam_2024*).

Enter essential project details in the Sites and Management Regimes sections. This information has already been gathered in the 'Site and Survey' form, such as the survey date, location coordinates, reef zone, reef type, depth and management regime type. Ensure that all fields are accurately filled out to maintain consistency and data integrity.

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### EXPORTING DATA

Once your project is complete, you can export the data in various formats (e.g., .xlsx or .csv) for further analysis or reporting. To export, navigate to the project's data page, select the desired format, and download.

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### SHARING YOUR PROJECT

Add key team members and collaborators as contributors to your MERMAID project. If your data wasn't shared with the Program before, ensure that John Burt (John.Burt@nyu.edu) and Rita Bento (rcc8949@nyu.edu) are added as "Read Only" contributors to ensure data visibility within the larger Regional Coral Reef Monitoring Program. Collaborators will be able to view, but not modify, your data, ensuring the integrity of the original dataset.

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### STORING BACKUP DATA

In addition to storing data on MERMAID, we recommend that all teams maintain their own backup copies of raw and processed data. Store these backups in at least two secure locations, such as an external hard drive and a cloud storage platform. For photoquadrat images, use the folder structure and naming conventions outlined in the **Post-Field Protocol** to ensure that data is easily retrievable.

By following these steps, you'll ensure that your data is securely stored, properly organized, and ready for analysis within MERMAID. Our team is available to assist with any issues you encounter along the way.

**Link**
More detailed instructions on how to use MERMAID can be found here.

# Next steps

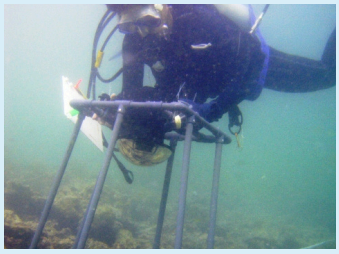
We are committed to supporting you at every stage of the monitoring process. You can contact us to:

- **Schedule a Zoom call** for detailed guidance, troubleshooting, or feedback on your data collection.
- Arrange **online training sessions** for you and your team on survey techniques, data analysis, or using tools like MERMAID and ReefCloud.
- Plan an **in-person site visit** or **workshop** to support on-the-ground efforts in your area.

Our goal is to make sure that you feel confident in both collecting and sharing coral reef data with the program.

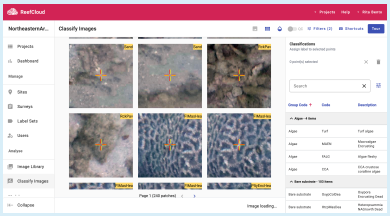
# Recap

Regional Coral Reef Monitoring Program in 3 steps:



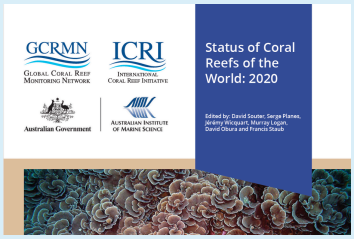
### Benthic surveys

Collaborators conduct benthic surveys across the ROPME Sea Area, gathering essential data on coral reef ecosystems.



### Data shared

Data can be shared with us at any stage of your project. We provide support with data processing, management, and analysis, ensuring a smooth workflow.




### Data analyzed and published

Your data will contribute to the **GCRMN Status of Coral Reefs of the World: 2025** report and the **Regional Data Paper**. All data will be properly attributed to its owners, with full citation, DOIs, and guaranteed co-authorship where applicable.

# Acknowledgments

**We would like to thank all the participants and collaborators who have contributed to the success of this monitoring program and in our collective efforts to contribute to the conservation of coral reefs.**

# Contact

For any questions, support, or to arrange a meeting, feel free to reach out to our team at:

**Rita Bento**
Research Associate, NYUAD
rcc8949@nyu.edu

We look forward to working with you and are always available to help with any aspect of your coral reef monitoring efforts.