MCP Long-Term Coral Reef Monitoring Program

Methodology

*Utilizing Citizen Science Data: Tailored Insights for Local Stakeholders*

December 2024

## 

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## 

## Introduction

### Coral Reefs

Coral reefs are a unique underwater ecosystem sustained by reef-building corals. Despite covering only 0.2% of the seafloor, they play a crucial role in hosting 25% of marine species. Furthermore, they contribute significantly to coastal protection, social well-being, food security, and economic stability (Souter et al., 2021). Owing to their intricate composition, coral reefs are renowned as biodiversity hotspots.

Considered the most biologically rich and productive environments on Earth, coral reefs provide direct or indirect benefits to around 1 billion people worldwide (Burke et al., 2011). Global estimates indicate that 1 billion individuals live within 100 kilometers of a reef, and 330 million reside within 30 kilometers of a reef, a circumstance that holds true for a significant portion of the Philippine population (Burke et al., 2011).

The Philippines is situated within the Coral Triangle bioregion, an expansive area stretching from the Philippines to the Solomon Islands, featuring more than 600 coral species, including at least 15 that are unique to this region (Veron et al., 2010). This represents over 75% of the world's coral species, making the Coral Triangle the most diverse coral ecosystem on the planet. Consequently, it is a prime candidate for conservation efforts aimed at the sustainable use of coral reef resources and services.

Ecosystem services, defined as the "wide array of benefits that ecosystems and their biodiversity confer on humanity" (Guerry et al., 2013), abound within the coral reef ecosystem. These services include:

* Human Health and Well-being: Coral reefs serve as a vital food source for coastal populations and offer recreational opportunities.
* Shoreline Protection: They reduce storm wave energy, acting as a natural barrier against erosion.
* Food Security and Livelihood: Coral reef fisheries directly support around 6 million people and generate employment in related sectors.
* Tourism: Coral reef tourism contributes a substantial 36 billion USD annually to the global economy.
* Biodiversity: Coral reefs provide a habitat for approximately 4,000 species of fish and 800 species of hard corals.
* Medicines: Corals yield substances that aid in developing new drugs for various diseases, including cancer.

### What threatens the Coral Reefs?

Coral reefs are facing a global decline, with many cases closely linked to the impacts of human activities (Souter et al., 2021). This trend is observable in the Southeast Asian region, although the deterioration is occurring at a slower rate (Kimura et al., 2022). This pattern is also evident in the coral reefs of the Philippines (Kimura et al., 2022), underscoring the urgent need for action to ensure their recovery and sustainable use.

Despite being well-established and ancient natural environments, coral reefs are confronted by a multitude of threats that can be categorized into local and global concerns (Burke et al., 2011; Woodhead et al., 2019). Local threats include:

* Overfishing: Commercial fishing, often targeting a limited number of species and sizes, can reduce reef resilience. The use of destructive fishing methods directly damages the coral.
* Coastal Developments: Unplanned human settlements, industrial activities, aquaculture, and other significant coastal changes can influence nearby habitats by increasing runoff, sediments, pollution, dredging, and landfilling.
* Land-Sourced Pollution: Pollution carried by rivers, including impacts from inland activities such as erosion, sewage, and runoff-related problems (livestock waste, pesticides, fertilizers), as well as plastic waste, significantly affect coral reefs.
* Marine-Sourced Pollution and Damage: Vessel pollution, which includes plastic, bilge water, fuel leaks, raw sewage, solid waste, and invasive species, as well as physical damage from anchors, groundings, and oil spills, pose substantial threats.

On the other hand, global threats are directly linked to human-induced climate change and have worldwide reach. The key changes affecting coral reefs include

* Warming Seas: Rising surface water temperatures (SST) due to climate change induce stress, bleaching, and, in extreme cases, the death of corals.
* Ocean Acidification: Increased atmospheric carbon dioxide levels lead to more acidic ocean waters, disrupting calcium carbonate fixation, which is essential for corals and shell-building organisms, resulting in slower coral growth.
* Storms Strength and Frequency: Warming ocean temperatures provide more energy for storms, generating extreme waves that damage coral. Additionally, there is an increased impact on land from heavy rainfall, such as flash floods, increased runoff, and landslides.

A recent trend observed in coral reefs is the degradation of reef conditions, leading to a coral-algal phase shift. This effect is characterized by a reduction in coral cover and its replacement by fleshy macroalgae colonization (McManus & Polsenberg, 2004), resulting in reduced reef resilience. The phase shift is often associated with the overexploitation of herbivorous species, increased sedimentation, and water eutrophication (Arias-González et al., 2017). It can be triggered by bleaching events, outbreaks of coral-eating species, and storm damage, all of which are plausible threats when considering the local reefs in South Negros Oriental.

### Monitoring Programs

According to Hill & Wilkinson 2004, a monitoring program consists of “a series of monitoring protocols that together provide a manager with the information needed to manage their reefs”. In this context, monitoring is defined as the repetition of surveys. Moreover, Protocols are defined as “selections of methods and how they are used to gain information at a site. This will include numbers of replicates, lengths of transect lines, specific information gathered, e.g. animals or plants to be counted or measured”.

Monitoring programs serve as vital tools in understanding and managing coral reef ecosystems. Their significance lies in providing valuable data on reef health, biodiversity, and environmental parameters, which are crucial for informed decision-making and conservation efforts (Flower et al, 2017).

There are a number of coral reef monitoring programs in the world. Some of the biggest and most important are the ones in the table below. These are the programs and references used to compare and streamline the MCP Long-Term Coral reef Monitoring Program.

Table 1 - Coral Reef Monitoring Programs Worldwide

| **Acronym** | **Full Name** | **Location** | **Link** | **Reference** |
| --- | --- | --- | --- | --- |
| AGRRA | Atlantic and Gulf Rapid Reef Assessment | Caribbean | <https://www.agrra.org/> | [AGRRA-5.5-English-Protocol.pdf](https://drive.google.com/file/d/1lyRebk65Am1LH3zzfhvFo3JOB6SG-VLm/view?usp=share_link) |
| CARICOMP | Caribbean Coastal Marine Productivity Program | Caribbean | - | [CARICOMP.pdf](https://drive.google.com/file/d/1S2jIJhKGkwFR-c4Rjzh1itUkgmUuCSZN/view?usp=share_link) |
| AIMS | Great Barrier Reef long-term monitoring | Australia | <https://www.aims.gov.au/research-topics/monitoring-and-discovery/monitoring-great-barrier-reef/long-term-monitoring-program> | [AIMS - English 1997.pdf](https://drive.google.com/file/d/1TaehEZ9dz8udcLiopNDYvHmQ8Zzim3Rq/view?usp=share_link) |
| REEFCHEK | Reef Check | Worldwide | <https://www.reefcheck.org/> |  |
| CRAMP | Coral Reef Assessment and Monitoring Program | Hawaii | <http://cramp.wcc.hawaii.edu/> | [CRAMP.pdf](https://drive.google.com/file/d/1hXMW13nQs5J5pX5KCP-aPSwFkMRlx5UW/view?usp=share_link) |
| CREMP | Coral Reef Evaluation and Monitoring Project | Florida | <http://myfwc.com/research/habitat/coral/cremp/> | [cremp-point-count-sop.pdf](https://drive.google.com/file/d/1XsnUfEpVn6rMve8clzbXbSmvSf66t6rI/view?usp=share_link) |
| NOAA | National Coral Reef Monitoring Plan Conservation Program NOAA Coral Reef | USA | <https://www.coris.noaa.gov/monitoring/welcome.html> | [noaa msm.pdf](https://drive.google.com/file/d/1WzzKS4i42xBLWFLFVkax2dW53ub_WAtz/view?usp=share_link) |
| MBRS SMP | Mesoamerican Barrier Reef Systems Project | Caribbean | - | [MESOAMERICAN\_BARRIER\_REEF\_SYSTEMS\_PROJECT\_MANUAL\_O.pdf](https://drive.google.com/file/d/1B_5sggGuQ9RrwAu7TySFY1NORGkENsrt/view?usp=drive_link) |

Utilizing data from monitoring programs, management actions can be tailored to address specific challenges facing coral reefs. These actions may include implementing regulations to protect vulnerable species, establishing Marine Protected Areas (MPAs), regulating sewage discharge, to conserve critical habitats, and developing strategies to mitigate the impacts of climate change. By harnessing the wealth of information provided by monitoring programs, stakeholders can effectively prioritize conservation resources and track progress over time (Flower et al. 2017).

### Citizen Science

Monitoring programs are often resource-intensive and logistically challenging to manage. However, there is a growing desire among the public to contribute to marine conservation efforts, particularly through diving activities. Citizen Science emerges as a powerful concept, bridging the gap between scientists and the general population. By engaging citizens in data collection and research activities, Citizen Science not only enriches scientific knowledge but also empowers individuals to become stewards of their marine environment (Conrad & Hilchey, 2011).

Through Citizen Science initiatives, volunteers gain valuable insights into marine ecology, contributing to meaningful conservation outcomes while enjoying rewarding experiences underwater. By fostering collaboration between scientists and citizens, Citizen Science plays a crucial role in democratizing scientific research and promoting public engagement in marine conservation (Freiwald, 2018).

### Food Security

Food security in the context of marine conservation can be defined as: “Making sure everyone has reliable access to sufficient nutritious and affordable food. This includes fish coming from sustainable fishing practices.”

In the Philippines, 42.7% of animal protein consumed is derived from fish (Belton & Thilsted 2014) and 38% of this fish originates from coral reef ecosystems. Data from Philippines Bureau of Fisheries and Aquatic Resources (BFAR) studies underscore the critical role of coral reefs in supporting food security and livelihoods specially for the most poor population. Marine Protected Areas (MPAs) play a pivotal role in replenishing fish stocks through the spillover effect, highlighting the importance of effective management and regulation (Alcala & Russ, 2006 ; Alcala, 2001. ; White et al 2002 ; Russ & Alcala, 1999).

However, not all MPAs are equally effective in achieving their conservation objectives. Factors such as location, size, and regulatory measures significantly influence MPA effectiveness. Evaluating the efficacy of MPAs requires assessing various parameters, including the time the MPA is established, the location, extent and the percentage of the coral reef that is inside the MPA. By understanding these factors, stakeholders can enhance MPA management strategies to safeguard food security and marine biodiversity (Flower et al, 2017).

### Reef Health

Reef Health in the context of marine conservation can be defined as: “Having balanced and diverse coral reefs that are resilient to threats and able to offer the services we need of them.”

Reef resilience, the ability of coral reefs to withstand and recover from environmental stressors, is a critical determinant of ecosystem health. Facing the inevitable threats, assessing this information can give an estimation of time and importance of each coral reef. Corals exhibiting lower resilience levels require targeted management interventions, and more restrictive measurements to facilitate recovery and enable communities to benefit from the ecosystem services provided by the reef. Using the UN Reef Assessment methodology (Maynard et al, 2017, Maynard et al, 2015), 38 different countries are conducting resilience assessments to identify vulnerable reefs and develop tailored conservation actions.

The Global Coral Reef Monitoring Network (GCRMN) facilitates comparisons between coral reefs worldwide, enabling stakeholders to benchmark their reefs against global standards and compare coral reefs around the globe (Souter et al, 2021). By assessing indicators such as hard coral cover and macroalgae cover, stakeholders can identify areas of concern and prioritize conservation efforts. Future reports will further evaluate fish density and additional factors, providing more comprehensive insights into reef health status and trends.

### Aesthetic / Touristic Value

Aesthetic Value in the context of marine conservation can be defined as: “The capacity a natural environment has in creating positive experiences and appreciation. How beautiful, how colorful, how clean, how healthy, how pristine they are.”

The aesthetic value of coral reefs encompasses their visual appeal and attractiveness to divers and other water activities. This multifaceted concept encompasses various factors, including biodiversity, coral health, and underwater landscapes. Assessing aesthetic value involves evaluating charismatic species, dive site highlights, and flagship species that contribute to the overall beauty of coral reef ecosystems (Marshall et al, 2019; Tribot et al, 2016).

Understanding the aesthetic value of coral reefs is crucial for promoting sustainable ecotourism and fostering public appreciation for marine biodiversity. By highlighting the beauty and uniqueness of coral reef environments, stakeholders can inspire greater conservation efforts and support for reef protection initiatives.

## Objectives

Our objectives encompass multifaceted aspects of coral reef conservation and management:

* Assessing MPA Effectiveness and Ensuring Food Security: We aim to evaluate the effectiveness of Marine Protected Areas (MPAs) in conserving coral reef ecosystems while simultaneously ensuring food security for local communities. This involves examining the impact of MPAs on fish populations and their contribution to the nutritional needs of coastal communities.
* Enhancing Reef Resilience and Tailored Management Decisions: We seek to evaluate the resilience of coral reefs and to suggest management strategies tailored to the unique characteristics of each dive site. Through comparative analyses with coral reefs worldwide, we aim to identify effective management practices that promote reef health and sustainability.
* Quantifying Recreational Value for water activities: Our objective is to quantify the attractiveness of coral reefs for recreational diving, snorkeling and boat tour activities. By assessing charismatic marine species and aesthetic qualities, we aim to provide insights into the recreational value of coral reef ecosystems and promote sustainable ecotourism practices.

These objectives collectively form the foundation of our efforts to conserve and sustainably manage coral reef ecosystems for present and future generations.

## 

## Methods

### Description

Monitoring programs around the world use a variety of methodologies to collect the replicates they need. Below is a brief description of the various methods that are employed by the programs in *Table 1* and an overview as to how MCP conducts surveys. All transects completed by MCP are 30m in length.

### Fish Method

The predominant method utilized for estimating fish assemblage and related indicators involves visual counting along a transect. The average length of these transects spans 30 to 80 meters, ensuring the inclusion of rare species and fast swimmers in the surveys. In all methodologies care is taken to minimise disturbance to the fish during the survey, either by providing a settling period or recording whilst laying a transect line. Monitoring programs also vary in how much of the water column they survey, some only monitor within 2.5m of the line, most monitor the entire column.

MCP surveyors lay the line in the designated area, and then leave. Laying the line can cause disturbance to the fish, by leaving the line for 15 minutes the majority of fish behaviour has returned to normal. Once the time is elapsed a buddy pair will conduct a belt transect, counting, sizing, and identifying all indicators within 2.5m of their side of the line, being sure to scan the entire water column. Surveyors look behind periodically to ensure they have not missed any indicator, if an indicator crosses the survey line volunteers must make note and later communicate to ensure it is not recorded twice in the database. The total transect time is limited to 10 minutes, in an effort to minimise the number of individuals passing in and out of the survey or being counted twice. Each specific indicator is recorded and sized in 5cm categories ie. 0-5, 5-10, 10-15, it is not needed to record where each indicator was spotted along the transect. Using specific coefficients we can calculate the average biomass at each site. Commercial value species are calculated separately as high numbers of Damselfish (not commercial) will affect the average biomass giving inaccurate data used for food security.

Provided with a 100m reel, surveyors are capable of completing 2 surveys in a dive, leaving a gap of 15m from the end of one survey and the start of the next.

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### Invertebrates Method

The visual estimation method within a transect is widely employed across all programs for the Macroinvertebrate Method. However, the lengths of the transects typically tend to be shorter than that used by MCP.

MCP surveyors lay the line in the designated area, the buddy team then swims back along the line completing a belt transect. Surveyors swim in a zig zag shape covering 2.5m on their side of the line, being careful to look under ledges and into crevices. If an indicator crosses the survey line volunteers must make note and later communicate to ensure it is not recorded twice in the database. Surveyors can still record indicators during any part of the survey which includes the swim back to the start and reeling in, provided they are certain they have not already recorded it and it falls within the boundaries of the transect. If there is any doubt the indicator is not counted. The total transect time is limited to 30 minutes, in an effort to minimise the number of individuals passing in and out of the survey or being counted twice. Each specific indicator is recorded and sized in 5cm categories ie. 0-5, 5-10,10-15, it is not needed to record where each indicator was spotted along the transect. Using specific coefficients we can calculate the average biomass at each site, or on average how many individuals of a specific indicator were recorded within the site.

### Substrate Method

The prevalent method for assessing substrate recovery involves the use of cameras and video surveys. However, for logistical reasons, this approach was not considered feasible. Spending an entire afternoon analyzing footage on computers may not be enjoyable for volunteers. PIT (point intercept) involves recording each point along a certain length, while LIT (line intercept) entails recording the start and finish of each feature in centimeters along the transect. PIT is easier to execute but may overlook rare and juvenile species, whereas LIT is more challenging but offers greater accuracy. The lengths of the transects used in both methods by other organisations typically tend to be shorter than that used by MCP.

Exploring taxonomic levels (Family, Genus, Species) provides valuable information about the reef. Family-level identification can offer substantial insights, while genus-level identification could enhance accuracy.

MCP surveyors lay the line in the designated area, the buddy team then swims back along the line, one member of the team will look within 2.5m on either side of the line looking for coral predators, using the same method as used by the invertebrate team. Due to the reduced indicator list in predation it is possible for one person to cover both sides of the line effectively. The other surveyor will travel above the line, stopping every 25cm and recording what growth form falls directly below that point. For cnidarians a health assessment will also be applied and recorded if the indicator is bleached, diseased, or being predated. At the end of the survey they should have a total of 120 points, meaning either the point at 0m or 30m was not recorded. These points are recorded as a tally to calculate the percentage cover of each growth form on the transect. It is not important where each point fell.

### General Method

* Distribution

Each survey site at MCP is divided into zones. Most sites are composed of 3 survey zones that are on average 30-45m in length to separate the site into 3 equal areas. Some of the smaller survey sites MCP monitors have only 2 zones, to ensure each zone is at least 1 survey length and contains a dense area of coral reef.

As well as having zones, each survey site is also divided into 3 depth ranges 3-7m, 9-13m and 15-19m, to account for the differences that can be seen on the flats and slopes of reefs. We know through historical data that certain sightings are more common than others at a given depth range. Transects are to be laid through the middle of the depth range, using a compass heading to ensure that it is laid parallel to the shore line.

If the topography of the site means it is impossible to keep a straight line heading and stay within the given depth range, it is more important to maintain depth.

Zones and depth ranges were introduced in an effort to reduce bias, and encourage an even spread of surveys across the entire site, as site size varies from 4-15 hectares. However it is important to note that this also introduces a degree of bias as the area where the transect can be laid is smaller and may result in surveys being conducted in the same area especially at smaller sites.

* Frequency

To enhance the resolution and quantity of data, surveys should be conducted monthly at dive sites. MCP’s long term monitoring program is based around the wet and dry seasons in the Philippines. Each survey season is 3 months, to ensure the replicates are representative of the entire season. Each methodology should complete 2 surveys per site, per depth range per month. Due to logistical constraints (such as the Amihan and Habagat monsoons causing wind and surge sites) it is sometimes not feasible to achieve 6 replicates. At a minimum 4 replicates per site are to be collected ensuring at least 1 replicate in each of the 3 survey zones.

* Logistics - Slates

The use of pre-printed slates is standard practice in monitoring programs worldwide. Slates used by MCP volunteers are prewritten with the most common sightings, this follows the same order as it is displayed in the database helping ensure accurate data entry.

* Logistics - Teams

To enhance safety and ensure surveys are conducted accurately, all surveys must be completed as a buddy pair. The surveyors reel out and then swim back along the line to conduct the survey. Volunteers trained in substrate, predation and invertebrates can share a survey line if needed for logistical reasons. Fish surveys must be conducted with minimal disturbance, other divers passing the line or snorkelers above a shallow line will invalidate the survey.

* Validations for New Surveyors

For each methodology volunteers complete both in-water and computer tests. New surveyors will be considered ready for independent surveying once they achieve a satisfactory level of similarity with the trainer's results (90%) and can show consistency in the accuracy of their ID skills.

Each methodology has 3 quizzes and 1 computer ID test, as well as 2 in-water tests assessing capability at completing a transect and ID skills. All quizzes have a pass rate of 75% all tests have a pass rate of 90%.

* Water quality

Currently under testing, MCP is trialing the use of a purpose-built water quality device. The device measures: dissolved oxygen, turbidity, temperature, salinity and dissolved solids. This section will be updated at the end of the trial period.

* Aesthetic / Touristic value

Although touristic value species such as turtles and nudibranchs are included as indicators within the above mentioned methods, the chance of some of these indicators passing through the transect is quite low, whereas the chance of seeing them is quite high. During all survey dives if a touristic value indicator is seen the surveyor will make a record. When inputting their survey data they will check off any indicators from the touristic list that was seen during any part of the dive (not just the survey) this information can then be used to give a representation of how often you would see these creatures. Ie XX dives were completed at SITE, on XX dives we saw a turtle.

### 

### Indicator Lists

The lists of indicators are established based on thorough analysis. For the fish and invertebrates lists, a similar methodology is employed. To define commercial value, reference is made to the lists provided by BFAR (Bureau of Fisheries and Aquatic Resources) and FAO (Food and Agriculture Organization), as well as Fidler's 2017 study on measuring MPA effectiveness in the Philippines. Only indicators present in at least one of these lists are included. The BFAR and FAO lists are filtered for Negros Oriental and the Philippines, focusing on animals inhabiting the coral reef environment.

For assessing reef health in these two methods, the reference point is the IUCN (International Union for Conservation of Nature) 2019 list for herbivorous fish and invertebrates, encompassing all relevant organisms.

Regarding aesthetic value, initially, charismatic animals are determined based on indicator lists from Tribot (2015) and Marshall et al (2019). Subsequently, information was gathered from divers, and the local community and stakeholders to ensure the relevant species were being recorded.

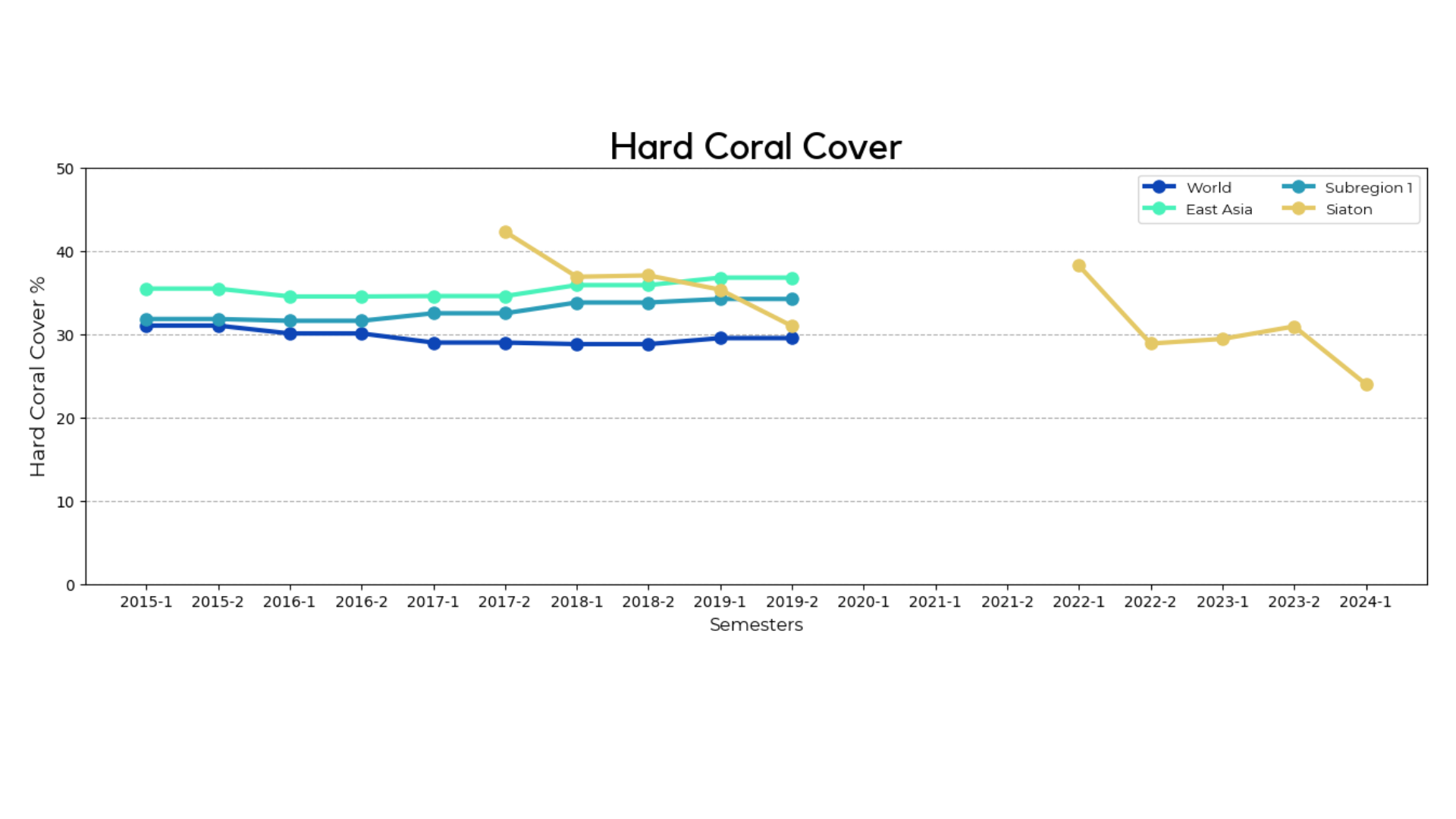
The Substrate list comprises hard coral growth forms in the Philippines, with references to resistant species (Marshall & Baird, 2000; Maynard et al, 2015). Other components are derived from indicator lists of previous projects, encompassing parameters and various sizes of macroalgae, as well as abiotic indicators.

#### Food Security

To make sure that the specific coral reef is contributing to food security it is needed to quantify two groups of indicators. First we need to access and characterize the commercial fish and commercial invertebrates populations assessing the density, biomass, average size, and community composition. Second assessment is the MPA effectiveness, that ideally is calculated by comparing MPAs with non MPAs, but inside our area we do not have control areas to quantify the effectiveness this way. MPA’s are compared against their own performance each season, taking into account factors that could contribute to the results such as river mouth discharges.

#### Reef Health

To compare the local reefs to the global data, this project follows the GCRMN parameters that are Hard Coral Cover, Algae Cover and the ratio between them. As the parameters are the same it is easy to compare how the local reefs are in a global context.



Example: In this graph you have the HCC for Siaton compared with 3 other lines:

* GCRMN Global hard coral cover (Souter et al 2021 Chapter 2 Fig 2.1)
* GCRMN East Asian Seas hard coral cover (Souter et al 2021 Chapter 7 Fig 7.5)
* GCRMN East Asian Seas Subregion 1 hard coral cover (Souter et al 2021 Chapter 7 Fig 7.6)

Bleaching, predation, and coral disease collected can also be used to show any sudden or growing concerns for the health of the reef.

#### Aesthetic / Touristic Value

To assess the aesthetic value of the reef, highlights of the dive site are recorded. This indicates the likelihood of encountering animals that attract divers, often referred to as charismatic animals/megafauna.

This information helps divers make informed decisions based on their personal preferences about where and when to visit a specific location. To estimate the chances of encountering attractive animals, we analyze how frequently these organisms are spotted during surveys. This provides a percentage indicating the likelihood of seeing a specific animal.

## 

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