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SUBJECT: **TECHNICAL GUIDE ON BIODIVERSITY ASSESSMENT AND MONITORING SYSTEM FOR COASTAL AND MARINE ECOSYSTEMS**

Pursuant to Republic Act (RA) No. 7586, or the "*National Integrated Protected Areas System (NIPAS) Act of 1992*", as amended by RA No. 11038, or the "*Expanded NIPAS Act of 2018*"; Section 9 of DENR Administrative Order No. 2016-26, "*Guidelines for the Implementation of the Coastal and Marine Ecosystems Management Program (CMEMP)*"; and to complement the DENR-BMB Technical Bulletin No. 2017-05, "*Guidelines on the Assessment of Coastal and Marine Ecosystems*", this Technical Bulletin on the *Guidelines on Biodiversity Assessment and Monitoring System (BAMS) for Coastal and Marine Ecosystems* is hereby issued for the information and guidance of all concerned.

Section 1. Objectives. This Guidelines on BAMS for coastal and marine ecosystems aims to provide the Protected Area Superintendents and field implementers standardized measures for assessment and monitoring the coastal and marine ecosystem that will aid them in implementing science-based management interventions. Specifically, the BAMS aims to:

i. Identify the trends in the condition of the composition and abundances of constituent species of the coastal and marine ecosystems and its use;
ii. Determine, quantify and assess the threats and stressors that causes the ecosystems' degradation.

Section 2. Scope. This Technical Bulletin shall be used to coastal and marine ecosystems under National Integrated Protected Areas System (NIPAS) Marine Protected Areas (MPAs) nationwide, and may also be used for identified Marine Key Biodiversity Areas (MKBAs), identified priority seascapes and critical habitats, and other coastal and marine conservation areas.

Section 3. Salient Features of the BAMS and Its Complementarity with other Assessment and Monitoring Tools/ Systems. This BAMS for coastal and marine ecosystems is an improved modification of the BMB Technical Bulletin No. 2017-05 that provides guidance in the proper selection of monitoring sites and stations, and the establishment of permanent monitoring transect(s)/plot(s) to be used for long term monitoring and management. It shall cover the assessment and monitoring of the following coastal and marine habitats within the NIPAS Marine Protected Area: (1) coral reef habitat and associated reef fish species; (2) seagrass beds; and (3) mangrove ecosystem. Sampling protocol for detailed assessment and establishment of monitoring sites and parameters shall be included for each ecosystem, as well updates on data analysis/interpretation. The key components of biodiversity to be assessed include state variables such as species composition, species richness and abundances, while process variables such as growth and recruitment in fixed plots, in addition to the state variables, are the parameters being checked for monitoring purposes. It is intended to complement and not substitute the

following assessment and monitoring tools/system that have been developed and issued by the BMB:

a) **Protected Area Suitability Assessment (PASA):** A tool for rapid assessment of biodiversity to determine the suitability of an area for establishment as protected area under specific categories of the NIPAS.
b) **BMB Technical Bulletin No. 2017-05, *Guidelines on the Assessment of Coastal and Marine Ecosystems*:** Set of standards and widely accepted methods/tools to determine the extent, cover, and condition of the various types of coastal and marine ecosystems (coral reefs, mangroves, seagrass, softbottom/mudflats, plankton, cryptobiota) developed to update the baselines of the coastal and marine habitats, thereby providing management guidance to the Regional implementers and local environmental managers in their respective areas.

Figure 1 illustrates the whole process flow of the BAMS, while details for the specific methods of assessment and monitoring for each habitat types are contained in Annex 1.

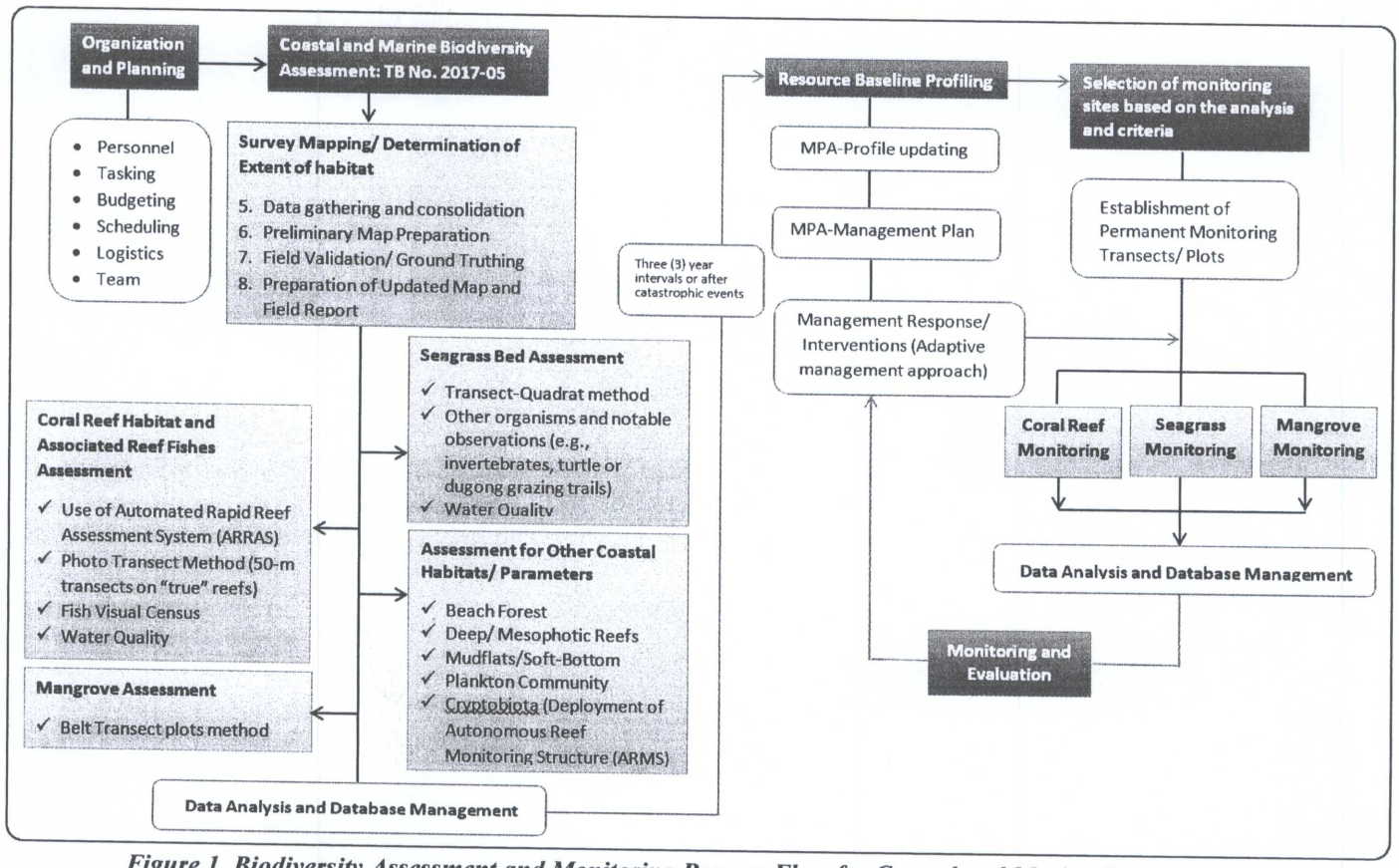

Figure 1. Biodiversity Assessment and Monitoring Process Flow for Coastal and Marine Ecosystems

The reassessment of coastal and marine ecosystems shall be conducted at least every three (3) years. On the other hand, the frequency of monitoring shall depend on specific habitat types and management objectives, as well as the available required manpower and resources, however, it should be conducted at least once a year for all types of coastal and marine ecosystems. In cases of catastrophic events such as strong typhoons, storm surges, extremely high sea surface temperatures that may lead to bleaching, etc., assessment activity shall be done immediately after.

Section 4. Team Formation and Composition. In the conduct of BAMS for coastal and marine ecosystems, partnerships with the academic institutions, local governments, and civil society organizations involved in coastal and marine biodiversity conservation shall be forged to enhance expertise on assessment and monitoring. The BAMS Team shall be created by the Regional Executive Director following the same team composition created under the BMB-Technical Bulletin 2016-05 on the *Guidelines on Biodiversity Assessment and Monitoring System for Terrestrial Ecosystems,* but with the following modifications:

4.1 PASu or coastal and marine conservation area manager as the BAMS Coordinator;
4.2 PASu staff members assigned either at the PENR or CENR Offices with knowledge and relevant skills/training (e.g., scuba diving) on the following: coastal and marine habitat assessment and monitoring; biodiversity database and mapping.
4.3 Technical Coastal LGU staff members who are involved in environment and natural resources management projects;
4.4 Representatives of indigenous peoples within the protected area, if any;
4.5 Faculty and researchers from higher education institutions with research interests in the marine protected areas and have academic agreement with the DENR; and,
4.6 Other members of the BAM team may include: civil society organizations involved in coastal and marine conservation; other concerned government agencies (e.g. Bureau of Fisheries and Aquatic Resources (BFAR)) or entities like development projects and interagency task forces in the locality.

The BAMS team for coastal and marine ecosystems may tap and seek assistance from the technical staff of DENR Regional Offices who were trained to conduct assessments for coastal and marine ecosystems under the previous DENR CARE-CaDRES project, as well as from the pool of mentors trained under the DENR-USAID-NOAA NIPAS MPA Capacity Building Program and the DOST-PCAARRD - DLSU Capacity Building on Reef Assessment and Coral Taxonomy Project.

Section 6. Reporting. The results of the assessment and monitoring and the analysis generated shall be reported by the PASu or BAMS Coordinator to the respective Management Board(s), equivalent management body, and or DENR Regional/Field Offices for appropriate management interventions. Both the results and recommendations for management interventions shall be submitted, for information and confirmation, by the PASus or BAMS Coordinator to the Office of the Secretary through the Office of the Regional Executive Directors and the Biodiversity Management Bureau. Raw data shall be organized into a database and shall be retained with the Office of the PASu, while the processed and other pertinent data shall be inputted to the Regional CMEMP/ Agos database. Affiliation with the MPA Support Network and local academic institutions to provide for back-up databases and image libraries is also encouraged.

Section 7. Fund Allocation. The Regional and Field Offices shall allocate necessary funding for the conduct of Biodiversity Assessment and Monitoring for the Coastal and Marine Ecosystems.

Section 8. Review and Evaluation. The methods and sampling design will continue to be modified and improved, hence, the implementation of measures, standardized methods, and tools provided herein shall be subjected to regular review and evaluation, and may be updated as necessary by the BMB in separate issuances/notices, taking into account the

most appropriate standards, efficient and cost effective technologies that maybe developed later on, and recognized by relevant institutions.

Section 8. Effectivity. This Technical Bulletin shall take effect immediately and shall be circulated for the information and guidance of all concerned.

RICARDO L. CALDERON, CESO III
Assistant Secretary for Staff Bureaus, and
BMB Director, in concurrent capacity

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ANNEX 1

Assessment and Monitoring Methods for Specific Coastal and Marine Ecosystem

Initially, in assessing and monitoring coastal and marine habitats, a special purpose map showing the relative location and extent of these areas is needed. Remote sensing images, available maps, and other relevant data and information on coastal and marine habitats (coral reefs, mangrove areas, seagrass beds, and soft-bottom or mudflats) from existing/ recent coastal and marine projects of DENR and other concerned agencies or academic institutions can be used. These preliminary maps and information will be used in determining the sampling design in conducting baseline reassessment and monitoring of the condition of each coastal and marine ecosystem type. While the concept of the general sampling protocol is discussed in detail in the BMB Technical Bulletin 2017-05, there are some specific considerations for specific coastal habitats which shall be discussed in the succeeding sections.

1. Coral Reef Ecosystem and associated reef fish species

A. Validation of location and initial site selection for assessment

From the satellite images and maps of the extent of coastal and marine habitats to be provided by the BMB, preliminary site selection will be done on the fringing reefs of the NIPAS-MPA. Fringing reefs, which are the most common type of reef formation, project seaward directly from the shore, forming borders along the shoreline and surrounding islands. Depending on the total size of the MPA coverage, available resources, and expertise, the selection of sites per NIPAS-MPA for assessment and monitoring maybe randomly (not haphazardly) selected based on the guidance provided in the BMB Technical Bulletin 2017-05. In addition, priority sites within reefs with wide reef flats[1], and reef slopes[2] (Figure 1) that face the dominant monsoon (NE or SW) should be chosen to give emphasis to the actively-accreting portions of well-developed reefs (Figure 2), i.e., those with significant carbonate deposits that result in the reef slope being distinct from the reef flat. Larger, fully-formed reefs provide more habitats, fisheries support, and greater ecosystem services (Licuanan et al., 2019).

These initially selected sites will be visited and reconnaissance survey will be done to check if these sites met the following criteria:

(a) the presence of a fringing reef flat that is at least 15 m wide;
(b) a defined reef crest[3];
(c) a reef slope that extends to about 5 m depth (corrected to mean sea level); and
(d) facing the NE or SW monsoon, or the waves created thereof.

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[1] **Reef Flat:** an area that is protected from wave action (Figure 1). The reef flat can extend for meters to hundreds of meters and the depth can range from a few centimeters to over two meters)

[2] **Reef Slopes:** the subtidal portion of the reef, extending from the reef crest or platform to the inter-reefal floor. The reef slope varies depending on location but is typified by dense coral growth and diversity.

[3] **Reef Crest:** the highest point of the reef (Figure 1). The reef crest breaks waves and receives the fullest impact of wave energy.

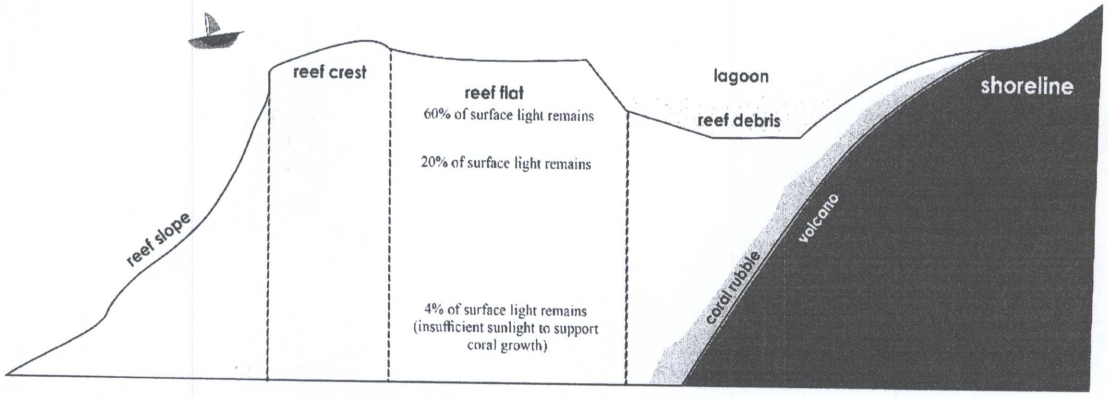
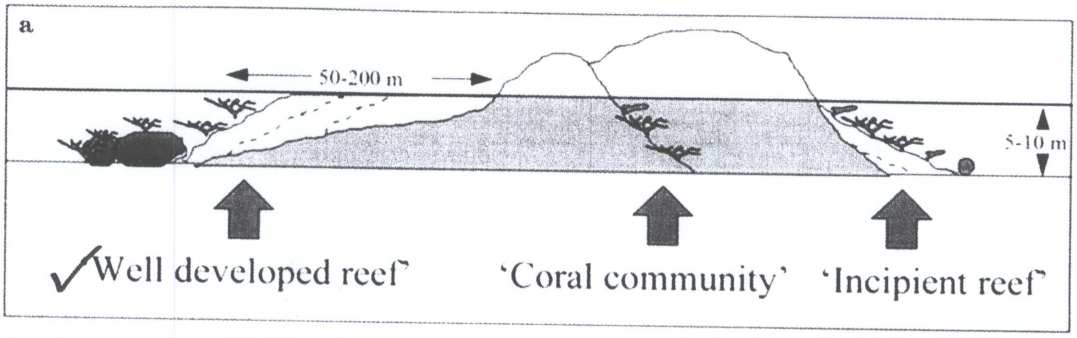


Figure 1. Typical reef zonation.



van Woesik and Done 1997

Figure 2. Typical dimensions/ development of fringing reef.

The Automated Rapid Reef Assessment System (ARRAS) tool may be used as an option for reconnaissance and mapping purposes.

B. Identifying Sampling Sites/Selection of Monitoring Sites

The reef assessment stations will be set on the upper reef slope of sites / reefs that qualify using the above-mentioned criteria. On the other hand, reef monitoring stations will be set on reef slopes that extend to about 5 m depth, but not necessarily on fully-formed reefs, and facing the dominant monsoon winds. Monitoring can be done at a minimum of once per annum or twice per year depending on the management objectives. As already mentioned in the BMB Technical Bulletin 2017-05, the suggested number of sampling sites and stations is not fixed and can vary depending on many other factors such as resources (availability of competent personnel, funding, time), natural variability and habitat diversity, and the desired minimum detectable change. The following are the general procedures and considerations for the identifying sampling stations for assessment and selection of monitoring stations:

Assessment
(1) Study the general ecosystem area. Make use of a rectified/ validated map (e.g., Google Earth® map with ground-truthing).

(2) On the map, divide the area into grids each with equal areas of habitat.
(3) Randomly (not haphazardly) choose grids that have habitats that meet the site selection criteria, making an equal case for density and patchiness, as well as proximity and distance to a possible source of impact. Avoid pseudo-replication or sampling grids that are too close to each other, or at regular (non-random) distances from each other that they are likely to be identical. Choose the sampling station that meet the site selection criteria within the randomly-chosen grids / sites. When choosing the final position of the 75m x 25m station, make sure the coral assemblage within the boundaries are homogenously-distributed. Avoid assemblages composed of patches of coral among patches of sand, silt, or rubble.
(4) The number of sampling stations would depend on the objectives vis-à-vis the resources and capacity of the management and the research body.
(5) If the general ecosystem area is small, or in the event that only one sampling station can be established, opt to sample a section that has the predominant character of the ecosystem.

Monitoring

(1) From among the stations sampled for assessment, pick out areas to conduct permanent monitoring. If there are 20 sampling stations, 3-5 of those could be made into permanent monitoring stations (BMB Technical Bulletin 2017-05). Stations where there is less variability (i.e., smaller standard deviations or standard errors) among the three to five 50m replicate transects) are preferred as these can be more sensitive and thus detect smaller changes in cover and diversity.
(2) It is better to choose monitoring stations that take on the predominant character of the ecosystem. If the objective is also to assess the impact of a source, it would be good to establish stations according to a gradient of proximity to the source of impact.
(3) Sample the monitoring stations with randomly-positioned transects, similar to how assessment stations are sampled.
(4) As resources allow, it is also recommended that a hierarchical sampling design is implemented, with two monitoring stations (75m x 25 m in dimensions; one to two hundred meters apart) making up a monitoring site, and with at least three monitoring sites (at least one km apart) per monitoring location.
(5) For the assessment stations chosen as monitoring stations, concrete blocks will be used to mark the general position of deeper edge of the stations. The coordinates of the locations will be determined using a Global Positioning System (GPS) unit and this information will be used to locate the station during the next monitoring visit to the area.

C. Field Methods and Data Analysis

The assessment and subsequent monitoring of the state of coral reefs (i.e., percentage cover, species composition and abundance) will be assessed and monitored using the Photo Transect Method, described in detail in van Woesik et al. (2009) and Luzon et

al. (2019) and in BMB Technical Bulletin 2017-05. In each monitoring station (75 m x 25 m in dimensions; see Figure 3), three to five randomly (not haphazardly) deployed 50-meter (m) transects will be laid on the reef, each transect following a uniform depth contour. Note that five 50-m lines is recommended for most local situations, particularly for monitoring. The deepest of the five transects should not be deeper than 6 m below the mean sea level.

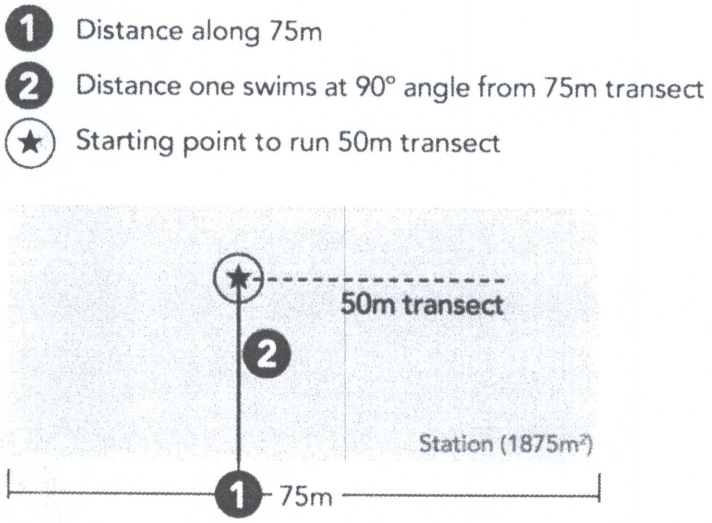


Figure 3. Randomization procedure used to place both transects and quadrats (van Woesik et al. 2009) **1** and **2** are random numbers generated by the relevant app and ranging from 0-25 (for **1**).

In addition to the new scale to describe coral cover (Table 1), this Technical Bulletin shall introduce the use of a new scale to describe coral diversity (Table 2) for better interpretation of results of assessments, monitoring, and applications in management:

Table 1: **New scale for coral cover** (Licuanan et al. 2017)

% Hard Coral Cover (HCC)	HCC Category
>44% HCC	HCC Category A
>33%–44% HCC	HCC Category B
>22%–33% HCC	HCC Category C
0%–22% HCC	HCC Category D

Table 2: **New scale for coral generic diversity** (Licuanan et al. 2019)

# of Taxonomic Amalgamation Units (TAUs)	Diversity Category
> 26 TAUs	Diversity Category A
>22 –26 TAUs	Diversity Category B
>18 - 22 TAUs	Diversity Category C
0-18 TAUs	Diversity Category D

Table 3: **List of Taxonomic Amalgamation Units (TAUs)** (Licuanan et al. 2017b)

Acanthastrea (ACAN)	*Millepora* (MILL)
Acropora branching (ACB)	*Montastrea* (MON)
Acropora corymbose (ACC)	*Montipora* branching (MONTB)
Acropora digitate (ACD)	*Montipora* encrusting (MONTE)
Acropora hispidose (ACH)	*Montipora* foliose (MONTF)
Acropora plate (ACT)	*Mycedium* (MYC)
Acropora robusta group (ACR)	Other branching corals (CB)
Astreopora (AST)	Other bubble corals (BUB)
Attached fungiids (AF)	Other encrusting corals (CE)
Caulastrea (CAU)	Other foliose corals (CF)
Coeloseris (COE)	Other free living fungiids (FOT)
Coscinarea (COS)	Other massive corals (CM)
Cyphastrea (CYP)	*Oulastrea* (OULA)
Diploastrea heliopora (DIP)	*Oulophyllia* (OULO)
Echinophyllia (ECHY)	*Oxypora* (OXY)
Echinopora (ECHI)	*Pachyseris* encrusting (PACE)
Euphyllia (EUP)	*Pachyseris* foliose (PACF)
Favia (FAV)	*Pavona* (PAV)
Favites (FVI)	*Pectinia* (PEC)
Fungia (CMR)	*Platygyra* (PLAT)
Galaxea (GAL)	*Pocillopora* (POC)
Goniastrea (GONIA)	*Porites* branching (PORB)
Goniopora (GONIO)	*Porites* encrusting (PORE)
Heliopora (HEL)	*Porites* massive (PORM)
Hydnophora (HYD)	*Seriatopora* (SER)
Isopora (ISO)	*Stylophora* (STY)
Leptoria (LEPA)	*Symphyllia* (SYM)
Leptoseris (LEPS)	*Tubipora musica* (TUBI)
Lobophyllia (LOB)	*Turbinaria* (TURB)
Merulina (MER)	

For field assessors who have expertise/advanced training on coral identification, the use of Taxonomic Amalgamation Units (TAUs), (Table 3; van Woesik et al. 2009) is recommended. Otherwise the "life-forms" described in BMB Technical Bulletin 2017-05 should be used. In latter case however, it is highly recommended that the *Porites* branching (PORB), *Porites* encrusting (PORE), and *Porites* massive (PORM) TAUs be recorded with the relevant life-forms (i.e., CB, CE, CM) in addition to *Acropora* life-forms and *Heliopora* to allow for inferences on disturbance history and potential resilience of coral communities (Go et al., in prep.).

D. Associated Reef Fishes and Cryptobionts

The same transects laid for the coral reef assessment and monitoring shall be used for the assessment of the associated fish assemblages. The fish visual census (FVC) method will be used. In case of cryptobiota monitoring, the Autonomous Reef Monitoring Structure (ARMS) shall be deployed in the same area where the coral reef monitoring stations are located. Refer to BMB Technical Bulletin 2017-05 for the methodologies' specific details and considerations.

2. Seagrass Beds

A. Validation of location and general extent of seagrass beds

In the case of seagrass bed assessment and monitoring, establishment of hierarchy of information is recommended. Existing and available remote sensed images of the extent of coastal resources/habitats may be used at the start, however, the information that can be generated from these require reconnaissance surveys and ground truthing, as seagrass beds are often mistaken as seaweed/algae community during the course of analysis of remotely sensed images. An initial visual survey of the area will provide information on the level of variation or patchiness there is within the seagrass beds. If high tide, or if the seagrass beds are located in the subtidal zones, initial survey can be done in the field using a boat, or simply using aerial photographs (drones). If reconnaissance survey can be conducted at low tide while the seagrass beds are exposed, the boundaries can be mapped by walking/ wading/ swimming around the perimeter of the bed/meadow, and making observations every 5-25 meters depending on the size of the area and time available. An important consideration in this activity is to find the inner (near the beach shoreline) and outer (towards the open sea) edges of seagrass beds, this can provide accurate information regarding the location and general extent of seagrass beds to be assessed/ monitored (McKenzie et al 2001).

B. Identifying Sampling Sites/Selection of Monitoring Sites

The number of sampling sites, which is usually around 3 to 6 sites, would depend on the extent of the seagrass habitat and homogeneity (or otherwise, patchiness). The patchier the habitat, the more sampling sites and sampling units (e.g., transects, quadrats) would be necessary to sufficiently represent the variability (Short et al. 2001). The objective is to always obtain unbiased representation of the study site (CARE-CaDRES Manual, in prep). The following are the general procedures and

considerations for the identifying sampling stations for assessment and selection of monitoring stations:

Assessment
(1) Study the general ecosystem area. Make use of a rectified/ validated map (e.g., Google Earth® map with ground-truthing). (2) On the map, divide the area into grids each with equal areas of habitat. (3) Randomly (not haphazardly) choose grids that have habitats that meet the site selection criteria, making an equal case for density and patchiness, as well as proximity and distance to a possible source of impact. Avoid pseudo-replication or sampling grids that are too close to each other, or at regular (non-random) distances from each other that they are likely to be identical. (4) The number of sampling stations would depend on the objectives vis-à-vis the resources and capacity of the management and the research body. It is suggested that at least one sampling station is established for every 25 hectares of the habitat of concern (BMB Technical Bulletin 2017-05). (5) If the general ecosystem area is small, or in the event that only one sampling station can be established, opt to sample a section that has the predominant character of the ecosystem.

Monitoring
(1) From among the stations sampled for assessment, pick out areas to conduct permanent monitoring. If there are 20 sampling stations, 3-5 of those could be made into permanent monitoring stations (BMB Technical Bulletin 2017-05). Stations where there is less variability (i.e., smaller standard deviations or standard errors among the replicates) are preferred as these can be more sensitive and thus detect smaller changes in cover and diversity. (2) It is better to choose stations that take on the predominant character of the ecosystem. If the objective is also to assess the impact of a source, it would be good to establish stations according to a gradient of proximity to the source of impact. (3) Lay permanent transects by placing markers and buoys at the start and end of every transect line and recording their position coordinates.

C. Field Methods and Data Analysis

The assessment and subsequent monitoring of the seagrass beds will be assessed and monitored through a fixed transect site. It must be noted, however, that this can only be used for monitoring intertidal seagrass meadows (or subtidal meadows with the use of SCUBA). Please refer to BMB Technical Bulletin 2017-05 for the specific details of the method and data analysis.

3. Mangrove Habitat

A. Site Consideration for Assessment

Mangrove forest is a unique ecosystem with community of trees occurring in a much defined zonation pattern. This mangrove zonation pattern is dictated by several factors but the most important ones are the type of substrate and the tolerance of the species to salinity and inundation. For instance, a particular zone can be dominated by a single species. Hence, in doing a mangrove survey, it is necessary that all mangroves from seaward to landward be properly sampled.

B. Field Methods and Data Analysis

The high water mark shall be identified before sampling. A baseline transect should be laid parallel to the shore, the length of which will depend on the extent of the mangrove forest in the selected site.

Transect lines should be established perpendicular to the baseline at every 100 meter interval. The length of transect lines may vary depending on the extent of the mangrove forest, but as much as possible, the transect lines should extend to the most landward zone of the mangrove forest.

A nested 10x10m quadrat will be established at every 100-meter interval of the transect lines. All trees inside the 10x10m quadrat with diameter of equal or greater than 5 centimeters will be identified and measured (diameter at breast height [DBH], MH, TH).

Small trees (<5 cm DBH), and other non-tree flora (shrubs, vines, herbs, ferns) will be identified and counted inside the 2x2m quadrat. The same field data sheet for the canopy and understory of the forestland can be used for mangroves.

Other observations within the vicinity of each mangrove station such as observed flowering and fruiting of the individual trees as well as other tree disturbance should be noted on the remarks column.

Specific details on the data analysis are contained in BMB Technical Bulletin 2017-05.

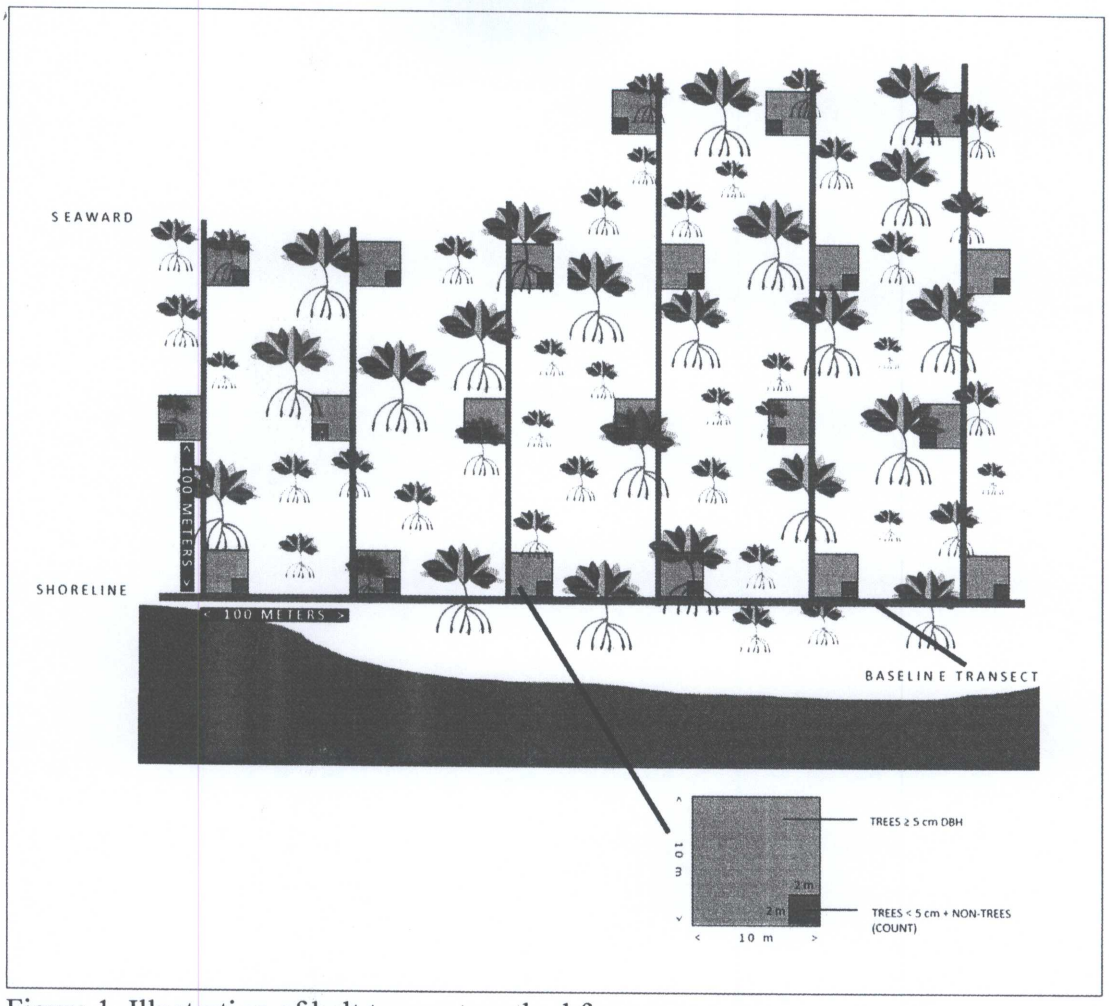


Figure 1. Illustration of belt transect method for mangroves

C. Establishing Monitoring Plots

Establish a 2-ha permanent plot following the international protocol for the establishment of permanent field plots. The plot must be regular (100m x 200m or 80m x 250m) for easy boundary delineation. A geodatabase will be developed to facilitate data storage and retrieval of the permanent plot. There will be two phases of geodatabase development for the permanent plot. First is the gridding and monument marking and the second is the building up of biodiversity information in the area using GIS.

The entire plot will be divided into 200 grids where each grid has a dimension of 10m x 10m. Monument markers will be driven in every corner and center of each grid. These corners will later geocoded for easy identification in the field and as future reference for efficient encoding of data.

Monitoring of plant growth (diameter at breast height, total height and crown diameter) should be done every five years after the baseline survey. Depending on availability and activity of the PA staff, basic information such as flowering, fruiting, clearing, cutting and other disturbances can be counted on a monthly basis. In cases of

catastrophic events such as strong typhoons, volcanic eruptions, etc., assessment activity will be done immediately after.

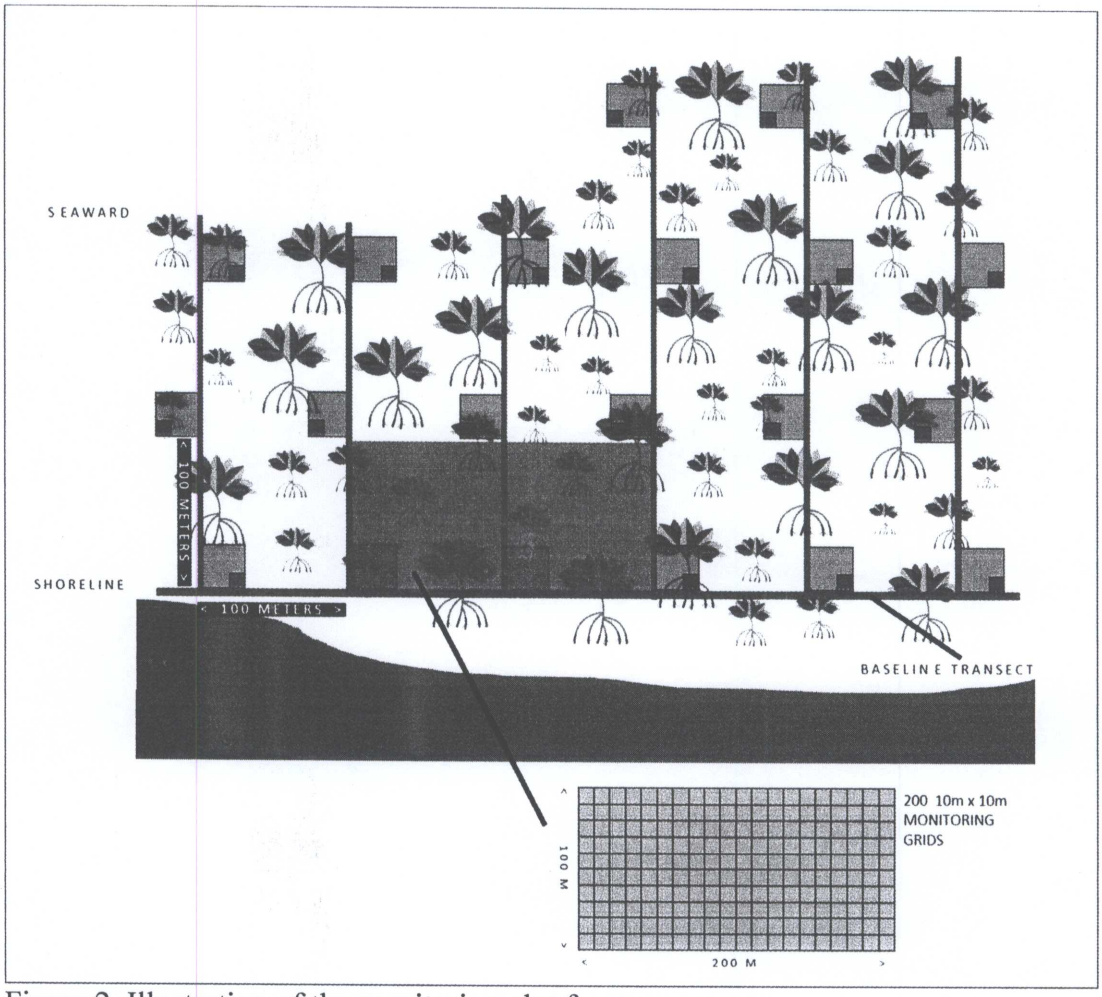


Figure 2. Illustration of the monitoring plot for mangroves