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SUBJECT: **GUIDELINES ON THE ASSESSMENT OF COASTAL AND MARINE ECOSYSTEMS**

Pursuant to Section 9 of DENR Administrative Order No. 2016-26 on the Guidelines for the Implementation of the Coastal and Marine Ecosystems Management Program (CMEMP), the attached "Guidelines on Assessment of Coastal and Marine Ecosystems" is hereby disseminated in support of MPA Network Establishment and Strengthening Component of CMEMP.

This Technical Bulletin is circulated for the information and guidance of all concerned.

THERESA MUNDITA S. LIM

GUIDELINES FOR ASSESSMENT OF COASTAL AND MARINE ECOSYSTEMS

Rationale

Coral reefs, seagrass, mangroves and soft bottom/mudflats provide various types of habitats for fish, invertebrates and other marine organisms essential for the completion of their life cycles. Coral reefs, mangroves, and associated habitats (e.g. beach forests and mudflats) protect coastal communities from strong wave action, winds, storm surges and tsunamis. More importantly, these habitats are important sources of food and income such as from fisheries and ecotourism. In addition, coastal and marine ecosystems are equally efficient sequestors of carbon dioxide making them important repositories tempering effects of climate change.

As the population increases, the demands for goods and services of coastal and marine ecosystems also increase often resulting to varying degrees of degradation of habitat condition. The threats include overexploitation, loss of habitats, pollution, destructive methods of extraction, perverse incentives and many others. Coastal habitats and resources in the Philippines are also threatened and declining due to catastrophic events related to climate change. The habitats have the natural capacity to recover from disturbances, however overall neglect and poor management impede its recovery. Thus, there is a need for proper management approach in order to decelerate loss and destruction, as well as concerted efforts to rehabilitate and allow the ecosystems to recover.

In order to develop an appropriate, logical and effective management strategy for the Philippines' coastal and marine ecosystem, there is a need for an accurate and updated assessment of the extent and condition of the country's coastal and marine ecosystems as well as the factors/threats/pressures affecting its state and health. Information on the condition of the various coastal and marine ecosystems on a national scale will help the DENR in calibrating appropriate management responses and set realistic annual targets.

There are ongoing assessments being implemented in selected sites under the DENR and DOST through DENR's Coral Reef Visualization and Assessment (CoRVA) and DOST's National Assessment of Coral Reef Ecosystems (NACRE). However, additional efforts are urgently needed to cover other sites in the Philippines.

The DENR, through its Coastal and Marine Ecosystems Management Program (CMEMP), developed this Technical Bulletin to provide guidance to the Regional implementers and local environmental managers on how to conduct mapping and assessment of the coastal and marine habitats (coral reef, mangrove, seagrass, softbottom/mudflats, plankton, cryptobiota) in their respective areas. Specifically, this guidelines aims to:

1. To determine the extent and cover of the various types of coastal and marine ecosystems within each jurisdiction (regional); and
2. To determine the condition, using standard and widely accepted methods, of the various coastal and marine ecosystems

This Technical Bulletin will apply nationwide for the assessment of coastal and marine environment to cover coral reefs, seagrass beds, mangrove stands, mudflats/soft bottoms and plankton communities.

METHODOLOGY

A. SURVEY MAPPING

I. Data Gathering and Consolidation

Remote Sensing images, available maps and other relevant data/information on coastal and marine ecosystems (coral reef, mangrove area, seagrass beds and mudflats) shall be gathered by DENR-BMB and other concerned agencies/academe i.e., Protected Area (PA), Historical data of coastal and marine ecosystems, Land Cover Map, Topographic Base Map, Administrative Boundary, Monument Description of PRS '92 Geodetic Control Points (GCPs), etc. The same shall be consolidated to produce baseline maps showing the extent of the coastal and marine habitats. The baseline maps produced will be the bases for the determination of the condition of the various coastal and marine resources in the country using the best available criteria.

II. Preliminary Map Preparation

A. Pre-processing

1. Vector file: The vector file shall be corrected/ projected to the reference *recent/available satellite image, Google or Bing Maps.*

2. Analog Map: The map shall be scanned and rectified to produce a geo-referenced map. The relevant features i.e., coastal and marine habitats within and/or adjacent to PA in the geo-referenced map shall be digitized to produce a vector files (lines and polygons).

3. Technical Descriptions (TDs): In case of other relevant datasets where only the Technical Descriptions are available, these TDs shall be encoded and plotted to generate vector file (lines and polygons). Back-up copies of the encoded/plotted TDs shall be created.

B. Preliminary Map Generation

1. Integration and Geoprocessing: The vector files of the coastal and marine habitats within and/or adjacent to PA, as well as the nearest PRS '92 GCPs shall be integrated/geo-processed and overlaid to recent/available satellite image using a GIS software. The PRS '92 GCPs will serve as tie point for the vector files and as reference in Global Positioning System (GPS) testing and localization for calibration purposes. Strategic corners within the subject area shall be determined (Figure 1).

2. A layout of the geo-processed vector file of coastal and marine habitats within and/or adjacent to PA shall be prepared. Print copy of this shall be produced which will serve as preliminary map showing the relative location and extent of the subject area indicating predetermined strategic corners for validation.

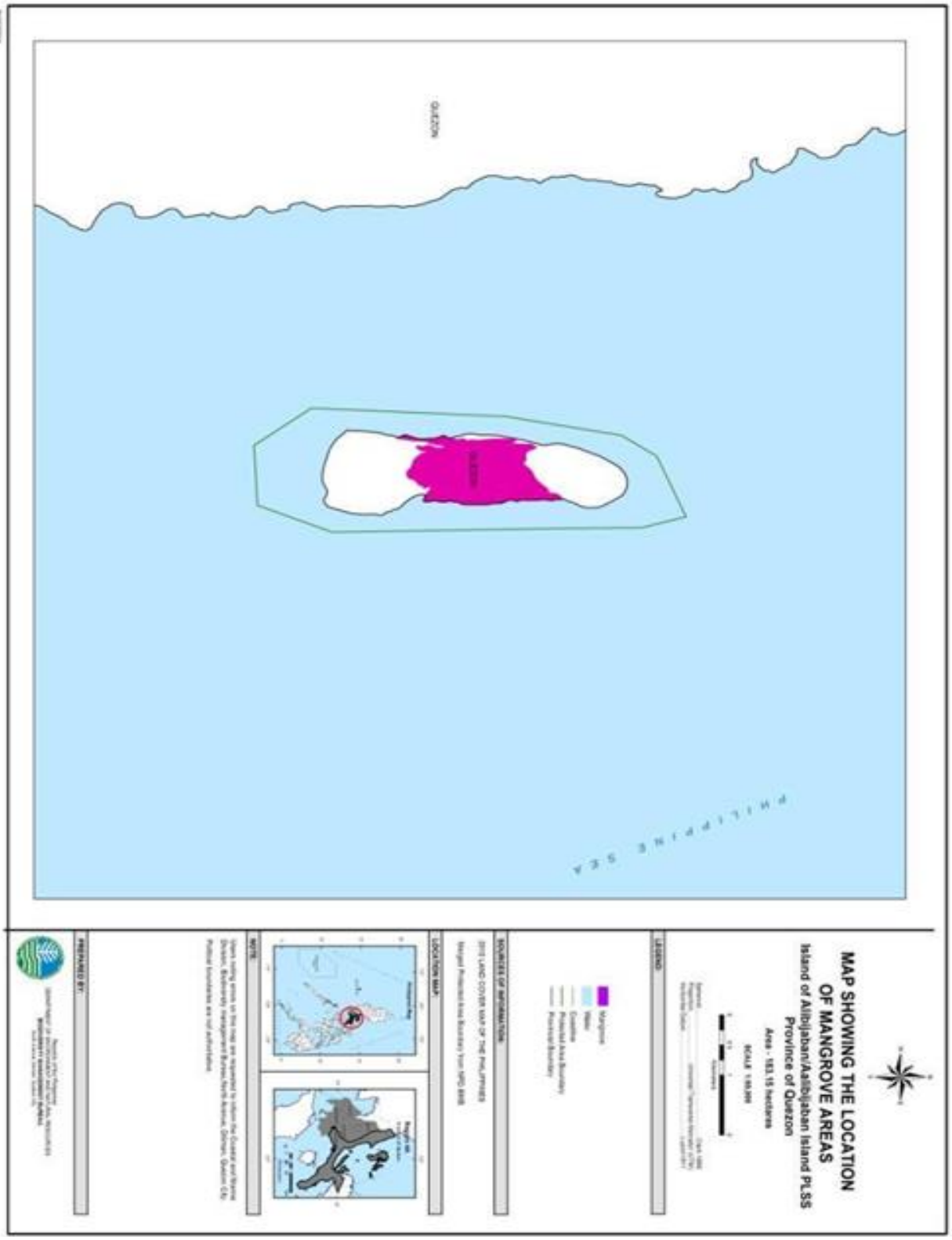


Figure 1. Sample preliminary map for validation

Table 1. Attribute entries for the vector file

Required Field	Field Properties	Description	Sample Entry
REGION	Text (50 Char)	Region Number	REGION IV-A
PROVINCE	Text (50 Char)	Name of Province	QUEZON
LANDCOVER	Text (50 Char)	Type of Land Cover	Mangrove forest
PANAME	Text (100 Char)	Name of PA	Island of Alibijaban / Alibijaban Island PLSS
AREA	Double (10,4)	Area of Mangrove in hectares	183.15
PA_TYPE	Text (50 Char)	Terrestrial/Marine	Terrestrial Protected Area

III. Field Validation/Ground Truthing

1. The Handheld GPS should be initialized/localized and tested before proceeding to the area using the PRS '92 GCPs as reference.

2. Predetermined strategic corners reflected in the preliminary map shall be validated on ground using Handheld GPS unit.

3. Using the navigational capability of the Handheld GPS and the uploaded waypoints, the direction and distance indicated therein will serve as guide in tracking the predetermined strategic corners of the coastal and marine habitats within and/or adjacent to PA.

4. Should there be discrepancy in the predetermined vis-à-vis actual location and extent of the area, the actual coordinates with full description and sketch of the area including landmark shall be recorded with supporting photos for documentations.

IV. Preparation of Updated Map and Field Report

1. The vector file of the location and extent of the coastal and marine habitats within and/or adjacent to PA based on the ground truthing shall be adjusted accordingly.

2. A layout of the adjusted vector files shall be prepared and a print copy of this shall be produced.

3. A field report and the updated map showing the location and extent of coastal and marine habitats within and/or adjacent to PA shall be prepared and submitted to the concerned CENRO/PENRO for endorsement to the DENR-BMB.

The generated maps will be used to choose sites for the detailed assessments of the overall conditions of the coastal and marine ecosystems. It is important to indicate on the map the locations and positions of the habitats for each of the various types of coastal and marine ecosystems present in each of the regions. This can be best shown using polygons. The area of the polygons can provide an initial estimate of the extent each type of coastal and marine ecosystem cover in each of the region. The suggested sample size for the detailed assessment and determination of the condition of each type of ecosystem is about 20 sampling sites per 500 hectares of an ecosystem.

A widely accepted protocol for sampling is provided by Green et al. (1979) and is summarized below.

B. SAMPLING PROTOCOL FOR COASTAL AND MARINE HABITAT ASSESSMENT

Green's (1979) Ten-Point [Field] Sampling Protocol[1]

I. State your questions clearly and concisely (objectives of the study)

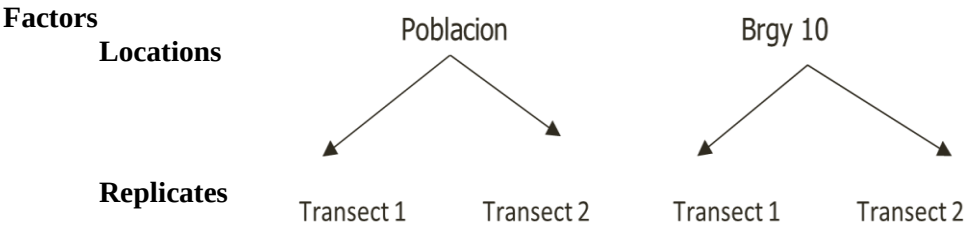
- Doable
- Measurable (Condition- good, fair, poor; uniformly good? Fair and poor?; What is their variability)
- It is at this stage that you should seek advice from a statistician about the design and subsequent analyses you may need
- Avoid collecting data in an unplanned manner and then seek statistical advice

II. Replication

- Unit of sample
  - set of observations in a transect
  - group of quadrats
  - Independent (free from bias or uninfluenced)
- Take replicate samples at all levels of interests (ex. Locations, times). *Be wary of pseudoreplication (Hurlbert, 1987)*
- Remember that variation or differences among locations (or times) can only be demonstrated by comparison to variation *within* locations (or times)
- The basis of any statistical test of your hypothesis is the ratio of the variation among locations to that within locations
- For example, you wish to examine species richness and percentage cover of corals between locations in the region
  - Single factor design for each parameter (species richness and abundance of corals (% cover)

Factor	Levels	n
Location	Poblacion, Brgy1, Brgy2,…, Brgy 10	10
Replicates		2
	Total samples	20

- **Sampling Design:**



[1] Green R.H. 1979. Sampling design and statistical methods for environmental biologists. John Wiley and Sons. N.Y. 257 pp.

III. Randomization

- Taking samples from "representative" or "typical" places is NOT random sampling.
- Collect samples independently (without bias).
- *Most of the serious violations of statistical tests is the non-independence of residual (error) terms*
- Bias from non-independent samples cannot be removed!
- Make sure that all possible samples are given the same chance of being sampled.
- Sample randomly within a location; use grid on maps and choose a grid from a table of random numbers (Figure 2)
- Similarly, when choosing day of sampling, use random numbers to choose the day.
- In field sampling, avoid systematic sampling, e.g. regular intervals- this increases systematic errors.

1	2	3	4	5
0	9	8	7	6

M	T	W	Th	F	S	Su
1	2	3	4	5	6	7

Figure 2. Grids for random sampling

IV. Controls

- Concept of "control" in an experiment is clear to all of us (i.e. it is a "site" or a "set-up" where "treatment" is absent and all else is the same)
- Replicated samples from a control is important to measure natural variability
- It is quite difficult but not impossible to look for a control in field studies.
- In our case, the most pristine site or the site with the least number of environmental threats (e.g. exploitation, pollution, illegal activities…)

V. Pilot Studies

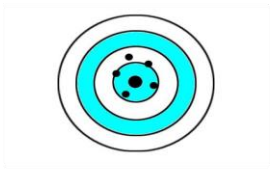
- This is an important component of a good sampling design but rarely given emphasis.
- Pilot studies are preliminary sampling to:
- refine and fine tune sampling design,
- Test efficiency of methods,
- Provide a range of variation of a parameter (expected variances).
- This is usually the only way to:
  - Assess efficiency of sampling method
  - Determine the presence of a large-scale spatial variability that would make stratification desirable
  - Determine size of sampling unit to maximize precision of sample estimates
  - Determine number of replicates required per site

VI. Efficiency of sampling methods

- Your sampling method is efficient under all relevant conditions
    - If your sampling method is more efficient in Site A than at Site B, then your comparison can be biased. Try standardization.

- Efficiency can mean either "accuracy" (closeness of a measurement or estimate to the true value) or "precision" (degree of concordance among a number of measurements or estimates for the same population).

High precision, poor accuracy –good replication but poorly randomized design



High accuracy, poor precision – Well randomized but poorly replicated design

High accuracy, high precision – good replication and well randomized design

- In broad terms, accuracy can be thought as reliability and precision as repeatability
- Replication improves precision and randomization improves accuracy

VII. Stratification

- This requires previous information
- If there is a large-scale pattern of variation in a factor of interest, then there is a need to stratify.
- Break up your areas into homogenous sub-areas or STRATA
- Allocate sampling effort (number of replicates) optimally to the strata.

VIII. Size of sampling units/number of replicate samples/cost-benefits analysis

- The size of your sample unit must be appropriate and this depends on the following:
- Size and shape of organism
- Size of the study area
- Spatial distribution of the organism (clustered or random)
- Cost of the sample collection (time, money, number of personnel, etc.)
- Maximizes the precision of the estimate.

IX. Analysis of data

- You must subject your data to the most appropriate type of analysis.
- You need to determine your design and match it with the appropriate analysis *a priori*
- There are a wide range of analytical packages available for ANOVAs, Multivariate tests, Classification and Ordination tests.

X. Accept your results

- Be objective.
- Avoid entering into a search for a method that will give you a more palatable answer.

C. SELECTION OF SAMPLING SITES FOR DETAILED ASSESSMENT, ESTABLISHMENT OF MONITORING SITES AND PARAMETERS

Once the total area covered by each of the coastal and marine ecosystem is estimated in each region, the total number of sampling sites can be determined using a randomization technique. Randomizaton improves the accuracy of measures and also provides for a wider scope of generalizations.

Randomization is defined as giving each possible sample an equal chance of being sampled. This refers to the manner by which each of the sampling sites is chosen. Random selection of sampling sites simply mean that each of the sampling chosen has an equal chance of being selected with the rest of the samples. This can be carried out by constructing identical grids on the map showing the locations of the given ecosystem, say coral reefs. For example, we construct identical 100 grids over the location of an ecosystem covering 500 with each grid representing an area of about 5 hectares. Each grid will be assigned a number and then draw 20 numbers at random (using a tambiolo or generating a random number from 1 to 100). The grids with the corresponding numbers drawn are designated sampling sites for that ecosystem (e.g. coral reefs).

Repeat the same procedure for another type of coastal ecosystem until all types of ecosystems are covered. The suggested number of sampling site per ecosystem type is 20 sampling sites per 500 hectares of that ecosystem. Hence, for every 500 hectares of any given ecosystem we choose randomly 20 sampling sites, 1000 hectares 40 sampling sites so on and so forth. The suggested number of sampling sites in this manual is not fixed and can vary depending on many other factors such as resources (availability of competent personnel, funding, time). In cases when the suggested number cannot be met, a reasonable justification must be provided.

The detailed assessment to determine the condition of each type of ecosystem will be conducted on these sampling sites following standard and widely accepted methodologies specific for each ecosystem. The determination of a condition of an ecosystem is based on an evaluation of key components of biodiversity as well as the levels of various threats to the ecosystem in a given location. The key components of biodiversity include species composition, species richness and abundances. Species composition refers to the identified species of animal, plant, and algae within the scope of the method, while species richness is simply the total number of species counted. Abundances refers to the number of individuals of each species and are expressed as densities such as number per unit area (x/m^2) or biomass per unit area (kg/m^2) for non-colonial individuals and as percentage cover for colonial individuals (e.g. corals).

Species composition and species richness provides an idea about the trophic structure of the ecosystem and together with abundance data they provide insights about ecosystem functionality. The levels of various threats are important to obtain because these are the factors that adversely affect the condition of the ecosystem (Table 2).

The monitoring sites will be chosen from the locations of the sampling sites after the baseline assessment. The baseline assessment will generate questions and provide targets from which the locations and number of monitoring sites will be determined. It is suggested that the monitoring sites are subsets of the sampling sites. Hence, 3-5 monitoring sites per 500 hectares of an ecosystem is sufficient. The frequency of monitoring will be made at least once a year for all types of coastal and marine ecosystems.

Table 2. Important parameters to examine biodiversity and generic threats for each given ecosystem.

TYPE OF ECOSYSTEM (sampling unit)	KEY BIOLOGICAL PARAMETERS	THREATS
1. Coral Reefs (50 m transects)	Species composition	Illegal fishing
	Number of species	Number of fishers
	Percentage cover	Pollution (e.g. siltation, industrial wastes, domestic wastes
	Other associated invertebrates	Coastal development
2. Associated reef fishes (50 m transects)	Species composition	Illegal fishing
	Number of species	Number of fishers
	Density and biomass	Pollution
3. Seagrass beds (quadrats per transect)	Species composition	Siltation
	Number of species	Coastal development
	Percentage cover	Pollution
	Other associated invertebrates (e.g. sea urchins, sea cucumbers)	
4. Mangroves (transect plots)	Species composition	Coastal development (e.g. conversion)
	Number of species	
	Density of seedlings, saplings and trees	Tree cutting
	Associated fauna and flora	Pollution

5. Mudflats/softbottom (volume of sediment ~500 cm^3 or 0.5 liters)	Species composition (infauna)	Coastal development
	Species richness	
	Density (number per sediment volume; #/m^3)	Pollution
6. Plankton (volume of water sampled in liters)	Species composition	Pollution
	Species richness	Sedimentation
	Density (number of cells per water volume; # cells per m^3)	
7. Cryptobiota (unit ARMS)	Species composition	
	Species richness	
	Density	

D. METHODS FOR DETAILED ASSESSMENTS OF ECOSYSTEMS

The following methods will be applied to the chosen sampling sites during the baseline assessments and the monitoring sites after the baseline assessments. The sampling unit applied to sampling sites will be transects for coral reefs and associated reef fish, quadrats in each transect for seagrass beds, transect plots for mangroves, volume of sediment samples for mudflats/softbottom, volume of sampled water for plankton, and ARMS (Autonomous Reef Monitoring Structures) unit for cryptobiota.

The general design is two replicate samples per sampling site within a location (see Figure 4). This approach is able to capture the variation in the state (i.e., diversity, abundances) and processes (i.e., growth, recruitment) of an ecosystem within and between each sampling site as well as within and between locations. At the Coastal and Marine Division of the BMB, the information on community structure and processes submitted by the regions can be analyzed to show variation in conditions of a given ecosystem within and between locations of regions.

In Figure 1, a location represents an area to be surveyed and may represent a province (e.g. Batangas) or a water body (e.g. Balayan Bay) usually in scales of several 10s km^2. A water body can also encompass several provinces such as Davao Gulf, Lingayen Bay, etc.

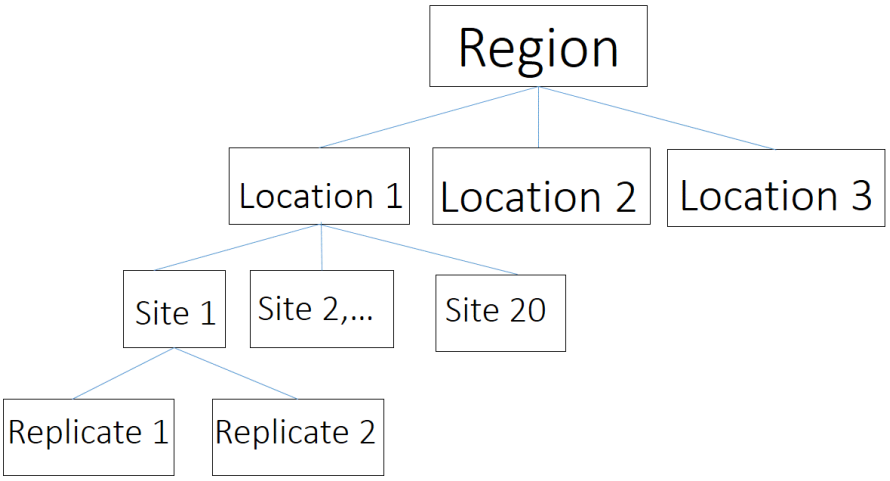


Figure 4. Suggested hierarchal sampling strategy

The coordinates of the location of each of the sampling site for all surveys is always obtained using a Global Positioning System. This is recorded and will form part of the information to a particular sampling site. If the sampling site is chosen as a monitoring site, then it is handy to relocate the site using the recorded coordinates.

CORAL REEFS

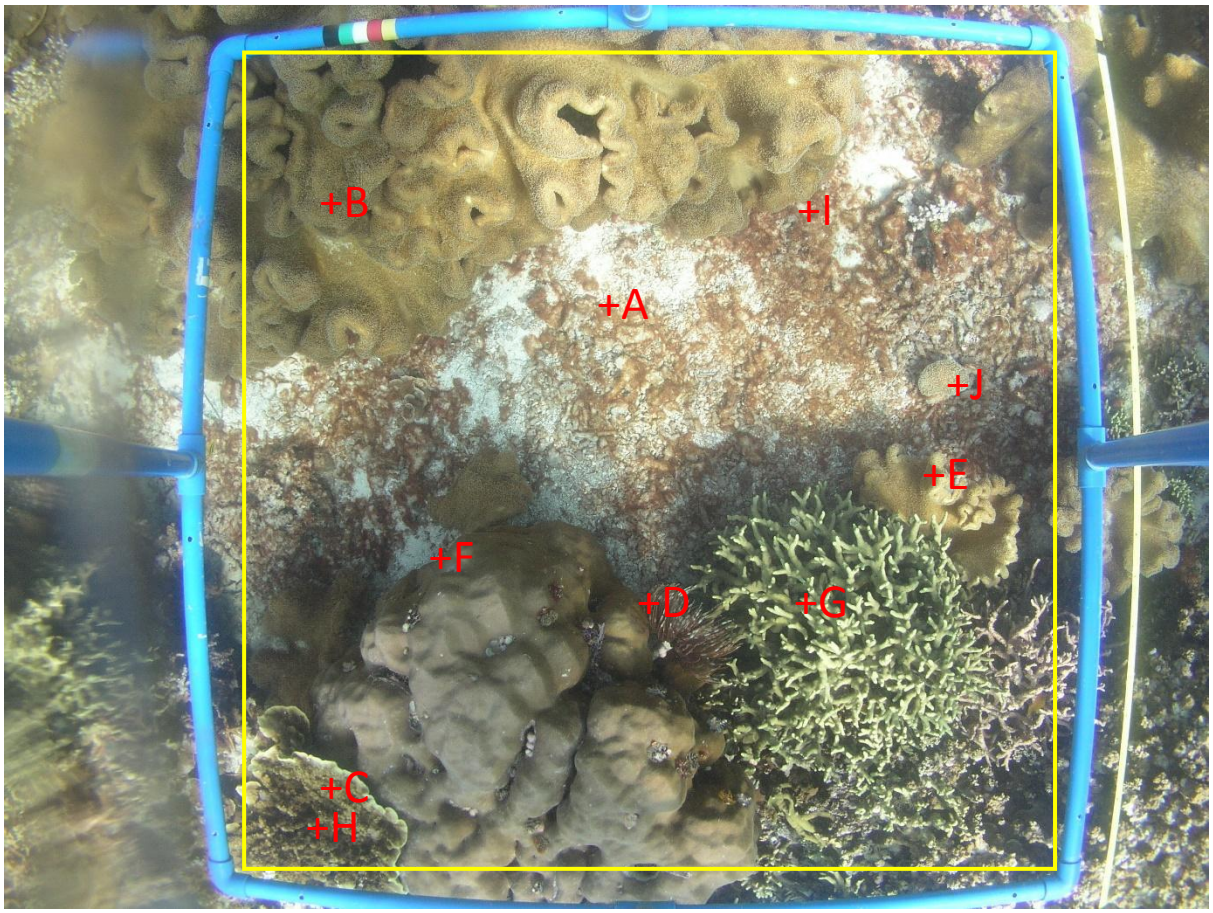


Figure 5. A sample phototransect frame superimposed with 10 points for scoring. The red "+" are marks of the points used for scoring.

The assessment and subsequent monitoring of the state of coral reefs (i.e., percentage cover, species composition and abundance) will be assessed using the phototransect method. In each of the monitoring station, two 50m transects will be laid on the reef following a uniform depth contour. Starting at the zero mark of transect, digital photographs will be taken at one meter interval using a digital still camera equipped with an underwater housing. Photographs will be obtained at a camera to substrate distance of 1.2 m.

The consistency of the camera distance to the substrate will be maintained using a stainless distance bar with a camera mounting provision. The camera is set at full wide angle to capture the largest possible area of the substrate. Photographs will be refined using the ADOBE Photoshop and will be processed using Coral Point Count with excel extension (CPCe) software. Each picture will be overlaid with ten random points (Figure 5) and the life forms intercepted in these points are sampled.

The life forms and hard coral genus intercepted by each of the points ("+") were recorded and scored. For the life form identification, the standard 28 benthic lifeform categories of English *et al*. (1997) were used. Percent cover was computed using the following equation:

$$\%\text{Cover} = \frac{\text{Total Sampled Points of Category}}{\text{Total No. of Points per transect}} \times 100$$

Coral reef status was then categorized based on live coral cover as established by Licuanan et al. (in press):

- Excellent — >44% live coral cover
- Good — 34-44% live coral cover
- Fair — 22-33% live coral cover
- Poor — 0-22% live coral cover

For the sampling sites chosen as monitoring sites, concrete blocks will be used to mark the general position of transect laid in the stations. The coordinates of the locations will be determined from a GPS and this information will be used to locate the station during the next monitoring visit the area. Monitoring shall be conducted once/twice a year.

The equipment required to conduct the Photo-transect method are listed below.

- SCUBA gears and tanks
- Transect lines (two 50 m or two 100 m lines)
- Underwater slates with pencil
- Underwater camera
- Tetrapod (specs specified below)
- GPS
- Surface marker buoys/balloons
- Laptop with Coral Point Count with Excel extensions (CPCe) software

Data processing

- Photographs shall be analyzed using the freeware Coral Point Count with Excel extensions (CPCe V3.6, Kohler and Gill 2006). A 1m x 1m area shall be manually defined within the photographs, where 10 random points were overlain.

- The benthos directly underlying each point (+) shall be identified (see Figure 5). Corals shall be identified to its lifeform category. The cover shall be determined based on the relative frequency of the benthos falling under each random point. CPCe can generate an excel file which contains details for the following:

	A	B	C	D	E	F	G	H	I	J
1	Project:					Analysis date:				
2	Dataset name:					Analysis by:				
3	Location:		Lat:	Long:						
4	File/sheetname:	C:\Users\iesm\Documents\SURVEY\TUBBATAHA APRIL 2013\USS GUARDIAN GROUNDING\								
5										
6	**TRANSECT NAME**	**T1**	**T2**	**T3**	**T4**	**T5**				
7	**Number of frames**	**29**	**35**	**22**	**28**	**19**				
8	**Total points**	**290**	**350**	**220**	**280**	**190**				
9	**Total points (minus tape+wand+shadow)**	**286**	**349**	**220**	**279**	**189**				
10	**MAJOR CATEGORY (% of transect)**							**MEAN**	**STD. DEV.**	**STD. ERROR**
11	CORAL (HC)	27.97	38.40	42.27	39.43	42.33		38.08	5.91	2.64
12	ALGAE ASSEMBLAGE (AA)	0.35	0.29	0.00	0.00	0.00		0.13	0.18	0.08
13	ABIOTIC (AB)	66.08	59.60	54.55	58.06	56.61		58.98	4.39	1.96
14	MACROALGAE (MA)	1.05	0.57	1.36	0.72	0.53		0.85	0.35	0.16
15	HALIMEDA (HA)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
16	OTHER BIOTA (OB)	4.55	1.15	1.82	1.79	0.53		1.97	1.54	0.69
17	TAPE, SHADOW, BLOCKS, IND (TWB)	1.38	0.29	0.00	0.36	0.53		0.51	0.52	0.23
18	Sum (excluding tape+shadow+wand)	100.00	100.00	100.00	100.00	100.00				
19										
20	**SUBCATEGORIES (% of transect)**							**MEAN**	**STD. DEV.**	**STD. ERROR**
21	**CORAL (HC)**									
22	Acanthastrea (ACAN)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
23	Acropora branching (ACB)	0.35	1.72	3.18	0.36	0.53		1.23	1.23	0.55
24	Acropora corymbose (ACC)	0.00	3.44	1.82	0.36	0.53		1.23	1.41	0.63
25	Acropora digitate (ACD)	0.00	0.57	0.00	0.00	0.00		0.11	0.26	0.11
26	Acropora hispidose (ACH)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
27	Acropora plate (ACT)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
28	Acropora robusta group (ACR)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
29	Astreopora (AST)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
30	Attached fungiids (AF)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
31	Bleached coral (BLEC)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
32	Caulastrea (CAU)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
33	Coeloseris (COE)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
34	Coscinarea (COS)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
35	Cyphastrea (CYP)	0.35	0.29	0.00	0.00	0.00		0.13	0.18	0.08
36	Diploastrea heliopora (DIP)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
37	Echinophyllia (ECHY)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
38	Echinopora (ECHI)	0.00	0.86	0.45	0.72	1.59		0.72	0.58	0.26
39	Euphyllia (EUP)	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
40	Favia (FAV)	1.75	0.29	1.36	0.00	1.59		1.00	0.80	0.36
41	Favites (FVI)	1.05	1.43	1.82	1.43	2.65		1.68	0.61	0.27

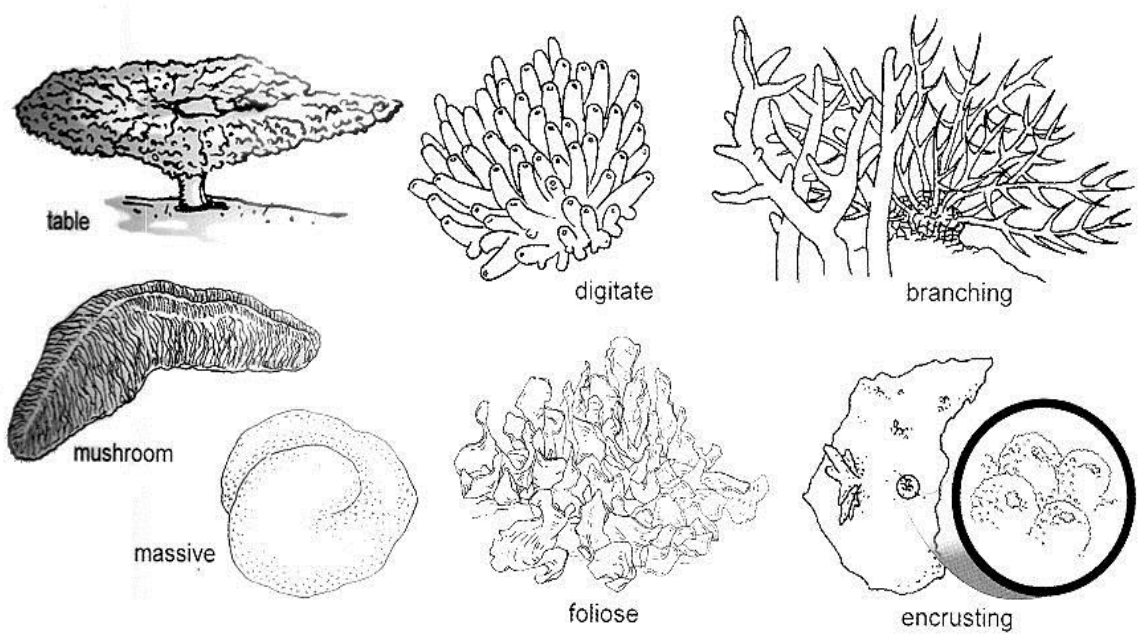
T4_imgsummary | T5_imgsummary | T1_%cover | T2_%cover | T3_%cover | T4_%cover | T5_%cov

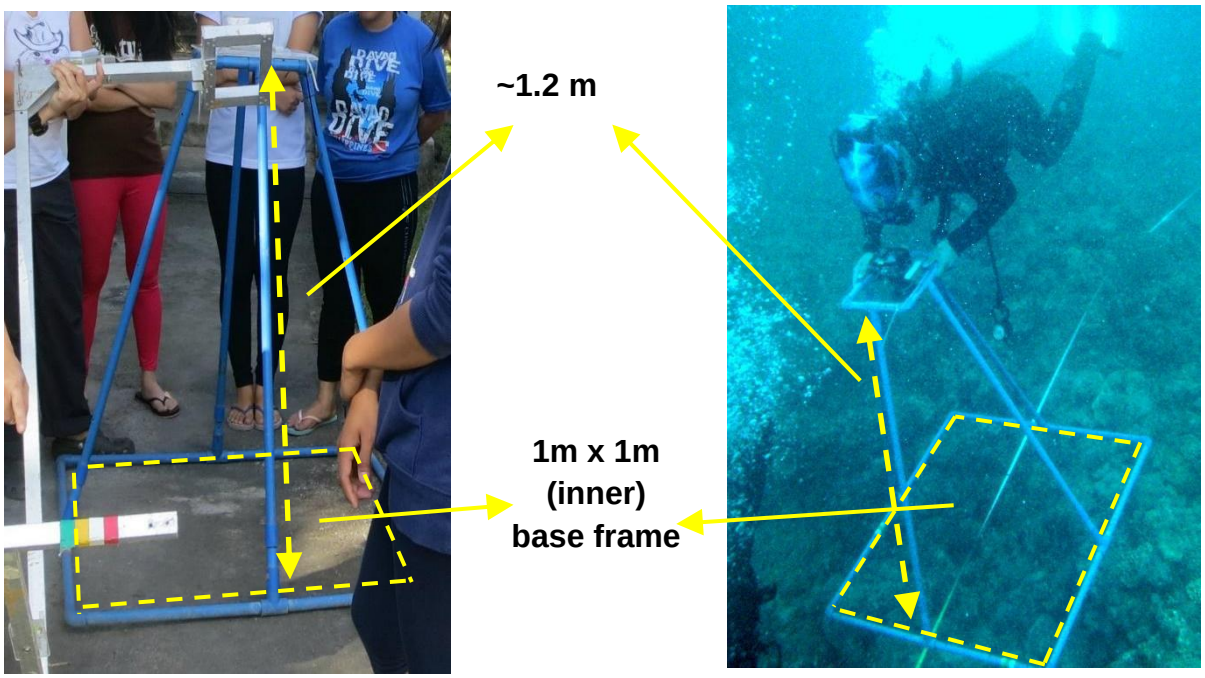
Figure 6. Sample CPCE Excel File

Corals and other benthic components shall be the identified based on the major categories (Table 3). Close up photos can be taken for coral colonies within each transect, to aid in the identification.

Table 3. Major categories of benthic lifeforms and their corresponding lifeform codes

Benthic category	Lifeform code	Benthic category	Lifeform code
Hard Coral		**Dead coral**	
Acropora		Dead coral	**DC**
Branching	**ACB**	Dead coral w algae	**DCA**
Digitate	**ACD**	**Soft Coral**	**SC**
Sub-massive	**ACS**	**Other organism**	
Tabulate	**ACT**	Sponge	**SP**
Non-Acropora		Zoanthids	**ZO**
Branching	**CB**	Other animals	**OT**
Encrusting	**CE**	**Algae**	
Foliose	**CF**	Algal assemblages	**AA**
Massive	**CM**	Coralline algae	**CA**
Sub-massive	**CS**	Halimeda	**HA**
Mellipora	**CME**	Macro-algae	**MA**
Heliopora	**CHL**	**Abiotic component**	
Mushroom	**CMR**	Rubble	**R**
		Sand	**S**
		Silt	**SI**
		Unidentified	**UNID**





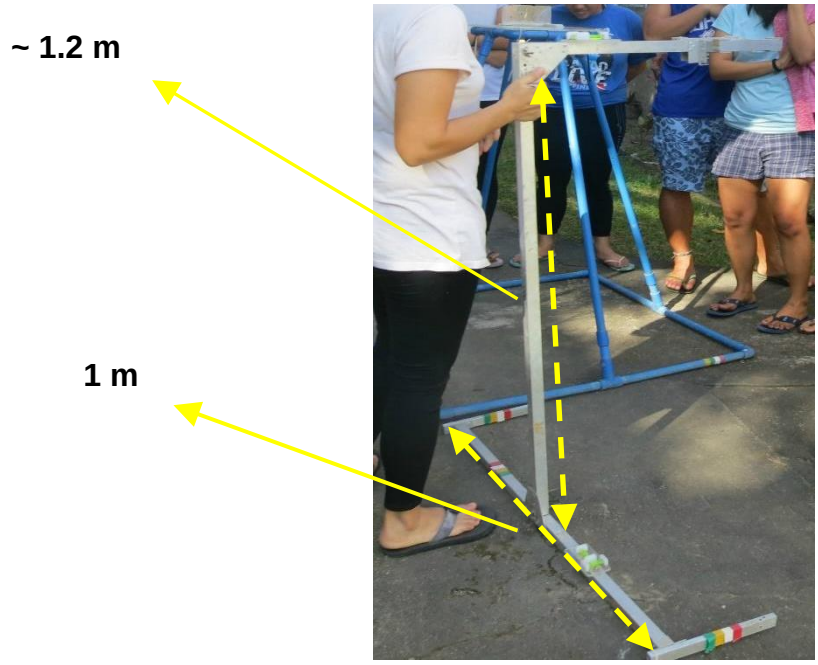


Figure 7. Upper L-R: Tetrapod specification; Down: Monopod specification

Camera specifications: At least 5mp digital camera with underwater housing (example INON type 2 wide angle lens compatible with the housing) or GoPro underwater camera

ASSOCIATED REEF FISH

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. The census starts about 20 minutes after transects are laid to provide fish time to return to natural activity. All fish encountered within 5m on left, right and above the line will be identified to lowest possible taxon level (see Figure 8) (Allen *et al*., 2003; Randall, 2005; Kuiter and Debelius, 2006), the individuals per species counted, and their total lengths estimated to the nearest centimeter. The information are recorded onto underwater writing slates (Table 4). The identification of fish may be limited to families (common names or local names) for non-technical divers, but up to species levels for competent and highly skilled observers (e.g. staff from Higher Education Institutions (HEIs). The field conduct of the FVC can be sourced to highly skilled observers whenever there is still none in the region.

These procedures follow the principles of the fish visual census technique described by English *et al*. (1997). The biomass of fish were estimated using the formula $\mathbf{W = aL^b}$ (**W** = weight in grams, **L** = length in cm, **a** and **b** = growth constants; Kulbicki *et al.*, 1993; Letourneur, 1998; Letourneur *et al.*, 1998; Gonzales *et al.*, 2000; Froese and Pauly, 2004).

The composition of the fish assemblages will also be determined by categorizing each species either as "major", "target" or "indicator species" (FishBase 2004). Major species are not the commercially important species targeted by fishers but are unique members of the fish communities and function as important trophic links of energy transfers. Target species are the commercially important fish and targeted by fishers for food. The indicator species are hard coral-associated species that may give an indication of the relative condition of the reefs (Crosby and Reese, 1996).

Monitoring shall be conducted once/twice a year depending on the resources of each region.

The equipment requirements for conducting a Fish Visual Census are the following:

- SCUBA gears and tanks
- Two 50m transect lines
- Underwater slates with pencils
- GPS
- Fish ID guides

Table 4. Suggested data format for the fish visual census

REEF FISH ASSESSMENT DATA SHEET			
Date:	4-Nov-15	**Site:**	T1
Location:	Batangas	**Depth:**	20 ft

Segment	Fish ID	Size/Count
0-5	Maya-Maya (Snapper)	15-10
	Lapu-Lapu (Grouper)	10-1
	Mameng (Wrasse)	25-2, 20-8
5-10	Molmol (Parrotfish)	12-3
	Danggit (Rabbitfish)	20-1
	Labahita (Surgeonfish)	20-1
10-15		
15-20		
20-25		
25-30….		

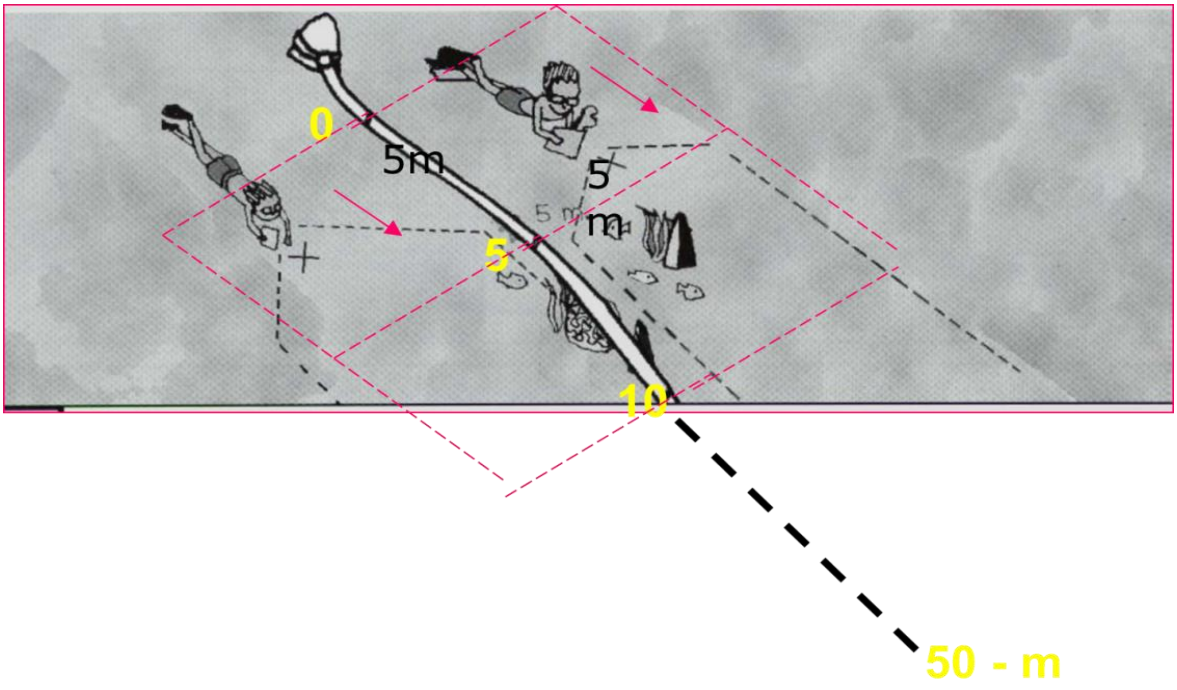


Figure 8. Illustration of fish visual census/survey

Figure 9. Sample Fish Identification Guide

Fish density computation = total count/area
Size class distribution = bar graph of frequency distributed by species or family

Fish biomass

$$W=aL^b$$

e.g. Acanthurus nigricans a=0.067; b=2.669
[*a* and *b* values from existing length – weight (gm) relationship data]

From data recorded: L= 15 cm, total count 5

$W= 0.067\ (15^{2.669})*5$
=461.352 grams

MANGROVES

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.

Unlike the terrestrial forestlands, the diversity in mangrove forest is significantly lower. However, if the associated flora and fauna are considered, the diversity of mangrove forests are among the highest. Mangroves support various animals groups such as monkeys, birds, insects, spiders, crustaceans, worms and algae.

At the chosen sampling sites for mangrove areas, two replicate transect lines are laid from the shoreline extending to the landward zone of the mangrove stand/forests. Each transect must be separated by at least 50m. Plots measuring 10m x 10m will be established along the transect line at intervals of 20 to 30 m. The number of plots per transect will be determined on the extent of the mangrove stand. All trees (growing with heights > 3m) enclosed with the 10m x 10m plot will be identified and counted and their percentage crown cover estimated. The percentage crown cover is obtained following the equation below.

$$\text{Percentage Crown Cover} = \frac{\text{total crown cover}}{\text{total area sampled}} \times 100$$

Then, within each 10m x 10m plot, a smaller 5m x 5m plot is made and all saplings (heights between 2 and 3 m) inside this are identified and counted. Similarly, within the 10m x 10m plot, a smaller 1m x 1m plot is made and all seedlings (heights < 1m) inside this smaller square is identified and counted.

The condition of the mangrove area is then assessed following the mangrove habitat criteria developed during a Participatory Coastal Resource Assessment in a Coastal Resource Management Project (PCRA-CRMP). A set of criteria is shown in Table 5.

Table 5. Criteria used to assess the condition of mangrove stands developed from a Participatory Coastal Resource Assessment during a Coastal Resource Management Project in Ragay Gulf.

Condition	**Criteria**
Excellent	- 76% and above in % of crown cover - 10 or more regeneration per sq.m. (Number of seedlings m^{-2}) - Average height of trees above 5m - Undisturbed to negligible disturbance
Good	- 51-75% crown cover - 7 to 10 regeneration per sq.m. (Number of seedlings m^{-2}) - Average height of trees is between 3 and 5 m - Slight disturbance and few cuttings

Fair	- 26-50% crown cover - 5 to 6 regeneration per sq.m. (Number of seedlings m^{-2}) - Average height of trees is between 2 and 3 m - moderate disturbance and noticeable cuttings
Poor	- 0 – 25 % crown cover - < 5 regeneration per sq. m. (Number of seedlings m^{-2}) - Average height of trees less than 2 m - heavy disturbance/cuttings/pollution, rampant conversion to other uses, nearly disturbed

Source: PCRA-CRMP

The equipment needed for the mangrove survey includes:

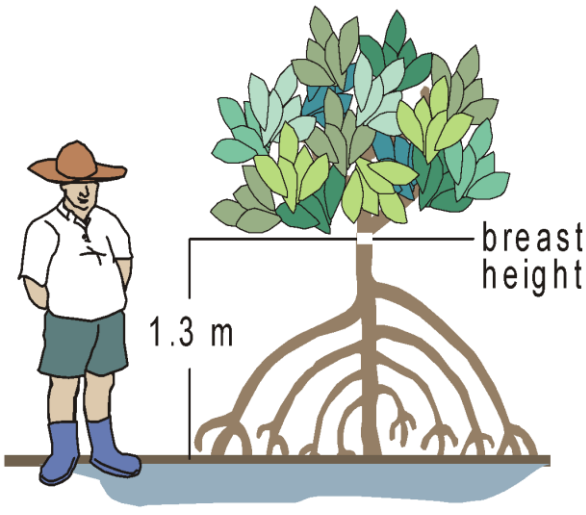
- 100m transect lines
- GPS
- Camera
- Data sheets
- Pencils
- Field guides

Annotation of the Survey Method

- 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. The observed flowering and fruiting of the individual trees as well as other tree disturbance should be noted on the remarks column.



- Other observations within the vicinity of each mangrove station shall also be noted.

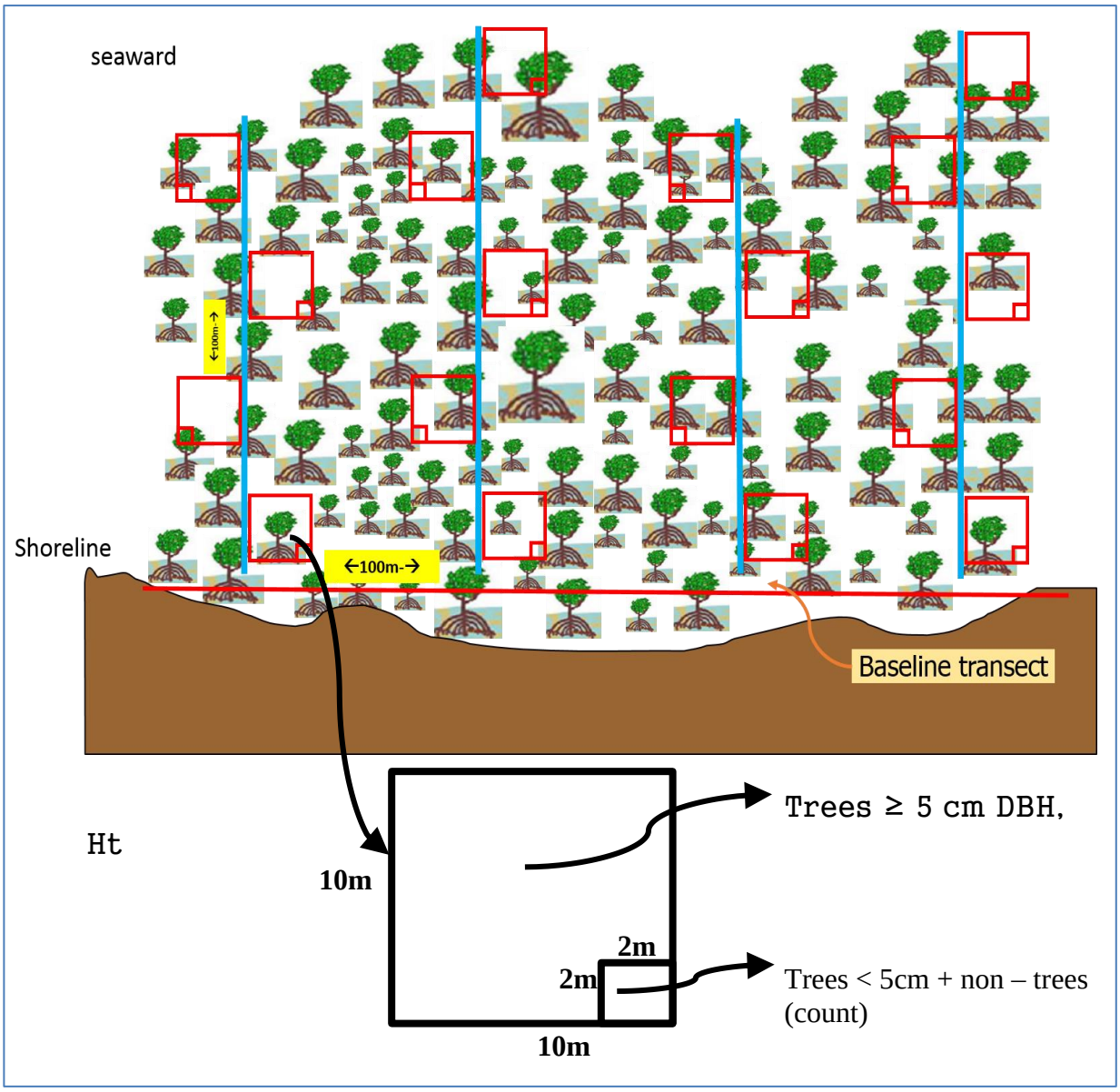


Figure 10. Illustration of belt transect method for mangroves

Table 6. Sample Mangrove assessment data sheet

MANGROVE ASSESSMENT DATA SHEET

Location:	_____	**Date:** _____			**Time:** _____
Plot No.: _____	**Quadrat No.** ____	**Coordinates:** **N** **E**		**Observer (s):**	
	Transect No. ____	**Elevation:** _____**masl**		**Vegetation Type:**	
		GPS unit:		**Weather:**	
No.	**Species**	**DBH (cm)**	**TH (m)**	**MH (m)**	**Remarks**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

DBH: diameter at breast height

TH: Total height (from base to crown)

Data Analysis

Tabulate and analyze all information gathered in the field to characterize the mangrove area (Table 6). Determine the relative density, relative abundance and relative frequency values for each species to obtain their Importance Value (IV). Importance values will be determined using the following formula:

Density = Number of individuals / Area sampled

Relative Density = Density for a species x 100 / Total density for all species

Frequency = Number of plots where species occur / Total number of plots samples

Relative Frequency = Species frequency value x 100
Total frequency for all species

Dominance = Basal area or volume for a species
Area sampled

Relative Dominance = Species dominance x 100
Total dominance for all species

Importance Value = Relative Density + Relative Frequency + Relative Dominance

Diversity Indices

Generate diversity indices (Shannon, Simpson's and Evenness index) using biodiversity software (such as MVSP, BioPro, Diversity, etc.) with the data on the number of species and abundance for each sampling quadrat. Shannon Index gives an estimate of species richness and distribution. Evenness Index tells us how evenly species and/or individuals are distributed inside a plot or quadrat. Simpson's Index gives the probability of getting different species when two individuals were drawn (with replacement) inside a plot.

SEAGRASS BEDS

The equipment needed to conduct seagrass survey are as follows:

- Three 50 m transect lines
- Pegs
- GPS
- Quadrats
- Underwater camera
- Plastic slates
- Pencils
- Rulers
- Field guides (seagrass identification sheet, percent cover standard sheet)
- Quadrat photo labeler

Quick Guide to Survey Method

- For the purpose of this Technical Bulletin, fixed transect site is recommended. It must be noted, however, that this can only be used for monitoring intertidal seagrass meadows (or subtidal meadows with the use of SCUBA).

- Three 50 m transect lines, separated by a 25 m distance in between shall be laid parallel to each other. Transect lines should be laid perpendicular to the shore, from the shallow intertidal zone to a depth until where seagrass is present. Start and end of the transect tapes should be marked using a GPS. Pegs can be used to hold transects in place until all sampling has been completed.

- A 0.5 m by 0.5 m quadrat shall be laid starting from the 0-m mark on the right side of each transect at 5 m interval. Data recorder should always walk on the left side of transect to avoid any sediment disturbance on the quadrats to be measured.

- Photograph of the quadrat will be taken at 5-, 25-, and 45-m or on quadrats of particular interest (e.g. dugong trail, high algal abundance, lots of gastropods, etc.). Photos should be taken BEFORE any measurements are taken to avoid sediment disturbance. Labels (code for locality, site number, transect, and quadrat) on each quadrat is highly recommended. Photo should be taken at a vertical angle as much as possible.

- Describe sediment composition:

    - *mud* - has a smooth and sticky texture. Grain size is less than 63 µm
    - *fine sand* - fairly smooth texture with some roughness just detectable. Not sticky in nature. Grain size greater than 63 µm and less than 0.25mm
    - *sand* - rough grainy texture, particles clearly distinguishable. Grain size greater than 0.25mm and less than 0.5mm
    - *coarse sand* - coarse texture, particles loose. Grain size greater than 0.5mm and less than 1mm
    - *gravel* - very coarse texture, with some small stones. Grain size is greater than 1mm.

- The seagrass species shall be identified (see seagrass ID guide) and the percent cover per species shall be estimated (Figure 11). Readings will be at every 5-m starting from 0-m up to 50-m. Seagrass composition must equal to 100% of the seagrass present in the quadrat regardless of the total cover.

- Using a ruler, the canopy height shall also be determined by haphazardly selecting 3-5 leaf blades from within the quadrat, ignoring the tallest 20% of leaves.

- Determine percent cover of epiphytes. Epiphytes are the algae that grow attached on the seagrass blades. To determine the percent cover of epiphytes, estimate the percentage of the total surface area of leaves covered by the algae.

- Percentage of non-epiphytic algae will also be measured using the same technique used for estimating seagrass cover.

- Other organisms (e.g. invertebrates, turtle or dugong grazing trails, etc.) in the quadrats shall also be recorded.

- The data gathered shall be encoded in the seagrass monitoring data sheet (Table 7).

Table 7. Sample seagrass monitoring data sheet

SEAGRASS MONITORING DATA SHEET

Observer:
Location: Date:
Site: Transect No.:

Start Time:
Start of Transect:

Quadrat	Sediment	Comments	Photo	% Seagrass Cover	% Seagrass Species Composition					Canopy Height (cm)	%Algae Cover	% Epiphyte Cover
1 (0 m)												
2 (5 m)												
3 (10m)												
4 (15m)												
5 (20m)												
6 (25m)												
7 (30m)												
8 (35m)												
9 (40m)												
10(45m)												
11(50m)												

End Time
End of Transect

Quadrat	Sediment	Comments	Photo	% Seagrass Cover	% Seagrass Species Composition					Canopy Height (cm)	% Algae Cover	% Epiphyte Cover
					Th	Cr	Cs	Ho	Hp			
1 (0 m)	Sandy-muddy	3-sea star		95	100	0	0	0	0	5,6,7	1	94
2 (5 m)	Sandy-muddy	0	x	75	0	60	0	0	40	8,7,6	0	98
3 (10 m)	Sandy-muddy	5-sea star		90	0	100	0	0	0	8,7,6	0	70
4 (15 m)	Sandy-muddy	2- sea star		85	0	100	0	0	0	8,7,9	0	30
5 (20 m)	Sandy-muddy	0		85	45	55	0	0	0	6,5,4	0	9
6 (25 m)	Sand-silt	Forams	x	20	0	80	0	5	15	10,7,9	0	40
7 (30 m)	Sand-silt			60	85	5	8	2	0	5,6,5	0	70
8 (35 m)	Sand-silt	Foram, 1-sea star		80	0	75	0	0	25	10,8,7	0	30
9 (40 m)	Sand-silt	1-cucumber, 1-shell		15	57	40	0	0	3	5,4,5	0	70
10 (45 m)	Sand-silt	Forams	x	60	70	30	0	0	0	4,3,5	0	70
11 (50 m)	Sand-silt	Forams		80	0	100	0	0	0	15,13,15	0	60

SUM	745	357	645	8	7	83		1	641
AVE	67.73	32.45	58.64	0.73	0.64	7.55		0.09	58.27

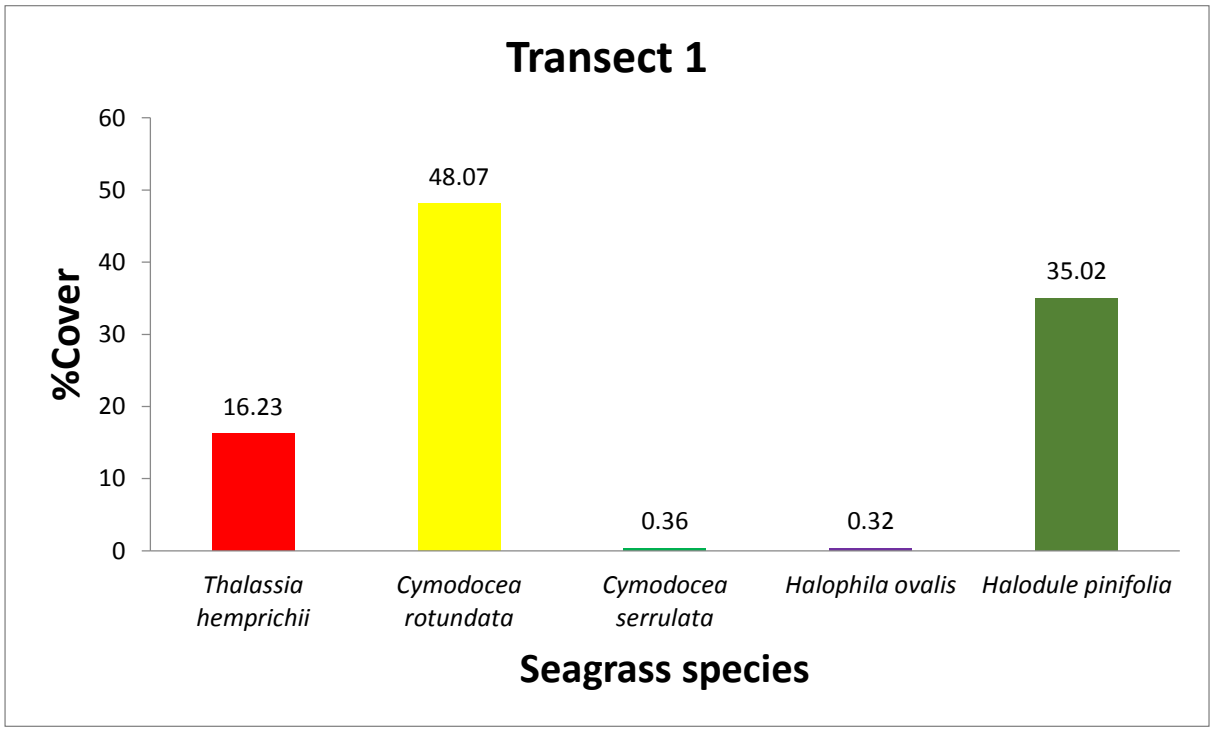


Figure 11. Sample Computations and Graph

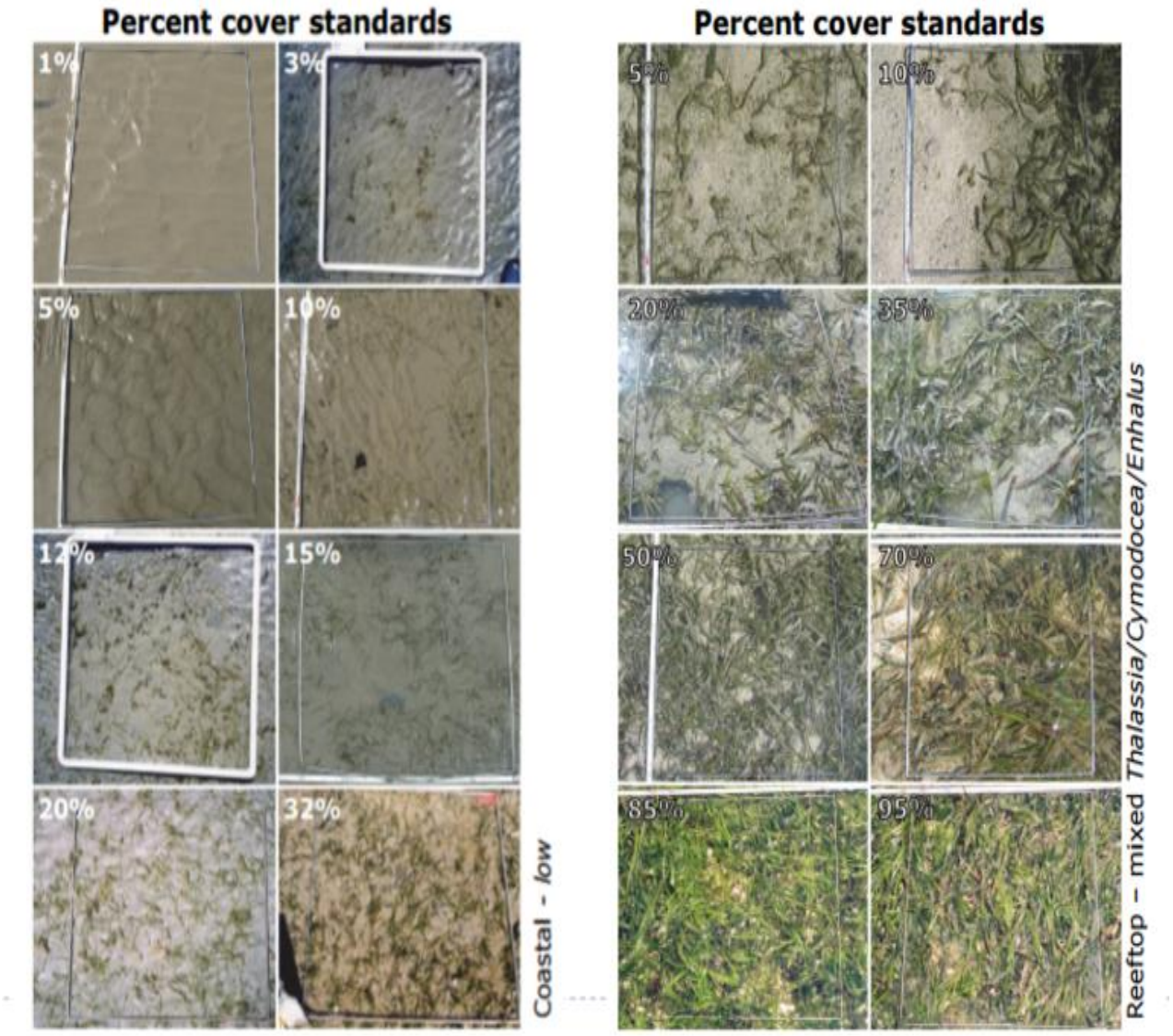


Figure 12. Illustration of Percent cover standards for seagrass

MUDFLATS/SOFTBOTTOM

Duplicate sediment samples are collected from each of the sampling sites. Each sample is collected using core boring sampler with an area of 78.5 cm^2 (see Figure 13) and inserted up to 30 cm into the mud. The volume of sediment sample obtained as this depth is about 2.4 liters.

Sampling sites should represent the three main zone/fringes of the softbottom habitat: supralittoral, midlittoral and infralittoral (Figure 12). These are where the core samples will be collected. The coordinates of the location where each sample was collected will also be recorded. Sediments collected using a core sampler (Figure 13) inserted to depths of 30 cm are sieved using a 0.5 mm mesh immediately after collection. All soft bottom fauna retained on the sieve are stored in a properly labeled plastic containers for analysis. All samples are stained with Rose Bengal and fixed in 10% buffered seawater formalin.

In the laboratory, samples are cleaned with tap water to get rid of excess formalin and sorted using a stereo microscope. All soft bottom fauna are identified to the lowest possible taxa (usually family level) and stored in vials containing 70% alcohol. Density is expressed as number of individuals m^{-2}. The identification can be sourced to local experts whenever there is no complement staff available within the region.

The list of equipment needed in the conduct of survey for softbottom/mudflats are the following:

- PVC Core Sampler (Figure 13)
- Waterproof slates with attached pencils
- Hand trowel
- Forceps
- Labels
- Sampling Bags
- Data Forms
- Guide Book/Field Manual for ID of macro-invertebrates
- Sieves
- Bucket/Ladle

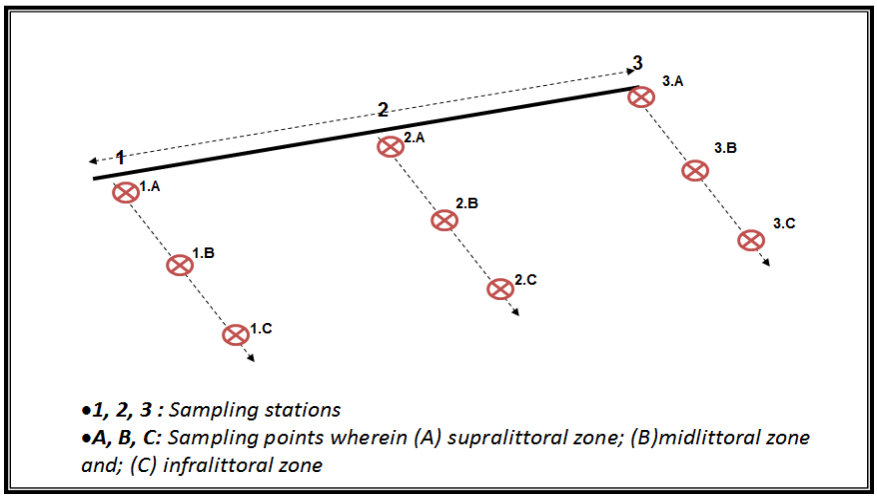


Figure 13. Macrobenthic collection sampling stations

Sample collection

- Collect sediment sample using a handheld core sampler (Figure 13).
- Each core shall be taken to a depth of 30 cm
- Carefully place each sediment sample in a bucket and mix it with some water. Do not spill any of the sample
- Avoid breakage of fragile mollusk and worms as you transfer each core sample to a bucket

Figure 14. Core sampler constructed from 60cm long PVC Pipe with 10cm diameter; Illustration of sample collection

Sieving

- Carefully mix water with the sediment in the bucket
- Pour the sediment-water emulsion over the sieve (1mm mesh size)
- Repeat this process until all sediments from your core sample has passed through the sieve
- Hand sort the visible macro-invertebrates
- Plastic bag and label each sample – indicate location (barangay), sampling station and core #

Figure 15. Process of sieving softbottom sediments

Sorting and Recording

- After transporting your bagged samples carefully into your laboratory, you may now start grouping your macro-invertebrates into categories
- Identify each specimen in your sample using field guides or manuals. Consider only specimens that are visibly identifiable (i.e. 1.0-2.0 cm in size)
- Separate identified specimens into groups of similar type (bivalves, gastropods, worms, crustaceans, etc.)
- Count and tally each species carefully under each group – this will be for the abundance and species diversity estimates (Table 8).

Figure 16. Process of sorting and recording softbottom specimens

Data Processing

- Before processing data, review the output data that we need to generate for our assessment. The values under the Quantity and Density corresponding for each group (e.g. bivalves, Gastropods) are simply totals of every species identified under each group.

Table 8. Softbottom Habitat Assessment Datasheet

SOFTBOTTOM HABITAT ASSESSMENT DATA SUMMARY FORM

Site Name: Municipality and Province:
Date:

Kind	**Quantity** (Average no. organisms for the three sampling point)	**Density** (no. of organisms per cubic meter)	**Relative Density** (% density)	**Species Richness** (Number of species found)	**Biodiversity Index** (Simpson's Index)	**Biodiversity Index** (Simpson's Reciprocal Index)
Gastropods (e.g. snails)	71.01	10050.96	53.93%	20	0.26797	3.71
Bivalves (e.g tahong, halaan)	52.33	7406.94	39.74%	56		
Crustaceans (shrimps, barnacles, crabs, etc.)	1	141.54	0.75%	0		
Oligochaetes/ Polychaetes	6.33	895.97	4.81%	6		
Other organisms	1	141.54	0.76%	0		
Total	**131.67**	**18636.94**	**100%**	**82**		

i. Quantity: Average number of organisms
   - To derive the quantity, simply average the totals of the three (3) replicates.

$$Ave\ \#Sp1 = \frac{Total\ \#\ of\ Sp.1\ in\ replicates\ a + b + c}{3}$$

ii. Density: Mean abundance per unit volume
   - Density is a measure of number of organisms divided by volume of corer

$$Density = \frac{Ave.no\ of\ individual\ per\ kind}{Total\ volume\ of\ corer\ (size\ of\ the\ corer)}$$

iii. Relative Density
   - Relative Density is useful in assessing which invertebrate group dominates an area. Dominant group are likely indicative of environmental condition of an area.

Relative density is computed in relation to the total density.

$$Relative\ Density\ = \frac{Density\ of\ Sp.1}{Total\ Density}$$

iv. Species Richness

- Species Richness is the number of species per sampling area.

$$Species\ Richness = individual\ count\ per\ species$$

v. Biodiversity Index (Based on count per species)

- Biodiversity indicates the health and complexity of a habitat. It is expressed by Biodiversity Index.

- Simpson's Index: A community dominated by one or two species is considered to be less diverse than one in which several different species have a similar abundance. As species richness and evenness increase, so diversity increases. Simpson's Diversity Index is a measure of diversity which takes into account both richness and evenness. With this index, 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity

- Simpson's Reciprocal Index: The higher the value, the greater the diversity. The maximum value is the number of species in the sample. The Biodiversity is computed the Simpson's Reciprocal Index.

$$Simpson's\ \ Index\ (D)\ = \frac{\sum\ \ \ \ n(n-1)}{N(N-1)}$$

$$Simpson's\ Reciprocal\ Index\ = \frac{1}{D}$$

PLANKTON

At each sampling site for plankton, samples of plankton communities are collected using a plankton net with a mesh size of 60 and a mouth diameter of 0.3 m (Figure 16). The plankton net is lowered to a depth of about 10-15 m depending on light penetration (Sechi disk depth) and raise at a rate of not higher than 1 m per second. The volume of water sampled is calculated by the area of the mouth of the plankton net times twice the depth the net was lowered.

The concentrated sample of water collected at the cod end is then transferred to a properly labeled vial. Phytoplankton samples are preserved with Lugols solution while samples of zooplankton are fixed with 10% formalin immediately after collection. All samples will be allowed to stand undisturbed for about a week to allow organisms to settle at the bottom of the container. Excess liquid will be carefully decanted until about 50 ml was left. For phytoplankton samples, a 1 ml aliquot subsample is placed in a Sedgewick-Rafter cell counter and was examined under a microscope. For zooplankton samples, a 1 ml aliquot subsample is placed in a petri dish with grids and was examined under a microscope. Plankton organisms are identified to the genus level whenever possible and their numbers counted. For this technical bulletin, we are limited to sample collection only. Plankton will be sampled using standard plankton net procedures. Samples shall be submitted to laboratory/academe to test for Chlorophyll A and community structure analysis.

The formula, $\phi_p = F$ $^{-1}$, is used to estimate density of phytoplankton where ϕ_p is the density of phytoplankton, F the number of cells counted and the total volume of water filtered in m^3. The formula, $\phi_z = C*A^{-1}*D*$ $^{-1}$, is used to estimate density of zooplankton, where ϕ_z is the density of zooplankton, C the number of organisms counted in the subsample, A the volume of the subsample in ml, and D the dilution volume in ml. All densities are expressed as number of plankton individual m^{-3}.

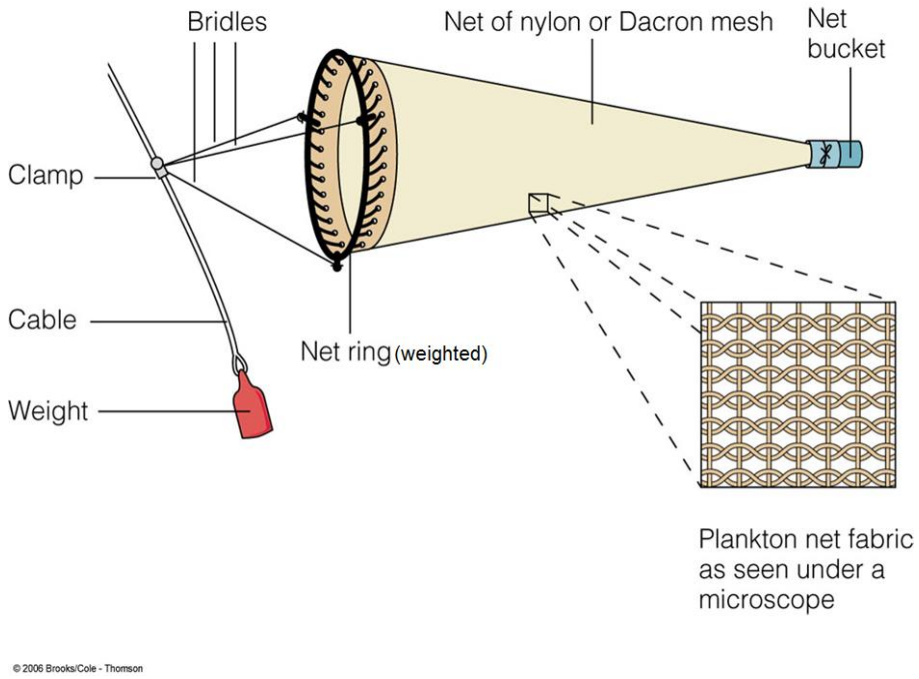
Samples may be collected from the area where coral reef assessment and monitoring was conducted. Monitoring shall be conducted once/twice a year.

The list of equipment for the survey of plankton include the following:

- Boat
- Plankton net
- Sampling bottles (clear) and labelling materials
- Buffered formalin solution (10%)
- Dipper

Quick Guide to Sample Collection

- The depth of the sampling area should exceed 10 m and the recommended time of sampling is between 10 am to 2pm.
- Lower the plankton net at a speed not to exceed 1m/second until it reaches the 10m marker
- Wait for about 30 seconds to allow the plankton net to settle
- Pull the rope at 1m/second
- Wash the outer sides of the net with sea water, but be careful not to allow water to enter the mouth of the plankton net
- Wait until all water has drained from the sides of the net to the net bucket
- Transfer the plankton concentrate in the net bucket to a labelled plastic bottle, then add buffered formalin solution
- Submit samples to the laboratory for Chlorophyll A test/analysis and community structure analysis



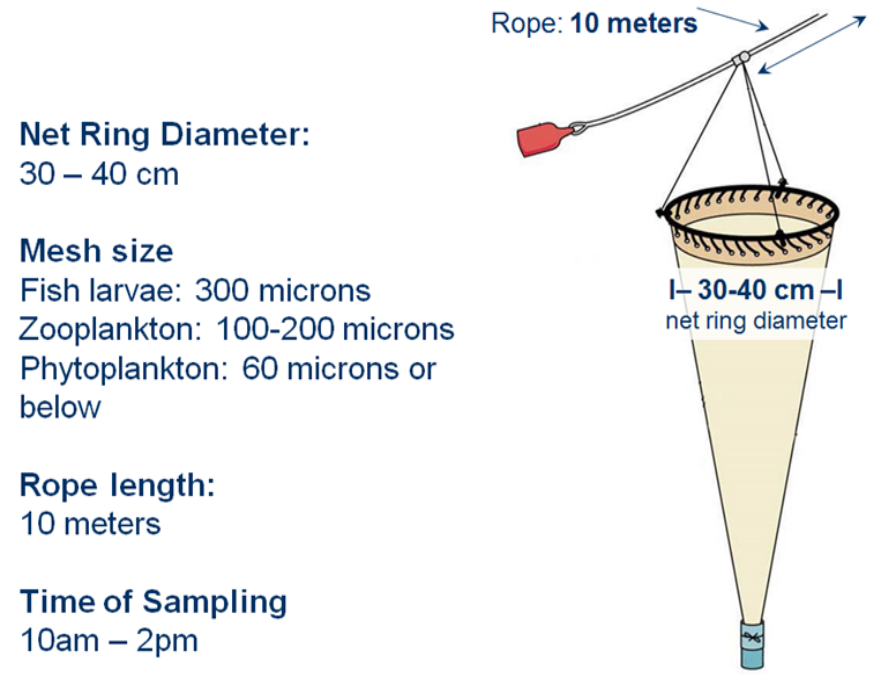


Figure 17. Plankton net specification

MARINE CRYPTOBIOTA

Marine Cryptobiota refers to small marine invertebrates living hidden in the crevices of the reefs. They support a wide range of functions such as: serving as building blocks of the reefs; supporting various levels of the food chain/web; potential source of chemical/medicinal compounds; indicator of reef health; and research (i.e. discovery of new species).

The assessment of marine cryptobiota will be carried using the Autonomous Reef Monitoring Structures (ARMS) in designated sites in the country. ARMS are specialized underwater monitoring unit used globally to monitor marine cryptobiota and the impacts of climate change, particularly ocean warming and ocean acidification. It is preferable that the sites are within a protected area and the number is limited and not as many as those earlier suggested for the other coastal and marine ecosystems. The units are deployed at the forereef habitat at depths of around 10-15 meters. The ARMS units will be soaked for at least 2 years before they are retrieved. Some of the ARMS units soaked for demonstration purposes will be retrieved annually during the Month of the Ocean to educate students on the diversity of organisms building the reefs and explain the importance and benefits people derive from the ecosystem. The number of sites where the ARMS will be deployed will be determined later.

However, for the purposes of this Technical Bulletin, only the deployment of ARMS will be discussed. Other instrumentation devices and methodologies are needed to link with climate change and ocean acidification.

A. Equipment

- Autonomous Reef Monitoring Structures *(Figure 17; see attached ARMS assembly materials and specifications)*
- Stainless steel "peg", threaded
- Sledgehammer/Mallet
- Zip ties
- SCUBA Diving gears
- GPS
- Underwater camera

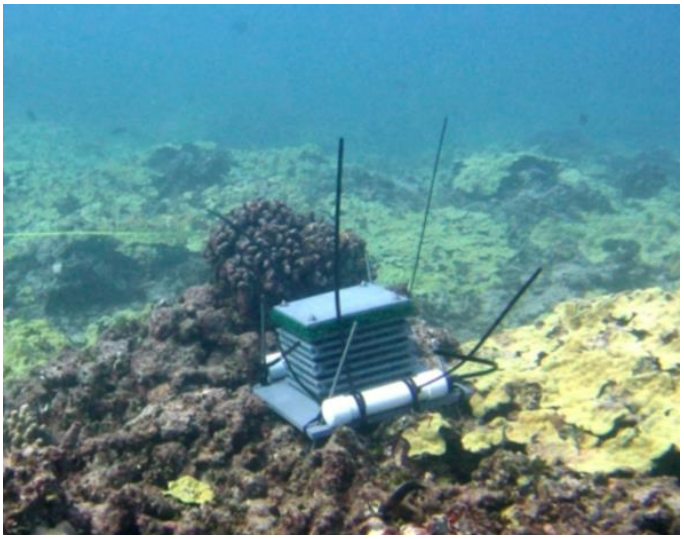


Figure 18. Autonomous Reef Monitoring Structure (ARMS)

B. Deployment

- Initial survey for site selection can be done prior the deployment. Once site has been selected, its location should be marked using a GPS.

- To deploy, 2-3 divers will lower the sampling unit to the pre-identified area. The unit will be installed in a rubble or bare patch so as to minimize collateral damage to the reef area.

- Install the unit by driving the stainless pegs through each corner of the sampling unit to the substrate. If possible, stakes should be installed perpendicular to the substrate to facilitate ARMS removal at a later date by simply lifting it vertically off the stakes. In case it would not be possible to achieve a perpendicular orientation of the stakes, just be sure to hammer in the stakes to at least half of their length in whatever orientation allows this. Stability of the ARMS base plate is ultimately more important than stake orientation.

- Once the stakes are driven into the substrate through the holes in the base plate, use the 36" heavy duty zip ties to secure the base plate to the stakes. Thread a zip tie through a corner of the base plate and take multiple wraps around the stake before securing. Repeat for the remaining corners. A correctly installed ARMS unit should feel securely attached to the substrate with very little play (lateral or vertical) when manipulated by the diver.

- If for some reason the stakes cannot be installed through the corner holes of the base plate, they may be installed through the handles at opposing angles (crossed). Similarly, use the 36" heavy duty zip ties to secure the base plate to the stakes.

- Document the site with photos of the surrounding habitat as well as the deployed sampling unit.

- Three units will be deployed per site (i.e. per MPA) at a considerable distance from each other (approximately 2-5 meters as topography allows). The units will be soaked underwater for two (2) years and will be recovered after.

C. Sample and Data Processing

- In preparation for the ARMS retrieval and data processing after two (2) years, the regional/field offices and partner local academic institutions will be capacitated on field identification and classification of invertebrates.

- A separate technical bulletin on ARMS retrieval, field identification/classification of invertebrates, processing of samples, and re-deployment for monitoring purposes, will subsequently be issued.

D. Monitoring

- The regional/field staff, together with the LGUs, community, and the Bantay Dagat, shall monitor the deployed ARMS from time to time (i.e. monthly to prevent chances of being stolen). They may remove some overgrowth algae on the surface or surrounding the unit, while making sure that the other attached organisms are not displaced or removed.

REFERENCES

Coral Reef Visualization and Assessment (CoRVA) Habitat Assessment Training Manual

Deguit, E.T., R.P. Smith, W.P. Jatulan and A.T. White. 2004. **Participatory coastal resource assessment training guide**. Coastal Resource Management Project of the Department of Environment and Natural Resources, Cebu City, Philippines 134p.

Green R.H. 1979. **Sampling design and statistical methods for environmental biologists**. John Wiley and Sons. N.Y. 257 pp.

Protected Area Management Enhancement (PAME) Habitat Assessment Training Manual

Seagrass Watch

United States-National Oceanic and Atmospheric Administration (US NOAA)

ANNEX 1.

Please refer go to this link to access the coastal and marine-related reference materials below:
https://drive.google.com/drive/folders/0B0Vs1XsA7RVGUERjVVlNaGlLaFE

1. Survey and Mapping (presentation)

2. Sampling Protocol (presentation)

3. Coral Reefs
   - Benthic Lifeforms guide
   - Benthic Survey Methods (presentation)
   - CPCe software and instruction manual

4. Reef Fish
   - Reef Fish Identification and data processing (presentation)
   - Fish Visual Census (presentation)
   - Reef Fish Identification Manual
   - Sample reef fish data

5. Mangroves
   - Mangrove Field Guide
   - Mangrove Assessment Method (presentation)

6. Seagrass beds
   - Seagrass Identification Guide and assessment method (presentation)

7. Softbottom/Mudflats
   - Softbottom Assessment Method (presentation)

8. Plankton
   - Plankton Community Assessment (presentation)

9. Marine Cryptobiota
   - Marine Cryptobiota and ARMS (presentation)
   - ARMS assembly materials and specifications