HOW-TO GUIDELINE

Capacity Development in the Assessment and Monitoring of Marine Biological Diversity

Biodiversity Management Bureau
Republic of the Philippines
Department of Environment and Natural Resources

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

WorldFish

Coastal and Marine Biodiversity Assessment and Monitoring

A How-to Guideline

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September 2016

This document is developed as part of the GIZ-PAME funded project entitled "Capacity Development in the Assessment and Monitoring of Marine Biological Diversity."

Foreword

The Department of Environment and Natural Resources (DENR) partnered with the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety to launch the Protected Area Management Enhancement (PAME) Project in 2012. PAME is a five-year (2012-2017) project that aims to significantly improve the protection and management of Key Biodiversity Areas (KBAs) in the Philippines including interventions in existing and future protected areas. It is jointly implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and DENR's Biodiversity Management Bureau (BMB) in cooperation with DENR's Forest Management Bureau (FMB). The Project is duly guided by the training needs identified by the DENR regional staff particularly in the technical capacity on bio-physical assessment and monitoring including wildlife and coastal resources taxonomic identification and mapping.

In April 2015, GIZ-PAME commissioned WorldFish to lead the conduct of the ***"Capacity Development in the Assessment and Monitoring of Marine Biological Diversity"***, which seeks to improve the protection and management of key biodiversity areas in the Philippines, particularly in enhancing the management of 60 existing protected areas (PAs) and establishment and implementation of at least 100 new terrestrial and marine protected areas.

The activity specifically aims to improve the management and technical capacity of the DENR protected area and wildlife personnel, key local government unit (LGU) staff, the academe, and the local community and strengthen cooperation among various partners and relevant civil society organizations involved in conservation efforts. Key anticipated outputs of the project include: 1) recommendations for a simple, affordable and sustainable national biodiversity monitoring system; 2) course outline and training modules that will be used in other key biodiversity areas; 3) training workshop report and data summaries from two sites; and 4) national biodiversity trends synthesis with a review of the national biodiversity baseline and trend data. Among the major outputs of the project is the development of a training module intended for the use of DENR regional teams in the conduct of coastal and marine biodiversity assessment and monitoring activities.

To sustain the outcomes of the capacity development initiatives of the PAME project, it was decided that an assessment and monitoring system consistent across regions of the country be institutionalized by releasing a technical memo to all DENR regional offices. This how-to guideline for coastal and marine biodiversity assessment and monitoring was developed based on the training module developed by team of experts engaged by WorldFish to serve as an attachment to the technical memo for facilitating easier and better compliance.

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Introduction

The Philippines has been known for its rich coastal and marine biodiversity, however years of unguided and unmanaged use of the country's natural resources has led to the decline of valuable biological richness (CI et al. n.d.). A healthy biodiversity is important as it offers many natural and economic services such as protection of coastal areas and provision of food and livelihood, thus its depletion is far from being insignificant and irrelevant and must be addressed.

To address decline in biodiversity, there is a need to counteract its causes. The primary threats for many species are habitat destruction and ecosystem changes (CI et al. n.d.). Monitoring will help detect changes that significantly impact biodiversity and provide scientific basis for designing interventions to address causes of biodiversity loss.

The Biodiversity Monitoring System (BMS) was developed by NORDECO and DENR in 2001 to serve as a starting point for monitoring that is aimed towards ensuring that no major change the biodiversity of a protected area can go undetected. The developers however envisioned this document to further be developed with the operationalization of biodiversity monitoring in more areas in the country and with additional resources made available. These developments are now being pursued with the leadership of DENR.

Figure 1 provides an illustration of the amended coastal and marine biodiversity assessment and monitoring process overview. This process recognizes that monitoring of coastal and marine biodiversity concerns not only DENR but also other agencies and groups, particularly the academe, local government units (LGUs) and community members, and other government agencies particularly the Bureau of Fisheries and Aquatic Resources (BFAR) thus a planning and levelling off meeting is needed to establish an effective inter-agency approach. Each agency is to take an active role in the monitoring process, however, in consideration of resources, mandate, and capacity constraints, the design of this monitoring process have different expectations on the frequency of conduct of the different methods and the outputs of monitoring from each agency. These differences are described under the next sections of this guideline detailing the different methodologies and tools to be employed in the assessment and monitoring of coastal and marine biodiversity.

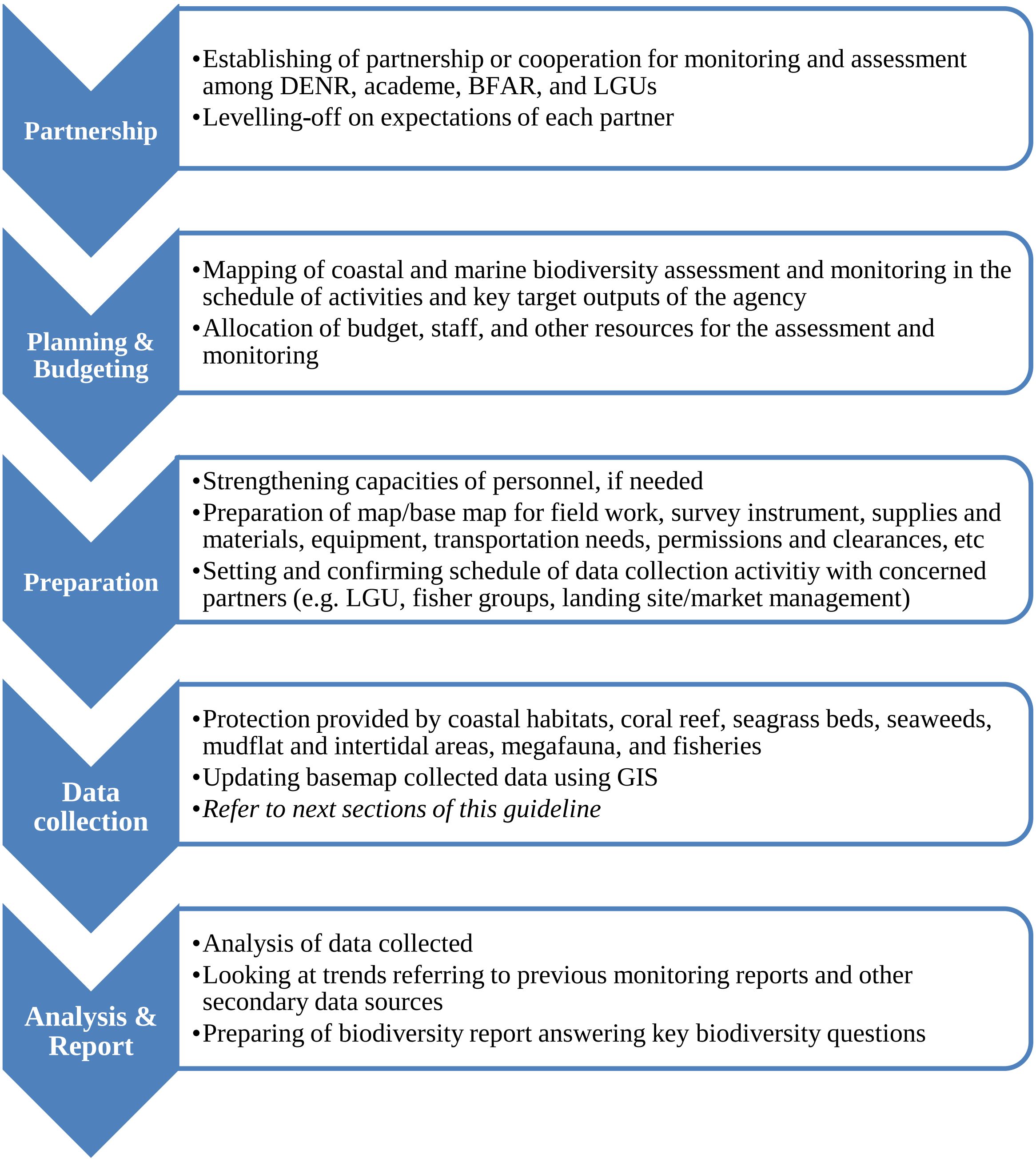


Figure 1. Overview of amended coastal and marine biodiversity monitoring process.

The process includes more methods and tools that those in the BMS, which entails more time and resources needed. Thus mapping coastal and marine biodiversity monitoring among the key activities of participating agencies, especially that of DENR, and allocating budget for it is a must.

In making logistical arrangements and budgeting for coastal and marine biodiversity monitoring, the following must be considered:

1. Number of persons needed and required capacities for conducting assessment and monitoring
2. Health and safety of personnel (i.e. access to health facilities, personal accident and life insurances)

3. Number and specification of transportation/vehicle to be procured or rented for transporting personnel and equipment as well as for actual data collection activity (i.e. boats, vans, pick-up, etc.)
4. Need for accommodation depending on distance of monitoring site to base of monitoring team
5. Appropriate gear (e.g. scuba and snorkeling gear) and equipment, and software for data collection and analysis and report making
6. Sufficient supplies for personnel welfare (i.e. food, water, medicine, first aid kit)
7. Enough supplies and materials for data collection proper
8. Facilities for data management, analysis, and storage

The following sections detailing the coastal and marine biodiversity assessment and monitoring tools and methods provides information on the minimum personnel and materials needed that can guide budgeting and logistics arrangement.

The amended assessment and monitoring process for coastal and marine biodiversity aims to generate various information (**Table 1**) needed to answer the key biodiversity questions used in evaluating the effectiveness of the management interventions in the area in addressing biodiversity conservation:

- Where are land cover, habitats, and ecosystems? And where are they being degraded/improving? (not just in PA but including buffer zones)
- Are the populations of threatened species of plants and animals declining/increasing?
- What are the causes of such decline/increase?
- Has management intervention had the intended impact on the ecosystem?
- Are there increased benefits to local communities from sustainable natural resource use?

Table 1. Data to be generated by coastal and marine biodiversity assessment and monitoring.

Taxa/Component	Methodology/Tool	Indicators/Indicative Data
Coastal Integrity and function of coastal habitats in preserving it	CIVAT	Exposure: • Relative sea-level change (mm/yr) • Wave exposure • Tidal range (m)
		Sensitivity • Coastal landform and rock type • Seasonal beach recovery • Slope from the shoreline to 20-m elevation • Width of reef flat or shore platform • Lateral continuity of reef flat or shore platform • Beach forest/vegetation • Coastal habitats as sediment source and stabilizer • Coastal and offshore mining • Structures on the foreshore
		Adaptive Capacity • Long-term shoreline trends (m/yr) • Continuity of sediment supply

Taxa/Component	Methodology/Tool	Indicators/Indicative Data
		• Guidelines regarding easement • Guidelines on coastal structures • Type of coastal development • Viability of coastal habitats as sediment source
		Vulnerability
Coral reef	Point Intercept Technique/ photo-transect & belt transect	Coral ID and lifeform category
		Percent live hard coral
		Percent dead coral cover, soft corals
		Relative Abundance of associated invertebrate
		Associated flora (% cover)
		Coral diseases
	Fish visual census	Fish species richness (Number of species)
		Fish abundance
Seagrass	Transect-quadrat method and belt transect for associated invertebrates	Seagrass species richness
		Percent seagrass cover
		Relative abundance
		Canopy height (cm)
		Shoot density (shoot/m2)
		Invertebrates species richness
		Invertebrates density (ind/ha)
		Dominant inverts group (% relative abundance)
Seaweeds	Transect-quadrat method and belt transect for associated invertebrates	Seaweed species richness
		Percent seaweed cover
		Relative abundance
		Invertebrates species richness
		Invertebrates density (ind/ha)
Intertidal mudflat	Belt transect	Macro invertebrates species richness
		Macro invertebrates density (ind/ha)
Megafauna	Focus group discussion/ Interview survey, Photo-identification	Biological diversity
		Range of distribution
	Focus group discussion/ Interview survey	Temporal variation*
	Photo-identification	Population abundance
	Nesting beach survey	Estimate number of reproductive females
		Estimate number of nests
		Estimate number of hatchlings
		Species of sea turtles
		Temporal variation*
	Opportunistic survey, Dugong feeding trail/monitoring survey	Presence and absence
	Opportunistic survey	Species sighted*
	Opportunistic survey, Dugong feeding trail/monitoring survey, Fish landing survey/market inspection	Extent of range of distribution*
	Dugong feeding trail monitoring/survey	Threats to dugongs*
	Fish landing survey/ Market	Important species of sharks and rays in the area

Taxa/Component	Methodology/Tool	Indicators/Indicative Data
	inspection	Threats to sharks and rays*
	Stranding data	Species composition of marine mammals stranded
Fisheries	Focus group discussion	Number of fishers per fishing village
		Changes in fish diversity/species composition
		Number of fishers per km^2 of fishing
		Fishing gear types and number of users/units
	Focus group discussion, Fish landing or dockside survey	Number of hours per fishing trip or day and number of fishing trips per day
	Fish landing or dockside survey	Catch composition (species richness)
		Landed weight per group/species
		Trophic structure analysis*
		Catch per unit effort (kg/g.u./trip)
	Market Surveys	Daily estimates of fish production
		Fishing revenues (gross income) in PhP
		Net incomes (GR – fishing costs) in PhP
		Price per kg of major kinds of fish
		Sources of fish products/fishing area
		Market destination of fish products
	Focus group discussion, Semi-structured interviews	Changes in fish production and diversity thru time (temporal)
	Semi-structured interviews	Fishing effort changes
		Historical trends in catch per unit effort
		Seasonality of fisheries resources
		Environmental impacts*
		Biodiversity loss or fish extirpation studies*

**If possible*

The subsequent sections of this document describes each of the tools and methodologies employed in the monitoring process and provides a detailed guide on how to conduct each one and how to process, manage, and analyze data generated. Also included in these chapters are the materials needed and minimum personnel capacity needed, expected frequency of conduct by different agencies/groups, and expected resolution of data produced by these groups.

Remote Sensing and GIS

By Dr. Nathaniel C. Bantayan

An effective and efficient assessment, monitoring, and evaluation tool for a protected area (PA) should consist of the following:

1. A set of base maps containing the protected area (PA) site descriptors namely: location, physical, hydro-meteorology, environmental and scoio-economic descriptors. For each descriptor, corresponding GIS maps are prepared (Annex 1)
2. A gridded GIS for the PA
3. A method for utilizing advanced technologies like Geographic Information Systems (GIS) and remote sensing, and
4. A method for data handling, processing and analysis thru GIS databasing.

The following data and information should be available for the PA: administrative boundaries; legal gazzettement; a management structure (i.e. Protected Area Management Bureau headed by a Protected Area Superintendent) ; updated land cover and land use data; tenure (where available), e.g. Community Based Forest Management (CBFM), Certificate of Ancestral Domain Claim/Title (CADC/CADT), Mineral Production Sharing Agreement (MPSA; where applicable); biodiversity values; and vulnerability to impacts of climate change and hazard prone areas, among others.

Thus the PA should have a base map that contains data and information on the following:

- Geographic extent of the PA (e.g. technical description expressed in GIS format)
- Current land cover and land use (e.g. land cover from 2010 or more recent data) focusing on the coastal habitats and infrastructure (e.g. settlements, commercial buildings, access roads, ports, among others)
- Administrative boundaries (e.g. down to barangay; expressed in GIS format) focusing on coastal communities and industries
- Bathymetry
- Watershed drainage system (i.e. river outlets) focusing on the downstream areas[1]
- Location and/or extent of key coastal/marine resources (e.g. coastal habitats, fishing grounds, nesting areas, feeding grounds)

The use of a base map in all assessment and monitoring activities for each of the thematic components (e.g. coastal habitat (corals, seagrass, etc.), coastal environment, megafauna, and fisheries) is vital in ensuring the relocation of points or areas of interest; that negative changes are addressed in a responsive manner; and that positive changes are promoted and maintained.

More importantly, the base map should contain the PA monitoring points for each of the thematic component. Key to the success of monitoring will be representativeness and repeatability. To achieve representativeness, a good base map showing the current land cover and land use vis-à-vis coastal habitat should be available. Ideally, each of the categories of the thematic component should have a monitoring point. For example, for the coastal habitat,

[1] A common delineation of a watershed is in terms of upstream, midstream and downstream. The downstream areas represent the most immediate impact zone for the coastal environment

one monitoring station should be established at the coral reef, and one monitoring station at the seagrass, and so on. When a habitat exists at more than one location, the choice of setting up a monitoring station becomes complicated. In such a case, the accessibility of the area and the presence of a willing partner in the barangay could be used as bases.

Repeatability provides the opportunity to return to the monitoring point at specific periods in the future. Thus, the choice of the monitoring point should enable such point to be relocated. In this case, a base map will be critical so that the location of the monitoring point can be easily delineated. In addition, the use of landmarks and other visible ground features should be used and the location marked using a GPS unit.

Below are some considerations in the preparation of a base map:

- Collection of relevant data (e.g. PA boundary, coastline, bathymetry, physiography, land cover, watersheds, rivers, hazards, administrative boundaries, and land use)
- The base map should be gathered from authorized sources (e.g. from the National Mapping and Resource Information Authority (NAMRIA) and/or Forest Management Bureau (FMB); from LGUs as shown in their Comprehensive Land Use Plans (CLUPs)); from the Mines and Geosciences Bureau (MGB); Philippines Statistics Authority; and relevant agencies of the Department of Agriculture (DA))
- The base map should be consistent for the PA to ensure repeatability of activities wherein the points of interest (POIs) or areas of interest (AOIs) (e.g. point intercept, manta tow, photo transect, visual census, seagrass watch, transect-quadrat, among others) can be relocated or revisited at future periods without much difficulty.
- The base map should be prepared in consultation with the stakeholders to encourage ownership and participation e.g. construction of a gear map.
- The base map should be prepared using current and available technologies like remote sensing (RS) and GIS. RS/GIS can produce the necessary visual tools (i.e. maps) to facilitate assessment and monitoring activities. The easiest and most common are OpenSource resources like GoogleEarth©
- RS/GIS can also be used to improve the recording (e.g. databasing) of field data and information of the thematic components. Thus, GIS data can be organized into specific thematic components with their corresponding feature attribute tables (i.e. geodatabase).

Equipment and Materials Needed

1. Preliminary base map
2. Laptop/computer
3. Maps and satellite imagery (e.g. NAMRIA, Google Earth, LandSat, Sentinel2)
4. GIS software (e.g. Quantum, ArcGIS)
5. Reliable internet connection
6. Minimum dataset (from other components of coastal and marine biodiversity assessment and monitoring)

Procedure

Executing commands may differ depending on the GIS software use. The steps below only describe what must be done. You can refer to the user's manual of the GIS software (e.g. QGIS Training Manual release 2.14 from qgis.org website) for a step-by-step guide on how to perform the following tasks. There is also a complete set of practical exercises contained in the new book on GIS by Bantayan, et al. 2015. The book contains two sets of exercises: one set on QGIS and another set on ArcGIS.

I. Base Map Development

1. Using the GIS software, prepare the basemap considering the characteristics of the map sources in terms of datum, source scale, projection, format (analog or digital), and date of preparation (i.e. lineage). Load the map from NAMRIA and/or from LGU, establish location parameters. Augment and/or enhance the map with available remote sensing images, vector coverages, and other available map.

   The topographic map sheets of the Philippines in particular are prepared using the Luzon 1911 datum. Other data generated from the field via the Global Positioning System (GPS) generally make use of the WGS84. While the data of the different maps need to be taken into consideration, it is recommended that these be expressed in a common GIS projection environment (i.e. transformation into UTM Zone 51N) to facilitate measurements and statistical analysis (metric–distance, area, and volume). See Annex 2 for a step-by-step guide on reprojecting maps in QGIS.

II. GIS Database Development

1. Develop the GIS database according to the thematic components of coastal and marine biodiversity assessment and monitoring, particularly corals, reef fish, seagrass, seaweeds, invertebrates, coastal wetlands and habitats, megafauna, and fisheries GIS themes. Each GIS theme will have its own set of attributes (i.e. minimum datasets) (**Table 2**) and legend or symbology.

   Attributes will be generated from the monitoring process for the different taxa or components as described in the other chapters of this guideline.

   Legend or symbology should be agreed upon by the department and should be consistent throughout different cycles of monitoring.

2. Develop a 1km x 1km grid (e.g. fishnet) that encompasses the PA by following a method based on the GAME model or GIS-based assessment, monitoring and evaluation (Bantayan, 2006, Bantayan, et al, 2015) based on the SUSDEV database system – a comprehensive database system for sustainable development planning, field operations, and monitoring developed by Dr. Juan Adolfo Revilla.

   Divide the study area (i.e. PA) into a 1 km X 1 km grid or 100 hectares. Each grid will have its own unique grid ID and can also be refined down to 10m X 10m granule depending on the precision of the analysis (**Fig. 2** and **Fig. 3**).

See Annex 3 for a step-by-step guide on generating GAME Units using QGIS. It is recommended that gridded maps are used during monitoring fieldwork as this would facilitate the mapping and encoding and updating of the base map.

Table 2. Minimum datasets for the different thematic components of coastal and marine biodiversity assessment and monitoring.

Taxa/Component	Minimum Dataset (MDS)	
Coastal integrity and coastal habitat	• High-resolution, site-specific base maps of coastal habitats • Distribution • Extent • Shapes • Sizes • Coastal landform and rock type	• Bathymetry • Slope from shoreline to 20-m elevation • Beach forest/vegetation • Coastal and offshore mining • Shoreline • Vulnerability
Corals	• Percent live hard coral cover per genus and life forms • Percent dead coral cover and soft corals • Percent cover of associated flora • Coral diseases	
Reef Fish	• Fish species and species richness • Fish abundance	• Fish size
Seagrass	• Percent seagrass cover • Species richness • Relative abundance	• Canopy height • Shoot density (optional)
Seaweed	• Seaweed cover focusing on dominant species • Seaweed species richness • Relative abundance	
Invertebrates	• Species richness • Species abundance	• Species density • Dominant invertebrate group
Megafauna	• Biological diversity • Range of distribution • Population abundance • Species present • Threats to megafauna • Temporal variation (optional)	• Estimated number of sea turtle reproductive females, nests, and hatchlings • Species composition of marine mammals stranded
Fisheries	• Number of fishers per fishing village • Number of fishers per km^2 of fishing • Total fishing effort • Catch composition • Catch per unit effort (CPUE) • Production	• Gear inventory and spatial map of fishing effort • Sources of fish products/fishing area • Fishing revenues and net income • Trophic structure (optional)

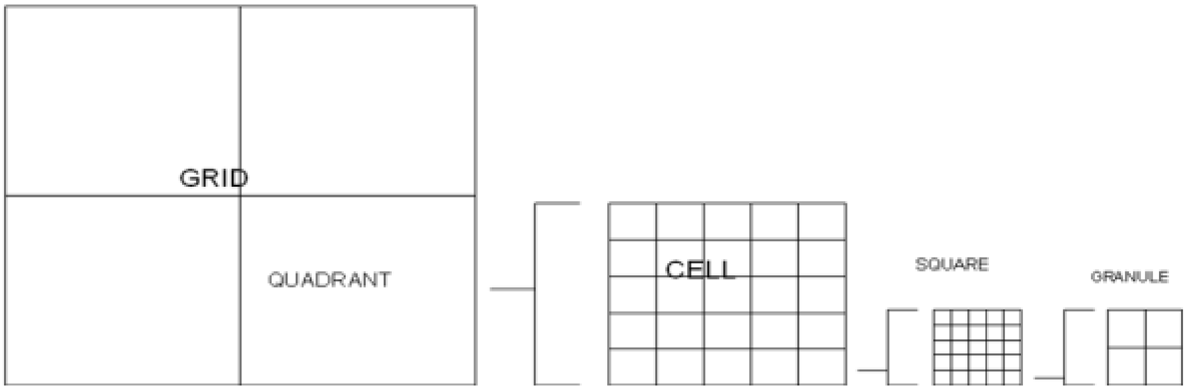


Figure 2. Grid GIS database (Bantayan et al. 2015).

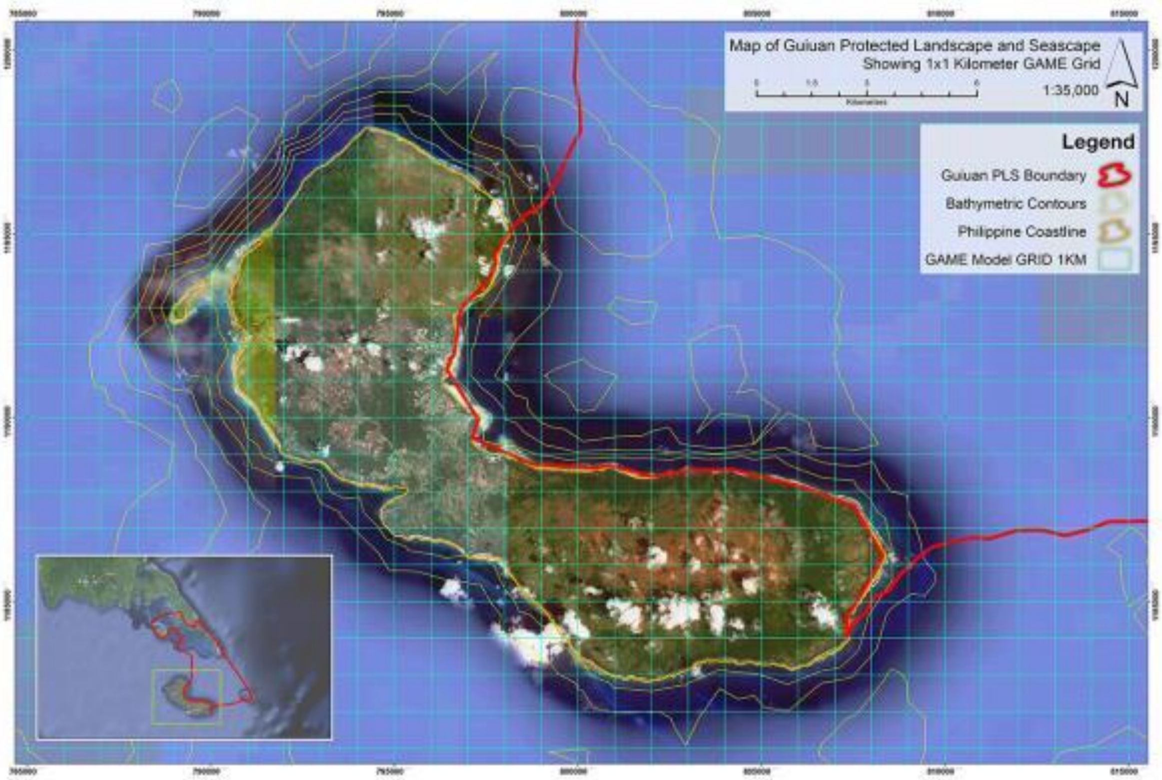


Figure 3. Gridded map of a portion of the Guiuan Marine Reserve Protected Landscape and Seascape.

3. For more effective monitoring, add a unique grid code (such as coral and seagrass cover) to the usual set of location parameters (e.g. region, province, municipality, barangay, sitio, grid ID). For example, **Figure 4** shows the GIS map and database of the Mana tow exercise conducted in Guiuan. The size of the icon indicates the condition of the coral corresponding to the protocol of the thematic component on coastal habitat assessment, i.e. larger icon means higher value. **Figure 5** on the other hand is the manta tow data base in which Figure 4 was based on.

4. It is recommended that the base map be updated with satellite images at five-year intervals.

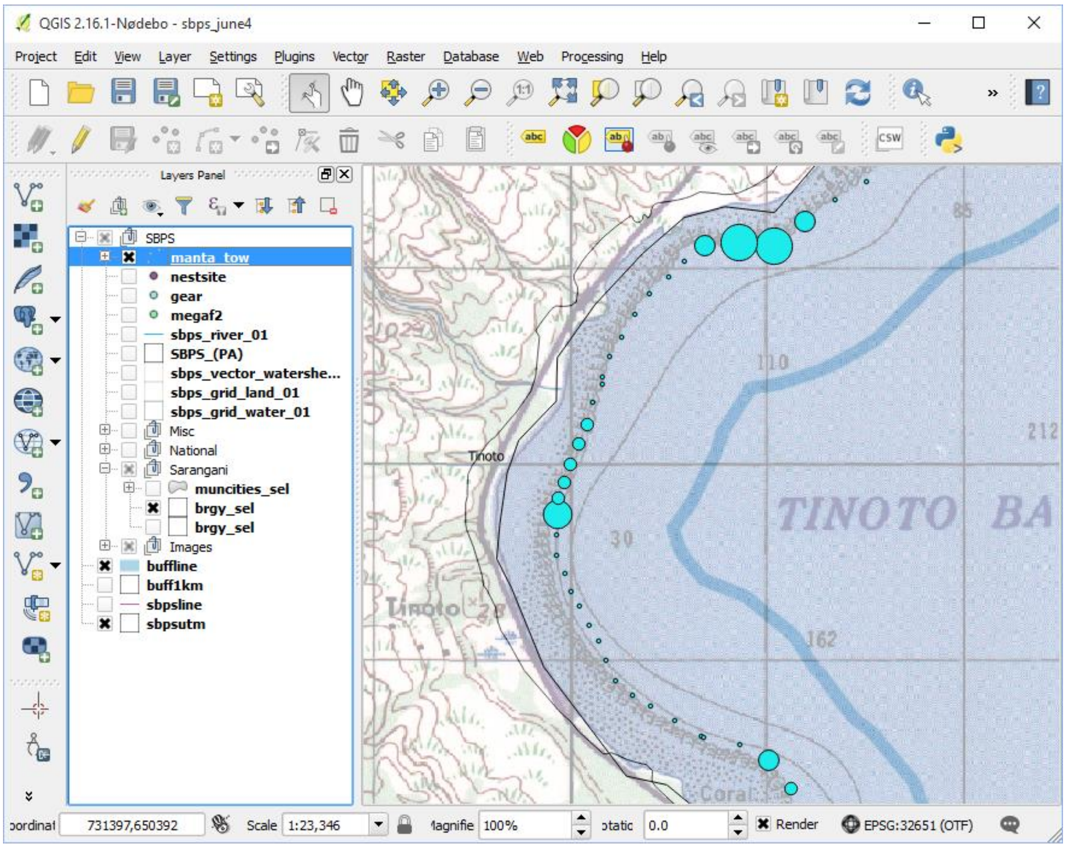
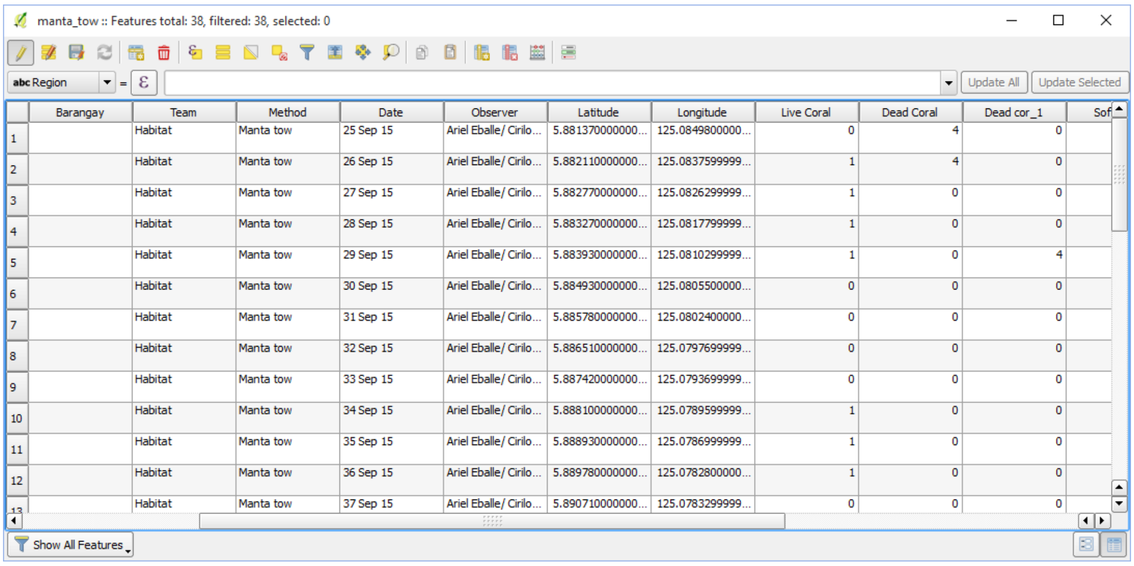


Figure 4. Manta tow map (size of circle denote hard coral cover).


manta_tow :: Features total: 38, filtered: 38, selected: 0

	Barangay	Team	Method	Date	Observer	Latitude	Longitude	Live Coral	Dead Coral	Dead cor_1	Sof
1		Habitat	Manta tow	25 Sep 15	Ariel Eballe/ Cirilo...	5.881370000000...	125.0849800000...	0	4	0	
2		Habitat	Manta tow	26 Sep 15	Ariel Eballe/ Cirilo...	5.882110000000...	125.0837599999...	1	4	0	
3		Habitat	Manta tow	27 Sep 15	Ariel Eballe/ Cirilo...	5.882770000000...	125.0826299999...	1	0	0	
4		Habitat	Manta tow	28 Sep 15	Ariel Eballe/ Cirilo...	5.883270000000...	125.0817799999...	1	0	0	
5		Habitat	Manta tow	29 Sep 15	Ariel Eballe/ Cirilo...	5.883930000000...	125.0810299999...	1	0	4	
6		Habitat	Manta tow	30 Sep 15	Ariel Eballe/ Cirilo...	5.884930000000...	125.0805500000...	0	0	0	
7		Habitat	Manta tow	31 Sep 15	Ariel Eballe/ Cirilo...	5.885780000000...	125.0802400000...	0	0	0	
8		Habitat	Manta tow	32 Sep 15	Ariel Eballe/ Cirilo...	5.886510000000...	125.0797699999...	0	0	0	
9		Habitat	Manta tow	33 Sep 15	Ariel Eballe/ Cirilo...	5.887420000000...	125.0793699999...	0	0	0	
10		Habitat	Manta tow	34 Sep 15	Ariel Eballe/ Cirilo...	5.888100000000...	125.0789599999...	1	0	0	
11		Habitat	Manta tow	35 Sep 15	Ariel Eballe/ Cirilo...	5.888930000000...	125.0786999999...	1	0	0	
12		Habitat	Manta tow	36 Sep 15	Ariel Eballe/ Cirilo...	5.889780000000...	125.0782800000...	1	0	0	
13		Habitat	Manta tow	37 Sep 15	Ariel Eballe/ Cirilo...	5.890710000000...	125.0783299999...	0	0	0	

Show All Features

Figure 5. GIS database for the Manta Tow.

For more details on the various practical applications, the succeeding sections on Protection Provided by Coastal Habitats to Coastal Areas, and biodiversity of Coral Reef, Seagrass, Mudflat and Intertidal Areas, Seaweed, Megafauna, and Fisheries are interspersed with methodologies and techniques on the use of GIS, remote sensing, and global navigation systems.

Protection Provided by Coastal Habitats to Coastal Areas

By Dr. Fernando P. Siringan, Ms. Yvainne Y. Sta. Maria, and Ms. Cyndi S. Ignacio

Coastal integrity is defined as "the overall state of the coast resulting from its geologic history (e.g. regional setting, geomorphology), the bio-physical processes (e.g. waves, tides, storms) that continuously shape and re-shape it, and human activities" (Siringan et al. 2013). For reef-fringed coasts and island systems, an integral part of coastal integrity is the presence of coastal habitats such as coral reefs, seagrasses, and mangroves, which provide protection for the adjacent shorelines. These coastal habitats are the main source of sediments for the adjacent carbonate coastlines as well as serve as natural wave buffers. This module aims to introduce methods that can be employed for monitoring coastal changes. Changes in the physical coast may be linked to the condition of the natural habitats through the Coastal Integrity Vulnerability Assessment Tool (CIVAT).

As an assessment tool, CIVAT is designed primarily for evaluating the present-day vulnerability of coastal areas to climate change hazards particularly sea-level rise and waves. Since it considers the coastal habitats as an integral part of the coast, the CIVAT can also provide a means for evaluating the vulnerability of the physical coast given the current status of the natural habitats. This assessment tool may be used across National Integrated Protected Area System (NIPAS) sites to determine the relative vulnerabilities of the different coastal areas. It can lead to the identification of PAs that are in need of intervention or adaptation measures in order to lessen their vulnerabilities. It will also help prioritize the measures needed to lessen the vulnerability of a coastal area. Once these measures are put in place, CIVAT may be repeated after five or 10 years to determine the success of the selected strategies in reducing the vulnerability of the physical coast. The success of CIVAT depends to a large extent on the quality of the data input and thus, beach monitoring as well as the collection and generation of relevant data, both primary and secondary, should precede the conduct of any vulnerability assessment.

This How-to-Guideline is based on the references below:

Siringan, F.P., Sta. Maria, M.Y.Y, Jordan, J.C. (2016). **Coastal erosion management in the Philippines: A Guidebook**. Prepared under the DOST-PCAARRD-funded project, "Acquisition of detailed bathymetry for coastal erosion management", 146 pp.

Siringan, F.P., Sta. Maria, M.Y.Y., Samson, M.I., Licuanan, W.R.Y., Rollon, R. 2013. Chapter 5: Coastal Integrity Vulnerability Assessment Tool. In: MERF. 2013. Vulnerability Assessment Tools for Coastal Ecosystems: A Guidebook. Marine Environment and Resources Foundation, Inc.: Quezon City, Philippines.

Siringan, F.P., Y.Y. Sta. Maria, J.C.J. Jordan, R.D. Ramos, C.L. Ringor, C.M.B. Jaraula, R.D. Berdin (unpublished). Section 2. Coastal Erosion Module. In: *Monitoring and Evaluation Manual for Climate Change.* Prepared under the DOST-PCAARRD-funded program, "Remote Sensing Information for Living Environments and

Nationwide Tools for Sentinel Ecosystems in our Archipelagic Seas (Resilient SEAS) for Climate Change”

Establishing Monitoring Sites

At the minimum, the areas to be selected for the application of CIVAT are coastal areas within NIPAS with human settlements and other ecologically critical sites (e.g., nesting ground for turtles). In the context of assessing and monitoring the coastal protection provided by coastal habitats, the coastline directly behind the coastal habitats being monitored (i.e. coral reefs, seagrass beds, and mangrove forests) should be selected as monitoring sites. Even without habitats, monitoring of critical coastal sites (e.g., eroding sites; with important infrastructures) within NIPAS should also be conducted. Note that when establishing monitoring sites, the ideal scale of monitoring should include the entire littoral cell, or a continuous segment of the coast that may be bounded by cliffs and/or rivers. Within a littoral cell, the sources and sinks of coastal sediments are confined, and there is connectivity in coastal processes through the longshore currents, which is responsible for the redistribution of sediments along the coast. This monitoring scheme can provide a better understanding of sediment dynamics in an area, which is critical for coastal stability.

Frequency of Monitoring

Tables 3 and 4 below show the recommended frequency and duration of conduct of CIVAT for each group and expected output from them.

Table 3. Recommended frequencies and durations of CIVAT methodologies per monitoring group.

Method	Frequency and duration*		
	Experts/Academe	DENR	LGU/Community
1. Shoreline tracing	At least 2 times/yr; once during the wet and dry season; After a storm event to monitor beach recovery	At least 2 times/yr; once during the wet and dry season; After a storm event to monitor beach recovery	At least 2 times/yr; once during the wet and dry season; After a storm event to monitor beach recovery**
2. Beach profiling	Concurrent with shoreline tracing	Concurrent with shoreline tracing	Concurrent with shoreline tracing
3. Sediment sampling	Concurrent with beach profiling	Concurrent with beach profiling	Concurrent with beach profiling
4. Photo documentation	Every fieldwork	Every fieldwork	Every fieldwork
5. Field observations	For CIVAT scoring; Note noticeable changes during monitoring	For CIVAT scoring; Note noticeable changes during monitoring	For CIVAT scoring; Note noticeable changes during monitoring
6. Anecdotal accounts/interview	First fieldwork to fill in data gaps and to determine causes of erosion; Seasonal to determine significant events	For CIVAT scoring (to determine beach recovery and other human activities); Event-based	For CIVAT scoring (to determine beach recovery and other human activities) Event-based

Method	Frequency and duration*		
	Experts/Academe	DENR	LGU/Community
7. Natural habitats assessment	For CIVAT scoring – must be done in same sites	For CIVAT scoring – must be done in same sites	For CIVAT scoring – must be done in same sites
8. Desktop analysis (a) Shoreline change analysis (b) Processing of beach profiling data (c) Slope calculation (d) Width and continuity of reef flat (e) Areal extent of seagrass (f) Identification of features using Google Earth	(a) after every fieldwork; (b) Same as (a); (c) For CIVAT scoring; (d) For CIVAT scoring; (e) For CIVAT scoring (f) For CIVAT scoring and monitoring	(a) after every fieldwork; (b) Same as (a); (c) For CIVAT scoring; (d) For CIVAT scoring; (e) For CIVAT scoring (f) For CIVAT scoring and monitoring	Depends on the capacity of LGU/community

**Duration would depend on the length of shoreline to be covered.*
***If LGU or community has no GPS, beach profiling as a monitoring method would be acceptable.*

Table 4. Expected output of CIVAT from each monitoring group.

Method	Output		
	Experts/Academe	DENR	LGU/Community
Beach profiling	Graphical comparison Volumetric loss of sediments Photodocumentation of beach profile changes	Graphical comparison Volumetric loss of sediments Photodocumentation of beach profile changes	Graphical comparison Photodocumentation of beach profile changes
Shoreline tracing	Long-term, seasonal and event-based shoreline trend Identify possible causes of shoreline trends	Shoreline change calculations for CIVAT	Shoreline change calculations for CIVAT
Sediment sampling	Use a cup for sampling. Determine sediment composition. Separate into discrete grain size using sieve • Calculate grain size parameters • Determine likely transport pathways	Compare a handful of sediment samples with a grain size comparator Describe sediment composition	Compare a handful of sediment samples with a grain size comparator Describe sediment composition
Photo documentation	Collection of time-series photos Comparison of time-series photos	Collection of time-series photos	Collection of time-series photos
Field observations	Observations collated every fieldwork Scale and extent of coastal structures	Note changes every fieldwork Features needed for CIVAT scoring	Note changes every fieldwork Features needed for CIVAT scoring

Method	Output		
	Experts/Academe	DENR	LGU/Community
Anecdotal accounts	Detailed; Following a questionnaire	May focus on items needed for CIVAT	May focus on items needed for CIVAT
Desktop analysis	Calculations using GIS software	Calculations using GIS software	Depends on the capacity of the LGU/community

Data Collection

I. Field Observations and Photodocumentation

Materials needed:

- Field notebook
- Digital camera

Procedure:

Observe, take note, and take photos of the following:

1. Indicators of erosion **(Fig. 6)**
    a. Exposed tree roots and leaning or fallen trees caused by wave scouring
    b. Exposed cable roots of *Avicennia* and *Sonneratia*
    c. Presence of continuous scarps (i.e. vertical cut created by wave scouring) on the berm.

Figure 6. Common indicators of erosion: (a) exposed tree roots and leaning or fallen trees, (b) exposed cable roots of *Avicennia* and *Sonneratia*, and (c) presence of continuous scarps on the berm (*Photos taken by Ms. Yvainne Sta. Maria and Ms. Cyndi Ignacio).*

2. Coastal types or landforms (i.e. sandy-gravel beaches, sandy beach underlain by beachrock, mangrove-shoreline, sandy beach with fringing reefs, and sandy beach without fringing reefs) **(Fig. 7).**
3.
4. Dominant land uses in each barangay

5. Beach vegetation (i.e. creeping variety, shrubs, and trees) and their relative proportions

6. Human activities such as beach mining classified in terms of scale (i.e. residential or commercial use)

7. Structures on the foreshore (including location and extent of coastal structures) such as groins, seawalls, and piers.

Figure 7. Different coastal landforms: (A) sandy-gravel beaches, (B) sandy beach underlain by beachrock, (C) sandy beach without fringing reefs, (D) mangrove fronted shoreline, and (F) sandy beach with fringing reefs. *(Photos taken by Ms. Yvainne Y. Sta. Maria and Ms. Cyndi Ignacio)*

II. Beach Profiling

Materials Needed:

- One (1) pair of 1.5 Emery rods (two pieces 1.5-meter polyvinyl chloride (PVC) pipes with 1-centimenter gradations)
- 50- or 100-meter transect tape
- One (1) pair of bubble level
- Digital camera
- Compass
- Handheld GPS
- Beach profiling worksheet or field notebook
- Clear hose (if area to be assessed has the horizon blocked or is inside a mangrove forest)
- Spray paint (if allowed for marking fixed points)
- Grain size comparator
- Cup for sediment sampling

Procedure:

A. Emery Method

The Emery method of beach profiling (Emery 1961) is a simple, low-cost method of mapping the cross-sectional elevation of a beach from a fixed inland point to a certain distance seaward. It involves measuring the difference in elevations between two rods (i.e. front or seaward rod and back or landward rod) with the horizon as the reference point (**Fig. 8**).

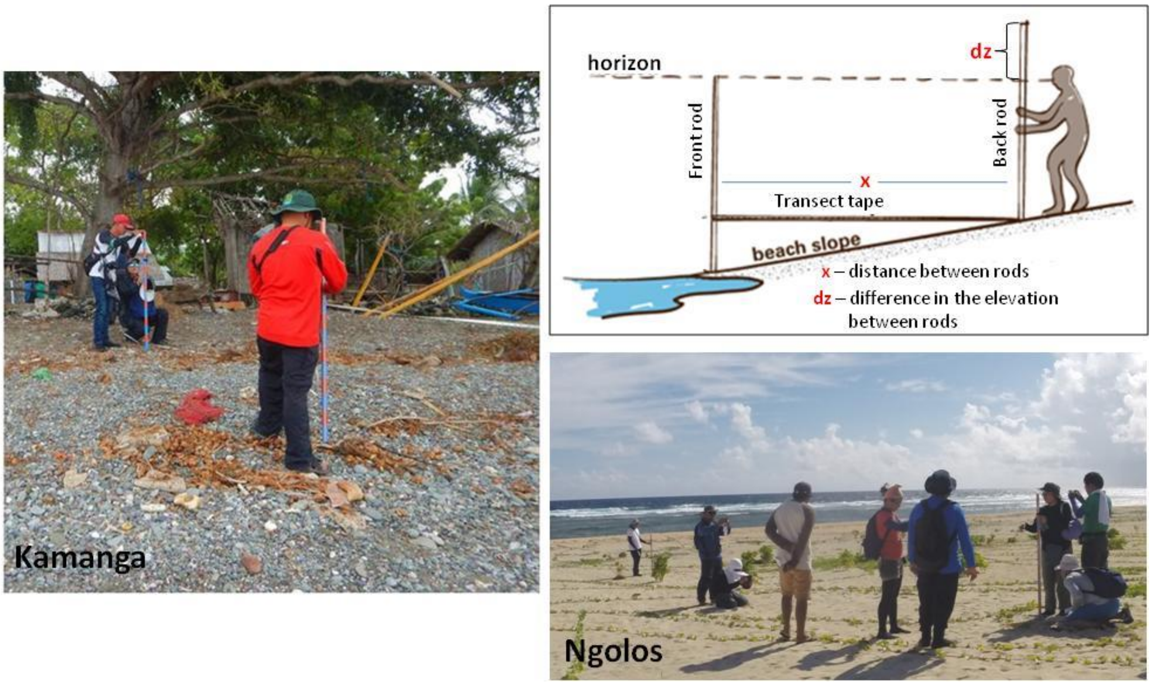


Figure 8. The Emery method of beach profiling. The elevation profile of a cross-sectional portion of a beach is measured as the difference in the elevations between the two rods, with the lower rod sighted to the horizon, where the elevation readings are referenced. (Top right image – modified from http://fcit.usf.edu/florida/teacher/ science/mod2/beach.profiles.html). *(Photos taken by Cyndi Ignacio and Ms. Lea Avilla)*

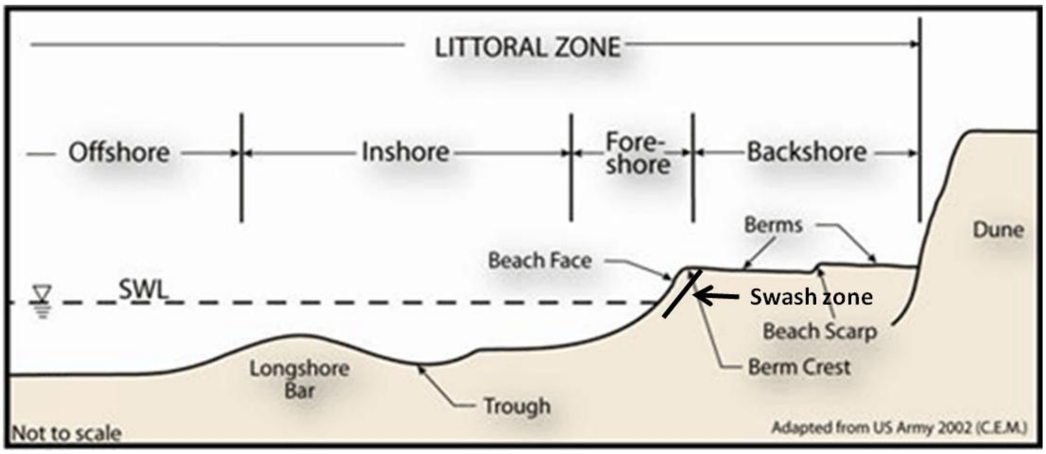
At least three (3) persons are needed to conduct the Emery Method: (1) The reader on the landward side, who will also function as the recorder; (2) Another person on the landward side who will ensure that the Emery rod is straight while the reader is making the reading; and (3) a third person to hold the seaward Emery rod and draw the transect tape seaward.

1. Select a site to be profiled. A transect perpendicular to the coast should be established where there is an observable change in beach configuration or where there are known critical sites within the PAs.

2. Establish the fixed point. This should mark the location of the transect and should be recognizable for subsequent monitoring even without the aid of a GPS. If allowed, mark it with a spray paint. Describe the fixed point in detail. If the first reading cannot be made on the fixed point, note the offset from it. To detect changes in the fixed point, there should be a reference feature or marking of which the height is known or measured. It will be measured repeatedly every time the transect is reoccupied for beach profiling. The fixed point including the other measurements taken should be photo-documented to ensure repeatability in subsequent monitoring.

3. The following should be noted on the worksheet or field notebook: a) name of transect (should begin with an abbreviated name of the site); b) date and time; c) location (name of municipality or beach); d) orientation of the transect (i.e., compass reading); and e) description of the fixed point as in (2). Readings should be recorded in the table with the following columns: (a) **Point**, (b) **X** (distance, in m), (c) **dz** (difference in elevation, in cm) and (d) **Remarks**.

4. Place the back (landward) rod on or near the fixed point and the other rod several meters seaward. The location of the front (seaward) rod may be dictated by fixed distances where elevation readings are to be measured. A better approach is to do measurements following the natural topography of the beach, particularly on the different zones of the beach profile such as the vegetation line, beach scarp if present, berm, high-tide line, and sea level or waterline at the time of the survey (**Fig. 9**). The distance between rods should not be more than 20m.



http://www.pilebuckinternational.com/chapter-5-coastal-sediment-processes/

Figure 9. Zones of beach profile.

5. Reading should start at Point 1 which corresponds to the position of the back (landward) rod. It can be the fixed point, or a certain distance away from the fixed point if adjustments were made. At Point 1, **X** and **dz** should be 0.

6. At Point 2, note the distance (**X**) between two rods. The difference in elevation, **dz**, between Point 1 and Point 2 is acquired by sighting the lower of the two rods to the horizon and projecting the intersection of the lower rod and the horizon onto the higher rod. If the beach is *sloping downward*, reading will be made on the back (or landward) rod and shall be recorded as a *negative value* (see **Fig. 8 top right image**). If the beach *slopes upward*, reading will be made at the front (or seaward) rod and shall be recorded as a *positive value* (**Fig. 10**). Note remarkable features or zones on the **Remarks** column (e.g., vegetation line, berm).

Figure 10. Reading made at seaward rod. Seaward reader points at the level (left) at which the landward reader sees the end of the landward rod align with the horizon. Value of the pointed level is recorded as a positive value.

7. After this, the rods will move seaward following the transect orientation, with the back rod occupying Point 2 and the front rod moving farther seaward to establish Point 3. Repeat step (5) to obtain distance and elevation measurements as the rods move seaward until the waterline or sea level is reached. At sea level, record the *time and GPS reading* on the Remarks section. DO NOT FORGET THIS AS THIS POINT WILL BE USED TO REFERENCE THE BEACH PROFILE TO MEAN SEA LEVEL (MSL), which is the elevation datum used by NAMRIA.

8. Repeat (7) until the desired water depth is reached and then end the survey.

9. Encode and process data (Proceed to data processing and desktop analysis section).

   It is important to time the survey during low tide but not too low that the entire reef flat is exposed. Remember that measurement at sea level is very important. If the reef flat is exposed when you conduct beach profiling, you will have to do measurements all to way to the waterline or sea level to be able to reference the profile to mean sea level. For comparison, the same extent will have to be covered in subsequent monitoring.

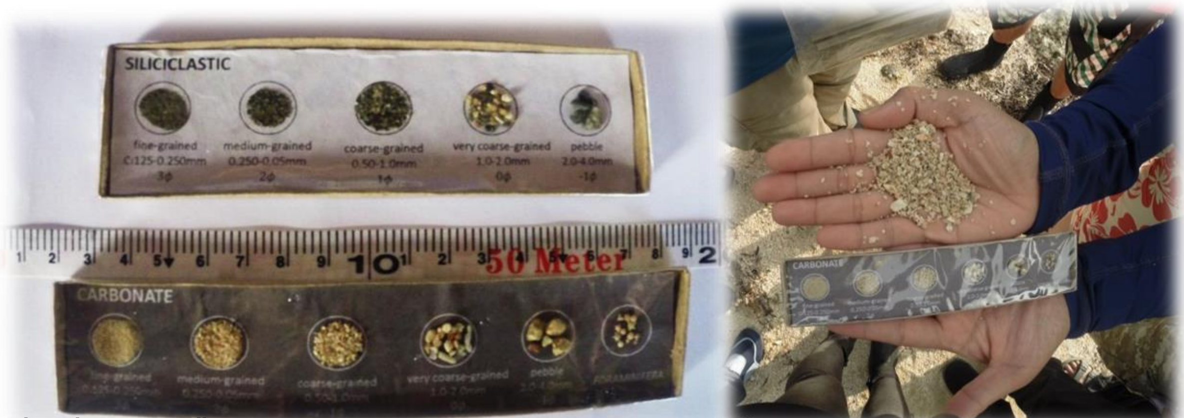
In areas where the horizon is blocked by land, or inside mangrove forests, a modified water level using a hose (http://www.glacierboats.com/tongass/waterlevel.html) can be used. Instead of the horizon, a clear hose is filled with water and the change in elevation is indicated by the difference in the height of the constant water level measured from the rods **(Fig. 11).**The water level in the hose adjusts as one move from higher to lower elevation or vice versa due to pressure differences.

Figure 11. A modified method of beach profiling referenced to constant water level. Instead of the horizon, a clear hose is filled with water and the change in elevation is indicated by the difference in the heights of the constant water level measured from the two rods (indicated by arrows, top left). *(Photos by Ms. Cyndi Ignacio).*

B. Sediment Characterization

1. Use a cup in acquiring sediment samples. Sediment should be sampled on the berm, beach face, and sea-level **(**see **Fig. 9)**.

2. Observe sediment size and composition along the beach profile. Use grain size comparator to determine the sizes of sediments along the transect **(Fig. 12)**.



Photos by Lea C. Avilla

Figure 12. Determining sediment sample size by using grain size comparator.

3. If there are noticeable changes in the size and composition, such as accumulation of gravel on a sandy beach, note them in the Remarks column.

   For detailed grain size fractionation, the sediment samples should be subjected to sieve analysis.

C. Photodocumentation

Photo-documentation of the vicinity of the beach profile is a must. This can be used to compare changes in beach configuration. Remember to take photos at the same location and at the same angle for better comparison of coastal features. Photos should be taken perpendicular to the coast (i.e., start and end of the beach profile) and at the sides from a seaward and landward vantage points.

III. Shoreline Tracing

Materials needed:

- Two (2) handheld GPS
- Digital camera

Procedure:

1. Conduct shoreline tracing concurrent with beach profiling. Together, these methods will provide a more accurate picture of beach sediment dynamics.

2. Walk along the shoreline while marking the GPS location every twelve steps, which approximates the ±3m positional error of the GPS. Ideally, the "true" shoreline should be located close to the mean sea level (MSL), which is the elevation datum used by NAMRIA. Since the exact MSL is not known, different approximations can be done depending on the type of beach characteristics:
   - Shoreline tracing along beaches with steep slope is simple as the translation of shoreline positions between tidal phases can be minimal, and thus may be within the GPS positional error. On steep coast, shoreline tracing can be done

at the waterline, during high tide. During low-tide, the mid-swash area, or the mid-tide line, can approximate the shoreline.

- On gentle coasts adjacent to fringing reefs or sand flat, there is a shoreline change reference feature called the beach toe, which marks the transition between the sloping beach face (**Fig. 13**) and the relatively flat surface of the adjacent platform. The beach toe in **Figure 13** is characterized by a break in the slope and a drastic change in sediment size and composition. Shoreline tracing can be done at the crest of the beach toe, which approximates the low-water line (Genz et al., 2007).

Figure 13. On coasts adjacent to fringing reefs or sandflat, shoreline tracing can be done at the beach toe, which is used as a shoreline change reference. On coasts adjacent to fringing reefs or sandflat, shoreline tracing can be done at the beach toe, which is used as a shoreline change reference. It is marked by a break in slope and drastic change in sediment size and composition.

- On gently sloping coasts, the translation of shoreline between tidal phases can be much larger than the GPS error. It is important to determine where the mid-tide line (MTL) is, or the mid0way between the low-tide line (LTL) and high-tide line (HTL) (see **Fig. 9**). The MTL can also be approximated by the mid-swash zone. The swash zone marks the area where the waves and tides move sediments up and down the seaward sloping portion beach called the beach face (see **Fig. 9**). Shoreline tracing should be conducted during low-tide conditions to better approximate the location of the MTL.

3. Using another GPS, map the extent of the high-water mark features such as vegetation line or continuous scarps concurrently with shoreline tracing particularly on gently sloping coasts. Together with beach profiling, simultaneous mapping of the shoreline and high-water mark features such as scarps and vegetation line can distinguish between actual beach erosion and redistribution of sediments on adjacent platform or reef flat.

IV. Anecdotal Accounts

Interview long-time coastal residents to determine the changes that cannot be captured by shoreline change analysis (e.g. comparing only the oldest and most recent shoreline positions). Ask them about shoreline changes during the intermittent years, and possible causes of erosion as well as annual shoreline changes, and whether the beach can recover after typhoons or strong-wave events. The respondents may also provide insights on how the government and local community have responded to this hazard.

Data Processing and Management

Materials needed:

- Computer with GIS software (e.g. QGIS), spreadsheet program (e.g. MS Excel), and Google Earth
- NAMRIA topographic maps and satellite images
- Scoring rubrics

I. <u>Beach Profiling Data</u>

1. Encode data in MS Excel or other spreadsheet software.
    - Do not forget to affix the correct sign (i.e. either positive (+) or negative (-)) to the data under the third column (dz or change in elevation in cm) as it will indicate whether the beach is sloping upward or downward
    - If the fixed point is **not** the first point, do not include it in the computation. The descriptions (e.g. height of wall relative to the rod, distance from the wall) will be important for locating the same spot for the repeated surveys as part of monitoring.
    - Note the time when sea level is reached as this point will be used for resetting the readings to sea level and correction for tides. Tide correction will be done if the tide data is not yet referenced to mean sea level.

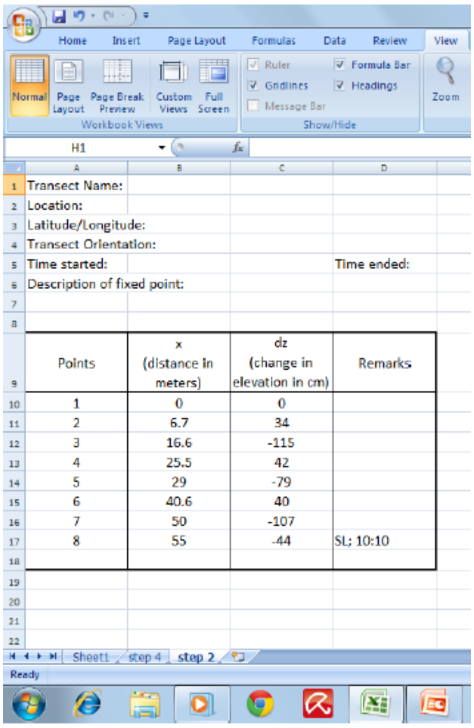


Figure 14. Example of an encoded beach profiling data.

2. Insert a column after the third column (dz) for the cumulative elevation (with column heading "Cumulative dz"). For the cells under this column, put in the formula for the cumulative summation of the dz (change in elevation in cm). For example, assuming that dz and cumulative dz are under columns C and D, respectively, then the cell D10 should have the value of C10, being the first entry in column C. For the second row of column D, D11, the formula should be "=D10+C11", which adds column C cumulatively. Apply the formula to the rest of the cells for Column D (*Cumulative dz).*

Points	x (distance in meters)	dz (change in elevation in cm)	Cumulative dz	Remarks
1	0	0	=C10	
2	6.7	34		
3	16.6	-115		
4	25.5	42		
5	29	-79		
6	40.6	40		
7	50	-107		
8	55	-44		

Points	x (distance in meters)	dz (change in elevation in cm)	Cumulative dz	Remarks
1	0	0	0	
2	6.7	34	=D10+C11	
3	16.6	-115		
4	25.5	42		
5	29	-79		
6	40.6	40		
7	50	-107		
8	55	-44		

Figure 15. Example of how to calculate Cumulative dz column.

3. Insert a column after “Cumulative dz” for a “Reset to SL” column. The **Reset the SL** column will give you a profile that is still not yet corrected for tides. Land elevation (dz) is always referenced to sea level. Thus the entry corresponding to sea level measurement in the “Cumulative dz” column should be set to zero (0). This can be done by adding the negative of the last cumulative dz value to the last cumulative dz value. For example, if the last cumulative dz value is -229, +299 should be added to it under the Reset to SL column of the same row. Apply this formula to the rest of the cells in Reset to SL column.

	Points	x (distance in meters)	dz (change in elevation in cm)	Cumulative dz	Reset to SL	Remarks
10	1	0	0	0		
11	2	6.7	34	34		
12	3	16.6	-115	-81		
13	4	25.5	42	-39		
14	5	29	-79	-118		
15	6	40.6	40	-78		
16	7	50	-107	-185		
17	8	55	-44	-229	=D17+229	SL; 10:10

	Points	x (distance in meters)	dz (change in elevation in cm)	Cumulative dz	Reset to SL	Remarks
10	1	0	0	0		
11	2	6.7	34	34		
12	3	16.6	-115	-81		
13	4	25.5	42	-39		
14	5	29	-79	-118		
15	6	40.6	40	-78		
16	7	50	-107	-185	=D16+229	
17	8	55	-44	-229	0	SL; 10:10
18						

Figure 16. Example of how to reset to sea level.

4. Add a column for Tide Corrected profile after the Reset to SL column. This is necessary because we still don't know where the 0 (or sea level is) relative to the MSL. In the Philippines, elevation data is always referred to MSL.
   - If tide data is already **referenced to MSL,** directly subtract the tide level to the values under reset to SL column. The tide level can be obtained from tide tables or wxtide32. Refer to attached guideline on how to get data from wxtide32 (Annex 4). In using dataset from wxtide32, get the tide level at the time when sea level was reached.
   - If tide data is **not yet** referenced to MSL, as in the case of the Philippines, follow the attached guidelines on tide correction
     - Get the tide level from Wxtide or NAMRIA predicted tide tables.
       - Get the tide level at the time when sea level rise reached during the survey (use the incremental tide option in wxtide to generate tide data per minute).
       - Get the mean tide level (MTL) or mean sea level (MSL) using the nearest station in the NAMRIA predicted tide table. Or estimate the MSL or MTL value from the wxtide.
     - Subtract the tide level at the time of the survey (tide level) from the MSL or MTL, as follows:

$$Tidediff = MSL - tidelevel$$

- On the "Tide corrected" column, subtract the tidediff from each entry in the preceding column, "Reset to SL"

  See Annex 5 for a detailed illustration of the tide correction procedure.

Points	x (distance in meters)	dz (change in elevation in cm)	Cumulative dz	Reset to SL	Tide Corrected	Remarks
1	0	0	0	229	200	
2	6.7	34	34	263	234	
3	16.6	-115	-81	148	119	
4	25.5	42	-39	190	161	
5	29	-79	-118	111	82	
6	40.6	40	-78	151	122	
7	50	-107	-185	44	15	
8	55	-44	-229	0	-29	

Figure 17. Example of tide correction for tide data not yet referenced to MSL.

5. Using Scatterplot, plot the uncorrected data ("Reset to SL" column) vs "Tide Corrected" column. Assign the 'Reset to SL' values on the y-axis (or Legend Entries (Series)) and the 'distance (x)' values on the x-axis (or Horizontal (Category) Axis Labels). With this, the graph should already show the uncorrected elevation data based on the Reset to SL values.

   Plot in the tide corrected data by adding the values under the "Tide Corrected" column to the y-axis. The graph should now show both the uncorrected (reset to SL) and tide corrected elevation data.

   During high tide, the tide corrected data should be higher than the uncorrected profile ("Reset to SL" column) because you are lowering the sea level at the time of the survey to mean sea (tide) level. Thus land elevation would appear higher after correcting for high tide. On the other hand, the tide corrected data should be lower than the uncorrected profile during low tide because you are raising the sea level at the time of the survey to mean sea level. Thus land elevation would appear lower if survey was done during low tide.

II. <u>Shoreline Change Computation</u>

This guideline outlines how to compute shoreline change using the change polygon method applied to shoreline datasets acquired from GPS shoreline mapping and shoreline traces derived from topographic maps, and satellite images such as Google Earth and LandSat. For more detailed and illustrated step-by-step guide, see demo of shoreline change computation using QGIS in Annex 6.

1. Process the most recent GPS shoreline trace. Download the marked coordinates from the GPS into a .csv (table) file.

2. Create a point shapefile from the .csv file by using QGIS or other GIS software.

3. Convert the resulting point shapefile into a line shapefile. This can be done by either manual or automatic tracing.
   - For manual tracing, add a new vector, selecting the type "Line" and then start creating the line to connect the series of points. Then add feature. For convenience, it is recommended that the *snapping* function (under settings) is enabled while creating the line. Snapping is an automatic editing operation in which points or features within a specified distance (tolerance) of other points or features are moved to match or coincide exactly with each other's coordinates. Save edits by clicking *Save Layer Edits*
   - For automatic tracing, the plugin *POINTS2ONE* should be installed. Once installed, double click the tool to use it. Input the point shapefile as the input vector layer. The plugin will automatically create the line. If the newly created line is not automatically added to QGIS, double click on the shapefile to manually add it.

4. Merge the resulting line shapefile of the most recent shoreline tracing with another trace of the same shore (either from an earlier GPS shoreline trace, NAMRIA topographic map, or satellite images) during a different time for visualization of the shoreline change. In doing so, make sure that the shapefiles to be merged are both in projected coordinate systems (PCS) (e.g. UTM). If any of shoreline traces are not in PCS, re-project the shapefile first to a projected one before merging into a single line shapefile.

5. Ensure that both ends of the shoreline traces intersect each other. In cases wherein the ends do not intersect, edit the shapefile and move the end of one line to the end (or vertex) of the other. This can be done through the *Node Tool* under *Toggle Editing*. Move the other end of the line if it also does not interest with the other line. Don't forget to save edits.

6. Create a polygon shapefile from the merged line shapefiles with intersecting ends.

7. Determine if polygons are seaward or landward of older shoreline. This can be done by adding a column in the Attribute Table of the Polygon shapefile. It is suggested that the column should be named "Trends". The type of data under this column should be whole number (integer).

   Highlight a particular polygon. Determine if the polygon is seaward or landward of the older shoreline. If the polygon is seaward, the trend on the polygon should be 1. If the polygon is landward, put -1 under *Trends.* Do this for all polygons created by the two shoreline traces, then save.

8. Copy the attribute table to Excel or spreadsheet program.

9. Compute net rate of change.

   Go to the Excel file. In the column after *Trends*, put in the formula which would multiply the *Area* value and the *Trends* value of the same row. Then sum up all the values under the new column. The summation will be the **Area** in square meters.

Go back to QGIS to get the length of the shoreline from the attribute table of either shoreline traces. If there is no length, add a column and label it *Length* in the attribute table of one of the shorelines. The data type under this column should be decimal number (real) with precision of 2. Then calculate the length using the Field Calculator of the software. Copy the **Length** from QGIS to the Excel file.

Compute the **Magnitude** in Excel by dividing the **Area** by the **Length.**

Determine the **Time interval** between the two shoreline traces by taking the difference in the year taken (or for the case of shorelines traced from topographic maps or satellite images, the year the map or image was created) – newer minus older.

Get the net rate of shoreline change in meter per year by dividing the **Magnitude** by **Time Interval.**

III. Vulnerability Scoring using CIVAT Rubrics

1. Use the CIVAT Scoring Rubrics (Annex 7) to determine the Exposure, Sensitivity, and Adaptive Capacity of each site. Score all the needed attributes for each site and input into the Rubrics.

A. Exposure

1.) Determine the values for the following attributes indicated in the Scoring Rubrics for Exposure:

- Relative sea-level change in millimeter per year (estimated from tide gauge data or satellite altimetry data)
- Wave exposure – published Relative Exposure Index (REI) for the barangay. As a proxy to REI, orientation of the coast with respect to the winds can be used, with coasts relatively protected from predominant winds scored at **1 to 2;** moderately exposed at **3 to 4;** and directly exposed at **5.**
- Tidal range – can be retrieved from wxtide or NAMRIA predicted table

2.) Assign the appropriate score based on the scoring guidelines shown in **Table 5**.

Table 5. Scoring guideline for exposure indicators.

EXPOSURE CRITERIA	Low		Medium		High
	(1-2)	**2**	**3**	**4**	**(5)**
Relative sea-level change (mm/yr)	≤ 0.1	≤ 2.4	> 2.4 to 3.8	> 3.8 to 7.6	>7.6
Wave exposure	Low		Medium		High
Tidal range (m)	≤ 1		1 - 2		>2
PROXY TO WAVE EXPOSURE					
Orientation of the coast to predominant winds/storms	*Relatively protected*		*Slightly exposed*		*Directly exposed*

3.) Sum up the scores for all the attributes.

4.) Rate the **Exposure** of the site, whether *Low*, *Medium*, or *High*, following the guide shown in **Table 6**.

Table 6. Rating guide for exposure.

Rating (Total number of Criteria = 3)	Range
Low (L)	3 – 7
Medium (M)	8 – 11
High (H)	12 - 15

B. Sensitivity

1.) Determine the following attributes which are indicated in the scoring rubrics for Sensitivity:

- Coastal landform and rock type – based on data collected through field observations, photodocumentation, and sediment characterization (done along with beach profiling).
- Seasonal beach recovery – based on the following data collected:
  - Beach profiling and shoreline tracing during and wet and dry season (i.e. if the profile appeared higher and longer than the previous one, then it is accreting.; if the profile is much shorter and flatter than the previous one, it is eroding; if there is minimal change in the profile, then it is relatively stable.)
  - Indicators of erosion observed during field observation: presence of scarp and tees with exposed roots with fresh markings; abundance of magnetite sand and coarse-grained sediments such as gravel; and human-induced shoreline retreat reflected by structures such as seawalls and groins
  - Anecdotal accounts: If the beach continues to erode after typhoons or strong winds, the shore is therefore eroding**.** If the shoreline returns to its original position, then the shore is considered stable. If the beach widens, the shore is accreting.
- Coastal slope – estimated from NAMRIA topographic map or Digital Elevation Models (DEM)
- Width of reef flat or shore platform – estimated from NAMRIA map or high-resolution satellite images in Google Earth
- Lateral continuity of reef flat or shore platform – estimated from NAMRIA topographic map or high-resolution satellite images in Google Earth
- Beach forest/vegetation – from field observation, photodocumentation, and tracing of extent of beach vegetation done along with shoreline tracing
- Coastal habitats –inputs from assessment and monitoring of coastal habitats and mangrove areas monitoring and assessment.
  - If habitat assessment is possible, consider the attributes listed below instead. Information needed for this can be taken from assessment and monitoring of coastal habitats, including mangrove forests:
    - Coral reef as sediment source
    - Seagrasses as sediment source and stabilizers
    - Mangroves as sediment trap
    - Mangroves as wave buffer
- Coastal and offshore mining – from field observation and photodocumentation
- Structures on the foreshore – from field observation and photodocumentation

2.) Assign the appropriate score based on the scoring guidelines shown in **Table 7**.

Table 7. Scoring guideline for sensitivity indicators.

	SENSITIVITY CRITERIA	**LOW**	**MEDIUM**	**HIGH**
		(1-2)	**(3-4)**	**(5)**
INTRINSIC FACTORS	**Coastal landform and rock type**	Rocky, cliffed coast; beach rock	Low cliff (<5m high); Cobble/ gravel beaches; alluvial plains; fringed by mangroves	Sandy beaches; deltas; mud/sandflat
	Seasonal beach recovery	Net Accretion	Stable	Net Erosion
	Slope from the shoreline to 20-m elevation (landward slope; rise over run)	>1:50	1:50-1:200	<1:200
	Width of reef flat or shore platform	>100	[50, 100]	<50
	Lateral continuity of reef flat or shore platform	>50%	[10-50]	<10%
	Beach forest/vegetation	Continuous and thick with many creeping variety	Continuous and thin with few creeping variety	Very patchy to none
	Coastal habitats	coral reef, mangroves and seagrasses or coral reef and mangroves are present	either coral reef or mangrove is present	none
	<u>If habitat assessment is possible</u>, use the following rubrics instead of presence or absence of coastal habitats (above item). See guide on scoring for each rubric on next table:			
	Coral reef as sediment source	*(average of criteria scores on next table)*		
	Seagrasses as sediment source and stabilizer	*(average of criteria scores on next table)*		
	Mangroves as sediment trap	*(average of criteria scores on next table)*		
	Mangroves as wave buffer	*(average of criteria scores on next table)*		
EXTRINSIC FACTORS	**Coastal and offshore mining (includes removal of fossilized corals on the fringing reef and beach)**	None to negligible amount of sediments being removed (i.e., sand and pebbles as souvenir items)	Consumption for HH use	Commercial scale
	Structures on the foreshore	None; one or two short groins (i.e., <5m long) and/or few properties on the easement with no apparent shoreline modification	Short groins & short solid-based pier (5 to 10m long); seawalls and properties with aggregate length of less than 10% of the shoreline length of the barangay	Groins and solid-based pier > 10m long; seawalls and other properties with aggregate length of more than 10% of the shoreline length of the barangay

If habitat assessment is possible, use the following rubrics (**Table 8**) instead of presence or absence of coastal habitats: (1) Coral as sediment source, (2) Seagrass bed as sediment source and stabilizers, (3) Mangroves as sediment trap, and (4) Mangroves as wave buffer. Each of these rubrics has its own set of criteria for scoring. For each rubric, score according to the guide below. Average the scores of the criteria under the same rubric. The average will then be the final score for that specific rubric which will contribute to the assessment of sensitivity.

Table 8. Scoring rubrics for habitat assessment results.

SENSITIVITY CRITERIA FOR HABITATS	**LOW (1 to 2 pts per criterion)**	**MEDIUM (3 to 4 pts per criterion)**	**HIGH (5 points per criterion)**
Coral as sediment source (average of the scores of the criteria below)			
living coral cover	over 50%	between 25 to 50%	less than 25%
coral community growth form in the shallow reef	at least half of the corals are hemispherical/ massive and encrusting	at least half of the corals are tabulate	at least half of the corals are branching and foliose
Seagrass bed as sediment source and stabilizer (average of the scores of the criteria below)			
areal extent relative to reef flat	seagrasses cover more than half of the reef flat	seagrasses cover more than 1/8 to 1/2 of of the reef flat	seagrasses cover less 1/8 of the reef flat
capacity to withstand storm removal and wave impacts	root system extensive; *Enhalus acoroides* and *Thalassia hemprichii* dominated	*Thalassia - Cymodocea-Halodule* beds	small sized species, i.e. *Halophila - Halodule* meadows
seagrass meadow type	mixed bed with over 5 species	2 to 4 species	monospecific bed
Mangroves as sediment trap (average of the scores of the criteria below)			
forest type	riverine-basin-fringing type; basin-fringing type	riverine-fringing type; fringing	no mangrove; scrub type
mangrove zonation	3 to 4 mangrove zones (*Avicennia-Sonneratia; Rhizophora; Ceriops-Bruguiera-Xylocarpus; Nypa* zones*)*	2 mangrove zones	only 1 mangrove zone present
capacity to trap sediments	at least half of the mangrove area are *Avicennia-Sonneratia* dominated	at least half of the mangrove area are dominated by species with pneumatophore (*Avicennia, Sonneratia)*and knee root (*Bruguiera*, *Ceriops tagal*) system	area is dominated by species with prop (*Rhizophora*) or buttress/ plank (*Xylocarpus granatum, Heritiera littoralis*)type of root system
Mangroves as wave buffer (average of the scores of the criteria below)			
forest type	riverine-basin-fringing type	riverine-fringing type	scrub-fringing type
present vs historical mangrove extent	0 to 25% of original mangrove area loss; at least 75% of seaward zone remaining	26 to 50% of original mangrove area loss	over 50% of original mangrove area loss

SENSITIVITY CRITERIA FOR HABITATS	**LOW (1 to 2 pts per criterion)**	**MEDIUM (3 to 4 pts per criterion)**	**HIGH (5 points per criterion)**
mangrove zonation	3 to 4 mangrove zones (*Avicennia-Sonneratia; Rhizophora; Ceriops-Bruguiera-Xylocarpus; Nypa* zones*)*	2 mangrove zones	only 1 mangrove zone present
mangrove canopy cover	mangrove area with over 50% canopy cover	mangrove area with canopy cover that is between 25% to 50%	mangrove area with less than 25% canopy cover
mangrove basal area	more than 50 m^2 per ha	between 25 to 50 m^2 per ha	less than 25 m^2 per ha

3.) Sum up the scores for all the attributes.

4.) Rate the **Sensitivity** of the site, whether *Low*, *Medium*, or *High*, following the guide in **Table 9**.

Table 9. Rating guide for sensitivity.

WITHOUT HABITAT ASSESSMENT (total number of criteria = 9)		**WITH HABITAT ASSESSMENT (total number of criteria = 12)**	
Rating	**Range**	**Rating**	**Range**
Low (L)	9 – 21	Low (L)	12 – 28
Medium (M)	22 – 33	Medium (M)	29 – 44
High (H)	34 – 45	High (H)	45 – 60

C. Adaptive Capacity

1.) Determine the following attributes which are indicated in the scoring rubrics for Adaptive Capacity (AC):

- Long-term shoreline trends (m/year) – from comparison of latest shoreline position (shoreline tracing from GPS survey or from latest Google Earth or satellite images) and shoreline traces from old maps and satellite images or from previous GPS survey; anecdotal accounts
- Continuity of sediment supply – from field observation or high-resolution images in Google Earth
- Guidelines on setback zones – from Coastal Land Use Plan (CLUP)
- Guidelines on coastal structures – from CLUP and zoning guidelines for the site.
- Type of coastal development – CLUP and field observation and photodocumentation
- Viability of coral reef as sediment source – can be taken from assessment and monitoring of coral reefs
- Viability of seagrasses as sediment source - can be taken from assessment and monitoring of seagrass beds
- Viability of mangroves as sediment trap - can be taken from assessment and monitoring of mangrove forests

- Viability of mangroves as wave buffer - can be taken from assessment and monitoring of mangrove forests

2.) Assign the appropriate score based on the scoring guidelines shown in **Table 10**.

Table 10. Scoring guideline for adaptive capacity indicators.

ADAPTIVE CAPACITY CRITERIA	LOW	MEDIUM	HIGH
	(1 to 2 points per criterion)	(3 to 4 points per criterion)	(5 pts per criterion)
Long-term shoreline trends (m/ year)	≤ -1 (eroding)	(-1,0)	>0 (accreting)
Continuity of sediment supply	if interruption in sediment supply is regional	if interruption in sediment supply is localized	If sediment supply is uninterrupted
Guidelines regarding the easement (setback zone)	No provision for easement (setback zone) in the CLUP and zoning guidelines	Setback policy is clearly stated in the CLUP and zoning guidelines; with <50% implementation	Implementation of setback policy is at least 50%
Guidelines on coastal structures	CLUP and zoning guidelines promotes the construction of permanent and solid-based structures along the coast	Clearly states the preference for semi-permanent or temporary structures to be built along the coast(e.g., made of light materials and on stilts) is in the CLUP and zoning guidelines	Prohibits construction of solid-based structures; For those already erected, CLUP/zoning guidelines has provision to remove or modify any structure causing obstruction and coastal modification
Type of coastal development	Industrial, Commercial, Highways, Large institutional facility	Residential	Agricultural, Fishpond, Open space, Greenbelt
Viability of coral reef as sediment source	*Use AC matrix for coastal habitats (next table)*		
Viability of seagrasses as sediment source			
Viability of mangroves as sediment trap			
Viability of mangroves as wave buffer			

Below (**Table 11**) is the AC matrix for coastal habitats. To get the score of the *Viability of mangroves as wave buffer*, get the average of the scores of the two criteria under it.

Table 11. Adaptive capacity matrix for coastal habitats.

ADAPTIVE CAPACITY CRITERIA FOR COASTAL HABITATS		**LOW** (1-2 pts per criterion)	**MEDIUM** (3 to 4 points per criterion)	**HIGH** (5 pts per criterion)
Viability of coral reef as sediment source	living coral cover	less than 25%	between 25 to 50%	over 50%
Viability of seagrasses as sediment source	capacity to recover from storm blow-outs	*Enhalus-Thalassia* dominated	*Thalassia - Cymodocea- Halodule* dominated	*Halophila - Halodule* dominated
Viability of mangroves as sediment source	capacity to trap sediments	area is dominated by species with prop (*Rhizophora*) or buttress/ plank (*Xylocarpus granatum, Heritiera littoralis*)type of root system	at least half of the mangrove area are dominated by species with pneumatophore (*Avicennia, Sonneratia)*and knee root (*Bruguiera, Ceriops tagal*) system	at least half of the mangrove area are *Avicennia-Sonneratia* dominated
Viability of mangroves as wave buffer	canopy cover	mangrove area with less than 25% canopy cover	mangrove area with canopy cover that is between 25% to 50%	mangrove area with over 50% canopy cover
	mangrove basal area	less than 25 m^2 per ha	between 25 to 50 m^2 per ha	more than 50 m^2 per ha

3.) Sum up the scores for all the attributes.

4.) Rate the **Adaptive Capacity** of the site, whether *Low*, *Medium*, or *High*, following the guide in **Table 12**.

Table 12. Rating guide for adaptive capacity.

WITHOUT HABITAT ASSESSMENT (total number of criteria = 5)		**WITH HABITAT ASSESSMENT (total number of criteria = 9)**	
Rating	**Range**	**Rating**	**Range**
Low (L)	5 – 11	Low (L)	9 – 21
Medium (M)	12 – 18	Medium (M)	22 – 23
High (H)	19 – 25	High (H)	34 – 45

2. Determine the Potential Impact **(PI)** of each site. This is done by cross-tabulating *Exposure* and *Sensitivity*. Rank the PI of each site as *Low, Medium,* or *High* based on the cross-tabulation guide in T**able 13**.

Table 13. Cross-tabulation guide for determining potential impact.

Sensitivity (S)

Exposure (E)	**L**	**M**	**H**
L	L	L	M
M	L	M	H
H	M	H	H

Therefore:

LL, LM, or ML combination equates to ***Low***
LH, MM, or HL combination equates to ***Medium***
MH, HM, or HH combination equate to ***High***

3. Determine the Vulnerability **(V).** This is done by comparing *Adaptive Capacity (AC)* to *Potential Impact (PI)* of each site*:*
   - If AC > PI, then the site has **Low V**
   - If AC = PI, then the site has **Medium V**
   - If AC < PI, then the site has **High V**

Coral Reef Biodiversity

By Dr. Wilfredo H. Uy

Coral reefs represent some of the most biologically diverse ecosystems on earth, providing critical habitats to marine organisms. The reef is constructed of limestone (calcium carbonate) secreted as skeletal material by corals and calcareous algae. The reefs support fisheries and their structure provides natural breakwaters that protect shorelines, other ecosystems, and human settlements from waves and storms. Coral reefs are found in shallow clear waters and are generally absent in turbid waters.

Several methods are recommended for the assessment and monitoring of coral reef biodiversity. These are manta tow technique, point intercept technique complemented by photo-transect, day time fish visual census, and belt transect for associated macro-invertebrates.

The Manta Tow Technique is a popular method carried out by towing snorkelers using a small boat (English et al 1997, Uychiaoco et al 2001). The method requires relatively clear water for good visibility. It is used for wide area survey to get a broader picture of the reef conditions. It is also used to guide the selection of monitoring stations, to detect large scale changes due to storm or siltation, and to detect occurrence of disturbances such as bleaching and infestation of crown of thorns (COT).

The Point Intercept Technique (PIT) provides a quick assessment of the coral reef area by providing estimates of the relative abundance of living (live coral, soft corals, algae) and non-living things (dead corals, sand, rocks). The indicators for PIT are percent live hard coral cover per genus and lifeforms, percent dead coral cover, soft coral, macro-algae, sand, and rocks. PIT is best done by scuba diving, however snorkel survey can also be done in shallow areas (Uychiaoco et al 2001).

Daytime Fish Visual Census (FVC) is the identification and counting of fish in a given area. It is a non-destructive method of estimating fish variety and abundance in a given area and uses the following parameters: species richness, fish abundance, and fish sizes. Fish count and size estimation can provide information on fish biomass and abundance. This method is widely used as recommended by English et al (1997) and Uychiaoco et al. (2001). More detailed ecological work such as determining trophic structures and ratio of the reef fish can provide information on reef health conditions. Trophic level values of fish species can be obtained from FishBase®.

Lastly, Belt Transect Method is used to estimate population and variety of invertebrates associated with the coral reef.

Establishing Monitoring Stations

Sites that are representative of the coral condition in the area and can be reached during all weather conditions should be chosen for the establishment of permanent monitoring stations. At least four stations for deployment of two 50m transects each will be identified, that is, two stations inside, and two stations outside marine protected areas (MPAs).

To determine suitable sites for monitoring purposes, conduct a general survey using manta tow (refer to Data Collection to see how). The survey will give you an overview of the coral reef which will reveal which sites best represent the area. For biodiversity monitoring purposes, the permanent monitoring sites should be established in areas of the coral reef with the best coral cover.

Other considerations for selection of locations for monitoring stations are as follows: For small islands, choose one site representing the windward (front-reef) zone and another representing the leeward (back-reef) zone. In regions where reversing monsoon winds prevail, select sites in reef areas exposed to the different monsoon winds.

The actual location of the transect (i.e. monitoring station) should be recorded using a GPS (i.e. recording the coordinates of both ends of the transect), noting landmarks or unique features that may help locate the site in future monitoring. Mark the position of the transect location by hammering a one-meter bar with loop at the upper end, and provided with a subsurface buoy for easy location in future monitoring activities.

Frequency of Monitoring and Expected Data Output

Tables 14 and 15 below show the recommended frequency, duration, and expected output of assessment and monitoring of coral reef biodiversity for each group.

Table 14. Recommended frequency and duration for coral reef biodiversity assessment and monitoring per monitoring group.

Method	Frequency and duration		
	Experts/Academe	**DENR**	**LGU/Community**
Manta tow technique for wide area survey of coral reef areas	Once every 5 years; 2-3 days per survey	Quarterly; 2-3 days per survey	Quarterly; 2-3 days per survey
Coral survey (PIT) complemented with photo-transect	Once every 2 years; 4-5 days per survey	Twice a year; 4-5 days per survey	Twice a year; 3-4 days per survey (minus photo-transect)
Daytime FVC for reef fish	Once every 2 years; 4-5 days per survey	Twice a year; 4-5 days per survey	Twice a year; 3-4 days per survey
Belt transect for macro-invertebrates	Once every 2 years; 4-5 days per survey	Twice a year; 4-5 days per survey	Twice a year; 3-4 days per survey

Table 15. Expected output of coral reef biodiversity assessment and monitoring for each monitoring group.

Ecosystem/ Resource and Method	Output/Indicators		
	Experts/Academe	**DENR**	**LGU/Community**
Manta tow technique	• Live coral cover • Dead coral cover • Soft corals • Coral bleaching • COT • Other observations: blasting, storm/anchor damage	• Live coral cover • Dead coral cover • Soft corals • Coral bleaching • COT • Other observations: blasting, storm/anchor damage	• Live coral cover • Dead coral cover • Soft corals • Coral bleaching • COT • Other observations: blasting, storm/anchor damage
Point-intercept technique (PIT) complemented with photo-transect	• Coral ID up to species level whenever possible and lifeform • Percent live hard coral • Percent dead coral cover, soft corals • Associated invertebrates e.g. crown of thorns, giant clams, sea cucumbers identified up to species level • Coral diseases	• Coral ID genus level and lifeform • Percent live hard coral • Percent dead coral cover, soft coral • Associated invertebrates e.g. crown of thorns, giant clams, sea cucumbers identified up to general level or major groups	• Percent live hard coral cover per lifeforms • Percent dead coral cover, soft coral • Associated invertebrates e.g. crown of thorns, giant clams, sea cucumbers identified by their local name • Categories classification using minimal number of codes
Daytime FVC for reef fish	• Fish ID up to species level • Species richness • Fish count per species • Fish abundance • Fish sizes (actual size estimates in cm) • Trophic structures/ratio	• Fish ID as major groups or genera, • Species richness • Fish count per major group or genera • Fish abundance • Fish sizes (3 size class)	• Fish ID using local names • Fish count per local names • Fish abundance • Fish sizes (3 size class)
Belt transect for macro-invertebrates	• Macro-invertebrates counted and identified up to species level	• Macro-invertebrates counted and identified up to genera level	• Macro-invertebrates counted and identified using local names

Data Collection

I. Manta Tow

Materials needed:

- Mask and snorkel
- Small boat

- GPS
- Manta board with rope (refer to **Fig. 18**)
- Writing slate and pencil (aside from the one attached to the manta board) or field notebook for above sea note taking

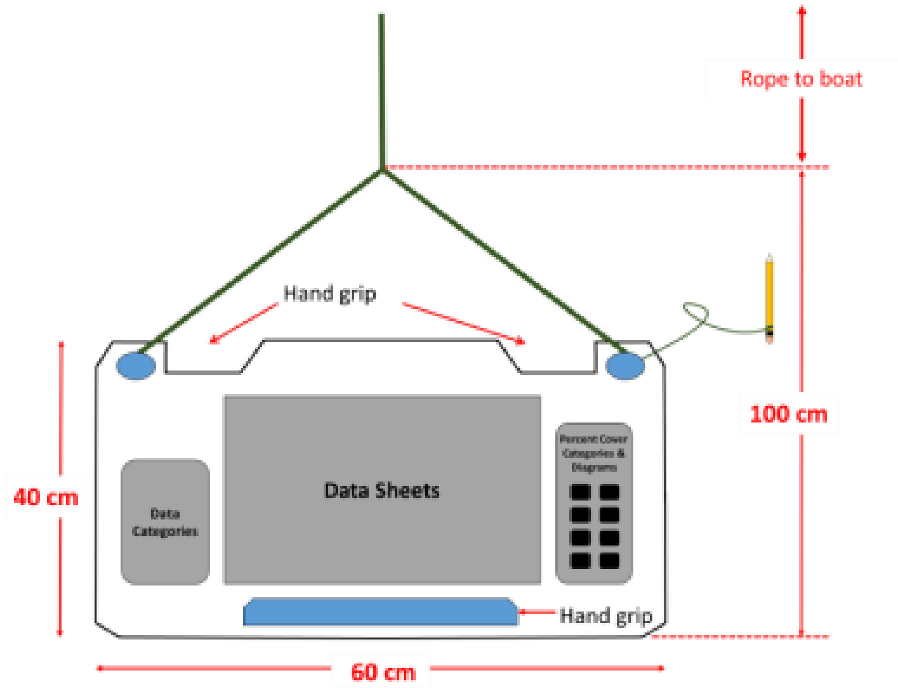


Figure 18. Schematic diagram of the manta board redrawn from English et al (1997).

Procedure:

In terms of human resources, a manta tow survey would require at least four persons: (1) a boat operator, (2) an observer who knows how to use mask and snorkel and must be physically fit to undergo long hours of sea and sun exposure, (3) a time tracker, and (4) a navigator.

Figure 19. View of observer while being towed.

1. Attach manta board to boat with 17m length of rope.

2. Observer geared with mask and snorkel grip on the board.

3. Run the boat along the reef crest at speed of three to five kilometers per hour, towing the Observers. Navigator may take note of activities along the shoreline such as number of fishing boats and structures like fish pens, floating cages, etc.

4. The time tracker should keep track of every run and signal the boat operator to reduce speed every two minutes for recording. At the same time, pull and jerk the rope to give signal to the observer to record.

5. The Navigator, on the other hand, should mark or record the coordinates of each stop using a GPS together with a map sketch.

6. The Observer will follow a tow sequence for each stop in sync with the Navigator. At each stop, the Observer will write down his/her rating of the percent live hard coral cover on the waterproof data sheet or writing slate attached to the manta board. Rating will be guided by the Percent Cover Index in **Table 16**:

Table 16. Percent cover index for manta tow.

Rating	Estimated Percent Live Hard Coral Cover (%)
1	0 – 10
2	11 – 30
3	31 – 50
4	51 – 75
5	76 - 100


Photo by Gary John B. Cabinta

Figure 20. Observer signaling direction towards next stop.

The Observer will also take note of any occurrence of disturbances such as coral bleaching and COT infestation.

Note:

- Need to ensure that all data sheets or writing slates are labelled with the location, date of tow, and observer's name for data management.
- The time tracker must be in constant watch of the observers for signals or directions. Synchronization of tow number is critical and this must be communicated properly to the observer using hand signals.

Optional: An observer may bring an underwater camera while towing. Pictures may be taken at any point during the towing (e.g. good coral cover, COT infestations, bleaching events, coral blasting, fish cages, etc). The camera must be synchronized with the GPS in terms of date and time. The resulting images may be synchronized with the GPS track using a freeware software GPicSync (Annex 8)

II. Point-intercept Technique with Photo-transect Method

Materials needed:

- Mask, snorkel, and fins
- Scuba gear
- Writing slates with pencil
- GPS
- Laminated field guides
- Data sheet

- Lead sinker with line or a plumb line
- Photo-kit for quadrat
- Transect tape (at least 50m)
- Underwater digital camera (preferably wide angle cameras)
- Monopod (preferably rust proof)

<u>Procedure:</u>

Considering the expected output from the representatives of academe and DENR, personnel who are certified scuba divers, strong swimmers, and physically fit to undergo diving and snorkeling are needed for the conduct of these methods. Personnel should also be adept in computer use for encoding and processing data. Representatives of the LGU and community, on the other hand, need not be certified scuba divers but they should be strong swimmers, knows how to snorkel, and should have good eyesight to write underwater using slates and pencils.

Basic knowledge on taxonomy and/or willingness to undergo training on taxonomy is also required from the personnel who will be conducting this survey.

1. Prior to going out on field, camera should be calibrated for the photo-transect. Photos for this method should cover 1x1m quadrat using the highest resolution possible. The objective of the calibration, therefore, is to adjust the distance of the camera to achieve a 1x1m-quadrat coverage in the resulting image. For camera with wide angles, distance may vary from 60 to 80cm. For camera with no wide angles, distance may be longer than 1m, thus wide angle cameras are recommended.

   Figure 21. Camera calibration: Determining the height of monopod (left) and distance of camera (right) from surface to capture a 1x1m quadrat photo.

   Personnel may choose to attach the camera with a rust-proof monopod with the stand already adjusted and fixed on the length equivalent to the distance determined in the calibration. By doing this, taking photos will be easier as the observer would not need to repeatedly determine the height from which he/she should take the picture since the monopod is already fixed on the right distance.

   Set the camera to take pictures in the highest resolution possible, set the right date, and turn on geo-tagging function, if available.

2. Lay two 50-meter transects along reef slope at three- to six- meter depth level, or along the established permanent monitoring station for coral reef. The transect tape should be stretched snugly to follow depth contours. For reefs with deeper areas, such as reef a wall, additional transects may be deployed at 10m depth level.

3. Determine and record the coordinates at the start and end of each transect using a GPS.

4. Using the plumb line as a guide, record categories such as coral genera and lifeform, dead coral algae, recently dead corals, sand/silt/rocks/rubbles, macro-algae, and coralline algae for every 0.25m, starting at point 0. It would be helpful if the transect tape is marked at 5 meter interval (e.g. with pink or yellow electric tape) prior to laying the transect for easier sighting of recording points.

Figure 22. Diver recording lifeform every 0.25m of the transect.

For convenience in recording, follow a standard coding system for the different lifeform categories. **Table 17** below is the suggested coding system for the different categories:

Table 17. Recommended coding system for coral and other lifeforms using point-intercept technique.

Group	Code	
Live Hard Coral	ACROPORA • **ACB** – Acropora branching • **ACE** – Acropora encrusting • **ACS** – Acropora submassive • **ACD** – Acropora digitate • **ACT** – Acropora tabulate	NON-ACROPORA • **CB** – Coral branching • **CE** – Coral encrusting • **CF** – Coral foliose • **CM** – Coral massive • **CS** – Coral submassive • **CMR** – Coral mushroom • **CME** – Coral *Millepora* (fire coral) • **CHL** – Coral *Heliopora* (blue coral)
Dead Coral	• **DC** – Dead coral	• **DCA** – Dead coral with algae
Other Biotic	OTHER FAUNA • **SC** – Soft bodied coral • **SP** – Sponge • **OT** – Other fauna (e.g. ascidians, anemonies, gorgonians, giant clams, etc.)	ALGAE • **AA** – Algal assemblage (i.e. consists of more than one species) • **CA** – Coralline algae • **MA** – Macro Algae • **TA** – Turf algae • **SG** – Seagrass
Abiotic	• **S** – Sand • **R** – Rubble • **SI** – Silt	• **WA** – Water (i.e. fissures deeper than 50cm) • **RCK** – Rock

A laminated field guide on lifeform identification (Annex 9) can be brought along during transect reading so that the observer can have an on-hand reference.

Ensure that the data written down in on the writing slates are labelled with the site name and transect number.

5. Take photos every 0.25m along the transect, ensuring that the photo captures a 1x1m quadrat.

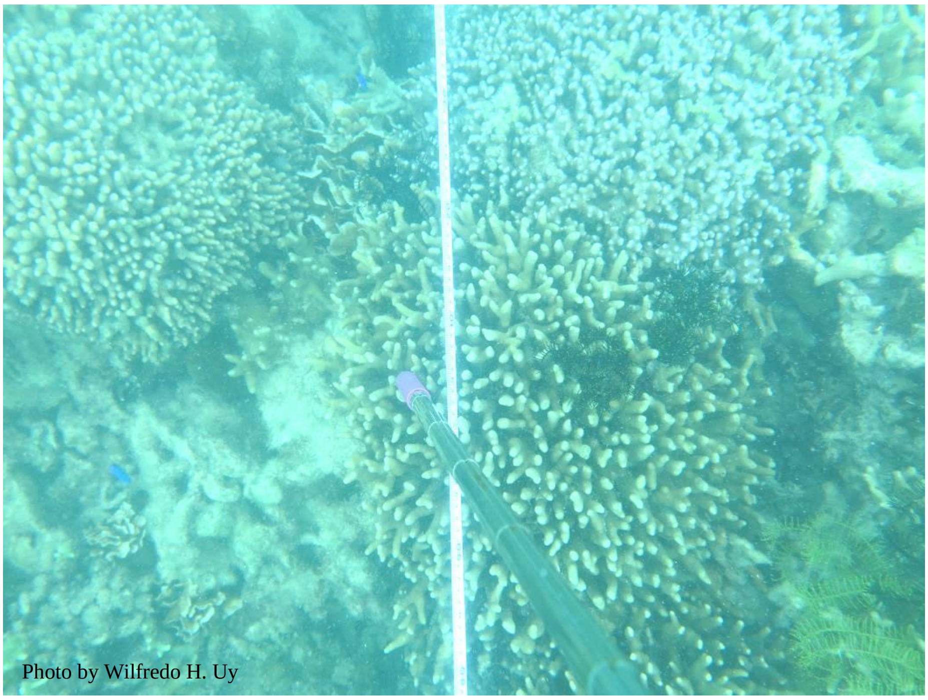


Photo by Wilfredo H. Uy

Figure 23. Sample 1x1m quadrat captured during photo-identification.

III. Daytime Fish Visual Census

Materials needed:

- Mask, snorkel, and fins
- Scuba gear
- Writing slates with pencil
- Transect tape (at least 50 meters)
- GPS
- Laminated fish guides

Procedure:

This survey can be done anytime during daylight hours and should be done in conjunction with the point intercept coral survey. The same transect lines established for the point-intercept technique will be used for the FVC.

The academe and DENR personnel who will do the FVC must be certified scuba divers physically fit to undergo long hours in the sea and sun, and should have basic training on fish identification. For representatives from the LGUs, they must know how to use the mask and snorkel; must be willing to learn basic taxonomy and field protocols, while recording data or information underwater.

1. Before doing the survey, it is best to swim and get acquainted with the fish species found in the area. Make a preliminary checklist of reef fish before doing the FVC.

2. After the transect is laid, wait for about 10 to 15 minutes to allow the fish to return after the disturbance.

3. Take note of the time of survey, visibility, and conditions of the coastal waters.

4. The fish census can be done either by snorkel survey for shallow stations and/or scuba diving for deeper stations. Observers read and record fish ID and count within 2.5m on the right side, 2.5m on the left side, and 5m above the transect. A laminated reef fish guide (Annex 10) can be used underwater as a handy reference. Counts for each fish identified should be obtained per size class (i.e. size ranges **1-10cm**, **11-20cm**, and **21-30cm).** If fish identified is longer than 30 cm, the estimated length of the fish should be recorded.

   If visibility is poor, it may be necessary to reduce the observation distance by half (1.25 m both sides and 2.5m above the transect).

   The transect should be surveyed as a complete 50 x 5m belt and should not be broken into smaller units.

Figure 24. Reef fish found within the 50m x 5m belt.

IV. Belt Transect for Macro-invertebrates in Coral Reefs

Materials needed:

- Mask, snorkel, and fins
- Scuba gear
- Transect tape (at least 50 meters)

- Laminated field guides
- Writing slates with pencil
- Pegs

Procedure:

This method will be done using the same transect laid for coral survey. Persons who will carry out the belt transect surveys must know how to use the mask and snorkel in shallow areas and certified scuba divers for deep transects. They must be physically fit to undergo long hours of work in the sea and sun, and must be able to identify species of invertebrates (or are willing to learn the basic taxonomy and field protocols) while recording data or information underwater.

Identify and count macro-invertebrates at 5m interval along the 50m transect, starting at point 0. Observation distance from the transect line at these intervals should be 2.5 meters to the left and 2.5 meters to the right. The field guide to common invertebrates (Annex 11) can be helpful in the invertebrate identification.

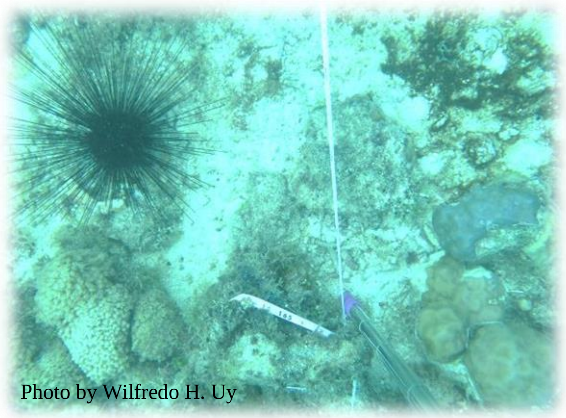


Figure 25. Some macro-invertebrates found in coral reefs.

Data Processing and Management

The spreadsheets on Annex 12 and Annex 13 are designed to organize data collected for assessment and monitoring of coral reef biodiversity and facilitate processing, storage, and management. Encode the collected data onto the spreadsheets.

I. Point Intercept Technique

The spreadsheet already contains the formula that would automatically compute the percent cover of live hard coral, dead coral, other animals, plants and algae, and abiotics with the entry of the PIT data collected. However, in the absence of these files, the percent cover of each lifeform and benthic category considered in the survey can be computed by dividing the frequency of the lifeform intercepted by the transect at 0.25m interval) by 200 (i.e. the total number of recordings made for the whole transect), then finally multiplying by 100 to convert the value into percentage (see below). Therefore, if ACB (*Acropora* branching) coral was recorded 100 times in the transect, the percent cover for that particular transect is 50%.

$$\% \ cover = \left(\frac{frequency \ of \ lifeform}{200}\right) x \ 100$$

The data can be summarized by collapsing the lifeforms into five groups:

1. Live coral – sum of percent cover of all *Acropora*, non-*Acropora*, and soft coral
2. Dead coral – sum of percent cover of dead coral and dead coral with algae
3. Flora – sum of percent cover of all algae and seagrass
4. Abiotic – sum of percent cover of rubble, rock, sand, silt, and water

The data summary can be presented in graphical form either as pie or bar chart.

II. Photo-Transect

Digital images obtained from the reef survey will be processed using the Coral Point Count with Excel Extension (CPCe) Version 4.1, a Windows-based software that provides a tool for the determination of coral cover using transect photographs (Kohler & Gill 2006). The photo-transect method with CPCe for image analyses are the same method used by the Coral Reef Visualization and Assessment (CoRVA) and the National Assessment of Coral Reef Environments (NACRE) projects. There may be slight modifications but results are comparable. A quick start guide for using CPCe can be accessed through the link http://cnso.nova.edu/forms/cpce_quickstart_guide.pdf.

Seagrass Biodiversity

By Dr. Wilfredo H. Uy

Seagrasess are truly submerged flowering plants that form extensive vegetation in shallow waters. Seagrass beds are often called nursery habitat because they provide shelter for small invertebrates, small fish, and juveniles of large organisms that support nearshore fisheries. At least 12 seagrass species has been identified in the Philippines out of the 50 species worldwide (Fortes 1989). Seagrass beds are also good indicators of coastal ecosystem changes because their loss signals a deterioration of ecological conditions (e.g. water quality).

Transect-quadrat method is used to estimate seagrass cover and relative abundance of the different seagrass species in a given area. It is a popular method being adopted globally for comparative assessment of the state of seagrass ecosystems. The method yields data on percent seagrass cover, species richness, canopy height, and associated invertebrates (e.g. sea cucumbers, sea urchins, and shellfish). The belt transect method is also employed to estimate variety and population size of invertebrates associated with the seagrass beds.

Establishing Monitoring Stations

In locating suitable sites for establishment of permanent monitoring stations for seagrass beds, it is best to visit seagrass beds within the area of concern during low tide to determine the extent of the seagrass meadow. It is highly encouraged that the extent of the seagrass beds be estimated using GPS and plotted in maps, if possible.

Choose an area that is relatively evenly shaped with no sandbanks, mud ridges, or changes in the meadow. Select a site that is representative of the seagrass in the area and is easy to revisit in future monitoring.

Place the first 50m transect parallel to the shore and mark the start and end of the transect using a GPS. Set the second transect 50m apart from the first transect going seaward and likewise mark the coordinates. These transects will represent the nearshore and middle portion of the seagrass bed.

To permanently mark the transect locations, drive a 1m iron bar with a loop at the top end, and attach a subsurface buoy. Permanent markers may be set at the start and end of every transect. Record the position of the iron bar using a GPS.

Frequency of Monitoring and Expected Data Output

Tables 18 and 19 below show the recommended frequency, duration, and expected output of seagrass biodiversity assessment and monitoring for each group.

Table 18. Recommended frequency and duration for seagrass biodiversity assessment and monitoring per monitoring group.

Method	Frequency and duration		
	Experts/Academe	DENR	LGU/Community
Transect-quadrat for seagrass	Once every 2 years; 4-5 days per survey	Twice a year; 4-5 days per survey	Twice a year; 3-4 days per survey
Belt transect for macro-invertebrates	Once every 2 years; 4-5 days per survey	Twice a year; 4-5 days per survey	Twice a year; 3-4 days per survey

Table 19. Expected output of seagrass biodiversity assessment and monitoring per monitoring group.

Ecosystem/ Resource and Method	Output/Indicators		
	Experts/Academe	DENR	LGU/Community
Transect-quadrat for seagrass	• Seagrass ID species level • Percent seagrass cover • Species richness • Species dominance and category • Canopy height, • Shoot density • Associated invertebrates counted and identified up to species level	• Seagrass ID species level • Percent seagrass cover • Species richness • Species dominance and category • Canopy height • Associated invertebrates counted and identified up to genera level	• Seagrass ID genus level or local names • Percent seagrass cover • Associated invertebrates counted and identified using local names
Belt transect for macro-invertebrates	• Macro-invertebrates counted and identified up to species level	• Macro-invertebrates counted and identified up to genera level	• Macro-invertebrates counted and identified using local names

Data Collection

I. Transect-quadrat Method for Seagrass Assessment

Materials needed:

- Mask and snorkel
- Transect tape (at least 50m)
- Writing slates with pencil
- GPS
- Pegs
- 0.5m x 0.5m quadrats (without grids)
- Ruler
- Underwater digital camera
- ID guides

Procedure:

The recommended transect-quadrat method for seagrass that will go into the BMS is modified after the SeagrassNet Protocol (Short et al 2001) and Seagrass Watch (McKenzie et al 2003). Transect tapes are laid parallel to the shoreline (SeagrassNet) instead of perpendicular to the shoreline. The quadrats will be placed regularly at 5m interval (Seagrass Watch) instead of random pre-set quadrats. Random quadrats may cause confusion if there are many sites to monitor.

1. Lay two 50m transects along the seagrass area parallel to the shoreline. Transects should be set at 50 meters apart to represent the nearshore and middle portion of the seagrass meadow. Record the coordinates of the beginning and end of each transect.

2. Set the quadrats at 5m interval, starting at point 5. Therefore, each transect should have a total of 10 readings or recordings.

   In setting down the quadrat, always place the quadrats on the right side of the transect line and walk on the left side to avoid trampling the seagrass.

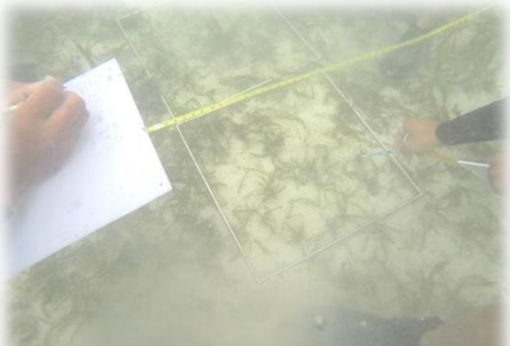


Photo by Gary John B. Cabinta

Figure 26. Seagrass percent cover estimation with the use of 0.5m x 0.5m quadrat without grids.

3. Inside each quadrat, record the seagrass species found and the percent cover of each species. For example, in one quadrat, a 20% cover of *Cymodocea rotundata* and 5% *Thalassia hemprichii* may be recorded. When no other seagrass species occur in that quadrat, then the remaining 75% of the quadrat is composed of substrate.

   Refer to Annex 14 for the seagrass species identification and percent cover estimation guides.

II. Belt Transect for Macro-invertebrates in Seagrass Beds

Materials needed:

- Mask, snorkel, and fins
- Scuba gear (optional)
- Transect tape (at least 50 meters)
- Laminated field guides
- Pegs

Procedure:

Assessment of macroinvertebrates will be done using the same transect laid for the seagrass survey. Persons who will do the belt transect survey must know how to use the mask and snorkel, or must be certified scuba divers for deep transects, and must be physically fit for long hours of work under the heat of the sun. Ability of the observer to identify species of invertebrates is important, otherwise he/she must be willing to learn basic taxonomy and field protocols.

Identify and count invertebrates at 5m interval along the 50m transect, beginning at point 0 (1 x 5m). The observation corridor along the transect is 0.5 meters to the left and right of the line. A field guide to common invertebrates (Annex 11) can be helpful in field identification of macroinvertebrate.

Figure 27. Some macro-invertebrates found commonly in seagrass beds.

> **Note:** If invertebrates are too many to count along the transect, such as gastropods, quadrat sampling may be used to quantify them. The quadrat size is 1x1m and set at 5 m interval along the transect. However, the belt transect should also be done for other invertebrates such as sea cucumbers, and crabs. Be cautious of the different sizes of quadrats used in the calculation – the values should be expressed as individuals/m^2 then converted to number individual/hectare.

Data Processing and Management

The spreadsheets on Annex 15 and Annex 13 are designed to help the organization of seagrass data and formulas are provided for the computation of percent seagrass cover.

Percent cover of each seagrass species for one whole transect is computed by getting the average of all its recorded percent cover within the transect. Summing up the averages for all seagrass species will yield the percent seagrass cover for that specific transect.

To estimate the percent seagrass cover of the whole site as represented by the transects established, get the average of the total percent seagrass cover of all transects. The same is done in estimating the percent cover of each seagrass species within the site.

Mudflat and Intertidal Areas Biodiversity

By Dr. Wilfredo H. Uy

Mudflats, also known as tidal flats, are considered important areas particularly for migratory birds due to the abundance of large food items such as small invertebrates (e.g. crabs and mollusks) and fish. They are usually found in sheltered areas such as bays, lagoons, and along mangrove areas. Belt transect method recommended as a tool to estimate population and variety of invertebrates associated with mudflat and intertidal areas.

Establishing Monitoring Stations

Mudflats are generally found between mangrove area and seagrass beds. It is best to locate monitoring stations in mudflats and intertidal areas near the locations of the seagrass monitoring stations.

Frequency of Monitoring and Expected Data Output

Tables 20 and 21 below show the recommended frequency, duration, and expected output of mudflat and intertidal areas biodiversity assessment and monitoring for each group.

Table 20. Recommended frequency and duration for mudflat and intertidal area biodiversity assessment and monitoring per monitoring group.

Method	Frequency and duration		
	Experts/Academe	DENR	LGU/Community
Belt transect for macro-invertebrates	Once every 2 years; 4-5 days per survey	Twice a year; 4-5 days per survey	Twice a year; 3-4 days per survey

Table 21. Expected output for mudflat and intertidal area biodiversity assessment and monitoring per monitoring group.

Ecosystem/ Resource and Method	Output/Indicators		
	Experts/Academe	DENR	LGU/Community
Belt transect for macro-invertebrates	• Macro-invertebrates counted and identified up to species level	• Macro-invertebrates counted and identified up to genera level	• Macro-invertebrates counted and identified using local names

Data Collection

Materials needed:

- Transect tape (at least 50 meters)
- Laminated field guides
- Pegs

Procedure:

Biodiversity assessment of mudflats and intertidal areas using the belt transect is generally carried out at low tides when the area is exposed to air, otherwise a mask and snorkel may be used. As in the coral and seagrass assessments the observers must be physically fit and must be able to identify species of invertebrates or are willing to learn the basic taxonomy and field protocols to obtain accurate data or information.

- Lay two 50m transects parallel to the shoreline along mudflats.

- Identify and count invertebrates at 5m interval along the 50m transect, starting at point 0. Annex 13 datasheet is recommended for data collection. Observation distance from the transect line at these intervals should be 0.5 meters to the left and 0.5 meters to the right. The field guide to common invertebrates (Annex 11) can be helpful in the invertebrate identification.



Figure 28. Belt transect on mudflats and some macro-invertebrates found within the transect.

Seaweed Biodiversity

By Dr. Wilfredo H. Uy

Seaweeds are also known as macroscopic benthic algae and are mostly associated with the rocky shores. They are non-flowering plants and usually do not form extensive beds as seagrasses do. Some species, such as the brown seaweed *Sargassum*, however, may form relatively extensive beds along the reef edge while others may form seasonal seaweed mats along beaches and intertidal areas, such as seasonal "blooms" of the green filamentous algae *Ulva*, *Enteromorpha*, *Chaetomorpha*, and others.

Assessment and monitoring method for seaweed biodiversity is designed in a way that it only looks into large and dominant seaweeds in rocky shores. The indicator considered in this method is seaweed cover focusing on dominant species e.g. *Sargassum* sp., *Gracilaria* sp., *Chaetomorpha* sp., and *Ulva* sp. (common species in green algal bloom). Other species of seaweeds may be included depending on the level of expertise of the observer.

As in seagrass biodiversity, assessment and monitoring of seaweed areas makes use of the transect quadrat and belt-transect methods.

Establishing Monitoring Stations

In locating suitable sites for establishment of permanent monitoring station for seaweeds in rocky shores, it is best to visit the area during low tide to determine the extent of seaweed forming meadows such as *Sargassum*. It is highly encouraged that the extent of the *Sargassum* beds be estimated using GPS and plotted in maps, if possible.

Select a site that is representative of the seaweeds in the area and is easy to revisit in future monitoring, ideally close to the coral reef monitoring stations.

To permanently mark the transect locations, drive a 1m iron bar with a loop at the top end, and attach a subsurface buoy. Permanent markers may be set at the start and end of every transects. Record the position of the iron bar using a GPS.

Frequency of Monitoring and Expected Data Output

Tables 22 and 23 below show the recommended frequency and duration seaweed areas biodiversity assessment and monitoring for each group and expected output from them.

Table 22. Recommended frequency and duration of seaweed biodiversity assessment and monitoring per monitoring group.

Method	**Frequency and duration**		
	Experts/Academe	**DENR**	**LGU/Community**
Transect-quadrat for seaweed	Once every 2 years; 4-5 days per survey	Twice a year; 4-5 days per survey	Twice a year; 3-4 days per survey
Belt transect for macro-invertebrates	Once every 2 years; 4-5 days per survey	Twice a year; 4-5 days per survey	Twice a year; 3-4 days per survey

Table 23. Expected output for seaweeds assessment and monitoring per monitoring group.

Ecosystem/ Resource and Method	**Output/Indicators**		
	Experts/Academe	**DENR**	**LGU/Community**
Transect-quadrat for seaweeds	• Seaweed ID up to species level • Seaweed cover (focus on dominant species e.g. *Sargassum, Gracilaria, Ulva* (green algal bloom) • Associated invertebrates counted and identified up to species level	• Seaweed ID up to genera level • Seaweed cover (focus on dominant species e.g. *Sargassum, Gracilaria, Ulva* (green algal bloom) • Associated invertebrates counted and identified up to genera level	• Seaweed ID using local names • Seaweed cover (focus on dominant species e.g. *Sargassum, Gracilaria, Ulva* (green algal bloom) • Associated invertebrates counted and identified using local names
Belt transect for macro-invertebrates	• Macro-invertebrates counted and identified up to species level	• Macro-invertebrates counted and identified up to genera level	• Macro-invertebrates counted and identified using local names

Data Collection

I. Transect-quadrat Method for Seaweed

Materials needed:

- Mask and snorkel
- Transect tape (at least 50m)
- Writing slates with pencil
- GPS
- Pegs
- 0.5m x 0.5m quadrats with 0.1 m grids
- Ruler
- Underwater digital camera

Procedure:

Personnel who will do the monitoring must know how to use the mask and snorkel; are physically fit to undergo long hours in the sea and sun; and must be able to identify species of seagrass, seaweeds, and invertebrates. For LGUs, participants must be willing to learn the basic taxonomy and field protocols, while recording data or information underwater. Suggested references for seaweed identification are the following: Calumpong & Meñez.1997, and Trono 1997.

1. Lay two 50m transects parallel to the shoreline along shallow rocky areas.

2. Set the quadrats at 5m interval, starting at point 5. Thus, each transect should have a total of 10 readings or recordings.

3. In each quadrat, record seaweed species and percent cover. Optional data are shoot density and photographs per quadrat.

   Reading is done per 0.1 x 0.1m grid using the categories by Saito & Atobe (1970) (**Table 24**). The actual cover per species is the average of the 25 small grids in every quadrat. To calculate the percent cover of every species per quadrat, use the midpoint equivalent of every score and get the sum of all the grids and divide by 25. See further details to calculate in English et al (1997).

Table 24. Species cover code after Saito and Atobe (1970).

Score	Amount of Substratum Covered	% Substratum Covered	Mid Point % Equivalent
5	More than ½	50 – 100	75
4	¼ to ½	25 – 50	37.5
3	1/8 to ¼	12.5 – 25	18.75
2	1/16 to 1/8	6.25 – 12.5	9.38
1	Less than 1/16	< 6.25	3.13
0	Absent	0	0

II. Belt Transect for Macro-invertebrates in Seaweed Areas

Materials needed:

- Mask, snorkel, and fins
- Scuba gear (optional)
- Transect tape (at least 50 meters)
- Laminated field guides
- Pegs

Procedure:

This assessment will be carried out using the same transect laid for seaweed survey. Masks and snorkels should be used in assessing macroinvertebrate species associated with seaweed communities. Observers must be physically fit to work long hours in the sea and sun, and must be able to identify species of invertebrates, otherwise he/she should be willing to learn the basic taxonomy and field protocols in faunal assessment in seaweed areas for accurate recording of data.

Identify and count invertebrates at 5m interval along the 50m transect, beginning at point 0. Annex 13 datasheet is recommended for data collection. Observation distance from the transect line at these intervals should be 0.5 meters to the left and 0.5 meters to the right. The field guide to common invertebrates (Annex 11) can be helpful in the invertebrate identification.

Note: If invertebrates are too many to count along the transect, such as gastropods, quadrat sampling may be used to quantify them. The quadrat size is 1x1m and set at 5 m interval along the transect. However, the belt transect should also be done for other invertebrates such as sea cucumbers, and crabs. Be cautious of the different sizes of quadrats used in the calculation – the values should be expressed as individuals/m^2 then converted to number individual/hectare.

Data Processing and Management

Percent cover of each seaweed species for one whole transect is computed by getting the average of all its recorded percent cover within the transect. Summing up the averages for all seaweed species will yield the percent seaweed cover for that specific transect.

To estimate the percent seaweed cover of the whole site as represented by the transects established, get the average of the total percent seaweed cover of all transects. The same is done in estimating the percent cover of each seaweed species within the site.

Megafauna Biodiversity

By Dr. Lemnuel V. Aragones and Ms. Apple Kristine S. Amor

Megafauna in the Philippine biodiversity context pertain to marine mammals (i.e. cetaceans and dugongs), sea turtles, and sharks and rays. The common feature of these animals is that they are mostly long-lived and have low reproductive potential. Also, most of these groups of animals are considered threatened, vulnerable and endangered. Globally, a few marine mammal species have already been declared extinct.

Assessment and monitoring of megafauna faces several constraints. Their elusive nature (i.e. barely surfacing for respiration, or even not surfacing at all in the case of sharks and rays) makes it hard for them to be sighted. In addition, identifying megafauna species is difficult. Oceanic habitats where they can be located are vast and defining meaning boundaries to distribution is challenging. Lastly, the state of knowledge regarding their habitats and habitat use, and the range of their populations and sub-populations are poor.

In consideration of these constraints, the tools and methods enumerated in **Table 25** are the recommended methods to be used for megafauna biodiversity assessment and monitoring. However, prior to the conduct of these methods, a focus group discussion (FGD) or key informant interviews should be done to build the "big picture" of megafauna biodiversity within the area of concern. FGD is a simple research tool used for gathering (baseline) information from an assemblage of people of similar backgrounds or experiences. A well facilitated FGD could provide broad scale information on the distribution and species diversity of marine mammals, sea turtles, and even sharks and rays. These could then be used to identify areas where the more specific methods maybe employed. Should the information generated from the FGD appear to be not consensual, structure interviews can be done.

Table 25. Recommended methods for megafauna biodiversity assessment and monitoring.

Megafauna	Method
Cetaceans	• Opportunistic survey • Photo-identification (boat-based surveys) • Gathering of stranding and bycatch data
Dugong	• Feeding trail survey • Opportunistic sightings • Gathering of stranding and bycatch data
Sea Turtle	• Nesting beach survey • Opportunistic sightings • Gathering of stranding and bycatch data
Sharks and Rays	• Market surveys or inspections • Photo-identification (e.g. whale sharks) • Fish landing surveys • Gathering of bycatch data

Opportunistic survey is when one uses predetermined navigational routes as platforms for sighting megafauna, primarily marine mammals (Aragones et. al.1997). The survey will, at the least, determine the presence or absence of megafauna in the area, particularly marine mammals and sea turtles.

Photo-identification of individuals is an important tool for studying animal behavior, ecology, and population biology (Wells 2002). The improvement of digital photography has allowed us to take as many shots as possible of the distinctive body parts to help identify individuals. In most dolphins the distinctive body part is the dorsal fin, while for those that fluke up (a behavior when the whale brings up its tail flukes out of the water just before diving), it is their flukes. As for whale sharks it is taking underwater photographs of its left side above the pectoral fin. In the context of megafauna like dolphins and whales and even whale sharks, tracking marked individuals through time can explain the abundance, recruitment, and survivorship of individuals in a particular population.

The Stranding Data is the process of gathering as much information about marine mammals that run around on the beach (dead or alive) or are in a helpless situation and are not able to return to their normal habitats. Marine mammals that strand have been implicated to come ashore to ensure that they can breathe as they are already weak. Likewise, sea turtles may sometimes strand as well, especially when they are sick. On the other hand, sharks and rays or even sea turtles may get entangled on fishing nets such as fish corrals. This process can generate information regarding the species of marine mammals that strand in the Philippines (Aragones et al. 2013). In the long-term, the information generated by recording every stranding event can elucidate the health of our oceans with the marine mammals serving as sentinels (Aragones et al. 2010). The Philippine Marine Mammal Stranding Network (PMMSN) has been gathering and collating recorded stranding data through the Marine Mammal Research and Stranding Laboratory of the University of the Philippines – Institute of Environmental Science and Meteorology.

The dugong feeding trail monitoring/survey can assess the index of relative abundance of dugongs in the area and monitor intensity of their feeding. This technique can also identify important feeding areas of the dugong, which could hopefully be protected further. This is truly an innovative way of monitoring the status of local dugong populations. This may be the only way for us here in the Philippines to at least come up with some index of relative abundance for this endangered marine mammal.

Nesting Beach Survey is the most commonly used technique globally to assess and monitor the status of sea turtle populations (e.g. Schroeder and Murphy 1999). Since the life cycle of sea turtles is complex, it is impossible to do an actual census. Thus, this technique, if well designed, allows one to assess and monitor the proportion of sea turtle populations by recording the number of nesting females, nests, emerging hatchlings and the success of nests in specific beaches. This method is able to calculate the relative abundance of the actual population of any sea turtle species. This technique also allows assessment and monitoring of status of sea turtle populations. Moreover, this will allow establishment of baselines for undervalued sea turtle nesting beaches in the Philippines.

Market inspection is a simple survey or monitoring technique applicable to a pre-selected group of products that are sold in the market. This survey or monitoring technique could give some idea of the species of sharks and rays within specific fishing grounds. This method could also give some idea of the threats these animals are currently facing.

The Fish Landing Survey is a typical fisheries technique for monitoring landed catches in a particular fishing ground. In this context of megafauna biodiversity monitoring, the technique is used to determine if any sharks and/or rays were landed within the particular fishing area of concern. If this survey is well designed, and fisheries enumerators are employed, the species and abundance of the sharks and rays can be determined. The size of landed sharks and rays can also indicate if the populations of these megafauna are still healthy (i.e. thriving). It should be noted, however, that some sharks and rays landed in a particular landing site may have been caught from other distant areas. Therefore, enumerators should ensure that that the source of the landed sharks and rays are determined and only consider those caught within the concerned area.

On top of monitoring megafauna biodiversity by employing these tools and techniques, it is recommended that a research activity using distance sampling be conducted. Such research activity will generate information on the estimation and calculation of the density or abundance of the cetacean species (populations) sighted within the survey areas. The technique can also be modified as boat-based surveys for dugongs (Aragones et al. 2012). However, distance sampling is recommended only for experts or researchers from the academe.

Establishing Monitoring Stations

The criteria for the selection of monitoring sites are based on the uniqueness of assemblage of reported/sighted/stranded megafauna based on the PMMSN Database, limited literature and archived media reports, and results of the FGD (see next section on how to conduct FGDs). Another criterion is based on the marine biogeographical zones of the Philippines:

- The Babuyan and Balintang Channels are important waters in the northern section of Luzon;
- The Eastern Philippine Sea is probably the most challenging area to assess and monitor megafauna;
- The Tañon Strait Protected Seascape (TSPS) is the only marine protected area allocated for cetaceans in recognition of the abundance and diversity of cetaceans in the area;
- The Sulu Sea is one of the most important basins in the Philippines;
- The Sarangani Bay is one of the most important embayment in southwestern section of Mindanao;
- The Western Philippines Sea is one of the most under-rated seas in terms of productivity and diversity. But this area has one of the stranding hotspots for cetaceans in the entire Philippines.

Frequency of Monitoring and Expected Data Output

Tables 26 and 27 below are the recommended frequency and duration megafauna biodiversity assessment and monitoring for each group and expected output from them.

Table 26. Recommended frequency and duration for megafauna biodiversity assessment and monitoring per monitoring group.

Method	Frequency and duration		
	Experts/Academe	**DENR**	**LGU/Community**
FGD	1/year, 3 days per monitoring	2/year, 5 days per monitoring	4/year, 5 days per monitoring
Photo ID (Cetaceans)	2/year, 5-7 days per monitoring	2/year, 7-10 days per monitoring	Optional
Nesting beach survey (sea turtles)	2/ year, 5 days per monitoring	2/ year, 5-7 days per monitoring	2/year, 10 days per monitoring
Opportunistic survey	2/year, 3 days per monitoring	2/year, 3-5 days per monitoring	2/month, 2 days per monitoring
Feeding scars (Dugong)	2/year, 3-5 days per monitoring	2/year, 3-5 days per monitoring	1/month, 2 days per monitoring
Fish landing monitoring (sharks, rays etc)	2/year, 3-5 days per monitoring	2/year, 5 days per monitoring	1/week, 2 days per monitoring
Market inspection (sharks, rays etc)	2/year, 3 days per monitoring	2/year, 5 days per monitoring	Every day
Distance sampling (Transect)*	1/year, 10-15 days per monitoring		
Interview (structured)**	1/year, 3 days per monitoring	1/year, 3 days per monitoring	2/year, 5 days per monitoring
Stranding Data***	Coordinate with Philippine Marine Mammal Stranding Network (PMMSN)	Coordinate with PMMSN	Coordinate with PMMSN

**Recommended only for specialist*
***Recommended only if FGD does not result to consensual information*
****Already being conducted by PMMSN nationwide*

Table 27. Expected output for megafauna biodiversity monitoring per monitoring group.

Ecosystem/ Resource and Method	Output		
	Experts/Academe	**DENR**	**LGU/Community**
FGD	Range of distribution and (if possible) biological diversity of associated megafauna at Order of Family or up to Genera levels; and possible context of temporal variations.	Range of distribution and (if possible) biological diversity of associated megafauna at Order of Family levels; and possible context of temporal variations.	Range of distribution and (if possible) species composition of associated megafauna at Class or Order levels; and possible context of temporal variations.
Photo-ID	Range of distribution and biological diversity of cetaceans at species level; and calculate population abundance in the context of temporal	Range of distribution and biological diversity of cetaceans at species level; and calculate population abundance in the context of temporal	

Ecosystem/ Resource and Method	Output		
	Experts/Academe	DENR	LGU/Community
	variations.	variations.	
Nesting Beach Survey	Estimate number of reproductive females, nests, hatchlings, and identify species of sea turtle; and(if possible) capture temporal variation through time (e.g. inter-annual).	Estimate number of reproductive females, nests, hatchlings, and identify species of sea turtle; and (if possible) capture temporal variation through time (e.g. inter-annual)	Estimate number of reproductive females, nests, hatchlings, and identify species of sea turtle
Opportunistic Survey	Presence or absence of species of megafauna; and (if possible) identify species of sighted megafauna. Can give information regarding possible extent of range of distribution and even threats to megafauna.	Presence or absence of species of megafauna; and (if possible) possibly identify species of sighted megafauna. Can give information regarding possible extent of range of distribution	Presence or absence of species of megafauna
Dugong Feeding Trail Monitoring/ Survey	Presence or absence of important dugong population; and (if possible) develop some index of relative abundance through time. Can give information regarding possible extent of range of distribution and even threats to dugongs	Presence or absence of important dugong population. Can give information regarding possible extent of range of distribution and even threats to dugongs	Presence or absence of important dugong population. Can give information regarding possible extent of range of distribution and even threats to dugongs
Fish Landing Survey	Identify important species of sharks and rays found within the area. Possibly determine relative abundance through catch per unit effort (CPUE) of the more commonly caught (or bycaught) sharks and rays. Can give information regarding possible extent of range of distribution and even threats to sharks and rays.	Identify important species of sharks and rays found within the area. Can give information regarding possible extent of range of distribution and even threats to sharks and rays.	Identify important sharks and rays found within the area. Can give information regarding possible extent of range of distribution and even threats to sharks and rays.
Market Inspection	Identify important species of sharks and rays found within the area and preferably being traded. If possible, determine relative abundance through size	Identify important species of sharks and rays found within the area and preferably being traded. Can provide information regarding possible extent of range	Identify important sharks and rays found within the area. Can provide information regarding possible extent of range of distribution and even threats to sharks and

Ecosystem/ Resource and Method	Output		
	Experts/Academe	DENR	LGU/Community
	estimation and/or amount being sold of the more commonly caught (or bycaught) sharks and rays. Can provide information regarding possible extent of range of distribution and even threats to sharks and rays.	of distribution and even threats to sharks and rays.	rays.
Distance Sampling	Density and abundance of various species of cetaceans that will be sighted within the boat transects. This technique can also describe the spatial extent and temporal variation in the species distribution.		
Interview Survey	Range of distribution and possibly biological diversity of associated megafauna at Order of Family or even Genera levels; and possible context of temporal variations.	Range of distribution and possibly biological diversity of associated megafauna at Order of Family levels; and possible context of temporal variations.	Range of distribution and possibly species composition of associated megafauna at Class or Order levels; and possible context of temporal variations.
Stranding data	The species composition of marine mammals that strand in various regions and provinces of the Philippines are being recorded through the efforts of the PMMSN and MMRSL. The national stranding database has the potentials to generate information regarding the most common species that strand to identification of stranding hotspots.		

Data Collection

I. Focus Group Discussion

<u>Materials needed:</u>

- Pens
- Notebooks
- Visual aide such as photos, posters, and maps may also help in most cases
- Snacks for participants

<u>Procedure:</u>

This method should be undertaken by staff members who are not involved in enforcement activities in the same area so as to encourage open discussion with local people. At least two persons are needed – one well trained moderator to facilitate discussions and one to record the minutes.

It is suggested to get a good proportion of key informants to participate. In the context of megafauna biodiversity monitoring, experienced fishers living within various areas of concern should be the ones recruited to participate.

The FGD for megafauna biodiversity monitoring can be done at the same time as that for the fisheries biodiversity monitoring however the moderator should ensure that there would be sufficient time to collect the data needed for both megafauna and fisheries biodiversity monitoring.

It is recommended that permanent FGD groups be established for monitoring purposes. For this, the barangay captains and other community leaders should be met to explain the objectives and activities of the monitoring system. The common interest of monitoring staff and local people in conservation should be stressed and the possible use of the monitoring data in a more sustained use of local natural resources should be mentioned (DENR & NORDECO 2001).

1. Give at least one week prior notice to target participants regarding the FGD to allow participants to allot time to attend. Make sure that the time set for the meeting is convenient for the participants.
2. Ask questions about species diversity and distribution of marine mammals, sea turtles, and even sharks and rays. Examples of such questions are what marine mammals/sea turtles/shark and rays have they seen in the area, where and when did they see them, and how many. Participants can even be asked to mark in prepared maps of the area the locations of the megafauna species.

   Keep participants honest by asking validation questions. In this case, validation questions are those that would require them to describe the particular group of animals that they claim they saw or have sighted in the area and the like.

3. When all needed information has been collected, thank the participants and draw the meeting to a close. It has been a practice that participants will be provided snacks. It is the moderator's call when the snacks will be given based on the time of FGD.

4. Evaluate information collected. The more specific megafauna biodiversity assessment methods to be employed and where these would be conducted should be determined with the guidance of the FGD results. If information generated is not consensual, plan for an Interview Survey.

II. Opportunistic Survey

<u>Materials needed:</u>

- Regular maritime vessel
- Binoculars
- GPS
- Camera and video camera
- Datasheets

Procedure:

A person adept at detection and identification of megafauna from a distance is required for this method.

1. Board a maritime vessel traversing predetermined navigational routes within the area of concern.

2. Record species and relative abundance (group size) sighted, including the location and time of sighting. The field guide developed by the Philippine Marine Mammal Stranding Network (Annex 16) is helpful in identifying cetacean species.

III. Photo-Identification

Materials needed:

- Single Lens Reflex (SLR) camera with zoom lens appropriate for wildlife photography (i.e. 300-600 mm)
- Binoculars (preferably with embedded reticle for distance estimation)
- Large memory cards for the camera
- GPS
- Good laptop or desktop with huge hard drive space or with extra external drive
    - Should have the following programs installed:
        - Photo editing software (e.g. Adobe Photoshop, Picassa)
        - Darwin
        - Mark
- A good size boat with a reasonable engine (avoid those with water pump engines and pump boats), elevated platforms, and trained crew
- Data survey sheets
- Pens or pencils

Procedure:

This technique is truly applicable in areas where the animals' habitat use of the area is more or less known or predictable (e.g. roosting or nursery areas, or migratory pathway).

Boat surveys for capturing photos should be done on fair weather for better quality of photos taken and in consideration of the safety of the monitoring team and boat crew.

Aside from skilled boat crew and operator, photo-identification for megafauna would require at least two persons – one observer who is skilled and trained in photography, and one recorder. However, if there are more people taking photos, the chances of getting more photos with good unique marks for various individuals, increases. The following are the important steps to consider in conducting the photo-identification survey:

1. Prior to actual survey conduct, fill in the following information in the preformatted data sheets: (1) station or location number, (2) Name of boat, (3)

Date of survey, (4) Name of observer/s, (5) Name of Recorder, (6) Time off port, and (7) Start of survey.

2. The boat captain must be oriented on the Cetacean Watching Protocol (Figure 29) prior to the actual survey in order to make sure that the animals will not be harassed during the survey taking into mind the no approach zone, no follow zone and the right distances from the group (see Annex 17). The protocol also allows the boat to maintain a perpendicular angle towards the dorsal fin/s or group from the photographer's perspective.

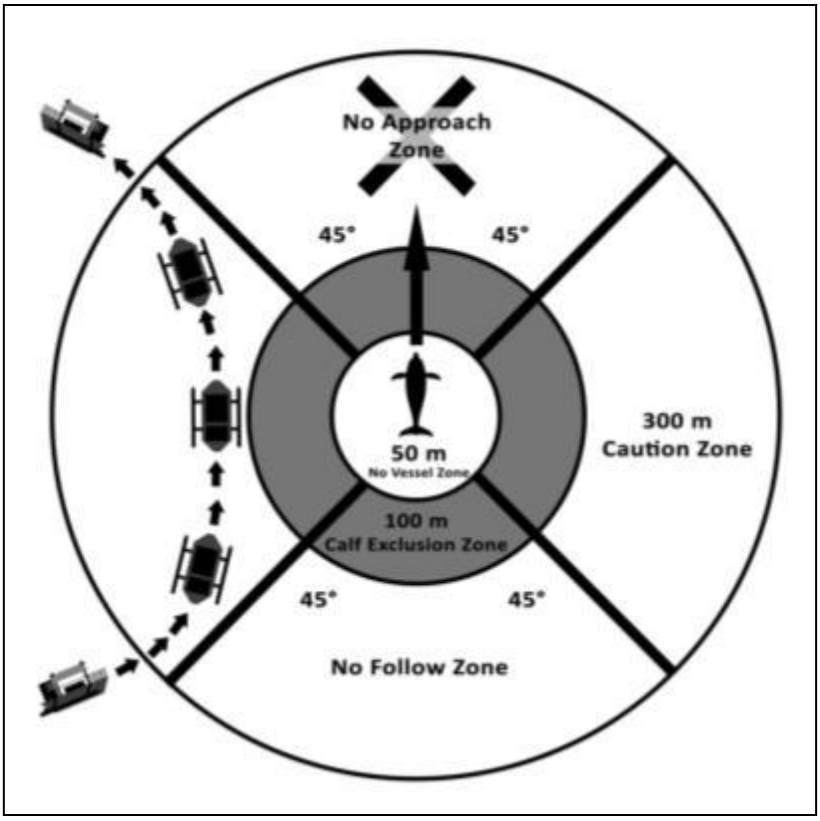


Figure 29. Diagram of the Cetacean Watching Protocol (Aragones et al., 2013).

3. Observers are to take photographs of cetaceans sighted during the boat survey. Observers should aim to capture quality photo of distinctive body parts of cetaceans sighted: dorsal fin for most dolphins and flukes for those that fluke up (a behavior when the whale brings up its tail flukes out of the water just before diving).

   At the same time, the Recorder should write down the following information in the data sheets (Annex 18) for every sighting of marine mammal or other megafauna species: (1) Initial time of sampling, (2) Sighting distance, (3) Time, (4) Track, (5) Sequence Number, (6) Coordinates of the boat location, (7) number of boats present at the time and its/their type, (8) Distance/angle of the group sighted and boat, (9) species identification of sighted marine mammal (can refer to Annex 16), (10) group structure, (11) Beaufort Sea State, (12) Cloud cover, and (13) Glare.

Distance of the group sighted can be estimate simply with experience. However, for less experienced observers, using binoculars with embedded reticle is recommended for estimating distance based on platform height.

On the other hand, angle of the boat towards the group is recorded in terms of hours of a clock, with the bow serving as the 12 o'clock reference (e.g. when the group is sighted on the right side of the boat, then the angle of the boat to be recorded is 3 o'clock). These could later be converted to angles with respect to the GPS since the track or heading is also recorded.

For the Bueafort Sea State and Cloud Cover, be guided by the **Table 28** and **Figure 30** respectively. For Glare, rate it as either *High Medium* or *Low.*

4. At the end of the boat survey, record the end time on the data sheet. **Figure 31** shows an example of a filled up survey datasheet.

5. After the boat survey, process photos taken. See section on *Date Processing and Management*.

Table 28. Beaufort Sea State (BSS) using the Modern Beaufort Scale.

Beaufort number	Wind Description	Wind Speed	Wave Height	Visual Clues
0	Calm	0 knots	0 feet	Sea is like a mirror. Smoke rises vertically.
1	Light Air	1-3 kts	< 1/2	Ripples with the appearance of scales are formed, but without foam crests. Smoke drifts from funnel.
2	Light breeze	4-6 kts	1/2 ft (max 1)	Small wavelets, still short but more pronounced, crests have glassy appearance and do not break. Wind felt on face. Smoke rises at about 80 degrees.
3	Gentle Breeze	7-10 kts	2 ft (max 3)	Large wavelets, crests begin to break. Foam of glassy appearance. Perhaps scattered white horses (white caps). Wind extends light flag and pennants. Smoke rises at about 70 deg.
4	Moderate Breeze	11-16 kts	3 ft (max 5)	Small waves, becoming longer. Fairly frequent white horses (white caps). Wind raises dust and loose paper on deck. Smoke rises at about 50 deg. No noticeable sound in the rigging. Slack halyards curve and sway. Heavy flag flaps limply.
5	Fresh Breeze	17-21kts	6 ft (max 8)	Moderate waves, taking more pronounced long form. Many white horses (white caps) are formed (chance of some spray). Wind felt strongly on face. Smoke rises at about 30 deg. Slack halyards whip while bending continuously to leeward. Taut halyards maintain slightly bent position. Low whistle in the rigging. Heavy flag doesn't extended but flaps over entire length.
6	Strong Breeze	22-27 kts	9 ft (max 12)	Large waves begin to form. White foam crests are more extensive everywhere (probably some spray). Wind stings face in temperatures below 35 deg F (2C). Slight effort in maintaining balance against wind. Smoke rises at about 15 deg. Both slack and taut halyards whip slightly in bent position. Low moaning, rather than whistle, in the rigging. Heavy flag extends and flaps more vigorous.
7	Near Gale	28-33 kts	13 ft (max 19)	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of wind. Necessary to lean slightly into the wind to maintain balance. Smoke rises at about 5 to 10 deg. Higher pitched moaning and whistling heard from rigging. Halyards still whip slightly. Heavy flag extends fully and flaps only at the end. Oilskins and loose clothing inflate and pull against the body.
8	Gale	34-40 kts	18 ft (max 25)	Moderately high waves of greater length. Edges of crests begin to break into the spindrift. The foam is blown in well-marked streaks along the direction of the wind. Head pushed back by the force of the wind if allowed to relax. Oilskins and loose clothing inflate and pull strongly. Halyards rigidly bent. Loud whistle from rigging. Heavy flag straight out and whipping.
9	Strong Gale	41-47 kts	23 ft (max 32)	High waves. Dense streaks of foam along direction of wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.
10	Storm	48-55 kts	29 ft (max 41)	Very high waves with long overhanging crests. The resulting foam, in great patches is blown in dense streaks along the direction of the wind. On the whole, the sea takes on a whitish appearance. Tumbling of the sea becomes heavy and shock-like. Visibility affected.
11	Violent Storm	56-63 kts	37 ft (max 52)	Exceptionally high waves (small and medium-sized ships might be for time lost to view behind the waves). The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere, the edges of the wave crests are blown into froth. Visibility greatly affected.
12	Hurricane	64+ kts	45+ ft	The air is filled with foam and spray. The sea is completely white with driving spray. Visibility is seriously affected.

http://www.wrh.noaa.gov

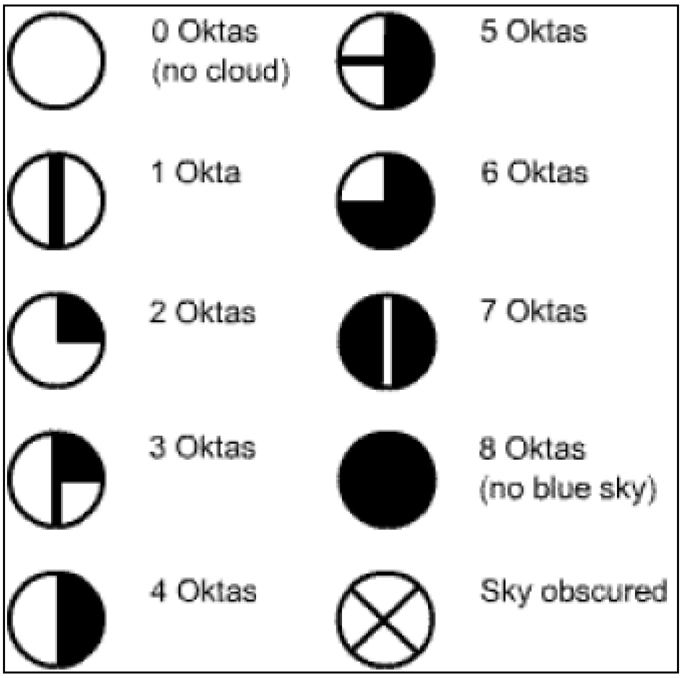


Figure 30. Cloud cover using Oktas.

MARINE MAMMAL SIGHTING DATASHEET
Station No./Location No.: 1
Name of boat: LGU Boat
Date: 3/24/2015
Observers: John, Elmer, Gilbert,Daisy, Michelle,
Recorder: Daisy
Time off port: 6:30am Start of survey: 7:00am end:2:00pm

Sighting No.	Initial time of sighting	Sighting distance	Time	Track	Seq no.	Location		+/- Boat		Distance (Angle)		species ID	Group structure				Merge /Split	+/- calves	BS	Environmental Conditions		
						Latitude	Longitude	No.	Type	Group	Boat		No. of groups	LE	BE	HE				BSS	CC	G
1	7:30	300m	7:40	90°	1	5.83597	125.15800	3	Fishing Boat	45	90	spinner	3	60	75	100		+	5	0	3	M
			7:45	100°	2	5.84210	125.15965															
			7:50	5°	3	5.89584	125.21903										merge					

Figure 31. Sample filled out data sheet.

IV. Stranding Data

The supervision of trained personnel with experience in several coastal places throughout the Philippines, in close coordination with the PMMSN, is required for the conduct of this technique. The PMMSN has a national database of stranding events of marine mammals in the Philippines. This could be done in close coordination with PMMSN and through the UP Institute of Environmental Science and Meteorology (UP IESM) Marine Mammal Research and Stranding Laboratory (MMRSL).

A spirit of collaboration between BMB and PMMSN must be encouraged. The PMMSN is composed of several organizations, from the academe (UP IESM), national government agencies (NGAs) (i.e. Bureau of Fisheries and Aquatic Resources or BFAR), LGUs to private industry.

With regards to the response protocol during stranding events, refer to Annex 19.

V. Dugong Feeding Trail Monitoring

Materials needed:

- Scuba gear
- Tape measure
- Ruler
- Slateboard
- Underwater camera

Procedure:

Personnel who are certified Scuba d divers who can identify dugong feeding scars or feeding trails are needed for this method.

Conduct the survey on known dugong feeding areas (deep seagrass areas) revealed during FGDs and structured interviews.

Photo by Gary John B. Cabinta

Figure 32. Sighted dugong feeding trail.

1. Dive down the identified dugong feeding area and search for feedings scars or trails.

2. Assess the freshness of the feeding scar by simply indicating whether it is new or old. Light colored cuts indicate a fresh or new feeding scar.

3. Measure and record the dimensions (length, width, and depth). Variation in sizes of dimensions of feeding trails suggests presence of several dugongs feeding in the area. However, without actually seeing the dugongs, the monitoring team should take caution in declaring a specific number of dugongs present since variation of feeding scar dimensions is only suggestive of presence of more than one dugong and is not definitive.

4. Make sure to take photos or video of the feeding trail.

VI. Nesting Beach Survey

Materials needed:

- Flashlight

- Camera
- Tape measure
- Data Sheets

Procedure:

Trained people who will regularly traverse or walk the known nesting beaches are required for this survey.

1. Visit areas where sea turtles are known to nest identified during FGDs and structured interviews. Map the nesting site using GPS to get the area (in hectares) utilized by sea turtles. This would define the nesting site.

2. Observe along the latest high tide line.

3. Record all crawls per species observed and indicate if the crawl is fresh or not. Also record presence and frequency of false crawls. Fill out the data sheet (Annex 20) accordingly.

   Differentiating nesting crawls and false crawls, identification of tracks per species, and sample filling out of data sheets are described in Annex 21.

4. Mark traversed track to avoid duplication.

VII. Market Survey

Materials needed:

- Camera and/or video-recorder
- Data sheets

Procedure:

1. Coordinate with Market supervisor. If it is a roadside stall, ask permission from the fish vendors prior to conducting to survey.

2. For every stalls seen selling sharks or rays, intercept the fish *komprador/*fish broker, if present. Ask where the sharks were caught.

   In these stalls, with the permission of the vendor, estimate the total volume of shark and ray catch per species.

   Take a sample of the total shark and ray catch per species and measure the total length and estimate the weight of sampled individuals

   Fill out datasheet (Annex 22) accordingly.

3. Take photos of the sharks of the shark or ray. Make sure to include a reference scale (ruler) in the photo.

At the minimum, make sure to take photos of the following parts of the shark and rays sampled:

- Lateral and ventral side
- Head
- Caudal fin
- Dorsal fin

VIII. Fish Landing Survey

Materials needed:

- Large fish board
- Weighing scale
- Data sheets
- Camera

Procedure:

1. Coordinate with the LGU/Barangay/Fisherfolk Association. Inquire the best time to do the survey.

2. Intercept only the fishers who caught sharks or rays. With their permission, estimate the total volume of sharks and rays catch.

   Enumerate species composition and detail abundance or volume per species.

   Sample the total catch per species and measure the total length and estimate weight of sampled individuals

   Ask and record the type of gear used and the location of the catch

   Fill out the data sheet (Annex 23) accordingly.

3. Take photos of the sharks of the shark or ray. Make sure to include a reference scale (ruler) in the photo.

   At the minimum, make sure to take photos of the following parts of the shark and rays sampled:

   - Lateral and ventral side
   - Head
   - Caudal fin
   - Dorsal fin.

Data Processing and Management

I. Photo-Identification

In processing the photographs, make sure to refer to the datasheet (Annex 18) for guidance. The following are the steps in cropping, grading, tracing and marking the dorsal fins:

1. Crop raw images using photo editing software such as Adobe Photoshop or Picasa to zoom in on distinctive body part (i.e. dorsal fin for most dolphins, flukes for those who fluke up, and left side above the pectoral fin for whale sharks). Make sure the leading edge and trailing edge (**Fig. 33**) is included in the cropped photo.

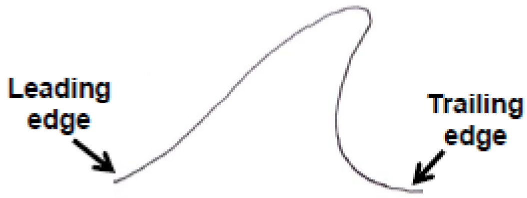


Figure 33. Leading edge and trailing edge of a typical dorsal fin.

2. The orientation of the dorsal fin in the cropped image should be have the leading edge on the left and the tailing edge at the right side of the photo. Flip the photo horizontally if needed.

3. Level the photo if needed by arbitrarily rotating the cropping tool so that the leading edge levels with the tailing edge. Displaying the grids is useful in aligning the leading edge and trailing edge.

4. Save the cropped photo as a JPEG file. Make sure the filename contains the date and image number. If multiple fins are cropped from one photo, the cropped photos must be labelled in order (in sequence) from left to right.

5. Save raw and cropped photos in separate folders by date taken.

6. Grade cropped images following methods of Urian et. al (1999) to create a folder of valid fins. Use a spreadsheet for grading.

   Five elements are considered in rating the photographic quality. Scores should be given for each of these elements for the estimation of the overall photographic quality.

   Focus or clarity refers to the crispness or sharpness of the photo. For this specific element, a score of **2** should be given to the photo if it has excellent focus; **4** for moderate focus, and **9** for poor focus and very blurry photo.

   Contrast is the range of tones in the image. A score of **1** means the photo has ideal contrast while the score of **3** has excessive or minimal contrast.

   Angle is the angle of fine to the camera. A score of **1** refers to perpendicular angle; **2** to slight angle; and **8** for oblique angle.

Partial pertains to the fin visibility wherein **1** means the fin, including the leading and trailing edges fully visible and **8** means that the fin is partially obscured in the image.

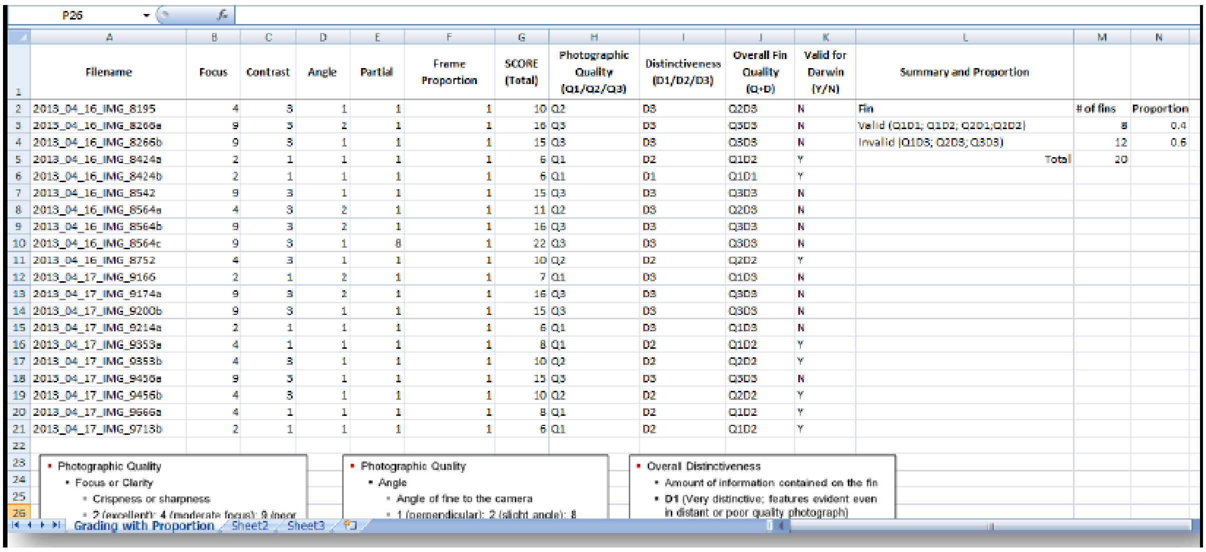
Lastly, the **proportion of the frame filled by the fin** is measured by the percent area the fin occupies relative to the frame. A score of **1** means that the percent area is greater than 5% while the score of **5** means it is less than 1%.

For each image, add all the score given for the five elements to rate its overall photographic quality. If the total is from 6 to 9, the image is deemed of excellent quality. A score of 10 to 12 is equivalent to average quality, and a score greater than 12 means that the image is of poor quality. In the spreadsheet, input Q1, Q2, or Q3 for excellent, average, and poor quality, respectively under Photographic Quality.

Another consideration for grading is **distinctiveness** or the amount of information contained on the fin. An image is given the rating of **D1** if it is very distinctive with features evident even in distant or poor quality photograph; **D2** if it has an average amount of information content with at least two features or one major feature visible on the fin; and **D3** if the image is not distinctive with very little information content in pattern, markings, or leading and trailing edge features.

Get the image grade by combining the Photographic Quality and Distinctiveness. Determine if the image is valid for Darwin base on its grade: Q1D1, Q1D2, Q2D1, and Q2D2 images are considered valid while Q1D3, Q2D3, and Q3D3 are considered not valid.

Compute the proportion of valid and invalid fins. **Figure 34** shows a sample of a filled out spreadsheet used for grading cropped images.



	Filename	Focus	Contrast	Angle	Partial	Frame Proportion	SCORE (Total)	Photographic Quality (Q1/Q2/Q3)	Distinctiveness (D1/D2/D3)	Overall Fin Quality (Q+D)	Valid for Darwin (Y/N)	Summary and Proportion		
2	2013_04_16_IMG_8195	4	3	1	1	1	10	Q2	D3	Q2D3	N	Fin	# of fins	Proportion
3	2013_04_16_IMG_8266a	9	3	2	1	1	16	Q3	D3	Q3D3	N	Valid (Q1D1; Q1D2; Q2D1;Q2D2)	8	0.4
4	2013_04_16_IMG_8266b	9	3	1	1	1	15	Q3	D3	Q3D3	N	Invalid (Q1D3; Q2D3; Q3D3)	12	0.6
5	2013_04_16_IMG_8424a	2	1	1	1	1	6	Q1	D2	Q1D2	Y	Total	20	
6	2013_04_16_IMG_8424b	2	1	1	1	1	6	Q1	D1	Q1D1	Y			
7	2013_04_16_IMG_8542	9	3	1	1	1	15	Q3	D3	Q3D3	N			
8	2013_04_16_IMG_8564a	4	3	2	1	1	11	Q2	D3	Q2D3	N			
9	2013_04_16_IMG_8564b	9	3	2	1	1	16	Q3	D3	Q3D3	N			
10	2013_04_16_IMG_8564c	9	3	1	8	1	22	Q3	D3	Q3D3	N			
11	2013_04_16_IMG_8752	4	3	1	1	1	10	Q2	D2	Q2D2	Y			
12	2013_04_17_IMG_9166	2	1	2	1	1	7	Q1	D3	Q1D3	N			
13	2013_04_17_IMG_9174a	9	3	2	1	1	16	Q3	D3	Q3D3	N			
14	2013_04_17_IMG_9200b	9	3	1	1	1	15	Q3	D3	Q3D3	N			
15	2013_04_17_IMG_9214a	2	1	1	1	1	6	Q1	D3	Q1D3	N			
16	2013_04_17_IMG_9353a	4	1	1	1	1	8	Q1	D2	Q1D2	Y			
17	2013_04_17_IMG_9353b	4	3	1	1	1	10	Q2	D2	Q2D2	Y			
18	2013_04_17_IMG_9456a	9	3	1	1	1	15	Q3	D3	Q3D3	N			
19	2013_04_17_IMG_9456b	4	3	1	1	1	10	Q2	D2	Q2D2	Y			
20	2013_04_17_IMG_9666a	4	1	1	1	1	8	Q1	D2	Q1D2	Y			
21	2013_04_17_IMG_9713b	2	1	1	1	1	6	Q1	D2	Q1D2	Y			

- Photographic Quality
  - Focus or Clarity
    - Crispness or sharpness

- Photographic Quality
  - Angle
    - Angle of fine to the camera

- Overall Distinctiveness
  - Amount of information contained on the fin
  - **D1** (Very distinctive; features evident even in distant or poor quality photograph)

Grading with Proportion / Sheet2 / Sheet3

Figure 34. Sample spreadsheet for cropped image grading.

Create a folder for valid fins. The images in this folder are those ready to be traced using Darwin software.

7. Trace, and marking the images in the folder using Darwin software.

   Launch Darwin and create New Survey Area and New Database. Include the species name in the database name. The database created must contain fins of the same species. For other species in the same survey area, click New Database within the Selected Survey Area

   Open image files of the indicated species from the created Valid for Darwin folder. Modify the image if needed.

   Enter known information. The necessary fields are the following:
   - ID Code = Acronym + filename
   - Name = Acronym (can be derived from description, e.g. UMNO which stands for upper middle with notch)
   - Damage category = location of the mark/s (refer to Annex 24)
   - Short description of the marking/s = e.g. upper middle with notch

   Trace the fin by clicking **Trace Outline**. Click start of fin (Leading Edge) and then the end of fin (Trailing Edge) for automatic/quick tracing of fin. Make any necessary corrections to outline trace using the displayed tools.

   Click **Save** then click **Add to Database.** Choosing only Add to Database will just add the fin to the database without attempting to match it. Open other images of the same species in the Valid for Darwin folder and repeat these steps for tracing, marking, and matching.

8. Match and mark valid fins with Darwin. Click **Match** to directly match a traced fin or create queues for matching by batch of traced fins.

   Queues can be created by adding the saved traced fins.

   Matching fins must have the same name/acronym. Mark new fins by properly (i.e. fins without a match in the database) by properly naming the fins based on marking codes.

9. Build Encounter Histories (EH) by creating a spreadsheet of the marked fins (use the marking codes) and the daily encounter dates as shown in **Figure 35**. Save the EH generated as **.inp** file in notepad.

10. Analyze EH using Mark software. Enter the EH by clicking **Select File** and uploading the .inp file. Provide title for the set of data.

    Select POPAN data type.

    Enter the number of encounter occasions and set Time Intervals (default value of 1 is equal to one year or one month).

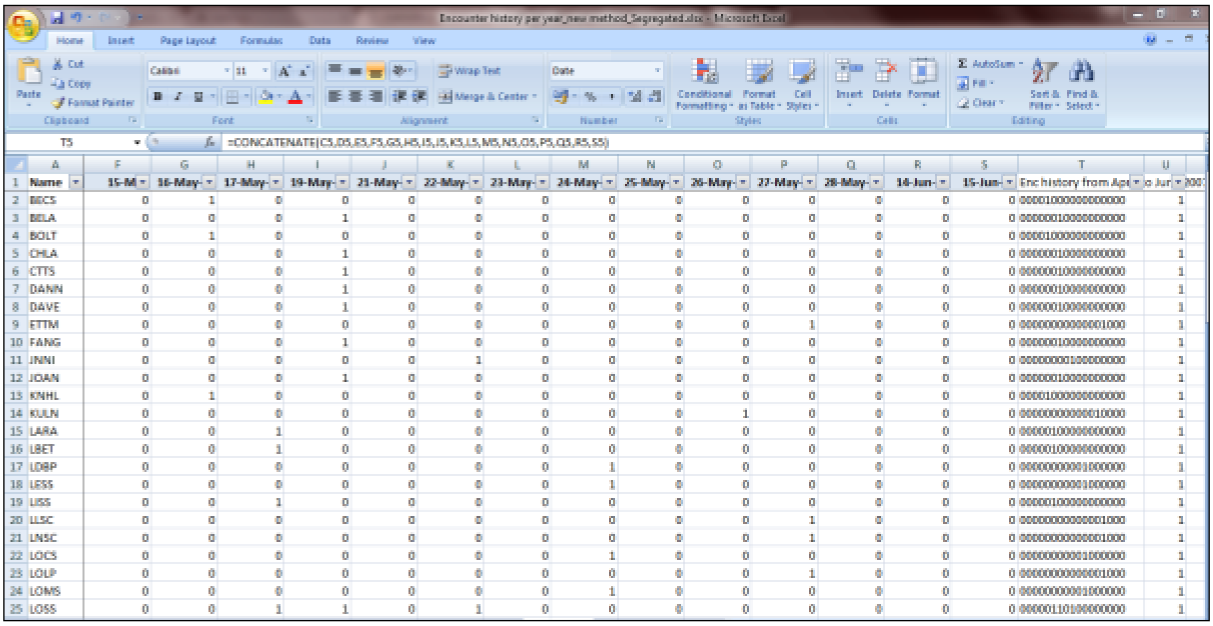
    Set Attribute groups to 1.

In the POPAN interface, specify POPAN parameters per model (capture **ρ**; survival ***Phi***; and entry ***PEnt).*** Models to be tested are:

- ρt,phit,pentt or *{pt, φt, bt}*
- ρ.,phit,pentt or *{p., φt, bt}*
- ρ.,phi.,pentt or *{p., φ., bt}*
- ρt,phi.,pentt or *{pt, φ., bt}*
- ρ.,phi.,pent. or *{p., φ., b.}*

Run MARK to generate AICs.

Refer to Program MARK manual (Cooch & White 2014) for more information.



	A	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Name	15-M	16-May-	17-May-	19-May-	21-May-	22-May-	23-May-	24-May-	25-May-	26-May-	27-May-	28-May-	14-Jun-	15-Jun-	Enc history from Apr	o Jur
2	BECS	0	1	0	0	0	0	0	0	0	0	0	0	0	0	00001000000000000	1
3	BELA	0	0	0	1	0	0	0	0	0	0	0	0	0	0	00000010000000000	1
4	BOLT	0	1	0	0	0	0	0	0	0	0	0	0	0	0	00001000000000000	1
5	CHLA	0	0	0	1	0	0	0	0	0	0	0	0	0	0	00000010000000000	1
6	CTTS	0	0	0	1	0	0	0	0	0	0	0	0	0	0	00000010000000000	1
7	DANN	0	0	0	1	0	0	0	0	0	0	0	0	0	0	00000010000000000	1
8	DAVE	0	0	0	1	0	0	0	0	0	0	0	0	0	0	00000010000000000	1
9	ETTM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	00000000000001000	1
10	FANG	0	0	0	1	0	0	0	0	0	0	0	0	0	0	00000010000000000	1
11	JNNI	0	0	0	0	0	1	0	0	0	0	0	0	0	0	00000000100000000	1
12	JOAN	0	0	0	1	0	0	0	0	0	0	0	0	0	0	00000010000000000	1
13	KNHL	0	1	0	0	0	0	0	0	0	0	0	0	0	0	00001000000000000	1
14	KULN	0	0	0	0	0	0	0	0	0	1	0	0	0	0	00000000000010000	1
15	LARA	0	0	1	0	0	0	0	0	0	0	0	0	0	0	00000100000000000	1
16	LBET	0	0	1	0	0	0	0	0	0	0	0	0	0	0	00000100000000000	1
17	LDBP	0	0	0	0	0	0	0	1	0	0	0	0	0	0	00000000001000000	1
18	LESS	0	0	0	0	0	0	0	1	0	0	0	0	0	0	00000000001000000	1
19	LISS	0	0	1	0	0	0	0	0	0	0	0	0	0	0	00000100000000000	1
20	LLSC	0	0	0	0	0	0	0	0	0	0	1	0	0	0	00000000000001000	1
21	LNSC	0	0	0	0	0	0	0	0	0	0	1	0	0	0	00000000000001000	1
22	LOCS	0	0	0	0	0	0	0	1	0	0	0	0	0	0	00000000001000000	1
23	LOLP	0	0	0	0	0	0	0	0	0	0	1	0	0	0	00000000000001000	1
24	LOMS	0	0	0	0	0	0	0	1	0	0	0	0	0	0	00000000001000000	1
25	LOSS	0	0	1	1	0	1	0	0	0	0	0	0	0	0	00000110100000000	1

Figure 35. Sample spreadsheet for building encounter histories.

11. Analyze the EH. Take note of the model with the lowest AIC for abundance and survival estimate.

    Open or retrieve MARK results with Notepad in **.FPT** format. Get the results from the chosen model with the lowest AIC. Generate the abundance by adjusting the population (N-hat) using the proportion computed previously (marked vs unmarked).

12. Graph results

Fisheries Biodiversity

By Dr. Asuncion B. De Guzman

A critical component of fisheries management around a marine KBA is a reliable fisheries profile or database which provides an initial picture of the fishery and its status so that formulating a management plan can be started. A more systematic monitoring is needed if the fisheries management program in any locality is to succeed in the long term. Since interviews serve as the principal source of information for fisheries profiles, there are limitations to the accuracy of estimates. However, as an initial assessment, the profile should allow the local government to set the direction of their management measures and to allow for their refinement in the long run by providing the basis for a more long term systematic monitoring program.

While detailed fisheries monitoring schedule will provide a comprehensive assessment of the state of the fishery within the KBAs, this approach is costly and requires a large amount of time and manpower that are often not readily available. The use of participatory methods is an alternative means of obtaining vital information that can guide the policy for the conservation of fisheries biodiversity. Participatory coastal resource appraisal (PCRA) is a desirable approach in data gathering when very little funds and manpower are available. Focus Group Discussion (FGD) is an important participatory method or approach that can be adopted in fisheries diversity monitoring. It is a form of group interview which can be used in both field data gathering and community validation (Pido et al. 1997). FGD is also a means of obtaining an inventory of fishing effort, that is, to determine the number of fishers, boat and gear types and their total counts in each village or municipality. This information is needed in estimating the total landed catch or fish production from a fishing ground. Other methods to be used are fish landing/dockside survey, market survey, and key informant or household interview.

The fish landing surveys are used to determine the most abundant kinds of fish caught and obtain estimates of average catch rates or catch per unit effort (CPUE) for each gear per fishing trip and of fish production (daily, monthly, and annual) of each fishery system.

Market surveys are conducted to collect economic and market information such as prices, sources, and destination of fish and invertebrate products. Regular conduct of market surveys (e.g. quarterly or annually) can provide information on changes in price and amount (weight or volume) of fish products through time. It is also a useful way of determining which kinds of fish are no longer abundant or caught in the locality.

Key informant or household survey is a semi-structured interview and field survey technique that is conducted with a representative number of fishing households. An interview schedule based on key questions is prepared and is used to obtain information on the fisheries' status and trends, such as changes in fish production and CPUE, fish composition, fishing effort, seasonality of fishery resources and area of fishing operation of major gear, and also environmental issues and impacts. The results of the key informant interviews can complement data from fish landing surveys and the FGDs.

On-board fish catch monitoring is an optional method of obtaining more accurate species composition and CPUE values. This approach, however, will require more manpower and logistics, poses more risk on the observer's safety, and will depend on the willingness of the fishing crew to take on an additional passenger.

Establishing Monitoring Stations

Fisheries diversity monitoring should be done particularly around marine KBAs. 'Fish spillover' is one of the top selling objectives of establishing MPAs. Monitoring changes in fisheries diversity adjacent to an MPA is a means of evaluating its success in protecting fish stocks and enhancing nearshore fish catches.

Monitoring of fisheries diversity and status in each KBA should be undertaken in at least three coastal fishing villages or barangays, although it is preferable that at least one FGD session is conducted in each barangay or cluster around the KBA. A stratified sampling approach is recommended to cover municipal and commercial fishing gear/vessels and should cover at least 10% of the total number of households in each site. This rule-of-thumb sampling approach, however, may be modified in case the fisher population size is too prohibitive (in terms of manpower, time and other logistics). Important criteria to consider for selection of monitoring areas would be number of fishers, presence of a designated fish landing area, and presence of both municipal and commercial fishing fleet. Another consideration is to identify a local academic institution with technical staff who can partner with and build the capacity of local government and DENR staff to undertake fisheries monitoring work.

Frequency of Monitoring and Expected Data Output

Table 29 presents the recommended frequency and duration of fisheries assessment and monitoring by each group while **Table 30** lists the expected output of these activities.

Table 29. Recommended frequency and duration for fisheries biodiversity assessment and monitoring per monitoring group.

Method	Frequency and duration		
	Experts/Academe	**DENR and BFAR**	**LGU/Community**
FGD	Once a year	Once a year	Once a year
Fishing Effort Inventory	Once a year	Once a year	Once a year
Fish Landing/Dockside Survey (includes census of species caught by various gears)	Quarterly 1 month per quarter; at least 15 days (spread over the month)	Twice a year (NE and SW monsoons); 5d/month (spread over the month)	Quarterly 1 month per quarter; at least 15 days (spread over the month)
On Board Vessel Fish Catch Monitoring*	Quarterly	Twice a year	Quarterly
Market Survey	Quarterly 1 day/week over 1 month per Q	Twice a year (NE and SW monsoons); 5d/month (spread over the month)	Quarterly 1 day/week over 1 month per Q
Key Informant/Household Interview	Once a year	Once a year	Once a year

Table 30. Expected output for fisheries biodiversity monitoring per monitoring group.

Method/Tool	Output Data/Information
Focus Group Discussion (FGD) Fishing Effort Inventory and Mapping with GPS * Fish landing or dockside survey	*Fishing effort, fishing intensity, and fish biodiversity* Number of fishers per fishing village Changes in fish diversity/species composition Number of fishers per km^2 of fishing ground Fishing gear types and number of users/units Boat type and number Number of fishing trips and number of hours/trip
Fish landing or dockside survey	*Fisheries diversity* Catch composition Landed weight per group/species Trophic structure analysis*
Fish landing or dockside survey Market surveys Supply and value chain study*	*Production estimates and fishing revenues* Catch rates or catch-per unit-effort (CPUE) Estimates of fish production (daily, monthly, annual) Fishing revenues and net incomes Price changes (by type of fish) Sources of fish products Destination of fish products
Focus Group Discussion (FGD) Semi-structured interviews	*Changes in fish production and diversity thru time (temporal)* Changes in fish composition Fishing effort changes Historical trends in CPUE Seasonality of fishery resources Environmental impacts Biodiversity loss or fish extirpation studies

**Indicates optional method that can be adopted depending on available manpower or in partnership with academic institutions*

Data Collection

I. Focus Group Discussion

Materials needed:

- Attendance sheets
- FGD guide tables
- Manila paper
- Markers (different colors)
- Blackboard and chalk (or white board and whiteboard markers)
- Masking tape
- Scissors
- Snacks for participants

Procedure:

This method should be undertaken by staff who are not involved in enforcement activities in the same area so as to encourage open discussion with local people. At least two persons are needed – one well trained moderator to facilitate discussions and one to record the minutes.

The FGD can be done with the members of fishers association, preferably 10-15 fishers who are using a variety of major fishing gear and who have sufficient fishing experience.

It is recommended that permanent FGD groups be established for monitoring purposes. For this, the barangay captains and other community leaders should be met to explain the objectives and activities of the monitoring system. The common interest of monitoring staff and local people in conservation should be stressed and the possible use of the monitoring data in a more sustained use of local natural resources should be mentioned (DENR & NORDECO 2001).

1. Give at least one week prior notice to target participants regarding the FGD to allow participants to allot time to attend. Make sure that the time set for the meeting is convenient for the participants.

2. The moderator should lead the discussion based on a set of questions designed to obtain the optimum amount of data to establish a profile of the local fishery. These include questions about fishing practices, fishing effort and intensity, seasonal fishing calendars and catch trends, as well as the resource and fisheries issues. The recorder on the other hand should note down the information shared in the discussions. The goal is to gather information to completely fill out the FGD Guide Tables (Annex 25). The facilitating team can choose to enlarge these tables in manila papers so that these can be filled together with the FGD participants.

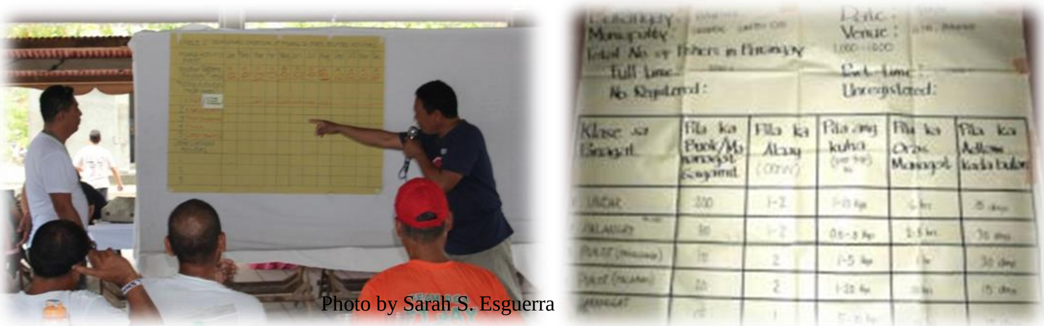


Figure 36. FGD to generate seasonal calendar of fishing activities and CPUE using FGD tables enlarged in manila paper.

A map of the area can be used to plot fishing grounds and map out gear use.

3. When all needed information have been collected, thank the participants and draw the meeting to a close. It has been a practice that participants will be provided snacks. It is the moderator's call when the snacks will be given during the FGD.

II. Fish Landing/Dockside Survey

Materials needed:

- Fish landing survey data forms
- Grid map
- Weighing scale
- Measuring tape, ruler, Vernier caliper, fish board
- Kitchen or digital weighing scale
- Plastic slates and pencils
- Specimen jars or resealable bags
- Money for buying fish samples, if needed
- Knife or scissors
- Field Guide to common fin fish families
- Field Guide to identification of commonly gathered invertebrate resources

Procedure:

1. Record the boat type, gear type, number of fishers, fishing time, landed weight, species composition, and weight by species (refer to Annexes 26 and 11)in the standard fish landing (FL) survey data sheet (Annex 27, Form 1).

   Engage a representative number of boats (i.e. at least 20%) that landed at the time of the survey. However, take note of the total number of boats and gear operating in the area. Fill out one data sheet per boat.

2. Interview the boat operator about the cost of operation per trip (i.e. cost and volume of fuel, number and cost of labor, cost of supplies, and other expenses). Also ask about their revenues (gross income) from fish sold and where they sell their fish (either the name of the market or the town/city). Also take note of theses information on the datasheet.

3. Borrow or buy samples of most abundant or major fish species per boat. Measure and record the total length (i.e. length from tip of the snout to the end of the longest part of the tail) and weight of each fish. Be sure that in measuring the total length, the measuring instrument remains horizontally straight and does not bend according to the curvature of the fish.

   Dissect each fish on the “belly” part to expose the gonads. Assess if the sex and maturity of the fish based on gonads using a 5-point gonadal maturity scale (Annex 28).

Figure 37. Visual assessment of sex and gonadal maturity of dissected fish.

   Fill out the preformatted datasheet for morphometrics and gonadal maturity (Annex 27, Form 2)

III. Market Survey

Materials needed:

- Market survey data form
- Field Guide to common fin fish families
- Field Guide to identification of commonly gathered invertebrate resources

Procedure:

1. Coordinate with the Market supervisor prior to conducting the survey. If the market is a roadside fish stall, ask permission from the fish vendors.

2. Preferably at least 10% of the market stalls should be surveyed at each monitoring period. In conducting the survey, inquire about the following:
   - Sources (i.e., fishing ground or landing site) of the fish or invertebrate products should be identified whenever possible. In most cases this information is known to the market stall owner or middleman
   - Buying price (from the fisher or middleman) and selling price (retail prices at the market stall) of each fish/invertebrate species should be obtained from each market stall owner.
   - Standard weight units (i.e. kg) should be used to compare unit prices across species. Appropriate weight conversions of bulk volume (e.g. *banyera* or styrofoam box) should be made.

   Fill out market survey form with the collected data (Annex 29).

IV. Household Survey or Semi-structured Key Informant Interview

Materials needed:

- Guide questions for key informant interview (KII)
- Household survey on fisheries and socio economics

Procedure:

1. Explain clearly the objective of the interview and ask the fisher if he/she is willing to participate.

2. With the fisher's approval, conduct the interview following the prepared questionnaire (Annex 30). This instrument may be modified in case more detailed information is needed.

Data Processing and Management

Long term monitoring of local fisheries is important to show changes in production levels and patterns through time as affected by seasonal wind patterns, changes in fishing effort levels or fishing area, and even climate change-related events. Relevant parameters or measures to describe the state of the local fisheries and simple mathematical tools to obtain estimates are described in the following:

a. **Estimates of Fishing Effort** – the amount of effort involved in fishing operations in a fishing ground (bay or gulf). In municipal or artisanal fisheries, effort can be expressed as either ***number of fishers, hours per day fishing, days per month, or number of gear units***. In commercial or industrial scale fishing, effort can be expressed as ***number of days at sea per fishing trip, horsepower of the fishing vessel, or number of boats per fishing fleet*** (Sparre 2000). Estimates of total effort can also be derived from information gathered from **interviews or FGDs, from each LGU's municipal fisherfolk registration, and from BFAR's commercial fishing vessel annual registration.**

   Fishing time (or duration of fishing) often expressed as number of hours, can be understood as total time away from the harbor or shore, divided into 1) time steaming to the fishing grounds, 2) time searching for fish and 3) actual fishing time (Gulland 1966). In municipal (or artisanal) fisheries where most fishing is conducted nearshore (can be reached after a short trip), the travel time to and from the fishing ground and search hours can be minimal. In commercial fisheries, on the other hand, travel time and search time can cover several hours. In stationary or passive gear operations, active fishing time is also called "soak time" or the amount of time a gear is actively in the water (and actually catching fish. Soak time is considered a more suitable indicator for measuring fishing activity and is useful in standardization of fishing effort (EUR-Lex 2011; www.fao.org/fishery).

b. **Catch per unit Effort (CPUE)** - also known as catch rates, or the amount of catch one fisher obtains from a single fishing operation during a fixed duration (i.e., hour, day or trip) for each gear type:

$$\boldsymbol{CPUE} = \frac{\boldsymbol{Total\ catch\ (in\ kg)}}{\boldsymbol{No.of\ fisher-hours, or\ fisher-days, or\ gear\ units}}$$

   Estimates of mean CPUE of all fishers sampled can be compared among gear types, landing areas, or municipalities and across months or years. Where the goal of monitoring is to provide an updated status of the fishery system, CPUE is considered an important management tool for long-term sustainability of fisheries (van Hoof & Salz, 2001).

   CPUE can be expressed in three ways, each with a specific utility:

   1.) *Catch per gear unit per trip (kg/g/trip)* – the amount of catch of one unit of gear in a single trip (a day or over a number of days, depending on the gear). This allows for an estimate of the total amount of catch landed by one gear type when the total number of gear units is known.

   2.) *Catch per fisher per trip (kg/f/trip)* – the amount of catch a fisher obtains from operating a gear type in one trip; derived by dividing the kg/g/trip by the number of crew members. This metric is useful in

> **Note:** Fishing duration here refers to the actual fishing hours per operation or 'soak time' (e.g. setting the net, handline or trap) and should not include travel time to and from the fishing ground.

estimating the gross revenues a fisher earns from a fishing day or trip by simply multiplying this CPUE measure with the average unit price of fish.

3.) *Catch per gear unit per hour* – the amount of catch of one gear unit per hour of fishing, derived by dividing kg/g/trip by the fishing duration (number of hours of one fishing operation). This metric allows for the comparison of catching efficiency of one gear with other types.

c. **Landed Catch** – this is the amount of fish landed in a given area (village, municipality/city, province or bay) by all fishers and all gears, and can be estimated from recorded catch of a sample of fishers or gears through the use of raising factors (Sparre, 2000). Sampling the catch of a number of fishers, boats or gears is fundamental to fisheries monitoring since it is virtually impossible to census the fisheries of an entire barangay, municipality or bay. Estimating total catch from samples is a basic use of data, a procedure known as 'raising the catch' to the total landed per unit area (Gulland 1966). The methodology of raising is closely linked to the hierarchy of stratification, also known as multi-level raising. The stratification at each level, from the single trip interview to the estimate of total landings of the country, should be well-defined to make the raising from one level to the next level possible and dependable (Sparre 2000).

An example of stratification in fisheries survey is as follows:

- Sampling the catch of the number of boats or gear type in a given day. This needs data on total number of boats or gears landing that day.
- Sampling the landed catch of a number of fish landing sites or coastal barangays in one municipality. This needs data on total number of coastal barangays in the respective municipality
- Sampling the landed catch of few municipalities in a bay or gulf. This needs data on number of municipalities/cities surrounding the bay
- Sampling the number of days within a month or for a whole year

Stratification can also be done with municipal (artisanal) and commercial (industrial) fishing boats or gear, or major and minor fish landing area.

1.) *Principles of Raising*

The basic principle of raising interview samples is illustrated in **Figure 38** (Sparre 2000). **Interviews with individual fishers in a landing center** (i.e. fish landing survey) would be the most practical means of getting catch data. Interviews containing information about the catch (or landings) per day can be combined with information on total effort and activity, involving a simple multiplication to obtain an estimate of the total catch (or landings). If other effort measures (number of gear units, boats, horsepower, etc.) are available, these may replace the "fishing days", which may improve the estimation of total landings.

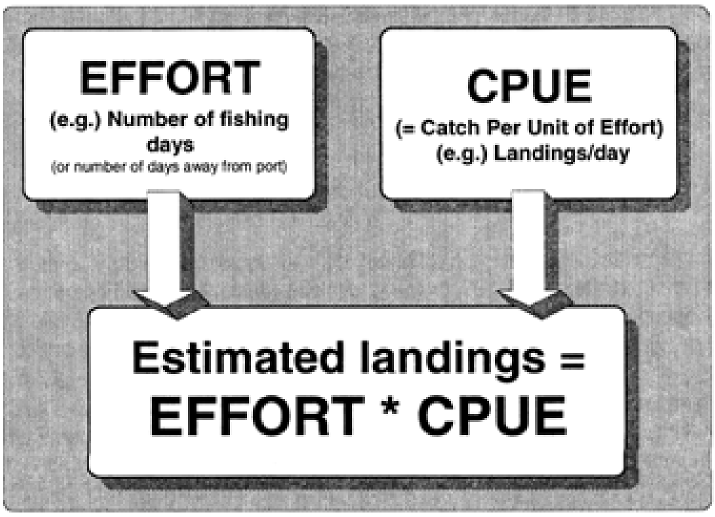


Figure 38. Raising of catch per unit of effort to total catches (Source: Sparre 2000).

If fishing vessels or boats are very similar (i.e. vessels belonging to the same fleet) then it is assumed that all vessels have approximately the same catch. If the number of vessels in the fleet is already identified, then the catch of the fleet can be estimated using the following formula:

$$\boldsymbol{Catch\ of\ fleet/month} = (\boldsymbol{catch\ of\ one\ vessel\ in\ a\ month}) * (\boldsymbol{Number\ of\ vessels\ in\ a\ fleet})$$

2.) Estimating Total Landed Catch

When an estimate of the total effort involved in a fishery is available, it is easy to obtain an estimate of the total amount of fish caught and landed in a given area within a specified period (day, month, year). To raise the sampled catch monitored over a number of days to the total landed catch in a month from a sample of landing areas (e.g. in a bay) or gears, use the following raising factor:

$$\boldsymbol{Raising\ Factor\ (RF)} = \frac{\boldsymbol{NT}}{\boldsymbol{nt}}$$

Where: N = total number of fish landing areas (FLA) or units of each gear type;
n = number of landing sites (or gear units) sampled or monitored;
T = total number of days fishing in a month;
t = number of days sampled

The calculated RF will then be multiplied by the total recorded catch (TRC) from the sampled fish landing areas (FLAs) or gear units to obtain an estimate of the total landed catch (TLC) for the month.

Example 1: *Raising the sampled catch of a gear to TLC in each month, if N = 15, n = 5, T = 20 days and t = 5 days, and TRC = 15 kg.*

TLC = (15*20) / (5*5) * 150 = 12.0 * 15 =180 kg *landed in a month by a gear type*

Example 2: *Raising the sampled catch from all gear types of a landing area to TLC of a municipality, if N = 3, n = 1, T = 20 and t = 5, and TRC (total catch in a day recorded in FLA) = 120 kg.*

TLC = (3*20) / (1*5) = 12.0 * 120 = 1,440 kg *landed catch in a month in 1 municipality (or city)*

To obtain the TLC of the entire bay (i.e. of all municipalities), the TLC per month of the sampled municipalities will be multiplied by the RF derived as follows:

$$\boldsymbol{RF = \frac{Number\ of\ municipalities\ around\ the\ bay\ (N)}{Number\ of\ monitored\ municipalities\ (n)}}$$

Thus, TLC for the entire bay can be computed as follows:

$$\boldsymbol{TLC\ of\ Entire\ Bay = \left(\frac{N}{n}\right) * TLC}$$

The annual landed catch can then be obtained by simply adding up the monthly TLC in a given year.

Data Analysis

KEY MONITORING QUESTIONS:

- Where are land cover, habitats, and ecosystems? And where are they being degraded/improving? (not just in PA but including buffer zones)
- Are the populations of threatened species of plants and animals declining/increasing?
- What are the causes of decline/increase?
- Has management intervention had the intended impact on the ecosystem?
- Are there increased benefits to local communities from sustainable natural resource use?

Data collected and processed need to be further analyzed to be able to answer the key monitoring questions which the regular monitoring process aims to answer. Data generated by other cooperating agencies (i.e. academe, LGU, BFAR) and secondary data sources such as baseline/previous biodiversity monitoring reports, CLUPs, CRMPs, etc. need to be integrated into the analysis.

1. To facilitate synthesis, consolidate data generated from all monitoring sites/stations using data summary matrices for coastal vulnerability (Annex 7) coastal habitats biodiversity (Annex 31), megafauna biodiversity (Annex 32), and fisheries biodiversity (Annex 33).

2. Update the base map of the concerned area using the data generated from the different monitoring methodologies conducted within the year.

3. Write a biodiversity synthesis report following the outline below. The different sections of the report should provide answers to the key monitoring questions substantiated by the data and information consolidated in the matrices and base map, and by trends observed by comparing the latest data with the baseline or previous biodiversity reports. It is also encouraged that the regional offices provide insight on the methodologies used for monitoring as these can identify any further improvements that needs to be made to the monitoring system or any constraints that must be addressed in order to comply to it more effectively.

   Regional offices are also encouraged to give recommendations on addressing threats to biodiversity or improving management of the MKBAs as they are the ones who know more about the area and the users of information on the coastal and marine natural resources.

SUGGESTED OUTLINE FOR BIODIVERSITY SYNTHESIS REPORT FOR EACH MARINE KEY BIODIVERSITY AREA:

I. **Introduction** - short relevant background on the marine KBA, e.g. establishment history
II. **Biophysical Setting** - geographical location & description- with base maps showing habitat/resources; areal estimates of coastal ecosystems
III. **Socio-economic Setting** - short statement on resource uses, economic status of coastal communities surrounding the mKBA – livelihood options, average HH income;
IV. **Status of and Trends in Coastal Habitats & Resources** (including GIS maps integrating habitat/resource information and areal estimates of coastal ecosystems)
   A. Reef Status and associated fauna (trends in hard coral cover and fish diversity, abundance, and biomass)
   B. Seagrass and associated fauna (trends seagrass cover and invertebrate diversity and abundance)
   C. Mudflats and seaweed areas (trends in seaweed cover and diversity and invertebrate diversity and abundance)
   D. Coastal Integrity with focus on contribution of coastal habitats to it
   E. Megafauna diversity and distribution
   F. Capture fisheries (biodiversity, fishing effort and catch, CPUE trends, economic benefits)
V. **Status of threatened species -** trends in relative abundance or populations of threatened species of plants and animals to see if they are increasing or declining, including causes of these increases or decline.
VI. **Impact of Management** – has management intervention had the intended impact on the ecosystem?
VII. **Benefits to local communities from sustainable natural resource use** – are there increased benefits to local communities from sustainable natural resource use? How much ecosystem services benefits are the PAs providing to the local communities? Where are the major ecosystem services being generated and where are they being used?
VIII. **Monitoring Approaches/Methodology and Gaps**
IX. **Recommendations**
X. **References**

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