Managing Coastal Marine Biodiversity and Protected Areas

For MPA managers

Module 4

Assessment and monitoring of coastal and marine biodiversity and relevant issues

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On behalf of:

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

of the Federal Republic of Germany

Disclaimer:

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Summary

This module provides an overview on different coastal and marine ecosystems, critical marine habitats, their importance and assessment. This also describes selected assessment methodologies of different critical habitats and different flora and fauna found in coastal and marine ecosystems. The module ends with an overview of the stakeholder mapping and analysis for an effective MPA management.

Key Messages

- While the focus on global and ecosystem processes is indeed imperative, controlled field experiments and carefully designed surveys and monitoring programs could be completely misinterpreted if analysis of data obtained via scuba is not also incorporated.

- Scuba created a scientific revolution by providing direct access to underwater habitats composing a large part of the biosphere. While there have been many important specific advances, we believe that the overarching benefit of scuba for marine population, community, and ecosystem ecology has been to facilitate the direct observation and manipulations of individual organisms and their surrounding conditions.

- Management of the marine environment is a matter of societal choice. It involves decision making in terms of allocating parts of three-dimensional marine spaces to specific uses to achieve stated ecological, economic and social objectives. People are central to this decision-making process and are the agents for change.

Detailed scientific data from a monitoring programme in a Marine Protected Area is often sought to provide a more rigorous picture of what is happening. However, monitoring is expensive; and the management of large systems or Protected Areas with multiple objectives and many values, usually with limited resources, means that monitoring efforts must be carefully targeted and well designed. The particular indicators chosen for monitoring should if possible provide at least some information on as wide a range of values as possible – for example healthy populations of an animal with a large home-range will often say something as well about the overall health of the ecosystem. Because the specific objectives for management will be different for each protected area, the content of monitoring and evaluation programmes for assessing outcomes will be correspondingly diverse

4.1 Difference between Inventory, assessment and monitoring

4.1.1 Inventory: Establish baseline

It is essential for the inventory to collect baseline information to describe the ecological character of the ecosystem, pressures and associated risks of adverse change in ecological character, and monitoring activities, which can include both survey and surveillance that provides information on the extent of any change. All these are important and interactive data gathering exercises. They should be considered as linked elements of this overall integrated framework which, when implemented, provides for identification of key features of the character of Protected Areas.

4.1.2 Assessment: Status, trends and threats

The identification of the status of, and threats to, the ecosystems as a basis for the collection of more specific information through monitoring activities.

4.1.3 Monitoring

Monitoring is the process for analyzing degree of change in status, trends and threats, including emergence of new threats in the ecosystem. This is to collect specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management.

4.2 Critical Habitat Assessment & Monitoring

4.2.1 Key questions regarding monitoring by the managers:

Critical habitat managers around the world have similar problems and questions that monitoring can answer. For example, managers need to know if:

- Critical habitats are healthy and improving;
- Threats are damaging the core animals/plants of the critical habitat or other organisms;
- Fish populations are increasing in a protected area;
- Management actions have been successful;
- Economies of local communities are maintained or improved;
- Communities understand the need for management and want to assist;
- Tourism is a positive or negative benefit for the coral reef area.

These questions and many others can be answered with an effective monitoring program, which will consist of a number of monitoring methods.

And some specific questions on the monitoring:

- How monitoring can help management;
- How to choose the best methods to suit your needs; and
- The good and bad points and associated costs of a wide range of monitoring methods.

Monitoring can be specific or general. There are different management information needs for each coastal or marine area, so monitoring programs must be designed to include a selection of protocols and methods to meet those needs. The protocols and methods outlined in this section represent the ones most commonly used on critical habitats around the world. Our advice is to use the standard and frequently used methods to monitor your critical habitat because these have been extensively tested. Using standard methods also means that you will be able to compare the status of your critical habitat with other critical habitat at regional and global scales.

4.2.2 How can monitoring help the MPA managers in effective management of their MPA ?

A major goal of a critical habitat monitoring program is to provide the data to support effective management. As more Marine Protected Areas (MPAs) are established, it is becoming increasingly important to monitor whether they are achieving their management goals.

Monitoring can assist with the effective management of a protected or managed coastal or marine area, through the following tasks:

1. **Resource assessment and mapping –** what and where are the resources in your critical habitat area that should be managed;
2. **Resource status and long-term trends –** what is the status of these resources and how are they changing over time;
3. **Status and long-term trends of user groups –** who are the major users and stakeholders of your critical habitat, what are their patterns of use and attitudes towards management, and how they are changing;
4. **Impacts of large-scale disturbances -** how do impacts like coral bleaching, crown of-thorns starfish (Acanthaster planci or commonly known as COTS) outbreaks and tropical storms, floods affect your critical habitat;
5. **Impacts of human activities –** how do the activities of people affect the critical habitat and its resources? This includes fishing, land use practices, coastal developments, and tourism;
6. **Performance evaluation & adaptive management -** how can monitoring be used to measure success of management goals and assist in adaptive management?
7. **Education and awareness raising –** how to provide support for critical habitat management through raising awareness and education of user communities, government, other stakeholders and management staff?
8. **Building resilience into MPAs -** how to design MPAs so they are more resilient to large scale disturbances such as coral bleaching or outbreaks of COTS, storms or tsunami or floods;
9. **Contributing to regional and global networks –** how to link up with and learn from other critical habitat managers around the world and assist others manage their critical habitats.

To monitor status of any value, it is usually necessary to decide:

- What attributes will be considered;
- What indicators of this attribute will be measured/assessed; and
- Methods to be used in measuring the indicator.

Table 6 Example of monitoring attributes, indicators and methods

Value	Attributes	Indicators	Method
Population of an endangered animal	Breeding success	Number if breeding females at sites x,y,z	Counting nests
		Mortality rate	Tag and recapture
Integrity of an indigenous art	Visibility of artwork Disturbance level of site	Vibrancy and clarity compared with the previous years	Photo-monitoring and analysis
		Evidence of graffiti, trampling and soil compaction	Photo-monitoring and soil compaction measures
Level of cooperation with local community	Proportion of community supporting the protected area	Number of incursions by local people recorded	Patrol database
		Report of positive progress at meetings	Subjective quarterly reports reviewed

4.3 Process of monitoring coastal and marine habitats and species:

4.3.1 Defining the objectives of research and monitoring[1]

Research is about understanding the functioning of a system, monitoring is the repeated observation of a phenomenon over time. The goal of the research and monitoring is to enable management to meet the purposes set for the MPA. This then determines the objectives of the research and monitoring.

Research and monitoring should provide answers to the following broad questions:

- What are, or have been, the pressures on the system (whether natural, e.g. severe storms, tectonic events or El Niño, or human-induced, such as pollution, habitat destruction or over-exploitation)?
- What is the state of the managed system, in particular of its:
    - Dominant biota,
    - Rare, endangered or threatened species,
    - Ecological processes (e.g. sedimentation, absorption of nutrients and toxic elements),
    - Ecological states (e.g. water quality, temperature, suspended sediment levels, nutrient levels)?
- What is, or has been, the effect of the management response?
- Are the measures specifi ed in the Management or Zoning

Plan being implemented?

- Are people complying with the conditions in the plan?
- Is management meeting its objectives?

1 Adapted from GESAMP (1996), with input on monitoring from Richard Kenchington and Kathy Walls.

4.3.2 Establish the ambit of research and monitoring

'Ambit' means the topics to be included in research and monitoring, such as testing whether water quality is improving, monitoring changes in fish stocks, and measuring the level of impact from tourists as visitor numbers grow. It also includes the geographic coverage, the time-scale to be covered, and related socio-economic factors.

In defining the ambit, it is advisable to focus on the ecosystem as the unit of study rather than be limited by the boundaries of the MPA itself. Because of the high connectivity in marine systems, there is little value in research and monitoring that is limited to small or medium sized MPAs. Moreover, the research and monitoring should include those terrestrial and marine areas that significantly affect the MPA.

Socio-economic factors, such as the economic benefits brought by the MPA, can be just as important as biological ones. Indeed, it is often the combination of the two that provides the most valuable information to the manager. For example, if a no-fishing policy is to be reviewed, the manager would need to know the measured changes in fish stocks and the effect on the livelihoods of fishers. It is also important to appreciate the values and needs of the human societies involved, and the capabilities and interests of the institutions that work with the management team. Natural and social scientists should contribute at every stage: the approach should be inter-disciplinary.

The resulting analysis should consider all relevant practices in a given location – typically including fisheries, aquaculture, agriculture, forestry, industry, waste disposal and tourism – in the context of the conservation objectives of the MPA and the needs and aspirations of the communities affected. It should distinguish between issues that are important over the long term (e.g. climate change, population growth and the consumption habits of society) and more immediate concerns, such as those associated with conflicts among user groups.

Table 1. Examples of research and monitoring for MPAs

Topic	Examples of research	Examples of Monitoring
Pollution Contaminant inputs (i.e. to control priorities)	Identifying major sources (industry, agriculture, fisheries, sewage, shipping, etc) and pathways (pipes/sewers, rivers, atmosphere, discards from ships, etc); developing suitable sampling and analytical methods.	Quantify loads of priority contaminants (e.g. heavy metals, nutrients, organochlorines, TBT, oil, faecal coliform bacteria).
Fishery management Stock depletion. causes and solutions	Investigate life-cycles, reproductive features, feeding requirements and habitats of affected species; identify factors (climatic, trophic, human etc) controlling inter-annual variations in these characteristics; determine local factors limiting recruitment, such as fishing methods and intensity, predation, disease, poor water quality, reduced spawning habitat, etc.	Implement a schedule of measurements to obtain more reliable data on temporal variations in key parameters as identified from prior research (e.g. numbers and age-classes of fish or shellfish harvested by different methods, availability of prey species, variations in water and prey quality, rates
Conservation of habitats and biodiversity Impacts of development/use of coastal areas and resources	Identify, classify and map remaining natural (undeveloped) habitats and compare with any historical records; characterize associated biotic communities and exploitable living resources; evaluate their inter-dependencies, ecological importance and sensitivities to human activities; identify factors that may determine habitat sustainability and appropriate measurable indicators of these factors; quantify relative extents of modified habitats and areas reclaimed for housing, industry, agriculture, aquaculture, forestry, tourism and recreation, transport, harbours and marinas; develop an interactive, computerized database to hold all such records.	Implement a long-term programme to quantify physical, biological and ecological changes in habitats with a particular focus on more sensitive species, communities and processes; develop indicators of long-term sustainability derived from prior research; maintain up-to-date records on rates of physical development and changes in patterns and intensities of human activities; record changes in demography, tourist numbers, aquaculture, fishery production, port traffic, offshore aggregate extraction, sewage and waste generation and other factors that may increase pressures on habitats and resources, or reduce biodiversity.

Sources: GESAMP, 1996

4.3.3 Find out what is already known

Once the objectives and ambit of the research and monitoring are decided, the next stage is to plan the detailed programme. First, it is vital to find out what is already known. This may mean sifting through and assessing a large amount of information of variable quality on a wide range of topics, a process that requires skill and judgement.

Local scientists can help, especially in evaluating the source and quality of research results, as can other local people. The process should identify any obvious gaps in scientific knowledge, their likely implications for the MPA and the possibilities of filling them within a realistic time and cost.

While each area presents its own challenge, there is a great deal of scientific knowledge relevant to MPAs to build on and borrow from. Often, special research is not necessary to answer management questions – they can be answered by looking at experience elsewhere.

4.3.4 Design and establish the research and monitoring programme

Without careful design and a systematic approach, volumes of information can be collected at great expense and effort, but these will not enable the critical questions to be answered. Simple and inexpensive technology is often all that is needed. Complex technology often absorbs much time and resources but confers only marginal benefits. Technology should never be applied for its own sake.

The precise design, scale and scope of a monitoring programme depend on the characteristics of the MPA. In many cases, the resources to establish and implement fully the level of research and monitoring identified are not available. The emphasis should then be on those elements that are most critical to assessing and achieving the objectives of the MPA. It is particularly important to measure changes in the ecology of the MPA, and resulting effects on the socio-economic condition of the human communities that depend on it.

Involving nearby scientific institutions is helpful. Their scientists are likely to be familiar with the historical and social roots of conflicts and may therefore be best able to deal with them. Physical proximity facilitates meetings and joint effort: modern electronic communication has many advantages, but nothing is as effective in solving complex problems as a group of people meeting and working together.

4.3.5 Conducting the assessment

4.3.5.1 BASIC STEPS

Conducting assessment of critical habitats and species included the following steps:

Step 1 – Collecting data in field

Step 2 – Manage and compile the data

Step 3 – Analyse the data

Step 4 – Interpretation and peer-review of data

Step 5 – Communicating the results and adapting the management planning based on the evaluation

Step 6 – continuously monitor the indicators at a regular frequency

4.3.5.2 ASSESSMENT OF MANGROVE HABITATS

Schwarz et al (2004) developed the method described in the following section. It can be used to understand the distribution, habitat and character of mangroves and their changes over time.

Transect method is used. Each transects needs to be permanently marked so that it can be returned to on different occasions and in successive years. Wooden stakes (approximately 100 cm × 5 cm × 5 cm) hammered into the ground will fulfil this purpose. Ideally these stakes will also be located with a GPS position and a simple sketch map made of the relevant features so that transects can be relocated if the markers are lost. Making measurements on transects running perpendicular to channels and/or the shoreline is recommended; however, the exact location will depend on the selected location or interest.

4.3.5.3 ASSESSMENT OF ESTUARINE HABITATS

Three potential assessment tools were developed by Robertson et al (2002) to represent different scales of investigation in an estuarine monitoring protocol:

- Preliminary assessment includes development of a decision matrix that allows managers to prioritize estuaries for monitoring and provide a defensible basis for their long-term planning.
- Broad-scale habitat mapping includes the development of robust GIS-based methodology for mapping the spatial distribution of intertidal estuarine habitats.
- Fine-scale environmental monitoring includes development of methodology to measure the spatial variations and inter-relationships of a suite of commonly measured indicators

4.3.5.4 ASSESSMENT OF BEACH HABITATS

Beaches that are used by the turtles nesting need to be monitored regularly, which is crucial in the conservation of marine turtles. Beaches and dunes are in constant motion, continually changing shape and shifting position in response to winds, waves, tides, the relative sea level and human activities. The most significant changes occur seasonally and after storms. Comparing season-to-season profiles and profiles taken before and after a significant storm clearly illustrates the important changes taking place along the shoreline and how quickly coastal landforms change.

Two-dimensional on-shore models are ideal for management applications as they are simpler and have fewer inputs compared with three-dimensional models or models that include long shore interactions.

4.3.5.5 ASSESSMENT METHODS FOR SEA TURTLES

Five species of Sea turtle including Olive ridely (Lepidochelys olivacea), Green Sea turtle (Chelonia mydas), Hawksbill (Eretmochelys imbricata), Leatherback (Dermochelys coriacea) and Loggerhead turtle (Caretta caretta) are repoted to occur in Indian waters.

The aim of Sea turtle monitoring program is to determine an increase or decrease of sea turtle population size in the nesting species, while at the same time increase the hatchling success through beach controlling and hatchery management. By collecting data through continuous nesting seasons the program allow us to compare reliable.

Key information to be gathered:

The monitoring programs should always include gathering and collating information through

- Assessment of marine turtle mortality related to fishery
- Assessment of marine turtle distribution at sea from information provided by fishers and
- Assessment of the feasibility of tracking entangled turtles after release to determine survivorship and migratory paths.

Equipment required for turtle monitoring:

- Torch with red filter Dark clothing, Notebooks with datasheets Closed toed shoes, 2 pencils, Tagging pliers, Tags, Alcohol, Measuring tape (50/100 m and 5 m), Gloves, Untreated plastic bags, GPS (not essential)

CONDUCTING THE ASSESSMENT

Dividing the beach into sectors

Setting out beach transects is a good way to determine which area has the highest density of nests. This can decide the place of the hatchery as well as areas in need of higher vigilance. Every 100 meters a marker post is to be placed to facilitate quick recording of location when gathering data.

Beach patrolling

Patrol groups should never be larger than four to six people. Whereas, large groups are harder to control working with a turtle and there is a much higher risk of disturbing the animal.

Location of nest

The sea turtle species nest at different levels of the beach. To record the location, it is advised to use the sector markers as well as a zone description. The recorded locations are wherever the turtle lays her eggs, not where she enters the beach.

Tagging sea turtles

Tagging should be done only when the egg laying is complete. A metal tagging scheme is a relatively cheap option compared to expensive micro-chipping techniques or the use of satellite transmitters, and standard tags can be obtained from various suppliers. There are two different sized tags; the large tag is designed for the Leatherback only, due to their size, while the second, smaller tag is for the smaller species including Hawksbill, Olive ridley, Green turtle and Loggerhead.

The turtle should be tagged on the left and the right flipper, starting with the lowest number tag on the left flipper. Tags provide us with information not only on the individual turtle but also on the species and their migration routes. The tag carries a message that requests tags to be returned if found (dead turtles in fishing nets or washed up). A small reward may be given to the person who sends the tag back. This allows us to understand the risks turtles face.

4.3.5.6 ASSESSMENT METHODS FOR COASTAL BIRDS

A coherent monitoring system of birds along the coastal area is important, in order to detect bird population changes, understand their causes and predict future changes. The measurement of regional population of bird dynamics should be as thorough as possible, and the aim should be to identify the population processes that are affected by environmental changes. Birds are usually monitored by counting pair numbers and densities of breeding populations (O'Connor 1985).

However, data on population sizes and densities do not reveal the causes of population trends, neither help to predict future population changes (Elmberg et al. 2006). Moreover, the effect of environmental changes may not refl ects immediately on a breeding population. This applies in particular to those seabirds that are long-lived, do not easily change their breeding sites (Grenquist 1965; Minton 1968) or may have delayed recruitment. Breeding success is a more rapid and direct indicator of environmental impact than pair numbers. Changes in breeding success may also provide clues to the factors affecting bird populations. Breeding success should therefore be included in seabird and coastal bird monitoring schemes and used in the assessment of environmental changes.

The assessment method for coast line birds will be a combination of point and round counts (Koskimies and Väisänen 1991). The coastal areas would be censused by walking standard routes along the shore and stopping at standard sites like feeding and wading grounds. The census route should chosen so that all breeding birds in the area could be counted. However, searching nests of many bird is impractical due to habitat structure, the nesting may be counted according to the pair numbers of the birds during the nesting seasons. The numbers of individuals can be converted into pair numbers according to the recommendations by Linkola (1959) either by dividing the individual number by two or by using the number of males or females as the pair number.

4.3.5.7 PREPARING TOWARDS UNDER-WATER ASSESSMENT: SCUBA DIVING

Since the anthropogenic impact (climate change, sedimentation, over exploitation, tourism, over and destructive fishing practices etc.), scientists have felt the necessity to measure ecological processes on spatial and temporal scales. While the focus on global and ecosystem processes is indeed imperative, controlled field experiments and carefully designed surveys and monitoring programs could be completely misinterpreted if analysis of data obtained via scuba is not also incorporated.

Scuba created a scientific revolution by providing direct access to underwater habitats composing a large part of the biosphere. While there have been many important specifi c advances, we believe that the overarching benefit of scuba for marine population, community, and ecosystem ecology has been to facilitate the direct observation and manipulations of individual organisms and their surrounding conditions.

Prior to scuba, subtidal organisms were studied primarily by peering into the water on calm and by analysing specimens collected by fi shing, dredging, or plankton nets. The invention of scuba enabled scientists to observe the behavior and ecology of organisms in their natural habitats, quantify patterns, study interactions, and conduct experiments to test hypotheses about ecological processes. Scuba has been associated with an increasing number of scientifi c publications and the rapid increase in our knowledge of marine biodiversity.

The diving certification

A proper certification in scuba diving is necessary, such as PADI (Professional Association of Diving Instructor) or equivalent and by qualified and experienced Scuba Diving instructor.

Open Water Diver Certification is a full entry level certification earned by successfully completing the entire Open Water Diver Course. The PADI Open Water Diver certification qualifies you to: Dive independently while applying the knowledge and skills you learn in this course, within the limits of your training and experience

Open Water Diver Course Structure

Open Water Diver course consists of three segments: Confined water dives, knowledge development and open water dives. Each plays an important role in learning to dive in meeting the performance objectives you need to qualify as a diver.

The training begin in the confined water (preferably in swimming pool), during which you apply dive principles, and learn and practice dive procedures and skills. You will do this in either a swimming pool, or a body of water with pool like conditions, under your instructor's guidance and supervision. There are five confined water dives that correspond with five knowledge development sections.

Knowledge development establishes the principles and basic information all divers need to have diving safety. It's divided into fi ve segments that you will complete primarily on your own time at your convenience using the manual and the PADI Open Water Diver video. For each segment, your instructor reviews and elaborates on the material, applying what you are learning to your specific needs, interests and the local dive environment. A short quiz confirms that you have picked up the information you need from that section.

The open water dives complete your training as an entry level diver by applying and further developing your knowledge and dive skills in a dive environment under your instructor's supervision and guidance. You will make at least four scuba diving and perhaps an optional skin dive, during this part of the Open Water Dive course.

4.3.5.8 SEA GRASS HABITAT ASSESSMENT

Seagrass beds are highly productive for fisheries by providing food and shelter for grazing fish and a place to grow for algae and invertebrates that the fish feed on. Seagrasses are nursery grounds for juveniles of commercial prawns and fishes. Seagrass meadows can change in several ways. There can be a change in biomass without a change in area; a change in area, or shape, depth or location of a meadow; a change in species composition, plant growth and productivity; the fauna and fl ora associated with the meadow; or a combination of some or all of these.

At the "meadow level", measures of species composition, and estimates of means and variances for parameters such as biomass or percent cover, can be easily obtained. Physical parameters measured usually include depth (below mean sea level, MSL) and sediment composition. Turbidity, light, salinity and temperature should ideally be included in monitoring. Currently, satellite imagery, coupled with GIS techniques, is considered to be one of the best tools for understanding changes in sea grass coverage. It is cost-effective and reliable.

Monitoring the amount of the seagrasses gives important information for fisheries but seagrass beds are naturally variable and some have annual periods of dieback. This should be considered and monitoring should be repeated at different times of the year. Manta towing is rarely possible in seagrass beds as the visibility is too low. Three methods can be used:

A. First is measuring the weight of living material or biomass by removing samples of it. As this is destructive, it should only be done in large seagrass beds. Second is a method to visually estimate the weight of the seagrass (biomass) by trained divers. Both methods need training and laboratory work.

B. A simpler method is to monitor the seagrass area from year to year to see whether they are declining or enlarging. This can be done using natural landmarks and marking the outlines of the seagrass beds on a map at a very low tide.

C. Even better is using aerial photography on a sunny day at low tide, when shallow water seagrass beds are obvious. Doing this annually at the same time of year will give a good idea of change in seagrass beds. Aerial photography will give a good indication of what is happening and what are the causes.

4.3.5.9 ASSESSMENT METHODS OF SEA MAMMALS

As sightings of marine mammals are comparatively rare, they are treated a little differently and shall collect data through systematic line transect survey following distance sampling procedure to estimate the absolute abundances of cetaceans population from visual sighting data (Johansen et. al., 2012; Hiby and Hammond 1989) in addition to that, Genetic, photographic, acoustic, and behavioral information of cetaceans can also be collected from the vessel.

The method involves 300 m (or 500 m) wide strip transects operated only on one side the ship (fi g). Longitudinally, the transects are subdivided into so-called observation periods (e.g. 2, 5 or 10 minute intervals) and the sightings (marine mammals) are grouped under these periods. No matter where marine mammals are sighted (inside or outside the transect strip), they are always recorded. However, during active survey focus is directed to the 180° ahead of the ship. Further, the angle relative to the course of the ship and the direct distance in meters to marine mammals are always recorded (Johansen et. al., 2012)

Visual census

The historical and still standard method for taking a census of marine mammals is visual surveying.

This is done either from aircraft or boats or shore-stations, or on rare occasions from kites, balloons or remote-controlled planes. Visual surveys are normally done along line transects (e.g. Morgan 1986, Palka and Pollard 1999). Subsequent biostatistical modelling estimates the total number of animals in a population from the number of animals seen.

4.3.5.10 ASSESSMENT METHODS OF CORAL REEF

Measurements of coral demographics, mortality and recruitment are combined with assessments of benthic cover types, biomass of algal functional groups, population structure of commercially valuable and ecologically relevant reef fishes, and environmental resilience indicators determined using a standardized, rapid quantitative survey protocol.

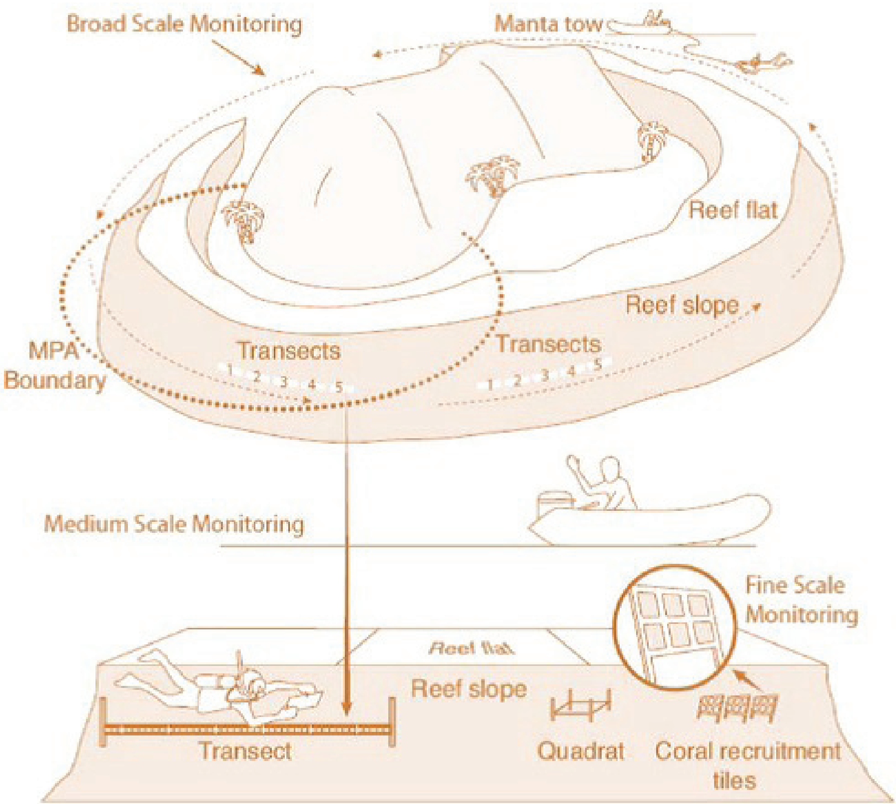
Concurrent ground truthing is used to define the bathymetry, identify habitat classes and their spatial distribution and extent, characterize dominant species assemblages, substrate types and underlying geomorphology and create high-resolution habitat maps.

The rapid assessment protocol can be adopted from Global coral reef expedition protocol and the IUCN Resilience Assessment of Coral Reefs protocol, with additional parameters. Quantitative data can be obtained on the

- coral community structure (diversity, size structure, partial mortality and condition), using 10 m × 1 m belt transects, and coral recruitment (five 0.25 m quadrates per 10 m transect);
- diversity, size and abundance of over 100 commercially valuable reef fishes (food and ornamental fishes) and ecologically relevant functional groups of reef fishes (e.g. herbivores, invertebrate feeders and piscivores) using 30 m × 1 m belt transects;
- cover and abundance of major functional groups of algae (turf algae, macroalgae, crustose coralline algae and erect coralline algae), corals and other benthic invertebrates using a point intercept method (100 points per 10 m transect); and
- approximately 50 other ecological and environmental resilience indicators.

These could be quantified (e.g. abundance of corallivores, disease prevalence), ranked on a scale of 1 to 5 (e.g. rugosity, slope), measured off satellite imagery (e.g. reef direction and size, distance from land, to nearest reef and associated habitat and to deep water), or obtained from external sources (e.g. sea surface temperature).

Coral reef assessment data are incorporated into a GIS database with satellite imagery forming a base layer, high resolution bathymetric and habitat maps developed through this program, and other available data layers.



An illustration of the three scales of monitoring: broad-scale covering large areas at lower resolution, e.g. with manta tow; medium-scale for higher resolution at medium scales e.g. line transects; and fine-scale for gathering high resolution data at small scales.

Fish census

Different fish species that appear together are referred to as a "fish assemblage." Three aspects of reef fish assemblages that can be monitored are:

- Diversity: the number of different species;
- Structure: species composition and relative abundance; and
- Population density: the number of fish of a given species per unit area.

The most common methods for visual fish censuses are: stationary counts, belt transects, and random swim techniques. In choosing a method, be sure to consider the behaviour of the relevant fish species (e.g., cryptic, schooling, attracted or repelled by divers).

- The stationary Census focuses on the relative abundance and frequency of occurrence of all species observed at the site.
- The belt transect method yields better density estimated and covers a larger area per census.
- The random swim technique provides more complete information on the total species richness.

Figure 1: Stationary Fish Census

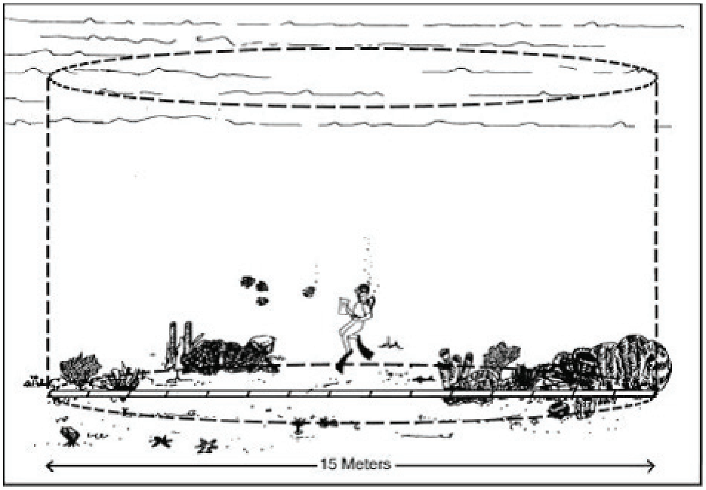
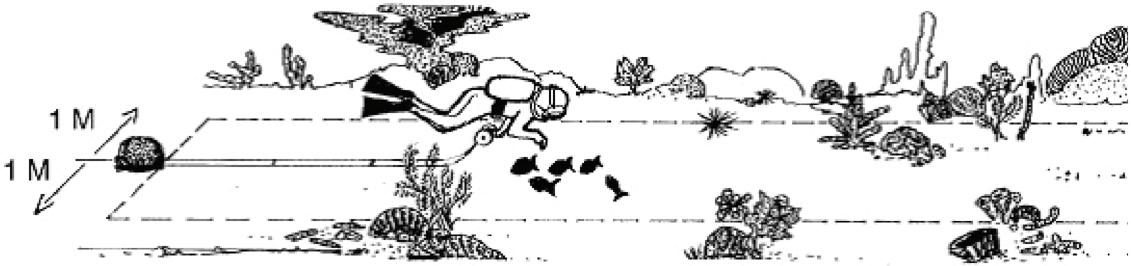


Figure 2: Belt transect census



4.4 Application in Management

4.4.1 How the MPA managers can use this data ?

- in their management plans
- day to day monitoring plans/ operational plans/ EIA reports
- Online databases like fish base
- Social media
- Their personal database/ site based management
- supporting scientific community
- publications

4.4.2 Suggested components of a basic monitoring program that will address a variety of situations.

The management question/ Situation	The type of monitoring programme to get answers
Coral bleaching	Monitor individual coral colonies; measure water temperature, Photo-synthatically active Radiation (PAR) and UV
Damage by boats, snorkelers, divers	Measure physically damaged area; record number of broken coral branches/plates
Over fishing	Fish census
Sediments from dredg-ing or runoff	Measure sedimentation rates and bacterial concentration

4.4.3 Specific situations

In these situations, MPA managers need to monitor at established quadrats or transects in the affected areas and at control sites

Baseline monitoring	Monitor individual coral colonies and live coral cover; measure water temperature, algal biomass, water transparency, and salinity; census reef fishes.
Sewage or other nutrient influx	Monitor individual coral colonies, measure nutrients, water temperature, algal biomass, live coral cover, salinity, dissolved oxygen and bacterial concentrations.
Desalination plant effluent	Measure water temperature and salinity
Storm damage	Monitor individual coral colonies; measure algal biomass; census reef fishes
Oil spill	Monitor individual coral colonies

4.5 Stakeholder mapping and analysis

4.5.1 What is a stakeholder?

Management of the marine environment is a matter of societal choice. It involves decision making in terms of allocating parts of three-dimensional marine spaces to specific uses to achieve stated ecological, economic and social objectives. People are central to this decision-making process and are the agents for change.

As such, stakeholder participation and involvement is integral to the success of any conservation planning n the coastal and marine areas. Increased stakeholder participation and involvement in the resource management decision-making process has gained acceptance worldwide

Stakeholder is a group or organization or individual who has an interest/ statutory responsibility/ practical role / influence, or who can be positively or negatively impacted by, or cause an impact on coastal and marine biodiversity conservation and management in the area under question.

4.5.2 Classification of stakeholders:

Stakeholders can be classified with regard to:

- o Their existing/ potential support to the conservation of coastal and marine biodiversity via protected areas, in the specific geographical area of reference (site/ state/national/ supranational)
  - supportive, neutral, hesitant, adverse
- o The dependence of livelihoods on different elements of coastal and marine biodiversity or protected areas
  - negligible, low, medium, high, very high
- o Their power to influence the management of coastal and marine protected areas
  - Very strong, strong, reasonable, low

- o Geographical area of influence and engagement
  - supra-national, national, regional, state-specific, local

4.5.3 Why involve stakeholders?

There are various reasons why it is important to involve stakeholders, including:

1. better understanding of the complexity of the ecosystem;
2. understanding of the human influence on the ecosystem and its management;
3. examining the compatibility and/or (potential) conflicts of multiple use objectives;
4. identifying, predicting and resolving areas of conflict; and
5. discovering existing patterns of interaction.

In addition, stakeholder involvement provides an opportunity to deepen mutual understanding about the issues at hand, explore and integrate ideas together, generate new options and solutions that may not have been considered individually and ensure the long-term availability of resources to achieve mutual goals.

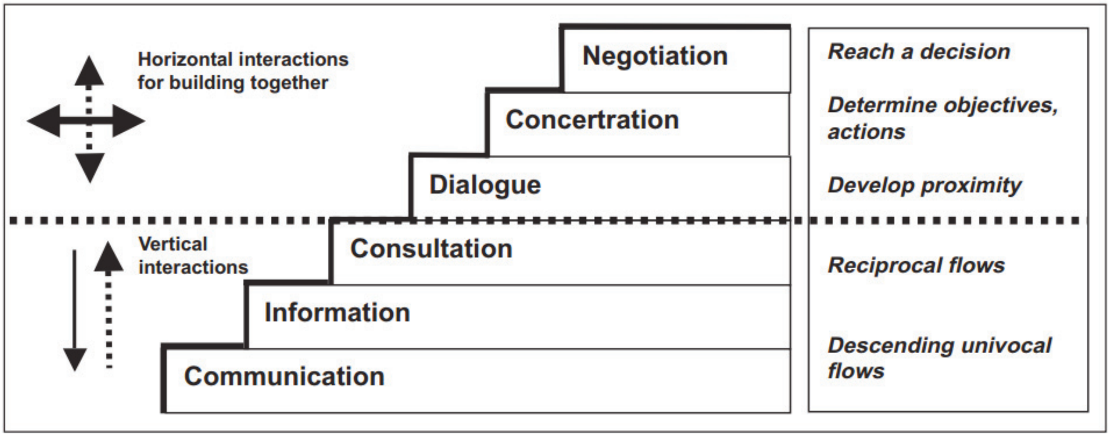
Stakeholder involvement can increase stability in a complex environment and expand capacity rather than diminish it under changing circumstances. All of these issues are becoming increasingly important in the context of MPA management to avoid incompatible uses, resolve conflicts and move toward ecosystem-based management.

4.5.4 Ways of stakeholder Participation

There is a range of types of potential stakeholder participation in MPA management..

Various scientists and resource managers agree that the involvement of stakeholders is a key aspect of successful implementation of ecosystem-based management.

Figure 3: Possible types of stakeholder participation



A key question, however, is who are the main stakeholders with regard to a particular area and how to involve them in an effective way. A comprehensive method that allows for doing this is by use of stakeholder analysis and mapping.

4.5.5 What is stakeholder analysis and why is it important?

Stakeholder analysis refers to a range of tools for the identification and description of stakeholders, their interrelationships, current and (potential) future interests and objectives and examines the question of how and to what extent they represent various segments of society.

More concretely, stakeholder analysis can be defined as: An approach and procedure for gaining understanding of a system by means of identifying the key actors and stakeholders in the system and assessing their respective interests in that system. The use of stakeholder analysis originated in the management sciences. It has now evolved into a field that incorporates economics, political science, game and decision theory and environmental science.

Seven major attributes are important for stakeholder analysis in natural resource management:

1. the various stakeholders related to the natural resource;
2. the group/coalition and to which they belong and can reasonably be associated with;
3. the kind and level of interest (and concerns) they have in the natural resource;
4. the importance and influence that each stakeholder has;
5. the stakeholders' position toward the use or conservation of natural resource;
6. the multiple 'hats' they wear;
7. the networks to which they belong.

Once key stakeholder groups are identified, it is important to find out what their interests and concerns are and how they are positioned toward the area and its resources. The interests, concerns and positions of the various stakeholders will differ as a result of factors including tenure, ownership, history of use, social organization, values and perceptions, and pattern or type of use.

After key stakeholders with interests in the proposed ecosystem are identified, they should be weighted as stakeholders with a primary, secondary or tertiary interest or stake in the area or its resources.

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