Training Resource Material

Coastal and Marine Biodiversity and Protected Area Management

Module 4

Assessment and monitoring of coastal and marine biodiversity and relevant issues

For MPA Managers

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Deutsche Gesellschaft
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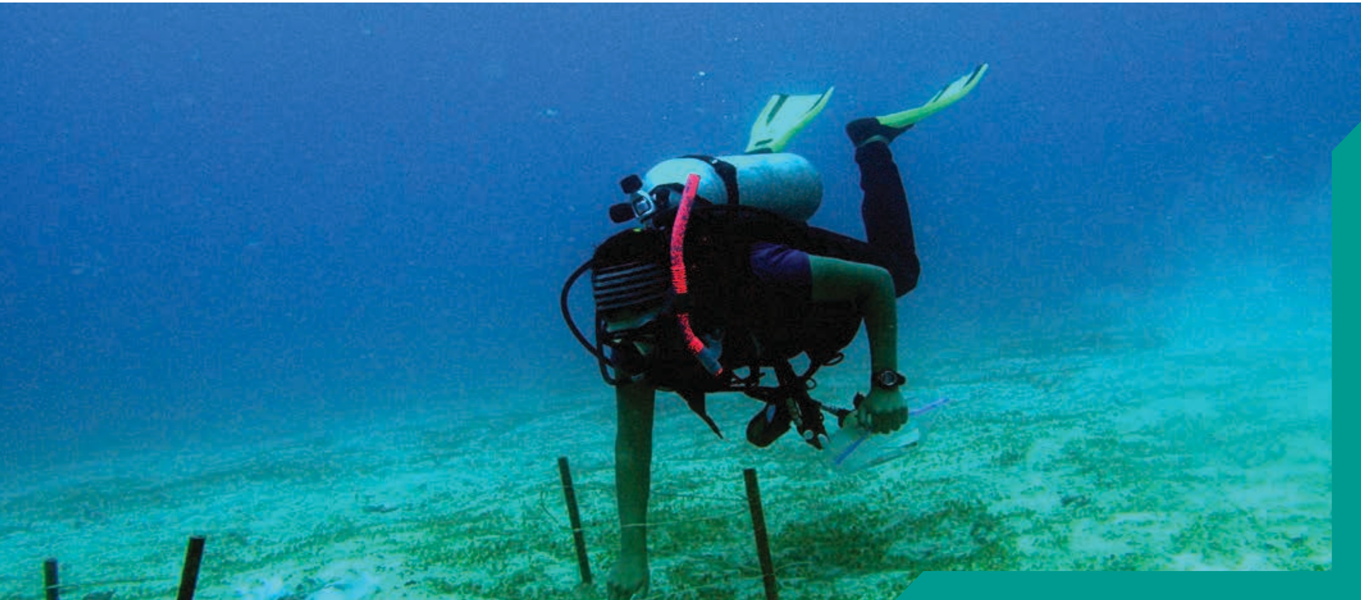

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Module 4

Assessment and monitoring of coastal and marine biodiversity and relevant issues

For MPA Managers

Summary

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

Imprint

Training Resource Material:
Coastal and Marine Biodiversity and Protected Area Management
for MPA Managers

Module 1: An Introduction to Coastal and Marine Biodiversity
Module 2: Coastal and marine Ecosystem Services and their Value
Module 3: From Landscape to seascape
Module 4: Assessment and monitoring of coastal and marine biodiversity and relevant issues
Module 5: Sustainable Fisheries Management
Module 6: Marine and Coastal Protected Areas
Module 7: Governance, law and policies for managing coastal and marine ecosystems, biodiversity and protected areas
Module 8: Coasts, climate change, natural disasters and coastal livelihoods
Module 9: Tools for mainstreaming: impact assessment and spatial planning
Module 10: Change Management and connectedness to nature
Module 11: Communicating Coastal and Marine Biodiversity Conservation issues
Module 12: Effective management Planning of coastal and marine protected areas

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Zusammenarbeit (GIZ) GmbH
Indo-German Biodiversity Programme
A-2/18, Safdarjung Enclave
New Delhi 110029, India
T +91-11-4949 5353
E biodiv.india@giz.de
W http://www.indo-germanbiodiversity.com

Wildlife Institute of India (WII)
P.O. Box 18, Chandrabani
Dehradun 248001
Uttarakhand, India
T +91-135-2640 910
E dwii@wii.gov.in
W www.wii.gov.in

Indira Gandhi National Forest Academy
(IGNFA)
Post Office New Forest,
Dehradun - 248006
Uttarakhand, India
Phone +91-135-2757316
Fax +91-135-2757314
E-Mail : director@ignfa.gov.in

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With guidance of:
Dr. Amita Prasad, Additional Secretary, Ministry of Environment, Forest and Climate Change (MoEFCC) Government of India
Dr. J. R. Bhatt, Advisor, Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India
Dr. Konrad Uebelhör, Director, Indo-German Biodiversity Programme, GIZ India
Dr. V. B. Mathur, Director, Wildlife Institute of India
Dr. Shashi Kumar, Director, Indira Gandhi National Forest Academy, India
Dr. J. Michael Vakily, Team Leader, CMPA Project, Indo-German Biodiversity Programme, GIZ India

Compiled and edited by:
Dr. Neeraj Khera, Senior Advisor, Indo-German Biodiversity Programme, GIZ India
Dr. K. Sivakumar, Scientist F, Wildlife Institute of India

Text and editing contributions from:
Dr. Sarang Kulkarni, Marine Biologist, Indian Institute of Scuba Diving and Aquatic Sports (IISDA), Dr. J.A. Johnson, Scientist D, Wildlife Institute of India; Dr. Ramesh Chinnasamy, Scientist C, Wildlife Institute of India; Dr. D. Adhavan, Project Associate, Wildlife Institute of India; Dr. Pradeep Mehta, Research and Programme Manager, Earthwatch Institute India; Mr. Luke Mendes, Writer, Filmmaker and Media Trainer, Mumbai; Mr. S. Gopikrishna Warrier, Regional Environment Manager, PANOS South Asia; Mr. Darryl D'Monte, Chairperson, Forum of Environmental Journalists of India (FEJI); Dr. Dirk Asendorpf, Journalist and Media Trainer, Germany; Ms Atiya Anis, Communications Expert, Indo-German Biodiversity Programme, GIZ India; Mr. Sanjay Dave, Charkha and Mr. Bharat Patel, MASS Gujarat [case studies of turtle rescue and community plantation of mangroves]; Dr. R. Ramesh and team, NCSCM [ecosystem services, differences between terrestrial and coastal ecosystems, GIS]; Ms Helina Jolly [economic valuation methods and examples]; Dr. S. Senthil Kumar, IGNFA.

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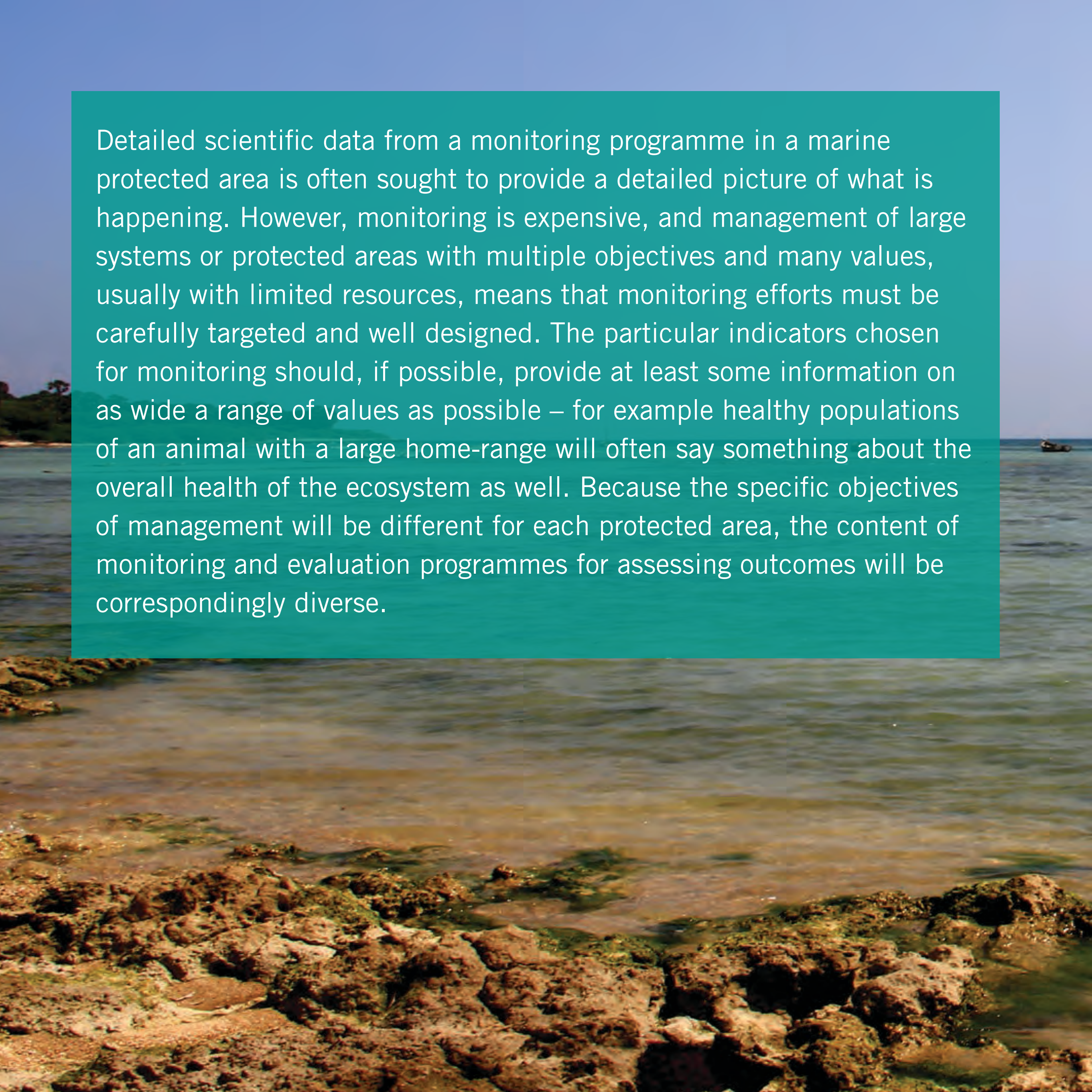
Table of
contents

Key messages

- While the focus on global and ecosystem processes is indeed imperative, controlled field experiments and carefully designed surveys and monitoring programmes 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 the 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 populations, communities and ecosystem ecology has been to facilitate direct observation and manipulation 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 detailed picture of what is happening. However, monitoring is expensive, and 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 about the overall health of the ecosystem as well. Because the specific objectives of 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 changes in the ecological character, and monitoring activities, which can include both survey and surveillance for 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.

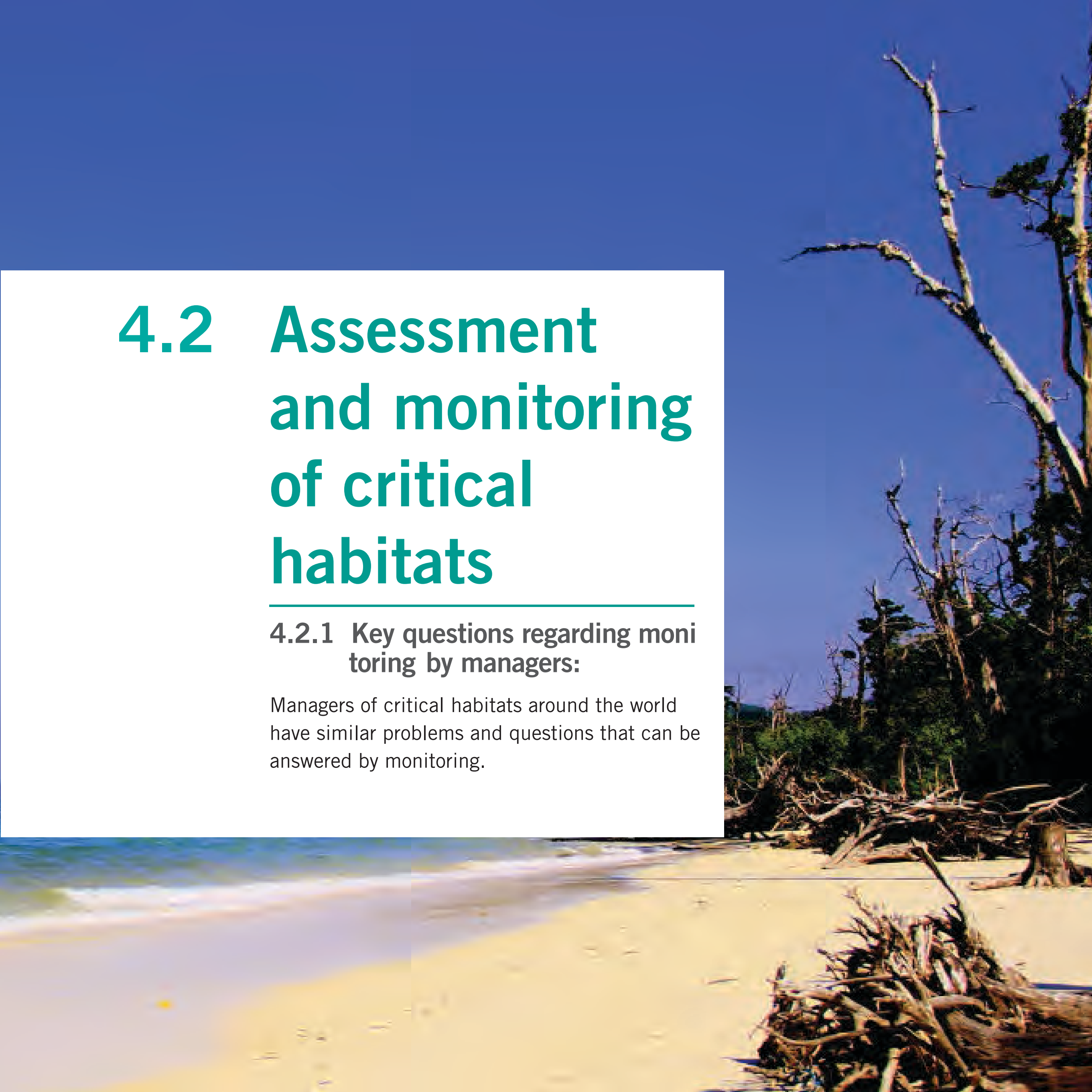
4.1.2 Assessment: Status, trends and threats

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

4.1.3 Monitoring

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

- 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 marine protected area;
- Management actions have been successful



4.2 Assessment and monitoring of critical habitats

4.2.1 Key questions regarding moni toring by managers:

Managers of critical habitats around the world have similar problems and questions that can be answered by monitoring.

For example, managers need to know if:

- The economies of local communities are maintained or improved;
- Communities understand the need for management and want to assist; and
- Tourism is a positive or negative impact for the ecosystem.

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

There are some specific questions related to monitoring:

- How can monitoring help management?
- How do you choose the best methods to suit your needs?
- What are the good and bad points and associated costs of various monitoring methods?

Monitoring can be specific or general. There are different management information needs for each coastal or marine areas, and so monitoring programmes 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 for 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 habitats at regional and global scales.

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

[Adapted from Wilkinson et. al. 2003]

A major goal of a critical habitat monitoring programme is to provide 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 MPA 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 MPA what are their patterns of use and attitudes towards the management, and how they are changing;
4. **Impacts of large-scale disturbances -** how do impacts like coral bleaching, Crown-of-Thorns Starfish (*Acanthaster planci*, commonly known as COTS) outbreaks, tropical storms and floods affect your MPA;
5. **Impacts of human activities –** how do the activities (including fishing, land use practices, coastal development and tourism) of the people affect the critical habitats in the MPA?
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 MPA management by raising awareness among and educating user communities, the government, other stakeholders and the management staff;
8. **Building resilience -** how to manage the MPA so that ir becomes more resilient to large-scale disturbances such as coral bleaching, outbreaks of COTS, storms, tsunamis or floods; and
9. **Contributing to regional and global networks –** how to link up with and learn from other critical MPA managers around the world and assist others with managing their MPAs.

To monitor the 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
- The methods to be used to measure the indicators.

Table 4.1 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

[Source: Hockings et.al 2006]

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

1 Adapted from Kelleher, G. (1999)

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

- What are 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 specified in the Management or Zoning Plan being implemented?
- Are people complying with the conditions in the plan?
- Is management meeting its objectives?

4.3.2 Establish the ambit of research and monitoring[2]

'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 the 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 effects 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 fishing, 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.**

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2 Adapted from Kelleher, 1999

Table 4.2 Examples of research and monitoring for MPAs (Source: Kelleher, 1999)

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, TB 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 meas urements to obtain more reliab 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 sp cies, variations in water and pr 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 c long-term sustainability derive from prior research; maintain up-to-date records on rates of physical development and changes in patterns and intens ties of human activities; recorc changes in demography, touris numbers, aquaculture, fishery production, port traffic, offsho aggregate extraction, sewage a waste generation and other fac tors that may increase pressur on habitats and resources, or reduce biodiversity.

4.3.3 Find out what is already known[3]

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 management, 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[4]

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 used 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 needed 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 the resulting effects on the socio-economic condition of the human communities that depend on it.**

3 Source: Kelleher, 1999

4 Source: Kelleher, 1999

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 habitats and species in an MPA includes the following steps:
Step 1 – Collecting data in the field
Step 2 – Managing and compile the data
Step 3 – Analysing the data
Step 4 – Interpretation and peer-review of data
Step 5 – Communicating the results and adapting the management planning on the basis of the evaluation
Step 6 – Monitoring the indicators continuously at a regular frequency

4.3.5.2 ASSESSMENT OF MANGROVE HABITATS[5]

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.

The transect method is used. Each transect 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.

5 Source : Prakash, S., Chinnasamy, R., and Sivakumar, K. (2013)

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 a robust GIS-based methodology for mapping the spatial distribution of intertidal estuarine habitats.
- Fine-scale environmental monitoring includes development of a methodology to measure the spatial variations and inter-relationships of a suite of commonly measured indicators.

4.3.5.4 ASSESSMENT OF BEACH HABITATS[6]

Beaches that are used by the turtles nesting need to be monitored regularly. Such monitoring 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. Recently, the impact of tourism on the beaches of Kovalam was evaluated by Ghosh and Datta (2012). The field activities and assessment of the beach morphology and interviewing of tourists and citizens were as in the methodology of Breda (2005). To study the geo-environmental profile, the values of several environmental parameters related to beach pollution and water quality status were obtained as primary and secondary level data. In addition, Dora et al (2012) studied the beach dynamics of Devbag, an island-sheltered estuarine coast, by observing the cross-shore beach profiles and textural characteristics of foreshore sediment to understand the annual cycle of intertidal beach dynamics.

6 Source : Prakash, S., Chinnasamy, R., and Sivakumar, K. (2013)


Photo by: Dr. K. Sivakumar/ WII

4.3.5.5 ASSESSMENT METHODS FOR SEA TURTLES

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

The aims of a sea turtle monitoring programme are to determine any change in the population of a nesting sea turtle species and to increase simultaneously increase the hatchling success through beach controlling and hatchery management. By collecting data through consecutive nesting seasons, the programme allows us to make reliable comparisons.

Key information to be gathered

Monitoring programs should always include gathering and collating information through

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

Conducting the assessment[7]

Equipment required for turtle monitoring

Torch with red filter, dark clothing, notebooks with data sheets, closed-toed shoes, two pencils, tagging pliers, tags, alcohol, measuring tape (50/100 m and 5 m), gloves, untreated plastic bags, GPS (not essential).

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7 Source : Frontier Nicaragua (2009)

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 location of the hatchery as well as areas in need of higher vigilance. When gathering data, a marker post is to be placed every 100 metres to facilitate quick recording of the location.

Beach patrolling

Patrol groups should never have more than four to six people. Large groups are harder to control when working with a turtle, and with such groups there is a much higher risk of disturbing the animal.

Location of nest

Sea turtle species nest at different levels of the beach. It is advised that both sector markers and a description of the zone be used to record the location. The recorded locations is wherever a turtle lays her eggs, not where she enters the beach.

Tagging sea turtles

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

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

Photo by: Dr. Ramesh C. / WII

4.3.5.6 ASSESSMENT METHODS FOR COASTAL BIRDS[8]

Birds are considered effective indicators of ecological health, and can very well indicate the soon-to-be visible changes in the ecosystem components and processes. Coastal birds also have a potential as indicators of several aspects of the coastal and marine environment. Therefore, coastal bird monitoring can be used as an effective early-warning system of complex and unexpected environmental changes, thus contributing to the management of coastal and marine protected areas.

A coherent system of monitoring birds along coastal areas is important for detecting bird population changes, understanding their causes and predicting future changes. Measurement of the dynamics of a regional bird population 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[9]).

However, data on population sizes and densities do not reveal the causes of population trends, nor help predict future population changes (Elmberg et al. 2006[10]). Moreover, the effect of environmental changes may not reflects 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[11]) or may have delayed recruitment. Breeding success is a more rapid and direct indicator of environmental impact compared with pair numbers. Changes in breeding success may also provide

8 Source: Rönkä, M., Saari, L., Hario, M., Hänninen, J. & Lehikoinen, E. 2011: Breeding success and breedingpopulation trends of waterfowl: implications for monitoring. - Wildlife Biology 17(3): 225–239.

9 O'Connor, R.J. 1985: Long-term monitoring of British bird populations. - Ornis Fennica 62: 73-79.

10 Elmberg, J., Nummi, P., Po¨ysa¨, H., Sjo¨berg, K., Gunnarsson, G., Clausen, P., Guillemain, M., Rodrigues, D. & Va¨a¨na¨nen, V-M. 2006: The scientific basis for new and sustainable management of migratory European ducks. - Wildlife Biology 12(2): 121-127.

11 Grenquist, P. 1965: Changes in abundance of some duck and sea-bird populations off the coast of Finland 1949-1963. - Finnish Game Research 27: 1-114.

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 used for coastline birds must be a combination of point and round counts (Koskimies and Väisänen 1991[12]). Coastal areas should be censused by walking standard routes along the shore and stopping at standard sites such as feeding and wading grounds. The census route should chosen so that all the breeding birds in the area can be counted. Because searching for the nests of many birds is impractical to the structure of the habitat, the nesting may be quantified through the number of pairs of birds during a nesting season. The numbers of individuals can be converted into pair numbers according to the recommendations made by Linkola (1959[13]), either by dividing the number of individuals by two or by using the number of males or females as the pair number.

Why monitor coastal birds[14]

Coastal birds are a significant part of the marine and island ecosystems, and they are good indicators of the health of the environment as they are amongst the highest order predators in the food chain. From the management point of view, coastal birds are relatively easy to monitor compared to other indicator animals due to their visibility and concentration at breeding and roosting sites. Thanks to a lot of bird watchers and researchers in this field, considerable biological information is available for coastal birds so it is possible to interpret monitoring data. Coastal birds are the subject of several international agreements, and therefore it becomes necessary to monitoring at least the migratory birds in the area.

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12 Koskimies, P. and R. A. Väisänen. 1991. Monitoring bird populations. Zoological Museum, Finnish Museum of Natural History. Helsinki, Finland. 144 pp.

13 Linkola, P. 1959. Zur Methodik der quantitativen Vogelforschung in den Binnengewässern. Ornis Fennica 36:66–78. (In German).

14 Turner, M (2002)

Which measures to be included in the monitoring plan:

- The monitoring can look into the population size of key bird species, especially the size of the breeding population
- Spatial and temporal variation in distribution of key birds species.
- Bird- habitat relationship can be monitored by studying the habitat-use by key bird species.
- Understanding the threats by monitoring the key factors known/ suspected to have negative impact on key habitat/ species, such as pollution levels, salinity, habitat loss etc.

How the field-level staff can continuously contribute to the monitoring plan?

Even if the MPA manager decides to go for a minimum monitoring approach, due to non-availability of financial or human resources, there is a lot that can be contributed in the monitoring plan by the field-level staff of the MPA. They can be given a structured plan for their daily/ regular observation recording in the field, where they can record coastal bird data during patrolling.

Photo by: Dr. Sarang Kulkarni

4.3.5.7 PREPARING TOWARDS UNDERWATER ASSESSMENT: SCUBA DIVING

Because of anthropogenic impacts (climate change, sedimentation, over-exploitation, tourism, over-fishing, destructive fishing practices, etc.), scientists have felt a need 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 programmes could be completely misinterpreted if analysis of data obtained using scuba are not incorporated.

Scuba created a scientific revolution by providing direct access to the underwater habitats that constitute a large part of the biosphere. While there have been many important specific advances, we believe that the overarching benefit of scuba for the ecology of marine populations, communities and ecosystems has been the facilitating of direct observation and manipulation of individual organisms and their surrounding conditions.

Prior to scuba, subtidal organisms were studied primarily by peering into the water on calm days and by analysing specimens collected by fishing, dredging or using plankton nets. The invention of scuba enabled scientists to observe the behaviour 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 scientific publications and the rapid increase in our knowledge of marine biodiversity.

Diving certification

Proper certification, such as by PADI (Professional Association of Diving Instructors), by a qualified and experienced scuba diving instructor, is necessary.

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 the course, within the limits of your training and experience.

Structure of Open Water Diver Course

The 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.

The training begin in confined water (preferably in a 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 to five knowledge development sections.

Knowledge development establishes the principles and basic information all divers need to have regarding diving safety. It is divided into five 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 explains the material, applying what you are learning to your specific needs and 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 dives and perhaps an optional skin dive during this part of the Open Water Dive course.

4.3.5.8 SEAGRASS HABITAT ASSESSMENT

Seagrass beds are highly productive for fisheries. They provide food and shelter for grazing fish and a place to grow for the algae and invertebrates that the fish feed on. Seagrasses are nursery grounds for the 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 the area, shape, depth or location of a meadow; a change in species composition, plant growth and productivity; changes in the fauna and flora associated with the meadow; or there can be 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 seagrass coverage. It is cost-effective and reliable.

Monitoring the amount of 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. The 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.

B. The second method is to visually estimate the weight of the seagrass (biomass) using trained divers. Both methods need training and laboratory work.

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

D. 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 changes in seagrass beds. Aerial photography will give a good indication of what is happening and what the causes are.

4.3.5.9 METHODS OF ASSESSING SEA MAMMALS

Data are collected through systematic line transect surveys using distance sampling procedures. Absolute abundances of cetacean populations are estimated from visual sighting data (Hiby and Hammond 1989). Genetic, photographic, acoustic and behavioural information about cetaceans can also be collected from vessel.

The method involves 300 metre (or 500 metre) wide strip transects operated only on one side of a ship. 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 an active survey, the 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 metres to marine mammals are always recorded.

Visual census

The historical and still standard method for of censusing marine mammals is visual surveying.

This is done either from aircraft, 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 METHODS OF ASSESSING CORAL REEFS

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 the underlying geomorphology and create high-resolution habitat maps.

The rapid assessment protocol can be adopted from the Global Coral Reef Expedition protocol and the IUCN Resilience Assessment of Coral Reefs protocol, with additional parameters. Quantitative data can be obtained on the following:

- coral community structure (diversity, size structure, partial mortality and condition), using 10 m × 1 m belt transects, and coral recruitment (five 0.25 m quadrats 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.

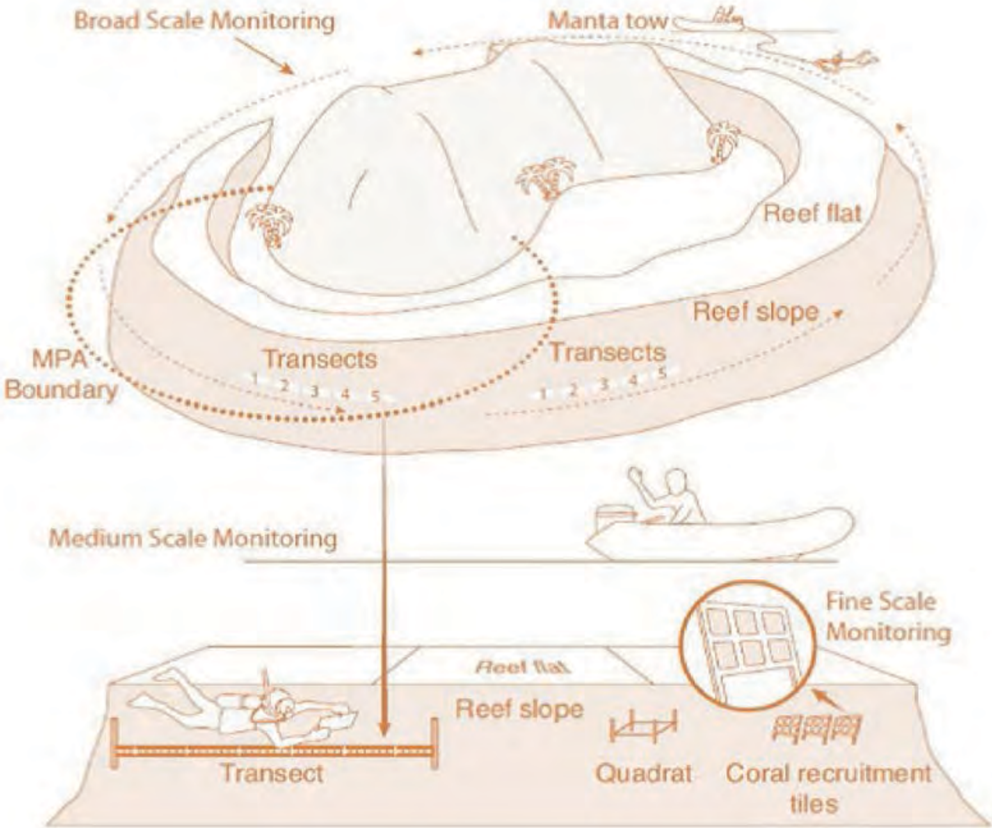


Figure 4.3 : An illustration of the three scales of monitoring: broad-scale covering large areas at lower resolution, e.g. with manta tow; medium-scale for higher resolution at medium scales e.g. line transects; and fine-scale for gathering high resolution data at small scales. (Source: Hill J, Wilkinson C. 2004)

4.3.5.11 ASSESSMENT METHOD FOR FISH[15]

Different fish species that appear together are referred to as ‘fish assemblages’. 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 abundances and frequencies of occurrence of all species observed at the site.
- The belt transect method yields better density estimates and covers a larger area per census.
- The random swim technique provides more complete information on the total species richness.

15 Source: Rogers et. al., 1994

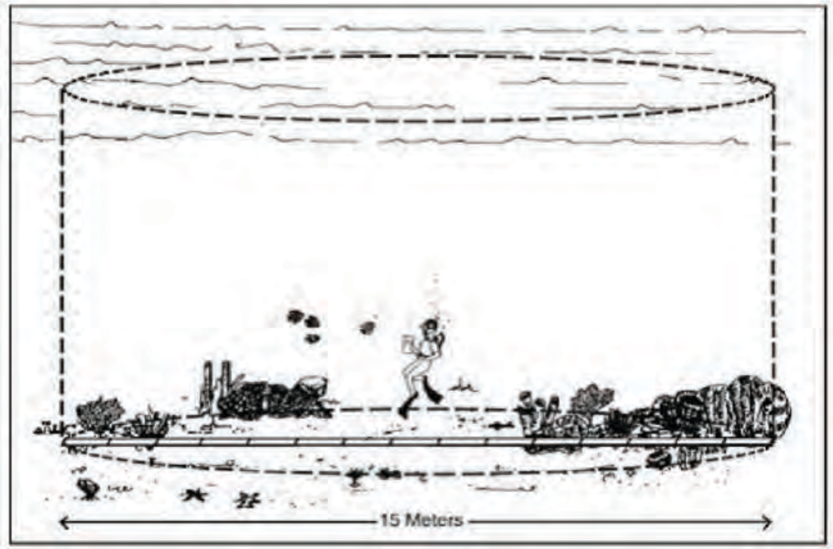


Figure 4.4 : Stationary fish census (Source: Rogers et. al., 1994)

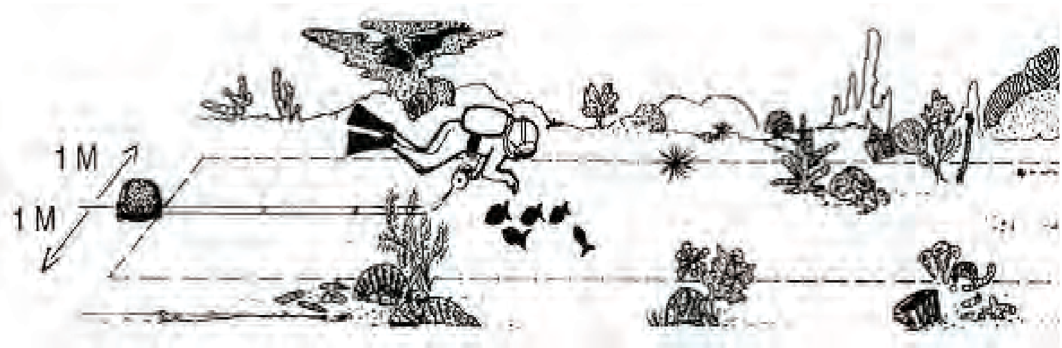
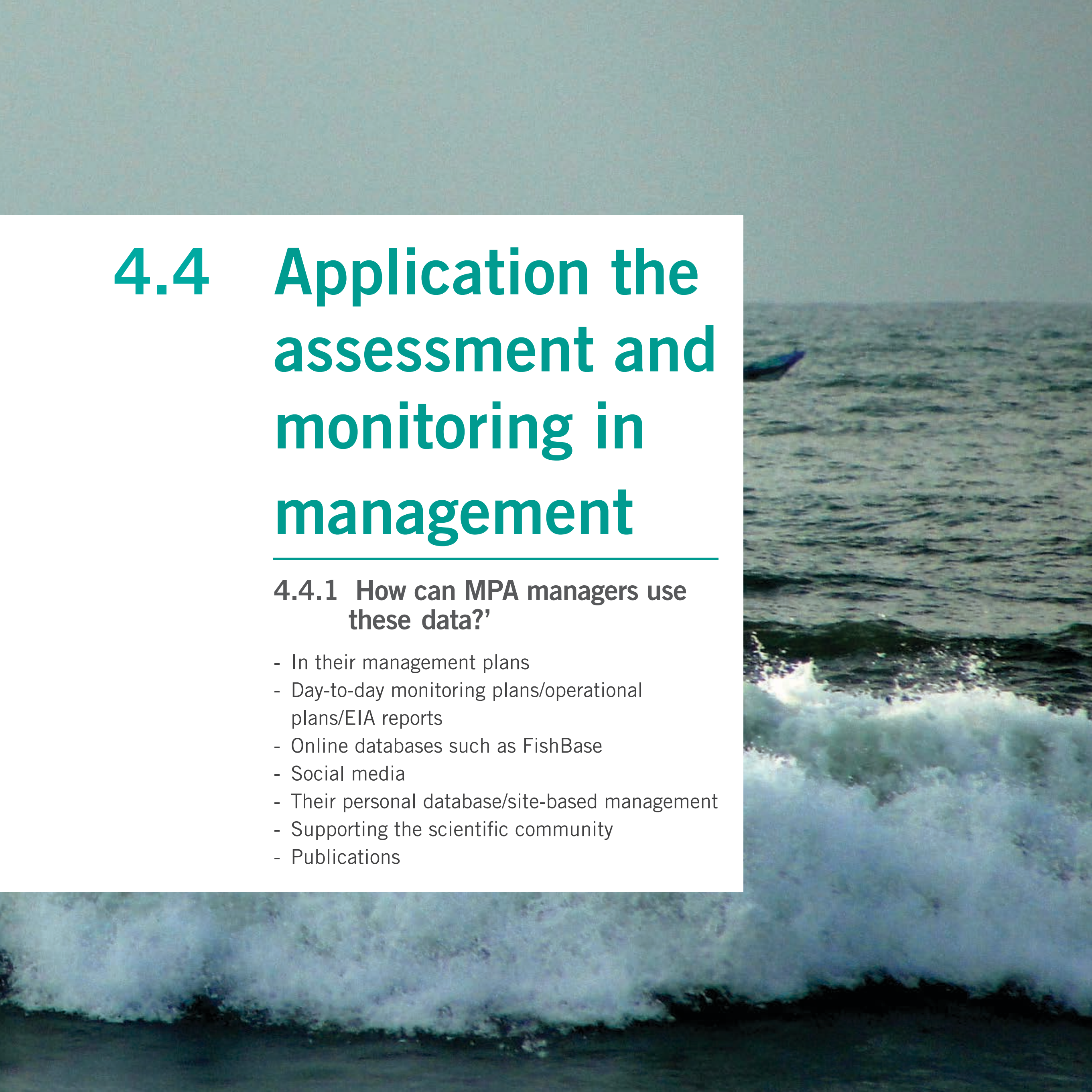


Figure 4.5 : Belt transect census (Source: Rogers et. al., 1994)



4.4 Application the assessment and monitoring in management

4.4.1 How can MPA managers use these data?'

- In their management plans
- Day-to-day monitoring plans/operational plans/EIA reports
- Online databases such as FishBase
- Social media
- Their personal database/site-based management
- Supporting the scientific community
- Publications

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

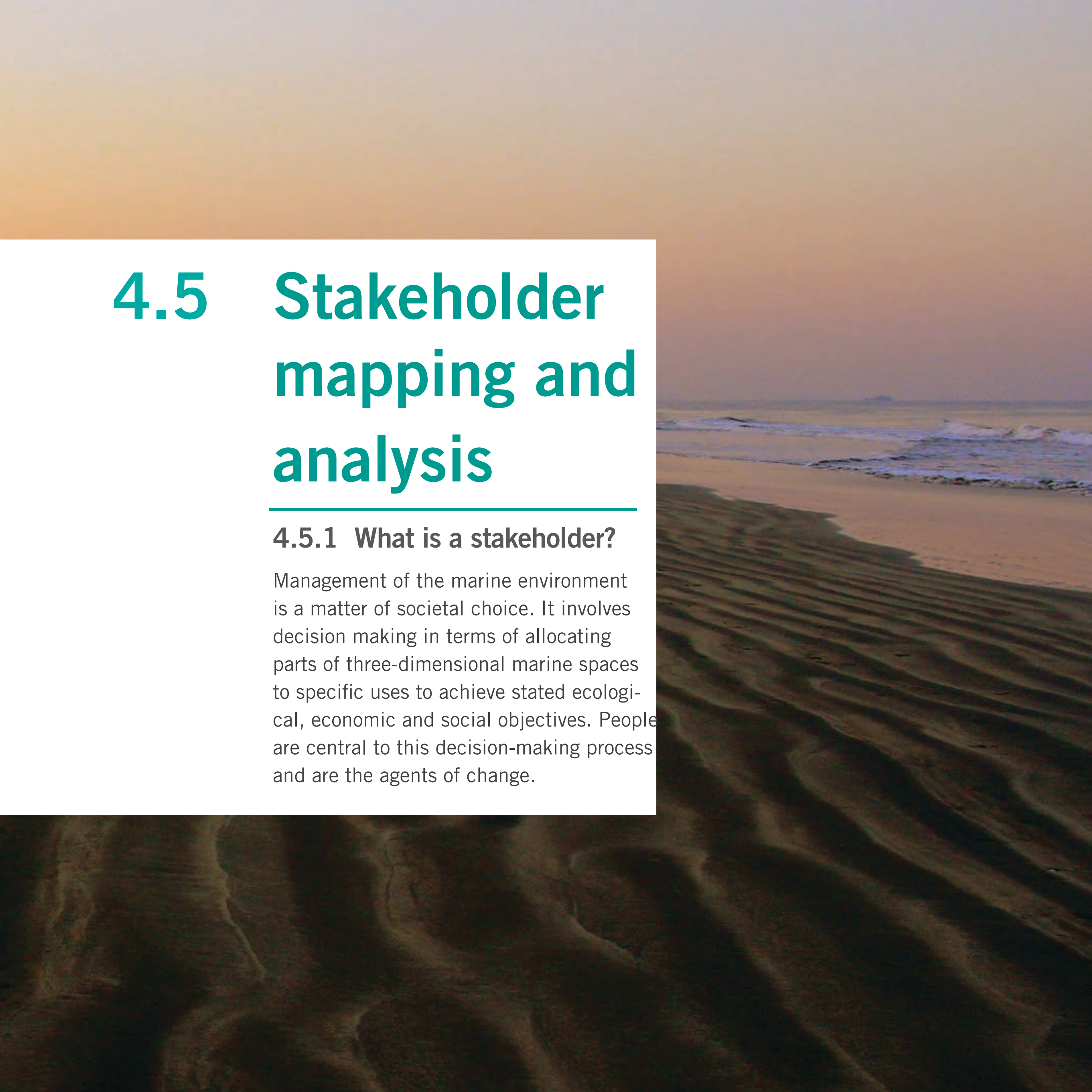
The charts below summarize the suggested components of a basic monitoring programme that will address a variety of situations. In all cases, it is a good idea to use photography to document.

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 dredging or runoff	Measure sedimentation rates and becterial concentration

4.4.3 What is to be monitored in different 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.
Deslination 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 of change.

As such, stakeholder participation and involvement are integral to the success of any conservation planning in 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 the 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 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.

A key question, however, is who the main stakeholders are with regard to a particular area and how to involve them in an effective way. A comprehensive method that allows for doing this is the 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. It examines the question of how and to what extent they represent various segments of society.

Figure 4.6 : Possible types of stakeholder participation

Source: Developed by ANAO, informed by D. Golubovic, 'An enabling framework for citizen participation in public policy: an outline of some of the major issues involved', The International Journal of Not-for-Profit Law, 12(4), 2010, and based on OECD, Citizens as Partners: Information, Consultation and Public Participation in Policy-Making, OECD, Paris, 2001, pp. 23–24, 28.

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 coastal and marine resource management:

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

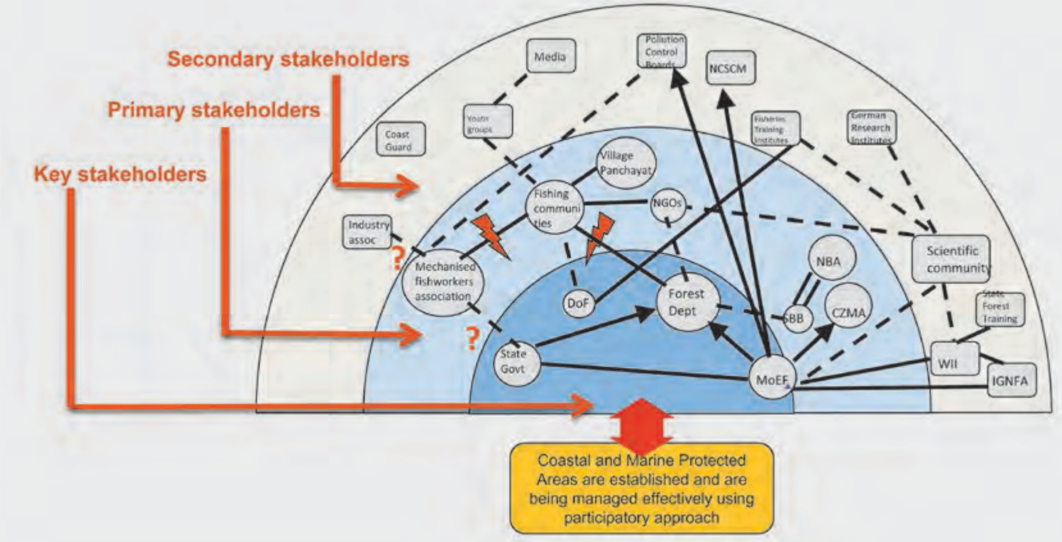


Figure 4.7 : Sample Stakeholder map - MPAs

Key stakeholder maps

	key or primary stakeholder with low influence
	key or primary stakeholder with high influence
V	veto player
	secondary stakeholder

Graphic elements

	Solid lines symbolise close relationships in terms of information exchange, frequency of contact, overlap of interests, coordination, mutual trust, etc.
?	Dotted lines symbolise weak or informal relationships. The question mark is added where the nature of the relationship is not yet clear.
	Double lines symbolise alliances and cooperation that are formalised contractually or institutionally.
	Arrows symbolise the direction of dominant relationships.
	Lines crossed by a bolt of lightning symbolise relationships marked by tension, conflicting interests or other forms of conflict.
	Cross lines symbolise relationships that have been interrupted or damaged.

Figure 4.8 : Influence-Interest grid for developing strategies for stakeholder engagement

[Source: http://ec.europa.eu/smart-regulation/guidelines/tool_50_en.htm#sdfootnote417sym]

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