The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA)

Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden
2nd Edition

PERSGA Technical Series No. 19 May 2019

PERSGA is an intergovernmental organization dedicated to the conservation of coastal and marine environments and the wise use of the natural resources in the region.

The Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (Jeddah Convention) 1982 provides the legal foundation for PERSGA. The Secretariat of the Organization was formally established in Jeddah following the Cairo Declaration of September 1995. The PERSGA member states are Djibouti, Egypt, Jordan, Saudi Arabia, Somalia, Sudan, and Yemen.

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'The Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden' (2nd Edition) was updated by Dr. Rebecca Klaus (SEM Project Consultant). Five new chapters has been included to address the current knowledge gap in participatory habitat mapping, fisheries monitoring, socio-economic monitoring, monitoring of MPAs management effectivennes and water quality monitoring. The 13 chapters of the updated manual were reviewed by many authors and experts. The work was carried out through the Strategic Ecosystem-Management (SEM) for the Red Sea and Gulf of Aden Project, a Global Environment Facility (GEF) project implemented by the World Bank and PERSGA.

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FOREWORD

The PERSGA Standard Survey Methods (SSMs) manual for Key Habitats and Key Species in the Red Sea and Gulf of Aden 1st Edition was developed and tested over a period of 4 years between 2000 and 2004. Each chapter was prepared by a group of specialists in their respective fields following a comprehensive process that was supported by the Strategic Action Programme (SAP) for the Red Sea and Gulf of Aden, which was the first GEF supported project executed by PERSGA and implemented by the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the World Bank with supplementary funding provided by the Islamic Development Bank.

During the past five years (2014-2018) PERSGA took another initiative through the execution of the Strategic Ecosystem-Based Management Project for the Red Sea and Gulf of Aden (SEM), also supported by the GEF and implemented by the World Bank. As a post SAP intervention, the SEM Project focused on improving management of marine resources in the Red Sea and Gulf of Aden through building on resource protection, incentive approach for communities, harmonization of the knowledge base for management of marine resources in PERSGA member countries, and on-the ground interventions that demonstrate sustainable use of these resources that increase benefits to stakeholder communities. Implemented over five years (2014-2018), the SEM Project early stage involved establishing the basis for Ecosystem-Based Management (EBM) through evaluating the present status and capacity for monitoring and assessing marine environment, especially the project pilot site at selected Marine Protected Areas (MPAs), including all technical, administrative and legislative aspects. These assessments identified gaps in the regional SSMs published earlier by PERSGA, and the needs for revision of the manual to fill these gaps in a second edition.

The review of the PERSGA SSM manual that resulted in this second edition included several significant improvements. The style of writing, which was originally orientated at a high-level scientific audience, was thoroughly revised to allow the accessibility of the manual to a broader lay audience. Many of the chapters present a range of methods to collect data that range in technical difficulty and associated costs. Such chapters required to include explanations on how to select the most appropriate method. The majority of the methods presented in the SSMs manual are fully comprehensive, but some refer the reader to other manuals or scientific literature for details on how to collect data for a specific parameter. This shortcoming was also to be revised by the second edition because absence of the details in such Standard regional manual could prove problematic, if the background literature is not immediately accessible to the reader. Also, while the majority of the methods presented include survey forms, others do not and required to be supplemented by standard forms. Finally, the SSMs manual 1st edition had some missing parts and needs to be extended to cover standard methods for monitoring socio-economic, fisheries, MPA management effectiveness, participatory mapping and water quality aspects. .

We are proud to provide our region with this updated SSMs guide. It has been reviewed by experts from all over the world and will be test by regional specialists and national teams. We hope this guide can be further improved upon in the future and will play its part in achieving the goal of monitoring for sustainable development of marine and coastal recourses in the region.

This guide will form an important tool to be used by national teams, specialists and managers to help make decisions that will prevent an otherwise irreversible decline in the status of marine habitats and species in the Red Sea and Gulf of Aden.

Prof. Ziad Abu Ghararah
Secretary General PERSGA

ACKNOWLEDGEMENTS

This updated Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden 2nd edition was prepared by PERSGA through the Strategic Ecosystem Management Project for the Red Sea and Gulf of Aden (SEM). Due acknowledgement is accorded to the Global Environmental Facility (GEF) and the World Bank (WB) for financial and administrative support. Our sincere thanks go to all the authors, illustrators and reviewers who contributed to the preparation of this manual.

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Our thanks are given to Dr. Maher Amer (PERSGA) for reviewing and editing all the chapters and for coordination between the consultant and the reviewers.

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ABBREVIATIONS AND ACRONYMS

AIMS	Australian Institute of Marine Science
CA	Correspondence Analysis
CI	Coral Replenishment Index
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CoT	Crown of Thorns (Starfish)
CTD	Conductivity Temperature Depth
DAN	Divers Alert Network
DAS	Divers Aware of Sharks
DCI	Decompression Illness
DIC	Dissolved Inorganic Carbon
DO	Dissolved Oxygen
EBM	Ecosystem Based Management
EI	Exposure Index
EIA	Environmental Impact Assessment
EMR	Electro-Magnetic Radiation
FAO	Food and Agriculture Organization of the United Nations
GCRMN	Global Coral Reef Monitoring Network
GEF	Global Environment Facility
GIS	Geographical Information System
GPS	Global Positioning System
HW	Head Width
HWN	High Water Neap
HWS	High Water Spring
ICZM	Integrated Coastal Zone Management
IT	Information Technology
IUCN	World Conservation Union
LE	Lower eulittoral
LE	lower eulittoral
LF	Littoral fringe
LWN	Low water neap
LWS	Low water spring

MBACI	Multiple Before-After Control-Impact
MDS	Multi-dimensional scaling
METT	Management Effectiveness Tracking Tool
MPA	Marine Protected Area
MS	Mean Squares
nDNA	nuclear DNA
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanographic and Aeronautical Administration
ONC	Operational Navigation Charts
PAR	photosynthetically active radiation
PC	Personal Computer
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
PL	Plastron Length
PQ	Permanent Quadrat
PTL	Permanent Transect Line
PVC	Polyvinyl Chloride
PW	Plastron Width
R/S	Root/Shoot ratio
RAM	Rapid Assessment Methods
RCEA	Rapid Coastal Environmental Assessment
RDA	Redundancy Analysis
REA	Rapid Ecological Site Assessment
RSA	Rapid Site Assessment
RSGA	Red Sea and Gulf of Aden
S	Species
SAP	Strategic Action Programme for the Red Sea and Gulf of Aden
SCA	Seabird Colony Register
SCL	Straight Carapace Length
SCUBA	Self Contained Underwater Breathing Apparatus
SCW	Straight Carapace Width
SD	Standard Deviation
SEM	Strategic Ecosystem Based Management

SF	Sublittoral Fringe
SMP	Seabird Monitoring Programme
SS	Sum of Squares
SSMs	Standard Survey Methods
SST	Sea Surface Temperature
TL	Tail Length
UE	Upper Eulittoral
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNOPS	United Nations Office for Project Services
WB	World Bank

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Introduction

1. INTRODUCTION

1.1 The PERSGA Strategic Ecosystem Management Project

PERSGA together with support from the World Bank is implementing the GEF funded project "Strategic Ecosystem Based Management of the Red Sea and Gulf of Aden", hereafter referred to as the SEM Project. The SEM Project focuses on improving management of marine resources in the Red Sea and Gulf of Aden through building on resource protection, incentive systems for communities and harmonization of the knowledge base of marine resources between PERSGA member countries. These outcomes will be achieved through the provision of technical assistance for selected MPAs, including awareness of participatory approach in using marine resources applying Ecosystem Based Management principles.

The SEM Project has three technical components and a fourth management component. The SEM Project will be implemented over four years. The early stage of the Project involved establishing the basis for Ecosystem Based Management (EBM) in the region through assessing the present status of the MPAs in terms of their technical, administrative and legislative aspects. As part of this project it was also recognised that there was a need to review the survey methods used in the region.

1.2 The PERSGA Standard Survey Methods Manual (2004)

'The PERSGA Standard Survey Methods (SSM) for Key Habitats and Key Species in the Red Sea and Gulf of Aden' was prepared cooperatively by a number of authors with specialised knowledge of the region. The manual was developed and tested over a period of 4 years between 2000 and 2004. The work was carried out through the Habitat and Biodiversity Conservation Component of the Strategic Action Programme for the Red Sea and Gulf of Aden, a Global Environment Facility (GEF) project implemented by the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the World Bank with supplementary funding provided by the Islamic Development Bank.

Each chapter was prepared by specialists in their respective fields following a comprehensive process that was supported through the Habitat and Biodiversity Conservation Component of the Strategic Action Programme for the Red Sea and Gulf of Aden, a Global Environment Facility (GEF) project implemented by the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the World Bank with supplementary funding provided by the Islamic Development Bank.

The process to prepare the manual was initiated following a review of the methods currently in use around the world. Methods were then drafted for each of the relevant fields: sub-tidal, coral reefs, seagrass beds, inter-tidal, mangroves, as well as for important groups such as reef fish, marine mammals, marine turtles and seabirds. The methods were discussed at a regional workshop in September 2000 held in Sharm el-Sheikh (Egypt) where scientists from both inside and outside the region reviewed the first drafts and provided the authors with useful comments.

During 2001 PERSGA conducted a series of training courses for regional specialists to teach them some of these specific methods. The training courses were also used as tools to evaluate the methods and to determine their applicability to the region. The results of the evaluations by the specialists recognized the suitability of these SSMs for the region due to their widespread use, their simplicity and the particular adaptations made to suit the region.

The original version of the manual had 9 individually authored chapters as listed below:

Chapter 1. Rapid Coastal Environmental Assessment

Dr. A.R.G. Price, Ecology and Epidemiology Group, Department of Biological Sciences, University of Warwick, Coventry CV4 7LA, England.

Chapter 2. Intertidal Biotopes

Dr. D. Jones, School of Ocean Sciences, University of Wales, Menai Bridge, Anglesey, Gwynedd LL59 5EY, Wales.

Chapter 3. Corals and Coral Communities

Dr. L. DeVantier, Australian Institute of Marine Science, Townsville, Queensland, Australia.

Chapter 4. Seagrasses and Seaweeds

Dr. F. Leliaert and Prof. Dr. E. Coppejans, Ghent Univeristy, Department of Biology, Research Group Phycology, Krijgslaan 281, S8, 9000 Ghent, Belgium.

Chapter 5. Subtidal Habitats

Dr. J. Kemp, Department of Biology, University of York, Heslington, York YO10 5DD, England.

Chapter 6. Reef Fish

Dr. W. Gladstone, Sustainable Resource Management and Coastal Ecology, Central Coast Campus, University of Newcastle, PO Box 127, Ourimbah, NSW 2258, Australia.

Chapter 7. Marine Turtles

Dr. N. Pilcher, Marine Research Foundation, 1-3A-7 The Peak, Lorong Puncak 1, 88400 Kota Kinabalu, Sabah, Malaysia.

Chapter 8. Breeding Seabirds

Dr. S.F. Newton, BirdWatch Ireland, Rockingham House, Newcastle, Co. Wicklow, Ireland.

Chapter 9. Marine Mammals

Dr. A. Preen, 'Oberon', Scott's Plain Road, Rollands Plains, 2441 NSW, Australia

Each of the chapters was prepared following a similar although not identical format. The chapters present a background rationale for the methods, followed by a description of the method or range of methods that can be used for a specific habitat or species group. The majority of methods are accompanied by an appropriate survey forms and a description on how to analyse the data and some also include identification guides.

1.3 Purpose of the updated PERSGA Standard Survey Methods Manual (2019)

The extent to which the final version of the PERSGA SSM Manual has been used within the countries in the region was prepared in 2004 was unknown. Indeed there has been limited opportunity for PERSGA to discover what environmental and social monitoring activities have been ongoing within each of the PERSGA countries.

To address this current knowledge gap, and to help inform any updates on the manual the PERSGA SEM project contracted regional consultants to review the current situation with regards monitoring in each of the Project partner countries. To help structure the reviews, the PERSGA SEM Monitoring consultant prepared two standard templates: (i) a word document with standard structure for the consultants to use in completing their reviews, and (ii) an excel spreadsheet for the consultants to populate with information on monitoring sites (see Annex 1.1 and Annex

1.2, respectively).

The reviews completed by the consultants were intended to help PERSGA and the SEM Monitoring Consultant to identify which monitoring methods have been adopted and applied most widely within the region. The reviews were also intended to help PERSGA to identify current capacity levels and training needs.

The regional monitoring consultants were then invited to attend a workshop at PERSGA on 25th to 26th February 2015 during which they will be asked to present the findings of their reviews. The regional workshop will also provide the opportunity for the national participants to discuss and validate the proposed content for the monitoring manual.

Even though the PERSGA SSM manual was prepared over 14 years ago, many of the methods included were based upon the globally standard survey methods for tropical marine ecosystems (English et al. 1997) and for the most part still reflect current best international practice. There are exceptions as would be expected over such a period of time, and the majority of these exceptions relate to the advancement and greater accessibility of new technologies for tracking animals or recording underwater images.

For example, the reduced cost of high resolution satellite imagery has increased the ability to create habitat maps at a finer scale of resolution, and this has demanded the development of new methods for ground-truthing surveys. Similarly, the wider availability of low cost underwater cameras has led to the proliferation of a range of photographic and videographic methods for recording benthos and fish. As a result, the use of cameras and videos are now much more commonly used in long term monitoring methods for coral reefs and associated communities.

In addition to the technological advancements there have also been updates to the standard visual underwater recording protocols for monitoring coral reef, such as the ReefCheck[1] protocol for the Red Sea. More specific methods have also since been developed for assessing Reef Resilience (Obura and Grimsditch 2009), Coral Diseases[2] (Raymundo et al. 2008) and other infestations. Other globally accepted standard survey protocols, similar to those developed for coral reefs, have been developed for seagrass habitats (SeagrassWatch[3] McKenzie et al. 2003 and McKenzie 2003).

There are some key gaps in the monitoring methods included in the PERSGA SSM manual which relate to the monitoring of: socio-economics, fisheries, MPA management effectiveness and water quality. Furthermore although the chapters are mostly presented in a consistent format there are certain gaps in terms of the level of explanation provided in each chapter. For example, several chapters present a range of different survey methods, but not all explain the reasons why one survey methods might be more appropriate than another. These and other priority gaps are further described below.

Distinction between levels of survey difficulty: The survey methods manual prepared by Hill and Wilkinson (2004) was among the first to fully recognise the need to distinguish between the levels of difficulty in the survey methods that they included in their survey manual. The authors classified the surveys methods into Level 1 - Community, Level 2 - Intermediate and Level 3 - Research level (Table 1.1). Many other manuals have since adopted a similar approach and this is something that certainly would be worthwhile PERSGA considering in the update of their

1 http://reefcheck.org/
2 http://coraldisease.org/diseases
3 http://www.seagrasswatch.org/home.html

manual.

Participatory monitoring programmes: Following on from the point above and in recognition of the need to increase stakeholder engagement in the monitoring and management of marine resources, there has also been a widespread increase in 'citizen' science monitoring programmes. Examples of these types of programmes include the 'Eye on the Reef'[4] programme in Australia, and the SandWatch[5] programme a global community level monitoring programme for beaches. In the Red Sea region, the Cousteau Society has supported the establishment of the 'Divers Aware of Sharks' [6] programme in Sudan and has developed 'Cousteau Divers'[7] as a more generic method for recording species and status. Supporting the more widespread adoption of these types of citizen science programmes would bring a wealth of benefits to the wider PERSGA region.

Fisheries monitoring programmes: Fisheries monitoring programmes are notoriously difficult to establish for tropical multi-species fisheries, especially where landings may occur in a haphazard manner along the coast instead on in fixed locations. To address this issue, participatory monitoring have been developed in both in the region and elsewhere that employ fishers and/or ex-fishers as data recorders. As the data recorders are more familiar with the local patterns in landings they tend to be better able to know when and where they need to be to collect data as compared to data recorders from the local authorities who may not know where or when fishers tend to land their catches. Although the widespread uptake of these types of participatory fisheries programmes has yet to fully materialise, the feasibility has now been fully demonstrated and these types of monitoring methods could easily be replicated in the Red Sea and Gulf of Aden with the support of the PERSGA SEM Project.

Socio-economic monitoring programmes: Although there is guidance on methods for use in monitoring the socio-economic situation among coastal and marine communities there is at present no standard socio-economic method for use within the Red Sea and Gulf of Aden region. This represents a significant gap in the standard survey methods manual that needs to be addressed. Socio-economic surveys can employ wide range of different approaches and there are hundreds of potential indicators that have been developed. There is no one-solution that fits all and the overarching advice when developing a new socio-economic survey protocol is the need to seek specialist advice from socio-economic experts during the survey design phase. The development of a standard protocol for the PERSGA region will thus demand input from a socio-economic expert.

Monitoring Marine Protected Area (MPA) Effectiveness: There are several methods available to assess MPA management effectiveness none of which have been adopted at the regional level. The MPA Scorecard methods (Staub and Hatziolus 2004) is currently being trialled as part of Component 1 of the SEM Project. The GEF has also developed the Management Effectiveness Tracking Tool (METT) for Biodiversity projects. The METT is very similar to the MPA Scorecard but it is a little more complicated. So it is expected that the MPA Scorecard method will provide the basis for monitoring management effectiveness during the current SEM Project.

Seawater Quality: There are various meth-

4 http://www.gbrmpa.gov.au/managing-the-reef/how-the-reefs-managed/eye-on-the-reef
5 http://www.sandwatch.ca/
6 http://www.cousteau.org/cause/shark-and-ray-project/
7 http://www.cousteaudivers.org/

ods available to monitor seawater quality some of have been adopted by countries in the region, but there are no recommendations on best practice standard methods.

Following discussions with PERSGA HQ it was proposed that the existing PERSGA SSM manual (PERSGA/GEF 2004) be left as it is as a stand-alone reference document. A priority list of monitoring indicators and the most appropriate methods for use in collecting data to inform these indicators for inclusion in the updated manual were discussed at the Jeddah Workshop (February 2015) in discussions with regional stakeholders.

e.g. Turtles

- Status of nesting beaches (tracks, nests etc)
- Presence of foraging turtles
- Movement patterns using tagging

e.g. Seabirds

- Nesting seabirds
- Other species observed / presence / absence / abundance

e.g. Marine mammals

- Species observed / presence / absence / abundance

e.g. Water quality

The discussion about the priority seawater parameters that could be included in a monitoring programme resulted in the following list;

- Temperature*
- Transparency*
- Salinity*
- Current
- Sea level*
- pH*
- Dissolved oxygen
- Nutrients
- Density
- Chlorophyll-a
- Organic and inorganic pollutants

* = indicators that the local community could be involved in collecting data for. It may also be possible to train local community members to take water samples for dispatch to the laboratory for analysis of specific variables.

The priority indicators selected and the preferred survey methods were reworked into a simpler more succinct and consistent format. If there was more one possible survey method, the methods have been graded according to difficulty (Table 1.1). A standard survey form for each of the methods has been prepared and the survey forms are provided alongside a description on how to complete each of the forms in a tabular format (Table 1.2). These short guides are intended for use as an aide memoire or cheat sheet, which surveyors can print out and take with them on the survey boat to remind themselves about how to correctly-complete the survey form

Table 1.1 Survey method levels

Level	Difficulty	
Level 1	Community	Can be implemented by personnel with limited previous experience in the specialism following a field training to familiarise them with the method
Level 2	Intermediate	Can be implemented by personnel with some previous experience in the specialism following a field training to familiarise them with the method
Level 3	Scientific / Advanced	Can be implemented by scientists or personnel experienced in the specialism following a field training to familiarise them with the method

Table 1.2 Example of the summary instructions presented in a tabular format to accompany each of the PERSGA standard survey forms

GROUND-TRUTHING SURVEY METHODS - LEVEL 1	
SURVEY INFORMATION	
Country	Record the country code. e.g. **SUD** = Sudan, **YEM** = Yemen, **DJI** = Djibouti. E**tc**
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Surveyors	Record the name and / or initials of the surveyors involved in the survey.
Weather	As weather will not usually change much while surveying, it can be recorded at the top of the survey sheet, using the following scale: **1**= Sun, no cloud, **2**= Sun part cloud (<50% cloud), **3**= Sun and cloud (50% and 50%), **4**= Cloud (full cloud), **5** = Cloud and rain.
Wind strength	As wind strength will not usually change much while surveying, it can be recorded at the top of the survey sheet, using the following scale: **1**= none (<4 kn), **2**= slight (4-6 kn), **3**= moderate (7-10 kn), **4**= strong (11-15 kn), **5**= very strong (>16 kns)
Wind direction	As the wind direction will not usually change much while surveying, it can be recorded at the top of the survey sheet. Use the compass rose (NSEW) to describe which direction the wind is coming from (e.g. is the wind coming from the SE or NW etc.).
SITE INFORMATION	
GPS Waypoint	Record the GPS waypoint number (you can use the original waypoint number as stored in the GPS).
Physical habitats	
Rock	Tick the box if the survey site is on rock
Gravel	Tick the box if the survey site is on gravel
Sand	Tick the box if the survey site is on sand
Mud/silt	Tick the box if the survey site is on silt / mud
Sabkha	Tick the box if the survey site is on sabkha
Wetland	Tick the box if the survey site is on the forereef slope of a coral reef
Temporary wetland	Tick the box if the survey site is on a temporary wetland area
Spring	Tick the box if the survey site is on a spring and record type in notes column (hot saline, freshwater)
Other	Tick the box if the dominant substrate type is another type, and record type in notes column
Vegetation / Flora	
Mangrove	Tick the box if the dominant cover is a mangrove
Coastal xerophytes	Tick the box if the dominant cover is a mixed coastal xerophytes
Acacia	Tick the box if the dominant cover is *Acacia*
Sueada	Tick the box if the dominant cover is *Sueda*
Grasses	Tick the box if the dominant cover is grasses
Invasive species	Tick the box if the dominant cover is invasive species such as *Prosopis*
Other	Tick the box if the dominant cover is another type (and note what it is)

Pressures / uses	
Salt pond / pan	Tick the box if the survey site is on a salt pan
Agricultural land	Tick the box if the survey site is on a agricultural land
Fish / Shrimp pond	Tick the box if the survey site is by a fish pond / shrimp pond
Urban / concrete	Tick the box if the survey site is in an urban area with concrete
Urban / tarmac	Tick the box if the survey site is in on a tarmac road
Other	Tick the box if the dominant cover is another type (and note what it is)
Photographs	Record the start and end number of the photographs for the site. To help distinguish the photographs from different sites, you can write the GPS waypoint number on a sheet of paper and photograph the number. You could photograph the survey form between sites, or the GPS screen showing the waypoint.
Description	Write a brief description of what you observe, mentioning the dominant physical and biological characteristics of the seabed e.g., '*Halophila ovalis* seagrass on flat sand with occasional sparse rubble and no other live cover' or 'Massive hard coral community dominated by *Porites* colonies interspersed by sand'. This description should include the names of the dominant species wherever possible. If there are species that you do not recognise, take photographs of the species.

1.4 Guidance on Dive Safety

The following provides advice on diving safely from Divers Alert Network (DAN).

- Plan the dive and dive the plan.
- Assess the risks before the survey - check site accessibility, weather, tides, time of day, etc.
- Arrange to have a reliable contact person to raise an alert if you and the survey team are not back at a specified or reasonable time.
- Take a mobile phone or marine radio and be sure to take the emergency contact details with you on the boat.
- Wear appropriate clothing and footwear and be sun-smart.
- Be aware of dangerous marine animals.
- All divers should be properly certified and trained how to administer First Aid with Oxygen.
- Even once qualified, divers should keep up their training and take advanced courses with properly qualified instructors, including dive rescue techniques and First Aid with Oxygen (Figure 1.1).
- Divers should undergo annual diving medical examinations, especially after illness and injury or if prescribed new regular medications.
- No data is worth risking human life. Never put yourself or others lives at risk.
- Use your instincts - if you do not feel safe then abandon the survey.
- While diving it is important to stay hydrated by drinking water regularly. Avoid alcohol or other substances and heavy exercise, before and after the dive.
- Before leaving the shore check that the dive boat you are using has a first aid kit and an oxygen kit (such as the DAN Oxygen kit).
- Dive equipment should be checked regularly and serviced annually to ensure that it is in good working condition. This includes your personal equipment and those of your dive buddy and dive tanks.
- Divers should always wear a buoyancy

control device (BCD), have a double regulator (including an octopus), a pressure gauge, watch and a dive knife. Even if using a dive computer, it is important to carry a depth gauge watch and dive tables.

- Always dive in favourable weather-sea conditions, and always with a buddy and with adequate surface support. Where possible always use a surface marker buoy.
- Dives should always be within certified training limits. Avoid “yo-yo” dive profiles and never hold your breath while ascending.
- Ascend at a maximum rate of 9-10 meters per minute until reaching 6 meters then stop and take a 3 minute decompression stop before surfacing.
- If any diver exhibits signs of a suspected decompression illness (DCI), administer 100% oxygen immediately using a suitable regulator. Do not attempt in-water recompression procedures. Call Divers Alert Network for advice!
- Divers should always wait for at least 12 hours before flying after a single dive and at least 24 hours before flying after repetitive dives and/or deco diving.

Figure 1.1 The Diving first aid kits and an oxygen kit (such as the DAN Trauma and Oxygen kits).

1.5 References

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1.6 Annexes

Annex 1.1 A word document with standard structure for the consultants to use in completing their reviews

PERSGA

Strategic Ecosystem Management (SEM) of the Red Sea and Gulf of Aden

Monitoring for Ecosystem Based Management

in [INSERT COUNTRY NAME]

[INSERT Author Name]

[Insert Date]

History of Monitoring in COUNTRY

Government Authorities Involved in Monitoring

Name of Government Institution XYZ

Please describe the organisation and the type of monitoring that they support or supported

If there is no government support for monitoring please write this

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Name of Government Institution XYZ

Please describe the organisation and the type of monitoring that they support or supported

If there is no government support for monitoring please write this

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If there are more than two government authorities involved in monitoring then please add another section

Universities and Research Institutions involved in Monitoring

University of XYZ

Please describe the organisation and the type of monitoring that they support or supported

If there are no Universities supporting monitoring please write this

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Research Institute of XYZ

Please describe the organisation and the type of monitoring that they support or supported

If there are no research institutes supporting monitoring please write this

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If there are more than two organisations involved in monitoring then please add another section

Non-Governmental Organisations involved in Monitoring

Name of the NGO

Please describe the organisation and the type of monitoring that they support or supported If there are no

NGOs supporting monitoring please write this

Name of the NGO

Please describe the organisation and the type of monitoring that they support or supported

----

If there are more than two organisations involved in monitoring then please add another section

External Organisations involved in Monitoring

Name of the External Organisation XYZ

Please describe the organisation (e.g. international Universities, etc) and the type of monitoring that they support or supported

----

If there are more than two external organisations involved in monitoring then please add another section

Donor Funded Projects that have supported Monitoring

Name of the Project XYZ

Please describe the organisation and the type of monitoring that they support or supported

----

Name of the Project XYZ

Please describe the project and the type of monitoring that they supported

----

If there are more than two projects involved in monitoring then please add another section

Research Expeditions / Projects supporting Monitoring

Name of the Research Expedition / Project XYZ

Please describe the organisation responsible and the type of monitoring that they supported

----

Name of the Research Expedition / Project XYZ

Please describe the organisation and the type of monitoring that they supported

----

Major Developments supporting Monitoring

Name of the Major Development XYZ

Please describe the organisation and the type of monitoring that they do

----

If there are more than two major developments involved in monitoring then please add another section. Types of Monitoring

Habitat Mapping

Please describe the habitat mapping that has been completed to date

----

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Rapid Environmental Assessment

Please describe the use of REA methods

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Intertidal Biotopes including Mangroves

Please describe any intertidal monitoring, including beaches*, rocky shores, estuaries, mangroves etc.*

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Coral Reefs & Associated Communities

Please describe any coral reef or coral community monitoring programs including monitoring of associated communities (e.g. fish and macorinvertebrates)

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Seagrasses and Seaweeds

Please describe any seagrass monitoring programs

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Subtidal Habitats

Please describe any other type of subtidal monitoring programs

----

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Marine Turtles

Please describe any turtle monitoring programs

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Breeding Seabirds

Please describe any breeding seabird monitoring programs

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Marine Mammals

Please describe any marine mammal monitoring programs

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Water Quality

Please describe any water quality monitoring programmes including sea water temperature

----

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Sediments

Please describe any sediment monitoring programs

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Plankton & Zooplankton

Please describe any plankton or zooplankton monitoring programs

----

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Fisheries

Please describe any fisheries monitoring programs

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Socio-economic

Please describe any socio-economic monitoring programs

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Marine Protected Area Programmes

Please describe any monitoring programmes specifically designed for monitoring MPAs

----

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Other

Please describe any other monitoring programs e.g. associated with major developments EIA etc.

SWOT Analysis

Strengths	Weaknesses
Opportunities	Threats

Use of PERSGA Standard Survey Methods

Use of PERSGA Survey Protocol	Yes ?	Example Reference where protocol used	No?	Alternative Protocol?
Rapid Coastal Environmental Assessment				
Intertidal Biotopes				
Corals and Coral Communities				
Seagrasses and Seaweeds				
Subtidal Habitats				
Reef Fish				
Marine Turtles				
Breeding Seabirds				
Marine Mammals				
Intertidal Biotopes				

Summary Description of Current Situation

Please summarise the current situation in your country with regards monitoring Current Situation

----

Significant Gaps

Summary SWOT Analysis

Please summarise the current situation in your country with regards monitoring

Strengths	Weaknesses
Opportunities	Threats

Needs assessment

Monitoring Types

Personnel

Training

Equipment

Annex 1.2 An excel spreadsheet for the consultants to populate with information on monitoring sites

Geographic_localisation			Monitoring_Site					
Country (e.g. Djibouti= Dji, Egypt=EGY, Jordan = JOR, Saudi Arabia = SAU, Sudan = SUD, Yemen =YEM)	Sector	Location_name	Site_name	Site_Longitude (WGS84) decimal d°	Site_Latitude (WGS84) decimal d°	Site_Structure	Site_permanently_ marked? (Yes / No)	Site_Depth (meters)
YEM	Gulf of Aden	Mukulla	DS01			Reef flat	Yes	5

Annex 1.2 Continued

Survey_targets	**Survey_metadata**					
Survey_target (e.g. turtles, birds, coral reef benthos, reef fish, macroinvertebrates, seagrass, beach / inter-tidal, mangrove, water quality, sediments etc).	Survey_protocol (e.g. Reef-Check, GCRMN, PERSGA SSM)	Survey_method (i.e. Belt transect, Line Intercept Transect, Point Intercept Transect, Quadrats, Video, Photoquadrats, etc.)	Size_of_unit_measured (e.g. 50m transect, 20m transect, 1 x 1 m quadrats)	Number of replicates per site (e.g. 3 transects)	Survey_Start (year)	Survey_End (year)

Annex 1.2 Continued

		Survey_methods	**Data ownership**			**Remarks**
Frequency (monthly, bi-annual, annual)	Last year	Method (e.g. Belt-transects, Line intercept transects, Photoquadrats etc)	Contracting Authority (i.e. who paid for the work)	Services Provider (i.e. who did the surveys)	Contact details (i.e. who is the person who has the data)	Please add any general remarks

2

Field Survey Methods for Habitat Mapping

2. FIELD SURVEY METHODS FOR HABITAT MAPPING

2.1 Background

Habitat maps are one of the key baseline datasets needed to plan and manage coastal and marine environments. A map showing the distribution of habitat types may be needed for a variety of purposes such as: determining the area of habitats, selecting appropriate locations for more detailed survey sites (e.g. for detailed biodiversity assessments, selection of appropriate long-term monitoring sites), understanding the relationship between habitats and resource use patterns by coastal communities, or habitats that might be impacted by climate change, or for the creation of zoning plans as part of a protected area management planning process. Habitat maps may already be available for the study area, but if there are no maps available or the maps are out of date, there is a range of field survey methods that can be used to collect the data needed to verify an existing habitat map or to create a new map. The process of collecting the field survey data that is used to verify or create a habitat map is called 'ground-truthing'. The following chapter presents an overview of the ground-truthing field survey methods that can be used to collect ground-truthing field data. A complimentary method that can be used to map the patterns of marine resource use is presented separately in the next chapters. A full description of the computer-based methods that are used to prepare habitat map, which involve using image processing software and Geographical Information Systems (GIS), are beyond the scope of the current manual, and the reader is referred to the website links and literature source (e.g. Green et al. 2000; Goodman et al. 2013, Edwards,1999; Hill and Wilkinson, 2004) provided in the reference section.

2.2 Overview

2.2.1 General approach

The main steps involved in preparing a habitat map are listed below:

- Goal and objectives – agree on the purpose of the habitat map;
- Image – select an appropriate image type and acquire the image;
- Pre-processing – prepare and interpret the image, and identify the range of habitat types that may be encountered during the field survey;
- Design ground truthing field survey – select field survey method and survey points;
- Field survey – collect the field survey data needed to create and / or verify the habitat map;
- Post-processing – analyse the field survey data and post-process the image to create and / or verify the habitat map;
- Assess accuracy –compare the habitat map with field survey data to determine the accuracy.

The goal and objective of the mapping exercise will determine the method and resources required in terms of the type imagery, field survey methods, equipment and personel. For example, if a simple map is needed to calculate the area covered by one or more habitat types (e.g. beach, mangrove, coral reef, seagrass beds), these can be created by delineating the boundary of the habitat by surveys on foot, by snorkelling or manta tows, using a hand-held Geographical Positioning System (GPS) to record the boundary coordinates. If more detailed habitat maps are needed that covering more than one habitat type, then remote sensing imagery acquired using sensors carried on-board boats, drones, aircraft or satellites can be used together with field surveys to collect more detailed ground-truthing data for use in creating and validating the habitat map.

This chapter focuses on the methods for collecting the ground-truthing data needed to create or validate a habitat map (Figure 2.1).

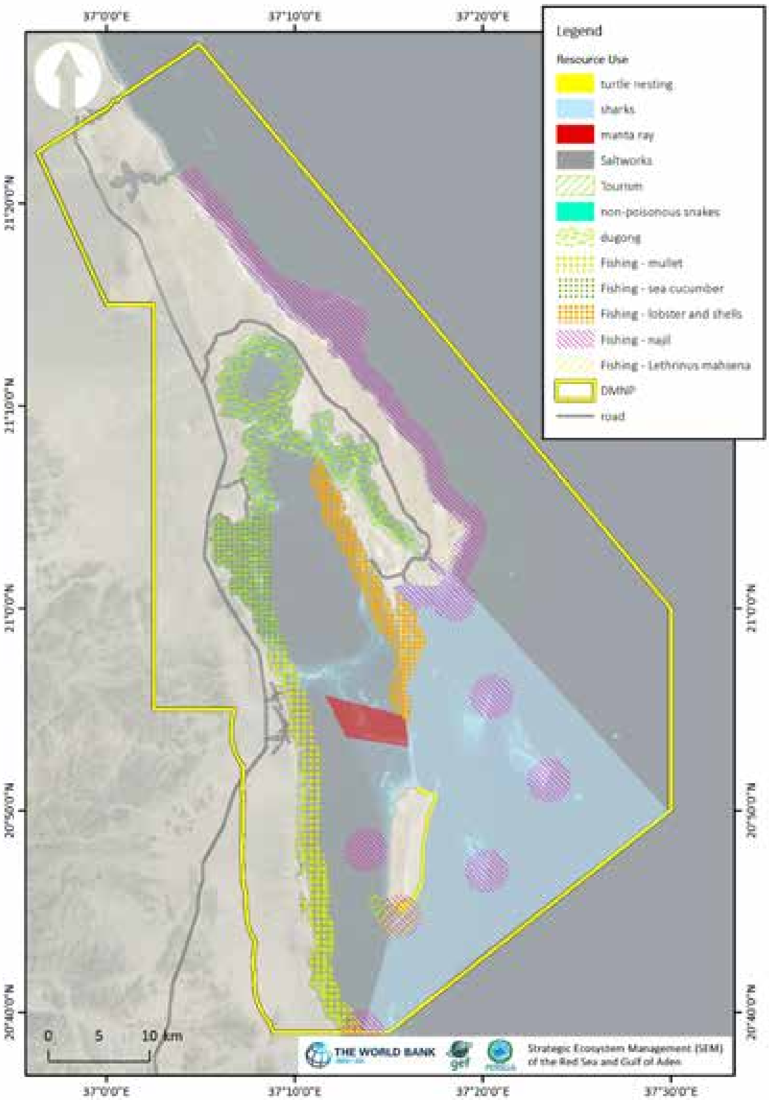

Figure 2.1 Map showing the distribution of resource use practices and local knowledge created from the participatory mapping study in October 2015 in Mohammed Qol, Sudan.

2.2.2 **Target**

Ground-truthing field surveys may be designed to target coastal or seabed habitats, or both. The field survey methods typically involve recording information about the habitat type together with information about the geographical location of the observations. The level of detail that needs to be recorded during the field surveys depends of the purpose of the map and other factors. Ground-truthing field survey methods typically involve recording information on both the physical (abiotic) characteristics (e.g. substrate type, exposure) and the conspicuous biological (biotic) communities (e.g. seagrass, macroalgae, coral)[8]. This type of information can then be used to construct hierarchical classification schemes can be used to reflect increasingly levels of similarity between habitat types (e.g. biotopes, biotope complexes, broad habitats, geomorphology).

Depth is an important consideration in subtidal habitat mapping as it affects both the type of remote sensing that can be used and field survey methods. For coastal habitats and subtidal habitats within water depths of less than 25-30 m, aerial or multispectral satellite imagery can be used. Seabed habitats in water beyond 25m deep can generally not be mapped by multispectral imagery. This is because there is reduction in the amount of light that can pass through the water column with increasing depth and the wavelength of light. Red wavelengths of light do not penetrate much deeper than 10m deep, while green wavelengths can reach 15m deep, and blue light can reach water depths of 25m deep. Beyond 25m depths, there is limited light that reaches the seabed, which also means that limited light is reflected back to the surface to be detected by the sensor. Subtidal habitat mapping of deeper water habitats can be achieved using boat-based acoustic techniques, such as multi-beam sonar.

Similarly, while collecting ground truthing survey data in subtidal marine environments can be achieved by snorkeling and SCUBA diving, it can be made more efficient by the use of drop-down cameras.

The principle indicators that can be derived from habitat maps are as follow:

- Habitat area (e.g. coral reef, mangrove, seagrass) within study area (Figure 2.2)
- Habitat percent cover (e.g. coral reef, mangrove, seagrass) within study area

8 A "biotope" is defined the combination of an abiotic (physical) habitat and its associated community of species (biological). In this context, habitat means the substratum (rock, sediment or biogenic reefs), topography and conditions (e.g. wave exposure, salinity, tidal currents and other water quality characteristics, like turbidity and oxygenation) that contribute to the overall nature of the shore or seabed. A "biotope" can be defined at a variety of scales (with related corresponding degrees of similarity).

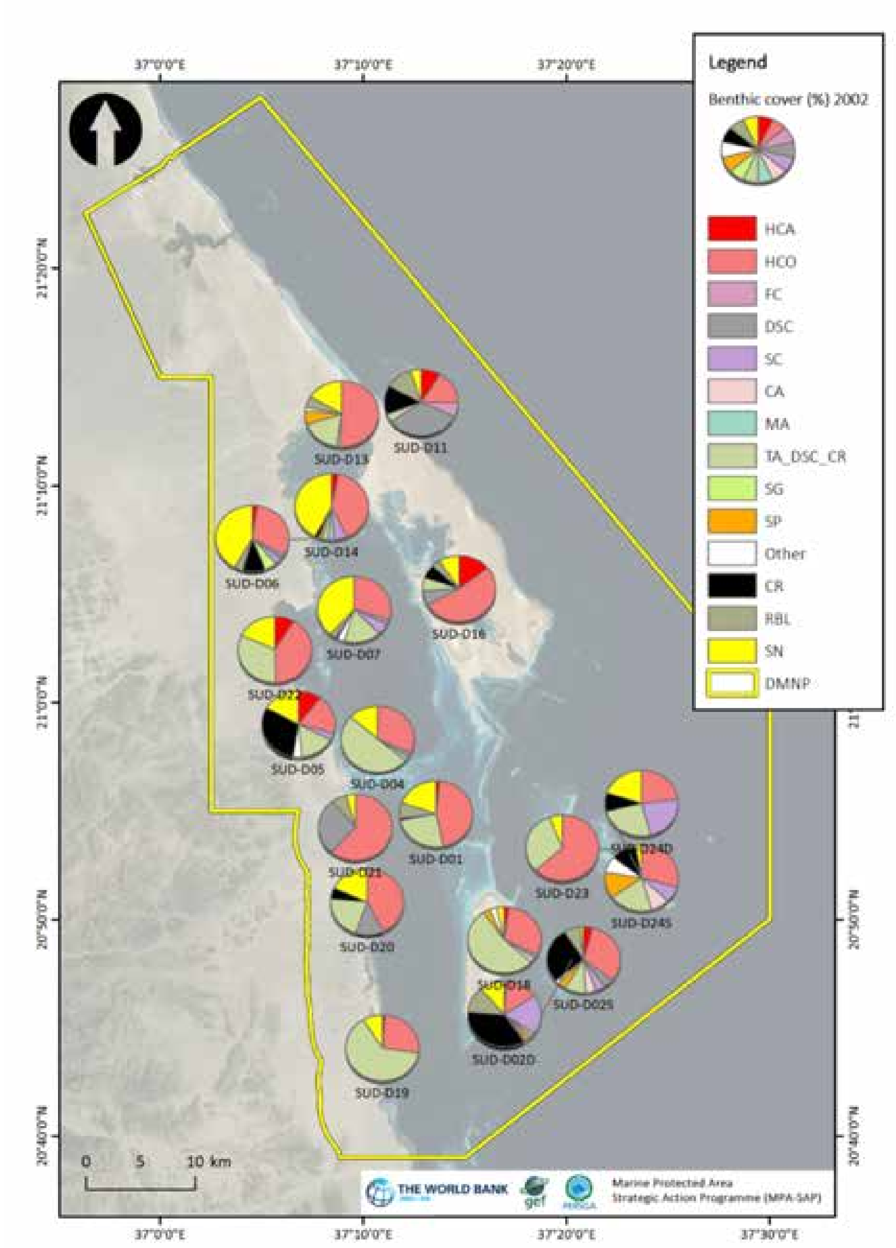

Figure 2.2 The principle indicators determined from habitat maps are habitat area and percent cover.

2.2.3 Field personnel

For coastal habitat mapping surveys, the survey team will normally include a minimum of two field surveyors and one driver. The operation of the GPS, recording of visual observations, and photography can all be completed by one trained surveyor. A field team of two people would allow the tasks to be subdivided and make the survey more efficient.

For subtidal surveys, the survey team will normally include a minimum of two field surveyors and one boat driver. As with coastal surveys, the operation of the GPS, recording of visual observations, and photography can be completed by one trained surveyor. A minimum of two people should be in the water for the surveys for safety reasons. The boat driver should remain on the boat in case of an emergency and the surveyors need to be collected.

If the subtidal surveys are being completed by SCUBA diving then the surveyors should be properly qualified in SCUBA diving. A fourth team member qualified in SCUBA diver should remain onboard the boat, with a full set of SCUBA kit, so that they can provide surface cover in the event that there is an accident underwater.

2.2.4 **Training / experience**

The level of experience and knowledge needed by the field survey team will depend on the objectives of the habitat map and the level of detail that needs to be illustrated in the map. Generally, field survey team members will need to be familiar with and able to identify the main habitat types, physical substrate categories (e.g. silt, sand, rock, coral etc) and the main faunal and floral groups (e.g. vegetation, hard coral, soft coral, seagrass, macroalgae, turf algae).

2.3 **Field Procedure**

There are several preparatory steps that need to be completed before commencing the field surveys, which are outlined below together with the field survey methods.

2.3.1 **Field equipment**

The equipment needed for both coastal and subtidal habitat mapping surveys include:

- Survey slate and pencil
- Survey forms
- Rubber bands or clips to attach the paper to the slate
- Handheld GPS (Geographical Positioning System) preferably with USB port
- Laminated maps, prepared using satellite imagery, showing the study area of interest
- Camera to take representative photographs of the habitats.

If the surveys are in the subtidal environment, the additional equipment needed include:

- Boat with an engine and preferably with some shade
- Camera with underwater housing
- Underwater viewing bucket (e.g. Plastimo Aquascope)
- Personal snorkelling / SCUBA diving equipment
- Optional extras include a drop-down video / stills camera

2.3.2 **Objective of habitat map**

The purpose of the habitat mapping exercise needs to be decided in advance, as this influences the type of image data needed, the field survey methods, the equipment to be used, and the level of expertise and training required by the survey team.

If, for example, the purpose of the habitat mapping exercise is to determine the area of mangrove, the methods and equipment neede will be very different from a habitat mapping exercise to determine the distribution and extent of all subtidal habitats.

2.3.3 **Selection of Image Type and Image**

Once the purpose of the habitat map has been agreed, a suitable image type needs to be selected and an image acquired. The image then needs to be prepared for use in the field surveys. There are many different types of remotely sensed imagery that can be used for creating habitat maps, which vary in terms of the spectral resolution (i.e. number of spectral bands) and spatial resolution (e.g. size of the individual picture units, known as 'pixels', on the ground).

The first type of remotely sensed imagery used for habitat mapping was aerial photography, which was replaced by multispectral visible imagery collected by sensors onboard satellites. Nowadays remotely sensed multispectral imagery for habitat mapping purposes is also being collected using sensors flown onboard drones.

One of the most widely used types of satellite data was collected by the sensors onboard the Landsat series of satellites. Landsat satellites have now been decommissioned and replaced by the Sentinel satellite series, which were originally developed with the primary purpose of delivering data for the European Commission's, Copernicus programme (Figure 2.3).

The Sentinel-2 satellite constellation consists of two satellites, in the same orbit, 180° apart for optimal coverage and data delivery. Sentinel-2A was launched on 23 June 2015 and Sentinel-2B followed on 7 March 2017. Together they cover all Earth's land surfaces, large islands, inland and coastal waters, with revisit frequency of five days at the equator.

The Sentinel-2 satellites carry high-resolution multispectral imagers with 13 spectral bands (443 nm–2190 nm) and have a swath width on the ground of 290 km. The spatial resolution of different spectral bands ranges from 10 m (4 visible and near-infrared bands), to 20 m (6 red-edge/shortwave-infrared bands) and 60 m (3 atmospheric correction bands).

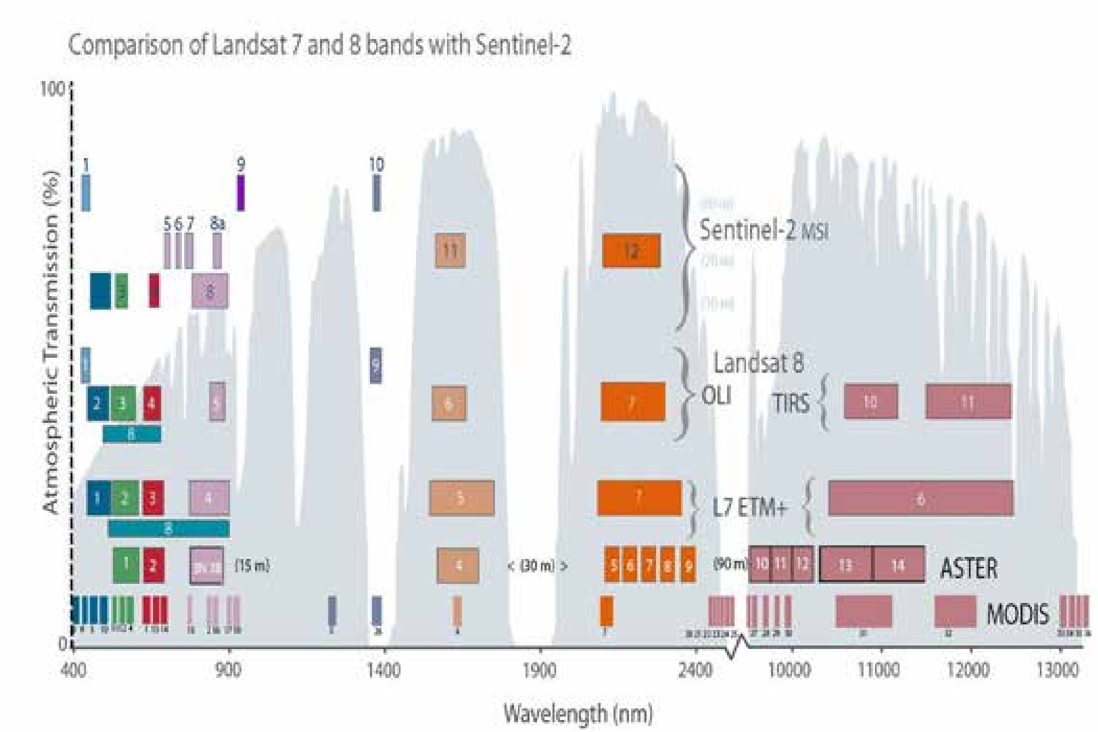

Figure 2.3 Comparison of Sentinel-2 and Landsat 8 and 7 spectral bands (Source: USGS)

Sentinel 2A data has a similar number of visible spectral bands as was provided by the Landsat series, the spatial resolution is higher (Landsat pixels were 30 m and the panchromatic band was 15 m). The higher return frequency of the Sentinel satellites means that there is more frequent data available, and the data is made available free of charge.

Sentinel-2 data can be accessed through the Copernicus Open Access Hub. Users need to register with the service before they can search and download data.

The data is delivered as image tiles (also called data granules). Each tile covers an area of 100km by 100km and is approximately 500 MB in size. The tiles are delivered as ortho-images (projected images) in a Universal Transerve Mercator WGS84 projection.

The tiles are normally delivered as Level-1C processed data, which is basic ground reflectance data. Level 2A data is user generated top of the atmosphere reflectance (atmospherically corrected) imagery, that is generated through using the Sentinel 2A toolbox.

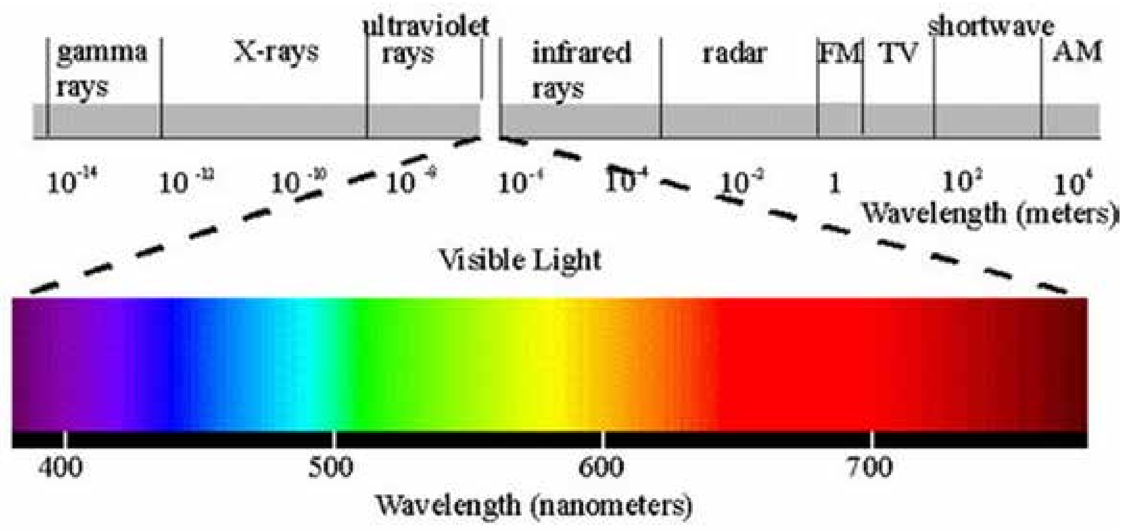

Figure 2.4 Spatial and spectral resolution of satellite images

(Source: https://www.satimagingcorp.com/services/resources/characterization-of-satellite-remote-sensing-systems/)

There are much higher resolution multi-spectral satellite data available from the Quickbird, GeoEye and WorldView satellite series. The sensors onboard these satellites record data within pixels that are equivalent to 2m by 2m on the ground or less. The sensors also often have more spectral bands. For example, the WorldView satellite data for example has 8 spectral bands (Figure 2.4).

2.3.4 Pre-processing

Sentinel satellite imagery can be imported into GIS software in the Level 1C format that is available for download from the website. The bands are provided as separate image files and the layers need to be composited to create the file. There are various processing techniques that should be applied to the satellite image before it is used, such as atmospheric correction, sun-glint correction and depth correction. The pre-processing of the satellite image would need to be done by a person with previous experience in working with remotely sensed imagery. For further information about the techniques, the reader is referred to the literature and websites provided in the reference section.

2.3.5 Survey Design

The field survey needs to be designed and the equipment organized before the field survey team is deployed. Once the pre-processing is complete, the provisional maps can be used to prepare the survey plan. As field time is expensive, the survey plan should be designed to be as efficient as possible and to cover as many habitat types as possible within the given timeframe.

The survey sites can be selected randomly within habitats (semi-stratified sampling) or non-randomly using a fixed grid. Both site selection methods have advantages, however the most efficient way is to design these types of surveys for marine surveys is to use sampling sites are located along imaginary box transects.

The first leg of the box transect is perpendicular to the coast, extending from the shore seawards to the deepest workable depth (depending on whether the surveys are being completed by snorkeling or by SCUBA diving). The second leg is then parallel to the coast. The third leg is perpendicular to the coast from the deepest depth shorewards. The fourth leg is then parallel to the shore, and so forth. The perpendicular survey legs allow the surveyors to cover the full range of habitats across different depths while the parallel transects allow the surveyors to collect more data either at depth or in the shallows. The perpendicular transects can be spread along the coast at distances of 500m to 5km, depending on the size of the area that is being surveyed and the number of days available for the survey.

Once the survey sites have been selected, these can be marked on a printed map by hand or the positions can be uploaded to a hand-held GPS unit to aid navigation in the field. The geographical coordinates can be entered manually into the GPS or they can be uploaded using a USB cable. Instructions on how to create GPS points and upload them to a handheld GPS using a USB cable are provided in Annex 2.4.

2.3.6 Field survey

Ground-truthing surveys (Level 1)

There are various methods that can be used to rapidly collect ground-truthing data over large areas in coastal and marine environments. The Level 1 methods are relatively quick and inexpensive to implement and can be used to collect information about the physical habitats, dominant cover types and habitat condition.

In coastal environments, the surveyors can navigate and move around the survey area by car or quadbike, then walk along survey transects on foot. The method and survey form are provided in Annex 2.1.

- Use the first GPS to navigate to the first survey site, or to the start of the first transect, by selecting the correct waypoint in the GPS and setting the point as a ‘Go to’ locations.
- On arriving at a site, the surveyors can use the second GPS to record the GPS position or waypoint and the waypoint number is recorded on the survey form.
- The surveyors should then spend 5 minutes observing their surroundings and record the dominant physical habitat, the dominant flora and any obvious human uses / pressure, within the immediate surroundings.

- Each survey should not take much more than 10 minutes to complete.

The most common method used in the marine environment is to use snorkel surveys or manta tows. The surveys can be conducted from a small boat and the surveyors need to prepare the equipment, survey form and survey slate before.

The method described below is for subtidal surveys.

- Use the first GPS to navigate to the first survey location, by selecting the correct waypoint in the GPS and setting the point as a ‘Go to’ locations.
- On arriving at a site, the surveyors use the second GPS to record the GPS position or waypoint. In subtidal habitats the depth is recorded using the hand held depth sounder and these information are recorded on the survey form.
- The surveyors enter the water and swim in a straight line or wandering path around the boat recording their observations within a fixed time window.
- The timed swims can be completed by snorkelling and can be between 2-10 minutes long. The amount of time spent surveying each site can be varied depending on the amount of time available to complete the whole survey, as long as the time spent per site is consistent for all sites and depth ranges.
- If the surveys are completed whilst diving, then multiple surveys can be completed within one dive at different depth ranges, starting with the deepest site first, then moving up the forereef slope onto the reef flat.
- Similarly, if the surveys are completed by snorkelling and / or the reef flat is not accessible by boat, then the surveyors may spend 5 minutes surveying the shallow forereef, before swimming onto the reef flat and spending another 5 minutes surveying the reef flat.
- If more than one depth range is surveyed per site, it is possible to record the GPS at the boat and make a note of the distance and direction for the next site. Alternatively, it is possible to use a GPS in a water proof housing that is attached to a surface marker buoy.
- If both surveyors are participating in the surveys, they can record their observations underwater and then discuss them on returning to the boat before completing the survey form together. The survey form for the Level 1 timed swim and instructions on how to complete the survey form are presented in Annex 2.1.

Ground-truthing surveys (Level 2)

The Level 2 method for subtidal surveys described below uses timed swims, similar to the Level 1 survey method but more detailed data is collected about the composition of the substrate and associated flora and fauna at each sites. The surveys are normally conducted on foot or from a small boat in the marine environment and the surveyors need to prepare the equipment, survey form and survey slate as before.

- Use the GPS to navigate to the first survey location, by selecting the correct waypoint in the GPS and setting the point as a ‘Go to’ locations.
- On arriving at a site, the surveyors record the GPS position using the second GPS and the depth using the hand held depth sounder and write these on the survey form.
- The surveyors enter the water and swim in a straight line or wandering path around the boat recording their observations within a fixed time window.

- The timed swims can be completed by snorkelling or by SCUBA and would usually last between 10-15 minutes each. The amount of time spent surveying each site can be varied depending on the amount of time available to complete the whole survey, as long as the time spent surveying each site is consistent for all sites and depth ranges.
- If the surveys are completed whilst diving, then multiple surveys can be completed within one dive at different depth ranges, starting with the deepest site first, then moving up the forereef slope onto the reef flat.
- Similarly, if the surveys are completed by snorkelling and / or the reef flat is not accessible by boat, then the surveyors may spend 5 minutes surveying the shallow forereef, before swimming onto the reef flat and spending another 5 minutes surveying the reef flat.
- If more than one depth range is surveyed per site, it is possible to record the GPS at the boat and make a note of the distance and direction for the next site. Alternatively, it is possible to use a GPS in a water proof housing that is attached to a surface marker buoy.
- If both surveyors are capable of doing the surveys, they can record their observations underwater and then discuss them on returning to the boat before completing the survey form together. The survey form for the timed swim and instructions on how to complete the survey form are presented below (Annexes 2.2, 2.3 and 2.4).

GPS tracked video or geotagged photoquadrats (Level 3)

A more advanced method for ground-truthing substidal areas is for the surveyors to complete the surveys while towing a GPS unit at the water surface, which is a method known as GPS tracked video or geotagged photoquadrats. The GPS is protected by containing it inside a waterproof housing which is then attached to a float or inflatable buoy that the surveyor connects to a dive reel, that is towed during the snorkel / dive.

For this survey method it is essential that the camera date and time is synchronized with the date and time on the GPS before the survey commences.

- The surveyors use the first GPS on the boat to navigate to the first survey location, by selecting the correct waypoint in the GPS and setting the point as a 'Go to' locations.
- On arriving at the first site, the surveyor measures the depth using a hand-held depth sounder and the waypoint using the second GPS and records these on the survey form.
- The GPS unit that is to be used to track the surveys is put into track mode so that it records the GPS position every 10 to 15 seconds. As each GPS unit is different the surveyor must refer to the manual that comes with the GPS to ensure that the GPS is set up correctly in track mode.
- The GPS unit that is to be used to track is placed inside the waterproof housing / container and attached to the buoy and dive reel before the surveyor enters the water.
- The surveyor enters the water and swims in a straight line from the boat recording video within a fixed time window.
- The timed swims can be completed by snorkelling or by SCUBA and would usually last between 10-15 minutes each. The amount of time spent surveying each site can be varied depending on the amount of time available to complete the whole survey, as long as the time spent surveying each site is consistent for all sites and

depth ranges.

- If the surveys are completed whilst diving, then multiple surveys can be completed within one dive at different depth ranges, starting with the deepest site first, then moving up the forereef slope onto the reef flat.
- Similarly, if the surveys are completed by snorkelling and / or the reef flat is not accessible by boat, then the surveyors may spend 5 minutes surveying the shallow forereef, before swimming onto the reef flat and spending another 5 minutes surveying the reef flat.
- On returning to the boat, the GPS that was being towed, is removed from the waterproof housing and the track saved and renamed, before the unit is switched off.

2.4 References

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Hill, J. and C. Wilkinson (2004) Methods for Ecological Monitoring of Coral Reefs. Version 1. Townsville, Australian Institute of Marine Science and Reef Check. http://www.icran.org/pdf/Methods_Ecological_Monitoring.pdf

Goodman, J., Purkis, S. and Phinn, S.R (2013) Coral Reef Remote Sensing: A Guide for Multi-level Sensing Mapping and Assessment. Springer Publishing ISBN 978-90-481-9291-5.

PERSGA/GEF (2004) Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden, PERSGA Technical Series No. 10, PERSGA, Jeddah.

Useful Web-sites

Remote Sensing Handbook http://www.unesco.org/csi/pub/source/rs.htm
Remote Sensing Toolkit https://www.gpem.uq.edu.au/rsrc-rstoolkit
Digital Globe (Quickbird, Worldview 2, Ikonos) www.digitalglobe.com
Google Earth earth.google.com
NASA Near Real Time MODIS rapidfire.sci.gsfc.nasa.gov/realtime/
NASA Land Processes Distributed Archive lpdaac.usgs.gov/data_access
NASA EOSDIS esdis.eosdis.nasa.gov/eosdis/overview.html

2.5 Annexes

Annex 2.1 Ground Truthing Survey Methods – Level 1 (Coastal)

GROUND-TRUTHING SURVEY METHODS - LEVEL 1	
SURVEY INFORMATION	
Country	Record the country code. e.g. **SUD** = Sudan, **YEM** = Yemen, **DJI** = Djibouti. E**tc**
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Surveyors	Record the name and / or initials of the surveyors involved in the survey.
Weather	As weather will not usually change much while surveying, it can be recorded at the top of the survey sheet, using the following scale: **1**= Sun, no cloud, **2**= Sun part cloud (<50% cloud), **3**= Sun and cloud (50% and 50%), **4**= Cloud (full cloud), **5** = Cloud and rain.
Wind strength	As wind strength will not usually change much while surveying, it can be recorded at the top of the survey sheet, using the following scale: **1**= none (<4 kn), **2**= slight (4-6 kn), **3**= moderate (7-10 kn), **4**= strong (11-15 kn), **5**= very strong (>16 kns)
Wind direction	As the wind direction will not usually change much while surveying, it can be recorded at the top of the survey sheet. Use the compass rose (NSEW) to describe which direction the wind is coming from (e.g. is the wind coming from the SE or NW etc.).
SITE INFORMATION	
GPS Waypoint	Record the GPS waypoint number (you can use the original waypoint number as stored in the GPS).
Physical habitats	
Rock	Tick the box if the survey site is on rock
Gravel	Tick the box if the survey site is on gravel
Sand	Tick the box if the survey site is on sand
Mud/silt	Tick the box if the survey site is on silt / mud
Sabkha	Tick the box if the survey site is on sabkha
Wetland	Tick the box if the survey site is on the forereef slope of a coral reef
Temporary wet-land	Tick the box if the survey site is on a temporary wetland area
Spring	Tick the box if the survey site is on a spring and record type in notes column (hot saline, freshwater)
Other	Tick the box if the dominant substrate type is another type, and record type in notes column
Vegetation / Flora	
Mangrove	Tick the box if the dominant cover is a mangrove
Coastal xero-phytes	Tick the box if the dominant cover is a mixed coastal xerophytes
Acacia	Tick the box if the dominant cover is Acacia
Sueada	Tick the box if the dominant cover is Sueda
Grasses	Tick the box if the dominant cover is grasses
Invasive species	Tick the box if the dominant cover is invasive species such as Prosopis
Other	Tick the box if the dominant cover is another type (and note what it is)

Pressures / uses	
Salt pond / pan	Tick the box if the survey site is on a salt pan
Agricultural land	Tick the box if the survey site is on a agricultural land
Fish / Shrimp pond	Tick the box if the survey site is by a fish pond / shrimp pond
Urban / concrete	Tick the box if the survey site is in an urban area with concrete
Urban / tarmac	Tick the box if the survey site is in on a tarmac road
Other	Tick the box if the dominant cover is another type (and note what it is)
Photographs	Record the start and end number of the photographs for the site. To help distinguish the photographs from different sites, you can write the GPS waypoint number on a sheet of paper and photograph the number. You could photograph the survey form between sites, or the GPS screen showing the waypoint.
Description	Write a brief description of what you observe, mentioning the dominant physical and biological characteristics of the seabed e.g., ‘*Halophila ovalis* seagrass on flat sand with occasional sparse rubble and no other live cover’. The description should include the names of the dominant species wherever possible. If there are species that you do not recognise, take photographs of the species.

GROUND-TRUTHING SURVEYS (Level 1) **Coastal Surveys** **Sheet Number___________**

Country:	**Location:**	**Date:**	**Surveyor:**
Weather:	**Wind Strength (1-5):**	**Direction (NSEW):**	**Temp Air (°C):**

Physical habitat										**Vegetation / Flora**							**Pressures / Uses**						**Photos**		
GPS Waypoint	**Rock**	**Gravel**	**Sanda**	**Mud / silt**	**Sabkha**	**Wetland (permanent)**	**Temporary wetland**	**Spring**	**Other**	**Mangrove**	**Coastal xerophytes**	***Acacia***	***Sueda***	**Grasses**	**Invasive sp.**	**Other**	**Salt pan/pond**	**Agricultural land**	**Fish / Shrimp pond**	**Urban - concrete**	**Urban - tarnac**	**Other**	**Photo no. start**	**Photo no. end**	**Notes / Description** – Tick the column that best suits the description of the physical habitat (e.g. rock, sand etc.) then tick one of the boxes if there is additional vegetation cover. Record the photograph start and end number, and then write a description of the habitat in the box below (e.g. Sand beach). Please use species in the descriptions where possible.

Annex 2.2 Ground-Truthing Survey Methods – Level 1 (Subtidal)

GROUND-TRUTHING SURVEY METHODS - LEVEL 1	
SURVEY INFORMATION	
Country	Record the country code. e.g. **SUD** = Sudan, **YEM** = Yemen, **DJI** = Djibouti. E**tc**
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Surveyors	Record the name and / or initials of the surveyors involved in the survey.
Weather	As weather will not usually change much while surveying, it can be recorded at the top of the survey sheet, using the following scale: **1**= Sun, no cloud, **2**= Sun part cloud (<50% cloud), **3**= Sun and cloud (50% and 50%), **4**= Cloud (full cloud), **5** = Cloud and rain.
Wind strength	As wind strength will not usually change much while surveying, it can be recorded at the top of the survey sheet, using the following scale: **1**= none (<4 kn), **2**= slight (4-6 kn), **3**= moderate (7-10 kn), **4**= strong (11-15 kn), **5**= very strong (>16 kns)
Wind direction	As the wind direction will not usually change much while surveying, it can be recorded at the top of the survey sheet. Use the compass rose (NSEW) to describe which direction the wind is coming from (e.g. is the wind coming from the SE or NW).
SITE INFORMATION	
GPS Way-point	Record the GPS waypoint number (you can use the original waypoint number as stored in the GPS).
Depth	Record the water depth (m)
Exposure	Record the exposure where: **1**= Zero - fully sheltered from local wave exposure; **2**= Indirect/dissipated exposure to wind/ swell; **3** = Wave influence, but not extreme; **4**= Angled face on to wind/ swell; **5**= Maximum local - very exposed.
Visibility (m)	Record the water visibility (vertical)
Lagoon	Tick the box if the survey site is with a lagoon
Reef flat	Tick the box if the survey site is on a reef flat of a coral reef
Forereef slope	Tick the box if the survey site is on the forereef slope of a coral reef
Deep water (>25m)	Tick the box if the survey site is over deep water >25m depth
Silt (Vase)	Tick the box if the dominant substrate type is silt
Sand (Sable)	Tick the box if the dominant substrate type is sand
Rock pavement	Tick the box if the dominant substrate type is rock pavement
Algal assemblage	Tick the box if the dominant cover is a mixed algal assemblage
Large macroalgae	Tick the box if the dominant cover is a large macroalgae (e.g. *Sargassum*)
Live hard coral	Tick the box if the dominant cover is live hard coral
Soft coral	Tick the box if the dominant cover is soft coral

Sparse seagrass	Tick the box if the dominant cover is sparse seagrass (<40%)
Dense seagrass	Tick the box if the dominant cover is dense seagrass (>40%)
Other	Tick the box if the dominant cover is another type (and note what it is)
Photo-graphs	Record the start and end number of the photographs for the site. To help distinguish the photographs from different sites, you can write the GPS waypoint number on a sheet of paper and photograph the number. You could photograph the survey form between sites, or the GPS screen showing the waypoint.
Descrip-tion	Write a brief description of what you observe, mentioning the dominant physical and biological characteristics of the seabed e.g., '*Halophila ovalis* seagrass on flat sand with occasional sparse rubble and no other live cover'. The description should include the names of the dominant species wherever possible. If there are species that you do not recognise, take photographs of the species.

GROUND-TRUTHING SURVEYS (Level 1) **Subtidal Surveys** **Sheet Number____________**

Country:	**Survey Sector:**	**Location:**	**Date:**
Surveyors:	**Weather:**	**Wind strength (1-5):**	**Wind direction (NSEW):**

GPS Waypoint	Depth (m)	Exposure	Visibility (m)	Lagoon	Reef flat	Reef slope	Deep water (>25m)	Silt / Vase	Sand / Sable	Rock pavement	Algal assemblage	Macroalgae	Sparse seagrass	Dense seagrass	Hard coral	Soft coral	Other	Photograph- start#	Photograph -end	**Notes / Description (dominant physical sub-strate, and biological cover)**

Annex 2.3 Ground Truthing Survey Methods – Level 2 & 3

GROUND-TRUTHING SURVEY METHODS - LEVEL 2 & 3	
SURVEY INFORMATION	
Country	Record the country code. e.g. **SUD** = Sudan, **YEM** = Yemen, **DJI** = Djibouti. E**tc**
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Surveyors	Record the name and / or initials of the surveyors involved in the survey.
Weather	As weather will not usually change much while surveying, it can be recorded at the top of the survey sheet, using the following scale: **1**= Sun, no cloud, **2**= Sun part cloud (<50% cloud), **3**= Sun and cloud (50% and 50%), **4**= Cloud (full cloud), **5** = Cloud and rain.
Wind strength	As wind strength will not usually change much while surveying, so can be recorded at the top of the survey sheet, using the following scale: **1**= none (<4kn), **2**= slight (4-6kn), **3**= moderate (7-10kn), **4**= strong (11-15kn), **5**= very strong (>16kns)
Wind direction	As the wind direction will not usually change much while surveying, it can be recorded at the top of the survey sheet. Use the compass rose (NSEW) to describe which direction the wind is coming from (e.g. is the wind coming from the SE or NW etc.).
SITE INFORMATION	
Waypoint	Record the GPS waypoint number.
Photographs / Video	Photographs that are representatives of the site and the species present are needed. Take photographs both vertically (from directly from above the substrate) to illustrate the composition and cover, and horizontally to capture the characteristics of the seascape / landscape. If using photoquadrats without a fixed frame: throw the quadrat at random within the survey area and photograph from directly above, being sure to check that the whole frame is included in each shot. Record the photograph numbers for the site - photograph start number and end number. You can also photograph the survey form. If using photoquadrats with a fixed frame: randomly position the frame within the survey area. Record the photograph numbers for the site - photograph start number and end number. You can also photograph the survey form. If using GPS tagged video or photoquadrats (Level 3) it is particularly important to ensure that the camera time and date is set the same as the time and date on the GPS before commencing the field surveys.
Depth min (m) & max (m)	Record the minimum and maximum depth at the site in metres. You can do this from the boat using a weighted line (rope with knots) or a measuring tape with a lead weight attached, or you can use a hand-held depth sounder (e.g. Plastimo or similar). You can use a dive computer set to freediving mode if snorkelling or normally if diving.
Visibility (m) horizontal:	Record the estimated horizontal distance to which you can see underwater in metres
Visibility (m) depth:	Record the depth to which you can see underwater in metres. You can use a secchi disk to record this if you have one or you can make one.
Exposure	Record the exposure where: **1**= Zero - fully sheltered from local wave exposure; **2**= Indirect/dissipated exposure to wind/ swell; **3** = Wave influence, but not extreme; **4**= Angled face on to wind/swell; **5**= Maximum local - very exposed.
Aspect	Record the orientation of the reef relative to north. Is the fore reef slope facing north (0 degrees), east (90 degrees), south (180 degrees), or west (270 degrees).

Slope	Try to estimate the slope of the seabed from horizontal using the following scale: **1**= flat (0 degrees); **2**= <45 degrees; **3**= >45 degrees <90 degrees; **4**= 90 degrees and; **5**= overhanging.
Seabed Relief	Try to estimate the macro-topography or relief of the seabed using the following scale: **1**= Flat, no structures; **2**= Low relief structures with between 1-10 cm elevation; **3**= Scattered low relief structures with 0.5-1 m elevation, separated by > 5 m **4**= Structures with 1-2 m elevation (e.g. bommies) 3-6 m apart; **5** = Spur and groove > 2 m relief; major structure, pillars or caves / a diver can pass in between.
Current strength	Current strength will often not change too much during a survey. Record the current strength after completing the survey. Use the scale: **1**= None; **2**= Light; **3**= Moderate; **4**= Strong; **5**= Dangerous
Current direction	Use the compass rose to record the direction the current is coming from (e.g. SE or S
Reef Type	Record the type of reef where the data was recorded (where possible you can use the Millennium Reef Map categories).
Reef Zone	Record the reef zone where the video transect was recorded (e.g. Lagoon, Reef flat / back reef, Reef crest, Fore reef slope). Where possible you can use the Millennium Reef Map categories zones.
PHYSICAL STRUCTURE (Total cover = 100%)	
HS (Hard substrate)	Estimate percentage substrate composed of hard flat, undulating or indented substrate
LB (Large blocks >1m)	Estimate percentage substrate composed of large blocks >1m (e.g. massive *Porites,* tabular *Acropora,* rock etc)
SB (Small blocks <1m)	Estimate percentage small blocks <1m (e.g. massive *Porites,* tabular *Acropora,* rock etc)
RB (Rubble / Debris)	Estimate percentage substrate composed of rubble
SN (Sand / Sable)	Estimate percentage substrate composed of sand
SI (Silt / Vase)	Estimate percentage substrate composed of silt
BIOLOGICAL COVER (Total cover = 100%)	
HC (Hard coral)	Estimate percentage (%) substrate covered by hard coral
RDC (Recently dead coral)	Estimate percentage (%) substrate covered by recently dead coral
DCA (Dead coral)	Estimate percentage (%) substrate covered by old dead coral with turf or coralline algae
SC (Soft coral)	Estimate percentage (%) substrate covered by soft coral
MA (Macroalgae)	Estimate percentage (%) substrate covered by macroalgal assemblage
CA (Coralline algae)	Estimate percentage (%) substrate covered by coralline algae on rock / rubble
TA (Turf algae)	Estimate percentage (%) substrate covered by turf algae on rock / rubble
SG (Seagrass)	Estimate percentage (%) substrate covered by seagrass
SP (Sponge)	Estimate percentage (%) substrate covered by sponge
OT (Other)	Estimate percentage (%) substrate covered by other living organisms (record what 'other' equals e.g. zooanthids, coralimorpharians etc.)
BA (Bare)	Estimate percentage (%) substrate not covered by living biological organisms
Description	Write a brief description of what you observe, mentioning the dominant physical and biological characteristics of the seabed e.g., *'Halophila ovalis seagrass on flat sand with occasional sparse rubble and no other live cover'* or '*Massive hard coral community dominated by Porites colonies interspersed by sand'*. This description should include the names of the dominant species whereever possible. If there are species that you do not recognise, take photographs of the species.

GROUND-TRUTHING SURVEYS (Level 2 & 3) **Subtidal Surveys** **Sheet Number____________**

Country:	**Sector:**	**Location:**	**Date:**	**Surveyors:**	
Weather:		**Wind strength (1-5):**		**Wind direction (NSEW):**	

Waypoint:		**Photographs / Video:**	**Depth (m) Min:**	**Depth (m) Max:**	
Exposure:		**Aspect:**	**Slope:**	**Seabed relief (1-5):**	
Visibility (m) horizontal:	**Visibility (m) depth:**	**Current strength (1-5):**	**Current direction (NSEW):**	**Water Temp (^oC) surface:**	**Water Temp (^oC) deep:**
Reef type:			**Zone:**		

Physical substrate (Total = 100 %)						**Biological cover** (Total = 100 %)										
HS	LB	SB	RB	SN	SI	HC	SC	DCA	RDC	MA	TA	CA	SG	SP	BA	OT

Description:

Waypoint:		**Photographs / Video:**	**Depth (m) Min:**	**Depth (m) Max:**	
Exposure:		**Aspect:**	**Slope:**	**Seabed relief (1-5):**	
Visibility (m) horizontal:	**Visibility (m) depth:**	**Current strength (1-5):**	**Current direction (NSEW):**	**Water Temp (^oC) surface:**	**Water Temp (^oC) deep:**
Reef type:			**Zone:**		

Physical substrate (Total = 100 %)						**Biological cover** (Total = 100 %)										
HS	LB	SB	RB	SN	SI	HC	SC	DCA	RDC	MA	TA	CA	SG	SP	BA	OT

Description:

Waypoint:		**Photographs / Video:**	**Depth (m) Min:**	**Depth (m) Max:**	
Exposure:		**Aspect:**	**Slope:**	**Seabed relief (1-5):**	
Visibility (m) horizontal:	**Visibility (m) depth:**	**Current strength (1-5):**	**Current direction (NSEW):**	**Water Temp (^oC) surface:**	**Water Temp (^oC) deep:**
Reef type:			**Zone:**		

Physical substrate (Total = 100 %)						**Biological cover** (Total = 100 %)										
HS	LB	SB	RB	SN	SI	HC	SC	DCA	RDC	MA	TA	CA	SG	SP	BA	OT

Description:

Annex 2.4 How to use a GPS to navigate to waypoints

Switch on GPS

1. Ensure the GPS has fresh batteries at the start of the survey and take a spare set of batteries on the survey.

2. Switch on the GPS by pressing the "On" button located on the right-hand side of the unit.

3. If the GPS has been used recently it will be ready to use almost immediately. If the GPS has not been used for a while, or not been used in the current location, it may take some time for the GPS to locate the correct configuration of satellites. As best practice it is always a good idea to check that it has found sufficient satellites to give an accurate position before recording waypoints.

4. To check the satellite status, use the **Page** button to switch onto the **Satellite** page. To do this repeatedly press the **Page** button to scroll through the different pages. When you find the correct page just release the **Page** button and the page will display.

5. The satellites that the GPS is using to produce a position will appear as green numbered satellite symbols on the 'Satellite' page. Once the GPS has located 3 or more satellites it will start to give a position. The more satellites located the more accurate the position.

6. Once you have checked that your GPS is working correctly you can now start your survey.

Selecting a GoTo waypoint to navigate to:

1. To locate the first survey point use the **Page** button to switch to **Waypoint Manager**.

2. The **Waypoint Manager** page shows the list of GPS waypoints already stored in the GPS memory.

3. There are two ways you can search for a waypoint in the Waypoint Manager (i) a text search function, where you can type in the name of the waypoint and (ii) by scrolling through the entire list.

4. Using the text search is good when you have a lot of waypoints loaded into the device. As there are not that many waypoints loaded into the GPS you can simply scroll through the list of waypoints to select the one you want to use.

5. To exit the text search function press the **Quit** button. You should now just see a list of waypoints.

6. Use the **arrow keys** to scroll down and select the first waypoint (e.g. **'SUD01'**)

7. Once you have selected the waypoint you want to navigate to press **Enter** button

8. A new screen appears which shows the details about the first waypoint 'SUD01'.

9. Use the arrows to select Go at the bottom of the screen, then press Enter.

10. You have now successfully set up a 'GoTo' waypoint in your GPS so that you can use this to navigate.

Navigation to the GoTo waypoint

1. To navigate to a selected waypoint use the 'Page' button to switch the GPS onto the Compass screen.
2. Use the Compass to screen navigate your way to the first waypoint.
3. When you arrive at the first waypoint, you can begin your survey.
4. First record a new 'waypoint' at your current survey location. To do this, first press the **Mark** button, then look at the GPS screen and record the number of your waypoint on the survey form. Then use the arrow keys to select **Done** if not already highlighted**,** then press the **Enter** button.

5. Remember to select ‘Done’ and press ‘Enter’ after marking the waypoint it will not be stored in the GPS memory.
6. Now observe your environment and complete the rest of the survey form.
7. Finish the survey by taking some photographs that are representative / characterise your location. Record the start and end number of the photographs and record a description of the environment.
8. You have now completed the survey at the first waypoint.
9. Now continue and repeat the above process for all other waypoint
10. When you have finished your surv please return to the workshop.

3

Intertidal Habitats (Mud, Sand, Rock, Saltmarsh and Mangrove)

3. INTERTIDAL HABITATS (MUD, SAND, ROCK, SALTMARSH AND MANGROVE)

3.1 Background

The intertidal zone, also known as the littoral zone, is a highly dynamic environment due to the changes that occur as a result of diurnal tidal patterns, including changes in temperature, aerial exposure and physical wave action. The coastline of the PERSGA region is predominantly fronted by fringing coral reefs or coral communities that protect the shoreline and create a more sheltered environment which permits the formation of sandy beaches, mudflats and saltmarshes and mangrove stands. Sandy and rocky shores are typically found on the seaward side of the littoral zone, while muddy habitats, salt marshes and mangroves dominate the landward side. Intertidal habitats can host a myriad of species that have adapted to withstand the often harsh and variable conditions and exhibit distinct zonation patterns. The dynamics of the intertidal zone within the Red Sea and Gulf of Aden are also affected by the monsoon seasons, which can cause changes in sea level of up to 0.5m, resulting in the inundation of some coastal regions during the winter months.

The original PERSGA/GEF (2004) SSM described several intertidal survey methods spread across several chapters. The methods included a broad scale semi-quantitative rapid assessment survey method that is suitable for providing preliminary information into the range of physical habitats, community types and impacts found within a study area. The other methods were more specific quantitative survey methods that are more suitable for use in long term monitoring programmes. The results of the rapid assessment surveys can also help identify suitable sites for inclusion in a long term monitoring programme.

The monitoring of the condition and dynamics of intertidal habitats is critical for detecting and understanding community dynamics in order to develop management measures to anticipate and reduce acute or chronic environmental impacts.

The monitoring of intertidal habitats can provide early insights into changes occurring elsewhere in the wider ecosystem, with potential cascading impacts on biodiversity and food webs.

The monitoring of intertidal habitats and associated biota can also provide information to inform management decisions related to both coastal developments and climate-change.

3.1.1 Rocky shores

The rocky shores of the PERSGA region are highly dynamic and range between flat terraces and vertical cliffs. These hard substrate habitats tend to support a high diversity of benthic and epibenthic species, and communities are variable due to the range of exposures and other environmental conditions (PERSGA/ GEF 2004).

3.1.2 Sandy beaches

Sandy shores vary in physical and biological characteristics, depending upon the degree of exposure to tide and wave action and range from 100m high dune-backed beaches of Socotra to narrow muddy stretches of sand between mangroves and lagoons in the Red Sea (PERSGA/ GEF 2004).

3.1.3 Mudflats

Mudflats are characterised by the high level of fine soft sediments, mostly composed of silt and clay particles. These habitats are found within sheltered areas such as embayments and harbours, as well as within saltmarshes and mangroves, which shelter this habitat from erosive wave action (PERSGA/ GEF 2004). Such habitats are often waterlogged and the sediments tend to have a high organic content, which promotes high microbial activity, which can impact on the amount of oxygen available to support biological communities (PERSGA/ GEF 2004).

3.1.4 Saltmarshes

Saltmarshes composed of a range of different halophytic plants occur throughout the Red Sea often in proximity to mangroves. Due to high evaporation rates, soil salinity may be very high and any fresh water inflow will extend the marshes landward. The halophytic plants and their root systems stabilise the sediments so that tidal influences tend to lead to the formation of a network of channels and creeks running between the patches of vegetation. Saltmarshes are highly productive habitats that can shelter and provide food for bird populations and are of significance for conservation.

3.1.5 Mangroves

Mangrove leaves, trunks and roots known as pneumatophores provide habitats for numerous organisms as well as stabilize the sediments which influence the water chemistry. Organisms living within the mangrove forests have adapted to living in brackish to saline tidal water and face inundation and periods of exposure with the tidal movements (Kauffman and Donato, 2012). Mangroves occur throughout the PERSGA region between high water spring (HWS) and high water neap (HWN) tide levels, covering an estimated total area of 450-500 km² (Sheppard *et al.* 1992; PERSGA/ GEF, 2004). Two species of mangrove tree (*Avicennia marina* and *Rhizophora mucronata)* are known to occur, with the former species being most common and found throughout the Red Sea. Both species proliferate better in terms of growth and colonization in the southern Red Sea, where trees can reach a height of 5-7m and stands can be 100-500 m wide (PERSGA/ GEF 2004).

3.1.6 Artificial habitats

A substantial proportion of the Red Sea coastline has been developed and artificial structures constructed within the intertidal zone. Examples of the types of artificial structures found in the PERSGA region include jetties, corniches, seawalls, marinas, and ports. These hard structures may be constructed from concrete or rock, and they provide a hard surface that is often colonised by communities similar to those found on rocky shores.

3.2 Overview

3.2.1 General approach

Surveying the intertidal zone involves recording information about the physical habitat and the associated biological communities across the full tidal range, from the low water spring to high water spring tide marks. Physical habitat surveys usually involve beach profiles, sediments and water quality surveys, as these can all influence the composition and distribution of living biota. Broad-scale rapid coastal assessment and key species surveys are often completed over the entire study area to help identify the range of habitats present and the zonation patterns within these habitats as well as the current status. The results of the rapid assessments and key species surveys can then be used to select appropriate permanent long term monitoring sites which are then surveyed on a monthly or seasonal basis. Long-term monitoring programmes should include sites that reflect both the natural undisturbed status and sites subject that are subject to human activities or perturbation.

3.2.2 **Target**

An intertidal survey programme would normally include:

- Intertidal habitat types, extent and condition
- Key species presence / absence within intertidal zones
- Physical habitat structure (profile and exposure).
- Sediment size and quality (if applicable)
- Abundance of epiflora and epifauna
- Abundance of inflora and infauna
- Water quality (temperature, salinity, dissolved oxygen, turbidity, pH and nutrients).

The biota of the Red Sea have been studied extensively since the 1700s and in general the intertidal biodiversity is now relatively well known (Forsskal 1775; Jones et al. 1987; Oliver 1992; Sheppard et al. 1992; Turner et al. 1999). The composition of the communities that are characteristics of the main habitats (rock, sand, mud, mangrove, saltmarsh) are known well enough known to permit the description of different shore levels within a biotope, based on presence and absence of species (Jones et al.1987).

3.2.3 **Field equipment**

The following is a list of the survey equipment required to conduct intertidal monitoring surveys:

- Survey forms, slate and pencil.
- Camera to record species and site photographs.
- GPS, compass and clinometer.
- 50 m measuring tape.
- Level and ranging poles for beach profiling.
- Quadrats (0.1 m^2 and 1 m^2).
- Bucket and shovel.
- Storage containers with 5% formalin for preserving samples for analysis post survey.
- Mercury thermometer with an accuracy of ±0.5°C or temperature probe.
- Oxygen probe.
- pH meter.
- Refractometer to measure salinity.
- Secchi disc to measure turbidity.
- Water sampling bottles (e.g. wide-neck Nansen bottles).
- Water quality testing kit (e.g. Lamotte).
- Syringe and filter paper.
- Boat for mudflat surveys on the rising tide.

Additional equipment that may be needed for permanent surveys:

- Concrete marker posts and paint.
- Sediment corer or a grab (e.g. van Veen grab).
- Sediment sieves with 2.0 mm and 1.0 mm, 0.5 mm and 0.1 mm mesh to grade sediment. samples and reveal burrowing species for identification.
- Weighing scales to evaluate sediment

sample composition.

- Desiccator to dry sediment samples prior to weighing.
- Drying oven to dry sediment samples prior to weighing.
- Plankton net for food web and migration surveys.
- Beach seine nets for sampling of marine organisms migrating during high tide.
- Haemocytometer for cell counts of microalgae in sediment samples.

3.2.4 Field personnel

A minimum of two field surveyors are needed for intertidal surveys to ensure that the surveys are conducted in a timely and safe manner.

3.2.5 Training / experience

The Rapid Coastal Environmental Assessment method does not require a high level of experience and can be completed by competent field staff. More experienced surveyors are needed for the Key Species Surveys and the more detailed survey methods that would be used at permanent long term monitoring sites. For all methods, at least one of the surveyors should already be familiar with or have received training in the survey method. One surveyor should also have knowledge of how to properly collect samples, and preserve and store specimens for analysis once ashore or for shipping to an expert for identification if necessary.

3.3 Field Procedures

3.3.1 Broad scale Rapid Assessment Methods

Two survey methods are provided here for use as rapid broad scale assessment methods, namely the Rapid Coastal Environmental Assessment (RCEA) survey method and Key Species Surveys, both of which were included in the original PERSGA SSM (PERSGA/GEF 2004). These semi-quantitative methods are intended to provide first level information about the coastal environment. The results can be used to design more detailed surveys for long term monitoring.

Rapid Coastal Environmental Assessment (RCEA)

The Rapid Coastal Environmental Assessment (RCEA) survey method was designed to provide broad scale data about the key physical and biological characteristics of the intertidal zone, and the presence of human impacts. The method was originally developed for use in the Red Sea (Price et al., 1998), and then used in the Arabian Gulf (Price et al. 1987; Price 1990).

Additional background about the RCEA method and potential applications are presented in Chapter 1 of the original PERSGA SSM manual and not repeated here (PERSGA/GEF 2004).

RCEA surveys should be designed to sample a representative selection of the coastal habitats within the study area. It is recommended that a minimum of 30 sites be sampled per survey area for statistical purposes (PERSGA/GEF 2004). The distribution of the RCEA survey sites within the survey area should take into consideration the variability of coast within the study area and be the survey strategy adapted accordingly (PERSGA/GEF 2004). For example:

- On a long homogenous coastlines (e.g. Red Sea), where coastal types are fairly consistent, RCEA survey sites can be more or less evenly spaced. Using a equidistant sampling approach can help to avoid bias, and the targeting of key features of 'interest' (e.g. a large mangrove stand), perhaps at the expense of other areas, such as an open sandy beach.
- On more complex, heterogeneous coastlines (e.g. coast of Socotra), an equidistant survey design may not be appropriate, as it may mean some habitat types are under-sampled. In this instance, a stratified random sampling approach would be more likely to ensure that the full range of habitat types are sampled.

For efficiency and to make best use of field time, the RCEA surveys should be integrated with the other surveys, such as key species surveys. Completing RCEA and key species surveys in parallel allows for the determination of vertical biological zones on the shore, which can aid and inform the selection of sites suitable for inclusion in long term permanent monitoring surveys.

Field Survey Method

Each RCEA site comprises a 'quadrat' of 500 x 500 m that extends from the shoreline 250 m inland and 250 m seaward into the subtidal zone (Figure 3.1). During the surveys, the abundance of biotopes (ecosystems), species groups, and magnitude of uses and pressures (impacts) are estimated and recorded within each quadrat (Table 3.1), using a logscale (Table 3.2).

It should be noted that the 500 x 500 m quadrat does not need to be demarcated on the ground and the dimensions are approximated in the field. Surveyors with previous experience of the method will tend to visually estimate the dimensions of the quadrat. Greater accuracy can be achieved by using a GPS to measure distances in the field.

Each site typically takes at least one hour complete, or longer if diving is required. The RCEA survey form together with instructions on how to complete the form are presented in Annex 3.1. A description about how to complete the RCEA are presented below:

Table 3.1 Ecosystems, species groups, uses and impacts examined by rapid assessment. (Counts of empty nesting pits included in estimates of turtles, since information on nesting locations is important for management.)

Ecosystem / Species		**Human Use / Pressures / Impacts**
Flora	**Fauna**	
Seagrass	Reefs / corals	Oil
Algae	Birds	Human litter (plastics, metal, other solid waste)
Halophytes	Turtles	Driftwood and wood litter
Mangroves	Mammals	Construction / development
Freshwater vegetation	Fish	Fishing
Other	Invertebrates	Other

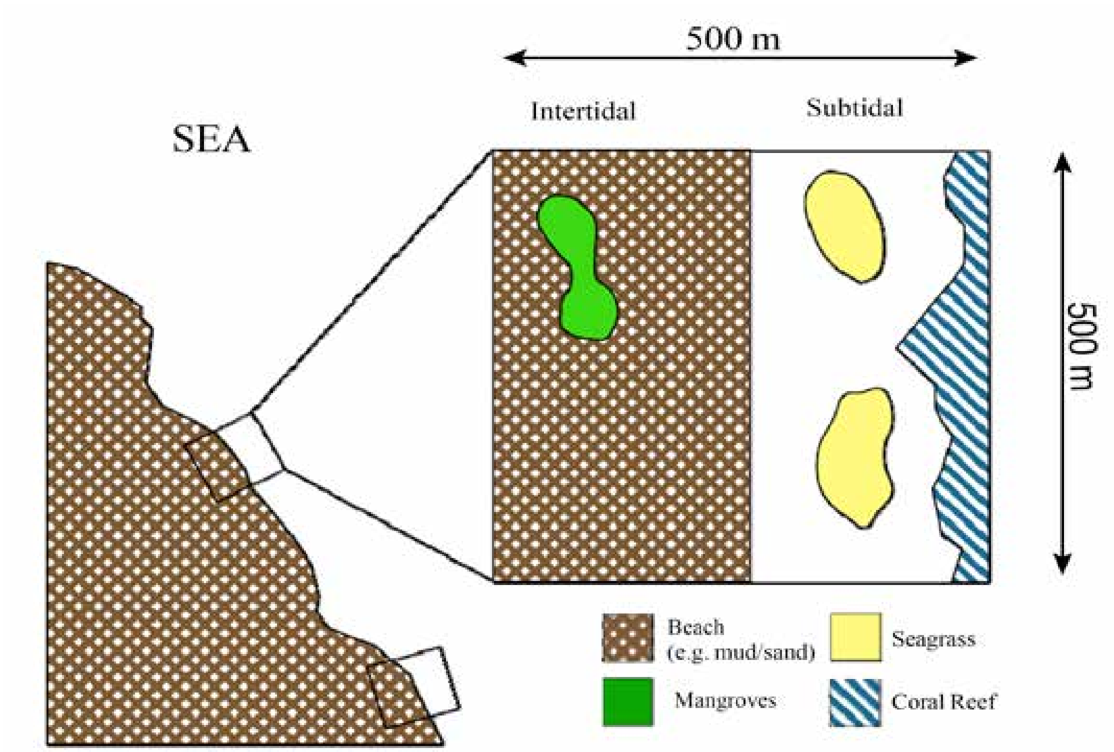


Figure 3.1 Schematic diagram showing configuration and dimensions of the 'site inspection quadrats' used in rapid environmental assessment. At each site, estimates are made of the abundance of key ecosystems and species groups, and human uses/environmental impacts within 250,000 m^2 (i.e. 500 x 500 m) (SOURCE: PERSGA/GEF 2004).

Table 3.2 Logarithmic ranked/ordinal scale of 0–6 used for abundance estimates of coastal habitat (flora and reefs) and species groups (fauna). The same scale is used to estimate the magnitude of uses/pressures (impacts) (after PERSGA/GEF 2004).

Ranked abundance/magnitude score (log scale)	**Areal extent (m^2): flora and reefs or No. of individuals: other fauna (equivalent arithmetic range)**
0	0
1	1-9
2	10-99
3	100-999
4	1,000-9,999
5	10,000-99,999
6	100,000 +

- Prepare the survey equipment including a survey slate with a copy of the Rapid Coastal Assessment Sheet.
- Record a GPS position on the shore, which will be the mid point of the 500 x 500 m survey quadrat and fill in the other information about the location of the site (name, date, surveyors, weather etc).
- Visual observations in the shoreward part of the quadrat (500 x 250 m) are assessed while walking.
- Visual observations in the subtidal component of the quadrat (500 x 250 m) are assessed while snorkelling (or SCUBA diving if there is a drop-off within 250 m of the shore).
- To estimate the aereal extent (m^2) of each habitat type (e.g. vegetation and reefs) within the quadrat, spot check assessments are made while walking or snorkelling, and converted into the logarithmic scale of 0–6 (Table 3 .2). For example, to estimate seagrass cover, six spot check snorkels may estimate cover as 50, 75, 60, 75, 20, and 90 per cent. The average value is about 60 per cent seagrass cover, which is equivalent to 0.6 x 500 x 250 = 75,000 m^2 = 5 on the log scale.
- To estimate the abundance of each faunal group (e.g. birds) in the quadrat, the area can be visually scanned and the number of individuals counted. The estimated number of individuals within each faunal group is then converted into the logarithmic scale of 0–6 (Table 3.2). For example, a bird population estimate of only 1,000 is assigned a score of 4, which would be the same as a bird population estimate of 4,000.

The relative magnitude of impacts are recorded using the same logscale as follows:

- Construction and development (e.g. jetties) and oil pollution are recorded using areal extent 0–6 logscale (as used for vegetation or reef areas).
- Human litter (e.g. metal, plastics, other solid waste & pollution) and driftwood are recorded using the numberical 0–6 logscale,
- Fishing impacts are assessed qualitatively according to relative magnitude (0 = no evidence and 6 = greatest evidence of impact)
- Crown-of-thorns (CoT) starfish and CoT scars are recorded using numberical 0–6 logscale.
- Coral bleaching (white) and algal turf on coral/reef are recorded using areal extent 0–6 logscale.

Once the surveys are completed, the field survey sheets should be checked for completeness and legibility. The data should then be entered into the computer, using the excel spreadsheet templates and the data analysed.

Key Species Surveys

The Key Species Surveys were one of the field methods included in the original PERSGA SSM manual (PERSGA/GEF 2004). The method is suitable for use as a rapid intertidal assessment method and can be used alongside the RCEA method. The surveys are conducted along transects perpendicular to the shore, usually starting from the shoreline and working up the beach. There are habitat specific Key Species Survey forms, which list the indicator species found within the main zones for each intertidal habitat types (sandy, rocky and muddy shores). These habitat specific survey forms and instructions on how to complete the forms are provided in Annex 3.3. A description about how to complete the Key Species Surveys field surveys is presented below:

- Set up a survey slate with the appropriate

Key Species Survey form for the habitat being surveyed (e.g. sandy beach, rocky shore, mud) and prepare the survey equipment.

- Starting at the top of the beach, record a GPS waypoint, and fill in the other information about the location of the site (name, date, surveyors, weather etc).
- Take four photographs of the site at the top of the beach, including a view along the beach in both directions and a view inland and down the beach.
- If surveying a rocky or sandy beach, walk straight down the beach and record a second GPS waypoint at the lowest point on the shoreline. Then select the first waypoint and use it as the "Go to" location in the GPS to orientate the survey directly back up the beach.
- On mud flats, it may be necessary to use a small inflatable dinghy to survey up the beach on a rising tide, especially if there is thick mud that would be difficult to walk through.
- Take four photographs of the site at the bottom of the beach, including a view along the beach in both directions and a view up the beach and out to sea.
- Starting at the bottom of the beach, identify and record the abundance of species encountered using the semi-quantitative scale (P/A = present/absent; R = rare; O = occasional; C = common; A = abundant; D = dominant);
- Walk up the beach and repeat the procedure within each littoral zone; identify and record the abundance of species encountered using the semi-quantitative scale (P/A = present/absent; R = rare; O = occasional; C = common; A = abundant; D = dominant);
- For species that are difficult to identify *in-situ,* take photographs and samples, stored in jars with 5% formalin so that they can be sent to an expert for identification.
- Other key points to remember when completing the Key Species Surveys, are as follows:
- Small species that are found in mud and sand habitats (e.g. amphipod *Talor chestia* and isopods *Tylos* and *Eurydice*) may only be revealed by sieving the sediment through a 1 mm mesh. This can be done at intervals up the beach.
- When burrows are encountered, the burrow itself should be photographed and then the species inhabiting the burrow uncovered by digging out the burrow using a shovel so that it can be identified *in-situ* or if necessary sampled for later identification.
- On mud flats it is important to note if surface microbial mats are present and the extent of the mats.
- Binoculars can be used to identify species that appear on the surface at low tide.
- On saltmarshes, only the key species listed under the littoral fringe of the mud survey form will be found.
- Where there is fresh water input into a saltmarsh, up to 20 species of saltmarsh plants such as *Phragmites* and *Typha* sp. may occur.
- On rocky shores, the species will exhibit strong zonation. It is particularly important to note the presence of tar and other pollutants covering rocks.

Once the surveys are completed, the field survey sheets should be checked for completeness and legibility. Data from the Key Species Sheets are then entered into the computer and analysed. Further details on the analytical techniques that can be used with these data are provided in Chapter 2 of the original PERSGA SSM manual (PERSGA/GEF 2004).

3.3.2 **Physical Characteristics**

Beach profiles, sediment and water quality surveys are an essential part of any baseline coastal assessment surveys and also often included in long term monitoring of intertidal zones. Several variables may be used in combination to create indices to rank or classify beach types. For example, the exposure index (EI) of Mclachlan (1983) is an example of an index that can be used to rank sand beaches, which is calculated using: beach profile, sand grain analysis, organic content, air temperature and temperature 10 cm below the surface, salinity, wave height, width of swash zone and depth of anoxic zone, and presence of permanent burrows).

Methods to measure these key variables are described below:

Beach Profiles

Beach profiles measure the shape of the beach, using a combination of distance and angle measurements along a transect perpendicular to the shoreline (Dalby 1987). The resulting profiles can be related to tide levels using local tide tables to understand zonation patterns. The profiles also allow for the calculation of cross-sectional area, which provides a measure of the amount of beach material present at each location. This information can be used to understand patterns of coastal erosion and accretion. Beach profiling is conducted while the tide is low by measuring short segments along the perpendicular transect. The survey forms together with instructions on how to complete the forms are presented in Annex 3.2. A summary description of how to complete the beach profiles are presented below:

- Prepare the survey equipment including a survey slate with a copy of the Beach Profile survey form, as well as measuring tape, ranging poles, clinometer, camera, GPS and batteries.
- Once on site, fill in the top part of the survey form, including date, time, location and initials or names of the surveyors.
- Establish a reference point in the vegetation line at the top of the beach. If the site is to become a long term monitoring station this reference mark should be made permanent (e.g. painted post set in concrete). Otherwise a temporary pole can be installed for the duration of the survey. The pole is photographed and a GPS position recorded.
- Measure the vertical distance between the top of the reference mark and the ground in centimetres and record this on the survey form.
- Walk along the transect line perpendicular to the shore to the lowest point, taking note and temporarily marking where there are small changes in the slope of the beach.
- Insert the ranging pole into the sediment at the lowest point on the beach ensuring that the ranging poles are inserted into the sand to the correct depth (the mark on the tip of the pole should be just covered by sand). The surveyor then needs to check their eye height on the ranging poles, Many ranging poles have stripes which can be used for this purpose.
- The surveyor then stands at the lowest point on the beach by the waters edge with one of the ranging poles inserted into the sand (position A) while the assistant surveyor moves up the beach to the first break in the slope, and inserts the second ranging pole into the sand (position B).
- The surveyor then looks up the beach towards the second pole and measures the angle between the matching markers on ranging poles using a clinometer. The

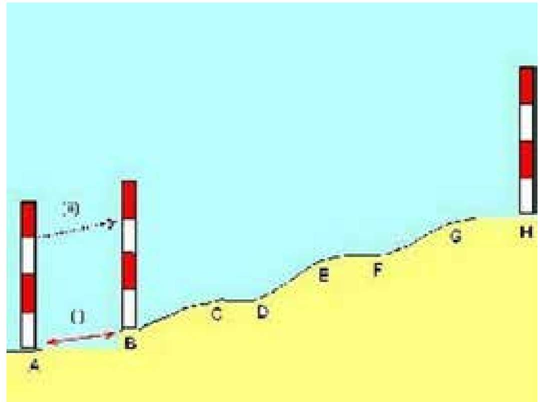
slope of that segment (A-B) is recorded on the survey form to the nearest degrees and minutes. It is important to note that the reading must be taken from the point on the ranging pole that coincides with the eye level of the person using the clinometer (Figure 3.2).

- The assistant surveyor then measures the ground distance between the ranging poles (A-B) using a measuring tape and this is recorded on the survey form.

- The assistant surveyor collects the ranging pole from position A and moves up the beach to position C. The first surveyor moves up the beach to position B and the process is repeated for segment B-C and until the top of the beach is reached.

The same profiling method can be used for both rocky, sandy and muddy beaches. For vertical cliffs it is possible to just use a measuring tape. Care is needed when assigning biological zones to tidal heights on vertical structures as exposure to wave action, shore aspect and insolation can drastically expand or contract bands of biotic zonation.

On salt marshes or mangroves, the profiles can be created using the above method, but where marshes are extensive, the use of the incoming tide to mark height above chart datum is usually adequate.



(a)

(b)

(c)

Figure 3.2 (a) Schematic diagram to illustrate how to lay out the ranging poles and measure distances and angles for each segment (b) Classic brass "Abney" level and (c) a modern clinometer.

3.3.3 Intertidal Sediment Quality

On beaches, sediment grain size analysis is conducted on replicate samples of sediment taken using a core or grab from the top, mid and bottom of the beach. Each sample collected is transferred to a polythene bag or another suitable storage container, labelled with the site, date and name of surveyors, and placed in a coolbox before being transported back to the laboratory.

Each sediment sample is first washed in freshwater to remove salt and then dried for 24 h in an oven at 60ºC. The sediment sample is cooled in a desiccator to prevent uptake of water from the atmosphere before the test samples are weighed out. Separate portions of the dried salt free sediment sample are then weighed out and used to calculate grain size and organic content.

A 200 g test sample of dried salt free sediment is passed through a series of sieves each of which has a different sized mesh. The sieving process separates the grains into different size fractions. Each size fraction of dried sediment is then weighed separately and the results used to calculate the sediment size class frequency distribution and sorting of sediments on the beach.

Another 200 g test sample of the dried salt free sediment is weighed out and placed in a muffle furnace for ashing at 450ºC for 30 minutes. The ashed sediment sample is cooled in a desiccator to prevent uptake of water from the atmosphere before being weighed again. The organic content of the sediment is then calculated as the difference between dry weight of salt free sediment and the desiccated weight of the ashed sediment.

3.3.4 Intertidal Water Quality

The measurement of water quality parameters, including temperature, salinity, oxygen is described in Chapter 4.

On sandy beaches and rocky shores, water samples can be collected at the shoreline just below the water surface using airtight Nansen bottles. Three samples should be collected at each station to ensure accuracy. Samples should be immediately transferred to a coolbox with ice to avoid overheating prior to testing. Samples can be tested *in-situ* or tested in the laboratory.

On rocky shores, it is important to record shaded and open shore surface rock temperatures, together with temperature and salinity in pools at different levels on the shore. Lagoons, pools and other irregularities also often trap sediments and the presence of these should be recorded and the water sampled.

In muddy habitats, including mudflats, saltmarshes and mangroves it is important to collect data on temperature, salinity, pH, sediment particle size and organic content. The *in-situ* measurement of temperature, oxygen or pH in muddy habitats can be achieved by digging a 20 cm hole into the sediment prior to inserting the probe for *in situ* measurements. Temperature measurements should be taken both in air and 10 cm below the sediment surface. To take water samples for salinity, a syringe with filter paper covering the tip is used to collect a water sample and squeeze it onto a refractometer.

3.3.5 Permanent monitoring and quantitative surveys

To monitor changes in the status of the intertidal habitats over time permanent intertidal monitoring sites need to be established and quantitative sampling methods used. The same technique can be used in across rocky, sandy and muddy habitat types with some minor modifications to the sampling methods. More specific guidance on the methods to use in saltmarshes and mangroves are presented below:

- Permanent transect lines are established perpendicular to the shore, extending between the low water to high water spring tide.
- Each transect is permanently marked using a post at the top of the shore, , which is preferably set in concrete. The position of the post is recorded using a GPS. The post can also be numbered and photographed for future reference.
- Both biological survey data and physical survey data are collected along the same transect as outlined above.
- Biological data are collected at four quantitative sampling stations per transect, using quadrats to sample epibiota and cores to sample infauna in soft sediment habitats, as follows:
- Quantitative sampling stations are positioned along the transect at four shore levels: littoral fringe (LF), upper eulittoral (UE), lower eulittoral (LE) and sublittoral fringe (SF), located at high water spring (HWS), high water neaps (HWN), low water neaps (LWN) and low water springs (LWS). The spacing of these depends on the shore profile.
- Five random replicate quadrats are completed at each quantitative sampling station to estimate densities of epifauna and epiflora.
- The quadrat size used to determine densities is varied depending on the species abundances to ensure that statistically useful data are obtained. Larger more widely spaced species (e.g. ghost crab *Ocypode* burrows) may require larger (e.g. 10m^2) quadrats whereas smaller more dense species (e.g.fiddler crab *Uca* sp. burrows) can be surveyed using a smaller (e.g. 1m^2) quadrat.
- To record macrofauna, use 5 replicate 1 m^2 quadrat counts of burrows (and burrows are initially dug out to identify inhabitants).
- To record smaller infauna, use 3 replicate 25 x 25 x 15 cm deep sediment cores that are dug out and sieved using a 1.0 mm mesh.
- In soft sediment habitats, infauna are sampled by taking 3 replicate 25 x 25 x 15 cm deep cores and sieving the sediment using 1.0 mm mesh. All the sieved material is preserved in 5% formalin in seawater for sorting, identification and counting in the laboratory.
- For exposed shores, the sand may have a larger particle size, and it may be necessary to use a 2 mm mesh to remove the excess sand.
- A smaller mesh (e.g. 0.5 mm) can be used to sample meiofauna, however macrofaunal biodiversity is usually considered sufficient.
- For deep soft mud, grab or core samples must be taken from a boat on the rising tide. A corer can be made of PVC tubing with a cross-sectional area of 0.01 m^2 and a length of 1 m. The corer is rotated into the sediment to a depth of 15 cm with the top end open; a lid or bung is then fitted to the open end to allow the corer to be withdrawn from the sediment whilst retaining the cored mud. Where the mud is consolidated or sticky it should be transferred to a bucket of water and broken down gently by hand, before sieving through a 1 mm sieve hung over the side of the boat and biota preserved in 5% formalin in seawater.
- In the laboratory each faunal sample is spread out in a shallow tray, just covered with water, and fauna sorted from the residual sediment are identified and counted. Final storage of samples is done in 70%

alcohol 30% glycerol solution. Rose Bengal may be used to stain biological material to facilitate its separation from sand.

- For biological surveys to assess food webs and migration in each biota, surf plankton net and beach seine nets can be used, especially at high tide, to sample biota migrating in during high tides. These surveys must make use of a boat or inflatable dinghy to access the survey areas.
- To assess potential succession of colonisation within the rocky shore survey area on a monthly basis, $1m^2$ can be cleared of all biota or use settlement plates at different levels of the shore for assessment at the next monitoring event.
- To quantify microbial mats for food web or other studies, small areas (5 cm^2) of surface sediment down to 1.5 mm depth are removed using a microscope cover slip. The sediment is mixed with a known volume of seawater, preserved using Lugol's iodine, and cells counted and identified using a haemocytometer slide.
- A 25 x 25 cm x 0.5 cm deep core can be taken and chlorophyll extracted with 90% acetone neutralised with magnesium carbonate over 24 h, centrifuged and the absorption of the supernatant read in a spectrophotometer (details given by Baker & Wolff 1987).

3.3.6 **Salt Marshes and Mangroves**

Salt marshes and mangrove forests provide many ecosystem goods and services, including economically important species and thus, monitoring can indicate changes that can have ecological, social and economic implications (Kauffman and Donato, 2012). Monitoring mangroves also involves sampling water and sediment quality, which directly impact on the species composition and assemblage as well as energy source for adjacent habitats. There are many different methods that can be used as described in English *et al*. (1997). The survey forms to assess mangrove habitats in the PERSGA region were modified to suit the mangroves found in the region and are presented in Annex 3.4 together with a description of how to complete these survey forms. Other key points to note about monitoring mangroves are as follows:

- Aerial photography and satellite imagery can be used to determine the extent of salt marshes and mangrove forests, and to determine different vegetation zones. Higher spatial resolution data also allows for tree counts to be made within mangroves and channel systems to be mapped within salt marshes.
- It is possible to measure height and girth at breast height for trees individually along a transect perpendicular to the shore. If stands are too dense to penetrate then the Transect Line Plot method of English *et al.* (1997) is recommended.
- On saltmarshes, the vegetation cover can be quantified using 1 m^2 quadrats (5 replicates) at intervals across the marsh. Depending on plant size, density (number of plants of each species per quadrat), or cover (area of each species per quadrat when viewed from above), estimates can be taken to quantify species and abundance. Care is needed in designing the sampling strategy if large plants such as *Phragmites* dominate (Dalby, 1987).
- In mangroves it is likely that species from rocky shore species, such as barnacles and mangrove oysters (*Saccostrea*), may be found on mangrove trunks and pneumatophores and some sand dwellers. Smaller quadrats (10 x 10 cm), with five replicates, can be used to quantify these types of sessile fauna.

3.4 Strengths / Weaknesses

Strengths	Weaknesses
• Survey methods are easy to follow and allow for surveyors to train community members to participate in the surveys. • Methodologies allow collection and transfer of data on a readily accessible basis. • Permanent monitoring survey data can be used in EIAs and other management interventions. • Data collected during in-field surveys can also be used for ground-truthing satellite imagery, which can be used at local, national and regional levels.	• Due to tidal regimes, surveys have to be timed appropriately to ensure ease of completion and safety. • Some of the equipment needed for intertidal surveys are quite expensive and require trained personnel; • GIS and remote sensing are expensive initially, especially in the purchase of the software and surveyor training. • Some tests cannot be carried out in the field so samples have to be brought ashore which can be laborious.

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3.6 Annexes

Annex 3.1 Rapid Coastal Environmental Assessment Surveys

RAPID COASTAL ENVIRONMENTAL ASSESSMENT SURVEYS	
SURVEY INFORMATION	
Country	Record the country code. e.g. **SUD** = Sudan, **YEM** = Yemen, **DJI** = Djibouti. Eec
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Time	Record the time in 24 hr format HH:MM e.g. 10:30
Surveyors	Record the name and / or initials of the surveyors involved in the survey.
Weather	As weather will not usually change much while surveying, it can be recorded at the top of the survey sheet, using the following scale: **1**= Sun, no cloud, **2**= Sun part cloud (<50% cloud), **3**= Sun and cloud (50% and 50%), **4**= Cloud (full cloud), **5** = Cloud and rain.
Wind strength	As wind strength will not usually change much while surveying, so can be recorded at the top of the survey sheet, using the following scale: **1**= none (<4kn), **2**= slight (4-6kn), **3**= moderate (7-10kn), **4**= strong (11-15kn), **5**= very strong (>16kns)
Wind direction	As the wind direction will not usually change much while surveying, it can be recorded at the top of the survey sheet. Use the compass rose (NSEW) to describe which direction the wind is coming from (e.g. is the wind coming from the SE etc.).
SITE INFORMATION	
Waypoint	Record the GPS waypoint number, . You can use the original waypoint number as shown in the GPS.
Site description	Record the site description, such as the life forms present and the benthic composition
Sketch profile	Draw the profile of the site, recording any notable features, such as buildings within the 500m by 500m quadrat.
FLORA	
Mangroves	Record aereal extent of mangrove using the 0-6 logscale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Seagrass	Record aereal extent of seagrass using the 0-6 logscale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Halophytes	Record aereal extent of halophytes using the 0-6 logscale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Algae	Record aereal extent of algae using the 0-6 logscale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Fresh water vegetation	Record aereal extent of freshwater vegetation using the 0-6 logscale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Other	Record aereal extent of other flora using the 0-6 logscale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
FAUNA	
Reefs and corals	Record aereal extent of coral reef and corals within the area using the 0-6 logscale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Birds	Record number of individual birds using the 0-6 logscale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Turtles	Record number of individual turtles using the 0-6 logscale; record swimming / feeding turtles in the subtidal separately from nesting turtles; insert a "x" in the third column to indicate their occurrence outside of the quadrat.

Mammals	Record number of individual mammals using the 0-6 logscale, and record type (e.g. goats, sheep, dogs, dugong); insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Fish	Record number of individual fish using the 0-6 logscale; record swimming / feeding turtles in the subtidal separately from nesting turtles; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Invertebrates	Record number of other invertebrates using the 0-6 logscale; and make a note of the type; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Other	Record number of individual other fauna using the 0-6 logscale; and record the type in the second column; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
IMPACTS	
Construction	Record aereal extent of construction and development (e.g. jetties) using the 0–6 log scale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Fishing/Collecting	Qualitative assessment of relative magnitude of fishing using 0–6 scale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Metal	Record the number of metallic litter items using the 0–6 scale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Plastics	Record the number of plastic litter items using the 0–6 log scale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Wood	Record the number of driftwood litter items using the 0–6 log scale; insert a "x" in the third column to indicate their occurrence outside of the quadrat.
Other	Record other impacts such as crown-of-thorns (CoT) starfish and CoT scars, using the log number 0–6 scale. Record the extent of recent coral bleaching (white) and algal turf on coral/reef, using the areal extent log 0–6 scale.
Comments	Record any other comments about the site.
Photographs	Record the start and end number of the photographs. There are different ways to help distinguish between the photographs from different sites. You can write the GPS waypoint number on a sheet of paper and photograph the number. You can photograph the survey form between sites, or the GPS screen showing the waypoint.

RAPID COASTAL ENVIRONMENTAL ASSESSMENTS **Survey Sheet No. ---------**

(Adapted from PERSGA/GEF 2004)

Country:	**Location:**	**Date:**	**Time:**
Surveyors:	**Weather:**	**Wind Strength:**	**Wind Direction:**
GPS Waypoint (centre)**:**	**Site Description:**		

SKETCH PROFILE	m m

1	Mangroves				FLORA
2	Seagrass				
3	Halophytes				
4	Algae				
5	Fresh water vegetation				
6	Other				
7	Reefs and corals				FAUNA
8	Birds				
9	Turtles				
10	Mammals				
11	Fish				
12	Invertebrates				
13	Other				
14	Construction				IMPACTS
15	Fishing/Collecting				
	Metal				
17	Plastics				
18	Wood				
19	CoTs / Scars				OTHER
20	CoT Scars				
21	Bleaching				
22	Algal turf				

Photographs	
Comments	

Annex 3.2 Beach Profiles

BEACH PROFILE	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti, etc.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 20150312 for the 12th March 2015.
Time	Record the time the survey was conducted.
Surveyors	Record the initials for the surveyors involved in the survey.
Weather	Record the weather using the following scale: **1**= Sun, no cloud; **2**= Sun part cloud (<50% cloud); **3**= Sun and cloud (50% and 50%); **4**= Cloud (full cloud); **5** = Cloud and rain
Wind strength	Record the wind strength using the following scale: 1= none (<4kn) 2= slight (4-6kn), 3= moderate (7-10kn), 4= strong (11-15kn), 5= very strong (>16kns)
Wind direction	Record wind direction using the compass rose to describe which direction the wind is coming from (e.g. SE or SSE)
SITE INFORMATION	
GPS Waypoint	Record the starting GPS waypoint number (you can use the original waypoint number as stored in the GPS).
Photographs	Take a photograph along the beach in either direction and up and down the beach, and any other observations. Record the start and end number of the photographs for the site. There are different ways to help distinguish between the photographs from different sites. You can write the GPS waypoint number on a sheet of paper and photograph the number. You can photograph the survey form between sites, or the GPS screen showing the waypoint.
Beach profile	Sketch the beach profile as the measurements are recorded. Also record the GPS waypoint number of each profile step (you can use the original waypoint number as stored in the GPS).
Observations	Write a brief description of what you observe mentioning any human activities that are occurring or take place within close proximity to the survey area, any sign of erosion or accretion or any other relevant information that can be used in long term monitoring.
Beach measurements	Record the following measurements to the nearest centimetre: • Vertical distance from the top of the reference mark to ground level (in metres). • Length of beach segments at each break of slope until the endpoint (in metres). • Segment slope at each break of slope until the endpoint (in degrees and minutes).
Comments	Record any additional observations.

BEACH PROFILE
(Adapted from UNESCO, 2010)

Country:	Location:	Date:	Time:
Surveyors:	Weather:	Wind strength (1-5):	Wind direction (NSEW):

Beach Profile

Observation (anything of interest e.g. presence of pits, indication of sand mining etc...):

Measurement from the top of the reference mark (in metres):

Segment	GPS waypoint	Length of segment (m)	Slope angle (degrees and minutes)	Photographs	Comments
A-B					
B-C					
C-D					
D-E					
E-F					
F-G					
G-H					

Annex 3.3 Key Species Surveys

KEY SPECIES SURVEYS	
SURVEY INFORMATION	
Country	Record the country code. e.g. **SUD** = Sudan, **YEM** = Yemen, **DJI** = Djibouti. E**tc**
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Time	Record the time in 24 hr format HH:MM e.g. 10:30
Surveyors	Record the name and / or initials of the surveyors involved in the survey.
Weather	As weather will not usually change much while surveying, it can be recorded at the top of the survey sheet, using the following scale: **1**= Sun, no cloud, **2**= Sun part cloud (<50% cloud), **3**= Sun and cloud (50% and 50%), **4**= Cloud (full cloud), **5** = Cloud and rain.
Wind strength	As wind strength will not usually change much while surveying, so can be recorded at the top of the survey sheet, using the following scale: **1**= none (<4kn), **2**= slight (4-6kn), **3**= moderate (7-10kn), **4**= strong (11-15kn), **5**= very strong (>16kns)
Wind direction	As the wind direction will not usually change much while surveying, it can be recorded at the top of the survey sheet. Use the compass rose (NSEW) to describe which direction the wind is coming from (e.g. is the wind coming from the SE or NW etc.).
SITE INFORMATION	
GPS waypoint	Record the GPS waypoint number of the capture location. You can use the original waypoint number as stored in the GPS.
Site description	Record the site description, such as the life forms present and the benthic composition
Photographs	Record the start and end number of the photographs. There are different ways to help distinguish between the photographs from different sites. You can write the GPS waypoint number on a sheet of paper and photograph the number. You can photograph the survey form between sites, or the GPS screen showing the waypoint.
BIOLOGICAL AND PHYSICAL CHARACTERISTICS INFORMATION	
Species occurrence	Record the presence, number and distribution of species within the quadrats found within the survey area.
Colonisation assessment	Record the number of species, species identification and distribution of colonized species within the survey area.
Biological characteristics	Record the presence of any transient organisms (flora and fauna), their numbers and distribution across the shore profile.
Sediment samples	Record the date, time and location of the sediment samples collected at each monitoring station of the survey area.
Water quality	Record the following measurements: • Temperature • Salinity • pH

KEY SPECIES– SAND BEACHES
(Adapted from: Jones 2004).

Country:	**Location:**	**Date:**	**Time:**
Surveyors:	**GPS 1** (littoral fringe):		**GPS 2** (subtidal fringe):
Air Temp (°C):	**Weather (1-5):**	**Wind strength (1-5):**	**Wind direction (NSEW):**

KEY SPECIES - SAND BEACHES								
	P/A	**R**	**O**	**C**	**A**	**D**	**Photo?**	**Sample?**
LITTORAL FRINGE								
Coenobita scaevola								
Ocypodes aratan								
Ocypode cordimana								
Tylos exiguous								
Talor chestia martensi								
Other								
UPPER EULITTORAL								
Eurydice arabica								
Excirolana orientalis								
Uca inversa inversa								
Uca lacteal albimanus								
Serenella leachii								
Macrophthalmus depressus								
Other								
LOWER EULITTORAL								
Hippa picta								
Hippa celaena								
Oliva bulbosa								
Nassarius clathratus								
Macrophthalmus depressus								
Other								
SUBLITTORAL FRINGE								
Echinodiscus auritus								
Holothuria arenicola								
Calappa hepatica								
Thalamita savignyi								
Halodule uninervis								
Astropecten polycanthus								
Thalassodendro nciliatum								
Other								

Key: P/A = present/absent; R = rare; O = occasional; C = common; A = abundant; D = dominant

NOTES:

Key species– Rocky Shores
(Adapted from: Jones 2004).

Country:	Location:	Date:	Time:
Surveyors:	GPS:		
Air Temp (°C):	Weather (1-5):	Wind strength (1-5):	Wind direction (NSEW):

KEY SPECIES - ROCKY SHORES								
	P/A	**R**	**O**	**C**	**A**	**D**	**Photos?**	**Sample?**
LITTORAL								
Nodolittorina natalensis								
Planaxis sulcatus								
Acanthopleura vaillantii								
Ligia pigmenta								
Chthamalus sp.								
Chiton peregrinus								
Grapsus albolineatus								
Other								
UPPER EULITTORAL								
Nerita undata								
Nerita politaor bignyana								
Cronia konkanensis								
Thais savignyi								
Metapograpsusmessor/thukuhar								
Cella narota								
Balanus amphitrite								
Tetraclita squamosal								
Enteromorpha sp.								
Other								
LOWER EULITTORAL								
Nerita albicilla								
Morula granulate								
Laurencia papillosa								
Saccostrea cucullata								
Ophioco mascolopendrina								
Echinometra mathaei								
Other								
SUBTIDAL FRINGE								
Zoanthus natalensis								
Echinometra mathaei								

Sargassum sp.								
Turbinaria sp.								
Colpomenia sinuosa								
Corals								
Other								

Key: P/A = present/absent; R = rare; O = occasional; C = common; A = abundant; D = dominant

KEY SPECIES– MUDFLATS, SALTMARSHES AND MANGROVE FORESTS
(Adapted from: Jones 2004).

Country:	Location:	Date:	Time:
Surveyors:	GPS:		
Air Temp (°C):	Weather (1-5):	Wind strength (1-5):	Wind direction (NSEW):

	Sample 1	Sample 2	Sample 3
Subsurface temp(°C):			
pH			
Salinity (‰)			
Dissolved O_2 (mg/L)			
Eh			

	P/A	**R**	**O**	**C**	**A**	**D**	**Photos?**	**Sample?**
LITTORAL FRINGE								
Microbial mats (Cyanophyta)								
Suaeda monoica								
Zygophyllum qartarense								
Arthrocnenum macrostachyum								
Aeluropus/Juncus								
Avicenna marina								
Rhizophora mucronata								
Uca inversa								
Dotilla sulcate								
Littorina scabra								
Serenella leachii								
UPPER EULITTORAL								
Uca tetragonon								
Uca lacteal albimana								
Metapograpsus messor								
Pirinella conica								
Cerithidea cingulate								
Periophthal muskoelreuteri								
Avicennia marina								
Rhizophora mucronata								
LOWER EULITTORAL								
Potamides conicus								
Macrophthalmus depressus								

Pinna bicolor								
SUBLITTORAL FRINGE								
Scylla serrata								
Portunus pelagicus								
Halophila ovalis								
Halodule uninervis								

Key: P/A = present/absent; R = rare; O = occasional; C = common; A = abundant; D = dominant

MUDFLATS AND MANGROVE FOREST SURVEY	
SURVEY INFORMATION	
Country	Record the country code. e.g. **SUD** = Sudan, **YEM** = Yemen, **DJI** = Djibouti. E**tc**
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Time	Record the time in 24 hr format HH:MM e.g. 10:30
Surveyors	Record the name and / or initials of the surveyors involved in the survey.
Weather	As weather will not usually change much while surveying, it can be recorded at the top of the survey sheet, using the following scale: **1**= Sun, no cloud, **2**= Sun part cloud (<50% cloud), **3**= Sun and cloud (50% and 50%), **4**= Cloud (full cloud), **5** = Cloud and rain.
Wind strength	As wind strength will not usually change much while surveying, so can be recorded at the top of the survey sheet, using the following scale: **1**= none (<4kn), **2**= slight (4-6kn), **3**= moderate (7-10kn), **4**= strong (11-15kn), **5**= very strong (>16kns)
Wind direction	As the wind direction will not usually change much while surveying, it can be recorded at the top of the survey sheet. Use the compass rose (NSEW) to describe which direction the wind is coming from (e.g. is the wind coming from the SE or NW etc.).
BIOLOGICAL AND PHYSICAL CHARACTERISTICS INFORMATION	
Water Quality assessment	Record the date, time, location of water samples collected during the survey for water quality analysis at each monitoring station. Also, record the following *in situ*: • Water temperature • Turbidity • Depth
Sediment samples	Record the date, time and location of the sediment samples collected at each monitoring station of the survey area.
Transient species composition	Record the composition, distribution and number of transient species encountered during the time of survey within the mangrove forests.
Propagule Emergence	Record the presence of any propagule emergence sighted within the survey area to assess long term colonization of the mangrove forests.
Biological characteristics	Record the presence of any resident organisms (flora and fauna), their numbers and distribution across the mangrove profile within the monitoring stations.
SITE INFORMATION	
GPS Waypoint	Record the GPS waypoint number of the monitoring stations (you can use the original waypoint number as stored in the GPS).
Description	Record the site description, such as types of substrate, vegetation present and zonation patterns..
Threats	Record potential threats present during survey that may hinder successful mangrove proliferation.
Photographs	Record the start and end number of the photographs. There are different ways to help distinguish between the photographs from different sites. You can write the GPS waypoint number on a sheet of paper and photograph the number. You can photograph the survey form between sites, or the GPS screen showing the waypoint.
Other information	Write a brief description of what you observe, mentioning any human activities that are occurring or take place within close proximity to the survey area or any other relevant information that can be used in long term monitoring.

Parameters	Sample 1	Sample 2	Sample 3
Date & Time			
GPS Coordinates			
Depth			
pH			
Temperature (°)			
Salinity *(‰)*			
Dissolved Oxygen (mg/L)			
Turbidity			
Nutrients			
Chlorophyll a			
Organic and Inorganic pollutants.			
Other information: include details of weather conditions, habitat types, presence of marine life and disturbances e.g. oil spill.			

MANGROVE SURVEY SHEET I
Physical data and general visual assessment

Site: **Date:** **Location:**

A) Physical readings:

Variable	Station											
	Littoral fringe			Upper Eulittoral			Lower Eulittoral			Sublittoral		
	R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3
Air Temp. (°C)												
Surface sediment Temp. (°C)												
Interstitial Salinity ppm												
Interstitial pH												
Eh (mv)												
Oxygen conc. (mg/l)												

B) Remarks on sediments characteristics

	Littoral fringe	Upper Eulittoral	Lower Eulittoral	Sublittoral
Mud content: *1=v. low; 2=low; 3=moderate; 4=high; 5=v. high*				
Sediment depth *(cm)*				
Colour (e.g. pale, light brown, dark brown, black)				

B) Standardized visual assessment of human impacts

Insert (Y) or (N); If yes, evaluate the impact as very low=1, low=2, moderate=3, high=4, or very high=5

Impact	Y/N	Evaluation				
Camel grazing		1	2	3	4	5
Wood cutting		1	2	3	4	5
Diverting or damming freshwater/ runoff		1	2	3	4	5
Diverting or damming tidal water		1	2	3	4	5
Oil residues or oil sheen		1	2	3	4	5
Garbage or other refuse		1	2	3	4	5
discharge of industrial waste from factories		1	2	3	4	5
discharge from aquaculture/ agriculture		1	2	3	4	5
Impacts from fishery activities		1	2	3	4	5
Impacts from salt pans		1	2	3	4	5

C) Other remarks:

MANGROVE SURVEY SHEET II
Mangrove vegetation

Site: **Date :** **Location :**

A) **Quadrate data:**

Variables and characteristics	Quadrate position			
	Littoral fringe	Upper Eulittoral	Lower Eulittoral	Sublittoral
I) Mangrove trees and seedlings (Quadrate size 10X10m)				
Total number of trees				
Height range (m)				
GBH range (cm)				
Dead standing trees				
Dead felled trees				
Heavily grazed trees and shrubs				
Mature trees with dropped limbs				
Trees with top dying uppermost and outermost sun branches				
Multi-stemmed trees				
Number of seedlings				
Dead seedlings				
Deformed propagules and seeds (1)				
Leaves with spotty chlorosis and necrosis(1)				
Twisting and curling leaves (1)				
II) Pneumatophores (Quadrate size 0.5X0.5m):				
Density of pneumatophores				
Branched pneumatophores				
Twisting and curling pneumato-phores				
Pneumatophore height range (cm)				
Pneumatophores with dead tips				

(1) *Indicate as not recorded=0, few=1, moderate=2, or many=3*

B) Comments on stand size and density:

C) Other notes:

MANGROVE SURVEY SHEET II
Mangrove vegetation

Site: **Date :** **Location :**

Species	Abundance (1)				Comments
	Upper fringe	Upper Eulittoral	Lower Eulittoral	Sub-littoral	

(1) Describe as 1=rare 2=Occasional, 3=Common , 4=Abundant or 5=Dominant

Other notes

4

Seawater Quality

4. SEAWATER QUALITY

4.1 Background

The measurement of ambient environmental conditions and seawater properties is an integral part of most marine monitoring programmes used to characterise sites and explain spatial variations between sites or over time due to changes in depth, oceanographic conditions, weather (e.g. wind, solar irradiation, or precipitation) and human impacts. The natural properties of seawater can be negatively affected by marine or land-based activities, which may introduce contaminants, via point or non-point sources including waterways, outfalls or pipelines, or from boats, rigs or other sources at sea. Contaminants might include solid waste, sediments, nutrients, heavy metals, organic compounds, hydrocarbons or pathogens (bacteria or viruses), which can degrade the quality of seawater and threaten sensitive marine habitats and flora and fauna. The degradation of seawater quality is recognised as one of the major global threats to marine biodiversity. Sensitive critical habitats, such as mangroves, seagrass beds and coral reefs that exist close to shore are most often exposed to these types of human influences. These habitats and the associated fauna provide a range of vital ecosystem goods and services for human populations; therefore, monitoring coastal and marine water quality provides information important for human as well as marine ecosystem health.

Land-based activities are usually the main source of pollution in coastal waters (e.g. agriculture, deforestation, urban or industrial development). Contaminants may be transported into the sea by the wind, including wind-blown dust, or via waterways and outfalls, particularly when there is flash flooding. Sediments introduced from the land into the sea may be suspended in the water column, reducing water clarity and preventing light from reaching the seabed. Suspended sediments can impact upon photosynthetic organisms including algae, seagrass and corals. When sediments settle on the seabed, the fine particles can smother benthic organisms; block the filter-feeding apparatus of benthic fauna, causing stress due to the additional energy required by the animal to clear the sediment. Land-derived run-off can also transport other contaminants, such as nutrients, heavy metals, pesticides and herbicides, which may have lethal or other sublethal effects on marine life. Untreated or partially treated sewage, animal or industrial waste, and aquaculture can introduce nitrogen and phosphorous, which can stimulate the growth of phytoplankton, and lead to eutrophication. Nutrients can also promote the growth of benthic algae, which can outcompete and overgrow other benthic organisms and result in green tides.

Some countries in the region have adopted water quality standards (e.g. Kingdom of Saudi Arabia, Egypt, and Jordan). These nationally adopted water quality standards typically provide specific guidance on:

- parameters to be monitored;
- sampling locations and frequency;
- sampling methods and equipment;
- schedules for sampling;
- methods for quality assurance and validation of sampling results;
- requirements for checking and interpreting results;
- responsibilities and necessary qualifications of staff;
- requirements for documentation and management of records;
- data be recorded and sorted; and

- detailed requirements for reporting and communicating results.

The analytical testing methods for determining compliance with water quality standards is often set to accord with the most recent edition of the Standard Methods for the Examination of Water and Wastewater published by the American Public Health Association (APHA)[9].

4.2 Overview

4.2.1 General approach

Marine water quality monitoring programmes involve the regular measurement of a suite of variables at a series of sampling sites at fixed intervals through time. Some variables can be measured *in-situ,* while others need to be measured in the laboratory, using water samples taken from the field. Several of the standard global protocols to monitor the conditions of tropical coastal and marine habitats integrate water quality monitoring (e.g. English *et al.* 1997). The variables included in these programmes are known determinants of habitat condition (e.g. seawater temperature, salinity, turbidity), and are relatively easy to measure as they do not require expensive equipment or high levels of specialised training. Monitoring of other variables, such as heavy metals or other contaminants, requires access to specialist field instruments, well-equipped laboratories and trained staff. In recent years, there has been an increase in the availability of instruments that can simultaneously record multiple parameters and data loggers that allow for the continuous *in-situ* recording of certain variables. These multiparameter probes and data loggers can increase the frequency and range of data that can be collected *in-situ* and some reduce the need for laboratory equipment. Specialised training is needed in how to use and maintain the equipment.

4.2.2 Target

There are many indicators that can be included in a seawater quality monitoring programme. The primary indicators covered in this chapter, and the core variables that should be recorded in any seawater quality monitoring programme, are as follows:

- Temperature
- Salinity
- Turbidity

The secondary indicators covered here, are also very important, but they require more equipment and staff trained in how to use the equipment:

- Dissolved oxygen
- Nutrients
- Chlorophyll *a*
- Light
- pH
- Organic and inorganic pollutants.

The other parameters that may be included in a water quality monitoring programme are listed in Table 4.1. Several countries in the region have adopted national standards for monitoring seawater quality. So before establishing a new monitoring programme it would advisable to check if there are any pre-existing standards and official protocols that need to be followed.

9 https://www.standardmethods.org/

Table 4.1 Water quality parameters measured in the laboratory

Laboratory analysis of seawater	Method/Equipment
Nitrate	Standard Colorimetric Method (e.g. Parsons et al 1985; Greenberg et al 1992; IOC/UNESCO, 1993)
Phosphate	Standard Colorimetric Method (e.g. Parsons et al 1985; Greenberg et al 1992; IOC/UNESCO, 1993)
Silicate	Standard Colorimetric Method (e.g. Parsons et al 1985; Greenberg et al 1992; IOC/UNESCO, 1993)
Oil & Grease	Standard Methods, APHA (1995)
Trace Metals (Cu, Pb, Zn, Cd, Cr)	Atomic Absorption Spectrophotometry (AAS)
Turbidity	Turbidity Meter
Suspended Particulate Matter (SPM)	Filtration and weighing
Sedimentation	Sediment trap analysis
Faecal coliforms (FC)	Standard Methods, APHA (1995)
Total coliforms (TC)	Standard Methods, APHA (1995)
Faecal Streptococci (FS)	Standard Methods, APHA (1995)

4.2.3 Field personnel

The regular measurement of *in-situ* parameters and collection of surface water samples can be done from the shore or from a small boat. A minimum of two surveyors are needed to ensure that samples are collected and processed in a timely manner, and for health and safety reasons while working at sea. Surveyors must at least be comfortable working at sea and willing to work in different weather and sea conditions, and preferably good at swimming and snorkelling. If SCUBA diving is required, the surveyors should be certified in SCUBA diving.

4.2.4 Training/experience

The degree of training and experience required depends on the method and instruments being used in the water quality monitoring programme. The Level 1 protocols included here are easily implementable with a basic level of training. The Level 2 and 3 protocols involve the use of instruments that may require calibration in the laboratory before each use and maintenance as well as access to wet-lab facilities and staff trained in the laboratory procedures. The calibration and routine maintenance of instruments, such as multiparameter probes, CTD and data loggers (e.g. data, downloads, cleaning and changing batteries), requires specialist training. Monitoring teams need to be trained in how to properly use the field instruments, calibration, maintenance and laboratory procedures, as well as data handling and analysis.

4.3 Field Procedure

The following outlines the procedures involved in a basic water quality monitoring survey, adapted from various sources (English *et al.* 1997; Howarth, 2011; National Park Services, 2013).

4.3.1 Field equipment

The following survey equipment is required to conduct a basic seawater quality monitoring:

- Water quality survey forms, clipboard and pencil, and eraser.

- GPS to record the location of where water samples have been collected.
- Water sampling bottles (wide necked dark glass bottles), labels and permanent marker.
- Cool box with ice
- Refractometer
- Mercury thermometer encased in protective housing ±0.5°C
- Secchi disc
- Additional equipment that can be used if available include:
- Conductivity Temperature Depth (CTD) meter
- Seawater temperature data loggers
- Turbidity meter (or multiparameter probe).
- Dissolved oxygen meter (or multiparameter probe)
- pH meter (or multiparameter probe)
- Portable light meter (e.g. LiCOR 1000 quantum meter).
- Photometer (Palintest) for testing other water quality parameters.

4.3.2 Survey / Sampling Design

Designing a marine water quality monitoring programmes requires the selection of sampling sites. These would normally include a set of regular sampling sites and another set of sites that would be sampled less frequently for comparative studies, and to provide greater temporal and spatial variability. To maximise efficiency in the field, marine water quality sampling sites may be located at long term beach, coral reef, seagrass or mangrove monitoring sites. Sampling sites would normally be visited more frequently, particularly at the start of the monitoring programme, to determine the variation during the baseline. Replicate measurements and water samples are normally taken at each site.

4.3.3 Preparation before entering the field

- The survey team should prepare the water sampling instruments, water sampling bottles, survey forms and other equipment.
- The water sampling bottles should be checked for leaks and each one being labelled in advance with the name/number of sites, replicate number and/or depth and date.
- Fill one small cooler box with ice and pack the bottles into the cool box.

4.3.4 Temperature

Recording temperature using a thermometer (Level 1)

- Hold a thermometer 30 cm below the surface of the water;
- Wait 1 minute to allow time for the thermometer to equilibrate with the temperature of surrounding water;
- Read the temperature while the thermometer is still submerged;
- Record the temperature on the survey form.
- Repeat the measurement 3 times per sampling site.
- If recording temperature at different depth ranges associated with survey transects, this may involve snorkelling or SCUBA diving and should only be conducted by an appropriately qualified surveyor.

Recording temperature using a temperature probe (Level 2)

- Switch on the handset and then hold the probe using the cable over the side of the boat, into the oncoming current away from the engine.
- Submerge the probe to 30cm below the sea surface and allow the temperature to equilibrate.
- Read the temperature from the screen while the probe is still submerged and record it on the survey form.
- If recording temperature at more depths,

lower the probe to the required depth, wait for the temperature to stabilise, then read the temperature from the screen and record it on the survey form.

Recording temperature using data loggers (Level 3)

Data loggers can be used to record *in-situ* seawater temperature data. The advantage of *in-situ* data loggers is that they can provide a continuous record at different stations and depths throughout the day and night instead of a one-off measure. The disadvantage with data loggers is that they need to be set up and maintained, and the data is only available when the loggers are downloaded. The alternative is to use a conductivity temperature and depth logger (CTD) or multi-parameter probe/sonde as described below.

There are several different types of underwater temperature data loggers available. The most commonly used models are the Onset Hobo™ loggers, due to their low cost and wide availability (Figure 4.1). These types of temperature loggers need to be setup before they are deployed using the proprietary software that is supplied with the logger.

The basic option (HOBO UA-001-08 8K Pendant Temp Logger) records temperature at different time intervals (Figure 4.1a), alternative option is the (HOBO U22-001 Hobo Water Temp *Pro* v2) which has a higher depth rating and longer battery life (Figure 4.1c). There is also another logger type that records both temperature and light levels (Figure 4.1b).

The survey team needs to have a copy of the software and connector / download device. There are two types of connectors for the Onset loggers, one for the pendant type loggers (Figure 4.1d) and another that can be used for both the pendants and Pro v2 (Figure 4.1e). Onset also provides a field data shuttle that can be used to download the data while still at sea (Figure 4.1f). This is a convenient addition when it is necessary to download and replace loggers in locations that are not frequently visited.

The procedure for setting up data loggers will be specific to each device. Presented below is an outline procedure that would be used with one of Onset temperature loggers:

- Decide on a sampling interval (i.e. how frequently data is recorded). The more frequently data is logged, the faster the on-board memory is taken up. So the interval also affects how often the data logger needs to be collected, downloaded and replaced.
- Connect the data logger to the computer using the correct USB connector cable.
- Launch the software and follow the software instructions on how to correctly set up the logger interval and how to launch the logger to start recording data. (Onset loggers allow the user to set-up a delayed start date and time).
- When the logger set-up procedure is completed, close the software and disconnect the USB connector from the computer.
- Pack the logger in a cool dark location while transporting to the site to avoid over-heating, which can affect the battery life.
- On arriving at the survey station, find a suitable area where the data logger can be securely attached to the substrate. This might be a demarcation buoys, a concrete block, or a permanent marker stake on a monitoring site.
- To connect the data logger to the substrate, use plastic cable ties and / or plastic coated wire. (Fish will nip at unusual coloured objects, so it is important to use multiple cable-ties and plastic coated wire in combination).
- Recover the data logger and download the data.

(a)

(b)

(c)

(d)

(e)

(f)

Figure 4.1 (a) Onset Hobo Pendant (temperature only) (b) Onset Hobo Pendant (temp. and light) and (c) Hobo Water Temp Pro v2 (d) HOBO BASE-U-1 Optic Base Station (only for use with pendants) (e) HOBO Optic USB Base station (for use with pendants or pros) (f) HOBO U-DTW-1 Waterproof Data Shuttle (for use with pendants or pros)

4.3.5 Salinity

Recording salinity using a refractometer (Level 1)

- Collect a water sample from the surface and at depth of the survey (see below).
- To use a refractometer to measure the salinity, use a pipette to place a drop of seawater under the refractometer cover.
- Hold the refractometer cover down, look through the eyepiece facing the instrument into the light so that salinity can be read.

Recording salinity using a CTD (Level 2 & 3)

A conductivity, temperature, and depth (CTD) instrument allows for the simultaneous recording of salinity, temperature across different depth ranges or profiles. One such instrument is the highly portable SonTek Castaway CTD (Figure 4.2). This CTD can be connected to a dive reel and deployed by hand over the side of a small boat. The device includes an integrated GPS and depth profile data can be downloaded to the computer using BlueTooth. The Castaway CTD records the following parameters:

- Salinity (±0.1 PSU)
- Density (990 to 1035 kg/m^3, ± 0.02 kg/m^3)
- Temperature (-5 to +45°C, ±0.05°C)
- Depth (0 to 100 m, ±0.01 m)
- Integrated GPS position to 10m depth

(a) (b)

Figure 4.2 Sontek CastawayTM CTD showing (a) CTD in the carrying case and (b) CTD ready to be deployed, attached to a dive reel at the top using caribiners and a dive weight at the base.

4.3.6 Turbidity

Recording visibility using a Secchi Disk (Level 1)

Clarity of water is important in producing products destined for human consumption and in many manufacturing operations. Beverage producers, food processors, and potable water treatment plants drawing from a surface water source commonly rely on fluid-particle separation processes such as sedimentation and filtration to increase clarity and ensure an acceptable product. The clarity of a natural body of water is an important determinant of its condition and productivity.

Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted with no change in direction or flux level through the sample. Correlation of turbidity with the weight or particle number concentration of suspended matter is difficult because the size, shape, and refractive index of the particles affect the light-scattering properties of the suspension.

Vertical visibility is a proxy measure of turbidity, which can be measured using a Secchi disk. The disc is attached to a weighted rope marked at 2 or 5m intervals. The disk itself is painted in alternating black and white quadrants.

- On arriving at the site, record the GPS position
- Lower the Secchi disc over the side of boat until the disk is no longer visible.
- Slowly bring the disk back up towards the surface until it becomes visible.
- Record the distance between the disk and the surface, using the marks on the rope as a guide while bringing the Secchi disk back onboard the boat.

Recording visibility on survey transects (Level 1)

Horizontal visibility is another proxy measure of turbidity, often estimated by SCUBA divers. This can be more accurately measured using a transect tape and Secchi disk underwater if the team members are working on transects at permanent monitoring sites.

- On arriving at the survey depth, one buddy pair swims into the distance along the transect carrying the Secchi disk, while the other buddy pair remains stationary.
- The stationary buddy pair signals the other buddy pair when the Secchi disk is no longer visible using an underwater rattle.
- The divers then swim slowly back bring the disk back into view. When the stationary buddy pair can see the Secchi disk they signal the other diver and record the distance along the survey tape.

Turbidity Meter (Level 3)

There are various instruments that have been developed to record turbidity. These include transmisso-meters, photometric turbidity meters and multi-parameter probes. A transmisso-meter measures the amount of particulate matter in-situ. A turbidity meter requires taking a water sample which is then tested *in-situ* or back in the lab. A multi-parameter probe (e.g. YSI ProDSS Handheld Multi-parameter Water Quality Meter) provides the option of recording various parameters including turbidity.

4.3.7 Other *in-situ* water quality monitoring methods (Level 2 & 3)

If the survey team is more experienced, and other instruments are available and staff are trained in how to use these instruments, then the above field methods for temperature, salinity, and turbidity can be replaced.

Light sensors (Level 3)

Corals and other photosynthetic organisms are dependent upon photosynthetically active radiation (PAR). The recording of PAR requires the use of a specialized sensor known as a PAR sensor. The most popular make available is the model produced by LiCOR. There are also small standalone PAR data loggers (e.g. Odyssey Light Loggers) that can be used to record PAR continuously *in-situ* underwater or on land, or both for comparative purposes.

Dissolved Oxygen (Level 3)

The dissolved oxygen (DO) content in natural water and waste water depends on the physical, chemical, and biochemical activities in a waterbody and it is a key test of water pollution. The DO content of seawater is very important for marine fauna as sustained exposure to low levels of dissolved oxygen (<6mg/l) can be fatal if sustained for periods of 24 hour or more. The measurement of DO can be done *in-situ* using a DO probe. There are various types of DO probes available, ranging from pocket sized probes and multi-parameter probes (see below). Alternatively DO can be tested in the laboratory using the Winkler method.

pH (Level 3)

Measurement of pH is one of the most important tests in water chemistry, as it affects many other components and tests (e.g. pH is used in alkalinity and carbon dioxide measurements and many others). At a given temperature the intensity of the acidic or basic character of a solution is indicated by pH or hydrogen ion activity. The acidity or alkalinity of seawater is measured by pH, which should range between 7.5 to 8.5. pH can be measured using a pH meter, using photometric methods or by using a multi-parameter probe.

Multi-parameter Sonde (Level 3)

There are now various multi-parameter probes or sondes on the market that can be used to simultaneously measure multiple marine water quality parameters (Figure 4.3). These types of probes or sondes can be deployed from the side of small boat and used to measure different parameters over multiple depth ranges to collect a depth profile or they can be left *in-situ* to record changes in multiple parameters over time. The sondes require careful handling and proper calibration in the laboratory before being deployed, all of which requires specialist training. An example of the parameters that can be measured using a multi-parameter probe/sonde include:

- Temperature
- Conductivity
- Specific Conductance
- Salinity
- Resistivity
- Total dissolved solids
- pH
- Oxidation-reduction potential (ORP)
- Depth or level
- Nitrate, Ammonium or Chloride
- Probes with additional optical ports can also be used to measure:
- ROX Optical
- DO
- Turbidity
- Chlorophyll
- Blue-Green Algae (*Phycocyanin* or *Phycoerythrin*)
- Rhodamine

(a)

(b)

Figure 4.3 Examples of the types of multi-parameter probes (a) YSI PRODSS Multi-parameter probe which can monitor up to 4 parameters, it has a hand held device attached which displays the readings. This model can be equipped with a cable up to 100m depth and a built in GPS; (b) YSI 6920 series sonde, which can be attached to a handheld data logger, similar to probe shown above. The sondes offer the potential to monitor more parameters and can be left in-situ for continuous monitoring.

4.3.8 **Taking Water Samples (Level 1)**

The following guidance explains how to collect seawater samples for testing in the laboratory.

- Water sampling can be done while from the shore, from a small boat or when SCUBA diving.
- On arriving at the survey site, complete the first part of the survey form, recording the date, time, name of surveyors, and record a GPS waypoint.
- Other site descriptions, such as the presence of marine flora and fauna, weather conditions, habitat types and any presence of disturbance such as algal bloom or marine debris should also be recorded.
- Water samples should be collected at three depths: at 0.5 cm from the sea surface and two other depths, so as to obtain a depth profile and replicates should be taken at

each depth to help ensure accuracy.

- When collecting water samples, care needs to be taken not to trap air bubbles in the collected samples and to avoid contamination of the sample, which requires rinsing the clean sampling bottles with the water sample on site, before taking the sample.
- When collecting water samples from the shore:
    - ◊ Wade into the water until over your knees and proceed as from boat
    - ◊ Avoid wave exposed sites
    - ◊ Avoid sites close to rubbish and areas where there are fishing boats (unless this is the reason for the surveys);
    - ◊ Keeping the lid on the bottle, submerge the bottle to approximately 30 cm depth;
    - ◊ Open the sampling bottle underwater.
    - ◊ Close the bottle under water and bring to surface.
    - ◊ Empty the bottle and repeat a further two times to flush with water.
    - ◊ Repeat, and the fourth time, keep the water sample.
    - ◊ Repeat the above three times.
- When collecting water samples from a small boat:
    - ◊ Stay on the side of the boat facing the current and at the front of the boat (away from the engine)
    - ◊ Lean over the side of the boat with the sampling bottle with the lid closed.
    - ◊ Open the sampling bottle underwater at approximately 30 cm depth.
    - ◊ Close the bottle under water and bring to surface.
    - ◊ Empty the bottle and repeat three times to flush with water.
- When collecting water samples while SCUBA diving:
    - ◊ Open the sampling bottle under water and flush it with water by applying pressure to the bottle several times before closing it.
    - ◊ Face the bottle into the current in front of you.
    - ◊ Stay about 50 cm above the ground and do not re-suspend sediments/algae etc.
- Once the water sample has been collected, the bottle can be returned to the cool box
- Three replicate samples should be collected at each depth.
- Samples should be taken straight to the laboratory once the surveyors get ashore or sent to a laboratory for analysis.

4.3.9 **Taking Sediment Samples (Level 1)**

Sediment samples were taken using a core or grab (Figure 4.4) from the sea bottom. Each sample collected is transferred to a polythene bag or another suitable storage container, labelled with the site, date and name of surveyors, and placed in a coolbox before being transported back to the laboratory.

Each sediment sample is first washed in freshwater to remove salt and then dried for 24 h in an oven at 60ºC. The sediment sample is cooled in a desiccator to prevent uptake of water from the atmosphere before the test samples are weighed out. Separate portions of the dried salt free sediment sample are then weighed out and used to calculate grain size and organic content.

A 200 g test sample of dried salt free sediment is passed through a series of sieves each of which has a different sized mesh. The sieving process separates the grains into different size fractions. Each size fraction of dried sediment is then weighed separately and the results used to calculate the sediment size class frequency distribution and sorting of bottom sediments.

Another 200 g test sample of the dried salt free sediment is weighed out and placed in a muffle furnace for ashing at 450ºC for 30 minutes. The ashed sediment sample is cooled in a desiccator to prevent uptake of water from the atmosphere before being weighed again. The organic content of the sediment is then calculated as the difference between dry weight of salt free sediment and the desiccated weight of the ashed sediment.

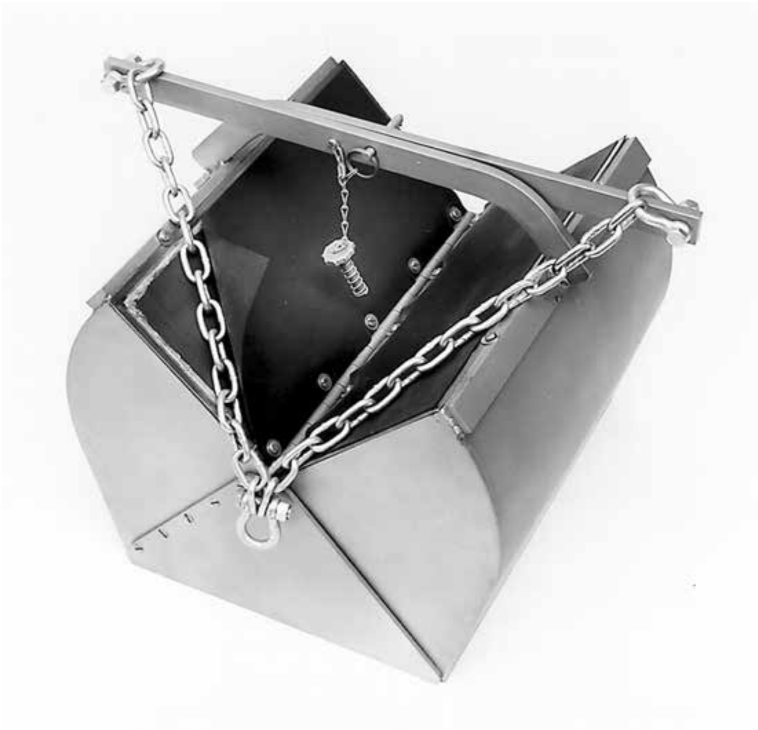

Figure 4.4 Sediment grab (Van Veen Grab)

4.3.10 In the Laboratory

If there is access to a wet-laboratory with trained staff, the marine water samples collected in the field can returned to them for testing. Alternatively, the samples should be sent to a certified laboratory for analysis.

A description of all the methods that may be needed to test marine water quality is beyond the scope of the current manual and the reader is referred to the references contained in Table 4.1 for further details.

The next section provides a description of some of the basic water quality tests that can be completed using a field Photometer. A photometer is a relatively easy piece of equipment to learn to use and can be used to test the following parameters:

◊ Nitrite
◊ Nitrate
◊ Phosphate
◊ Alkalinity (Alkaphot, Alkaphot M, Alkaphot P)
◊ pH
◊ Ammonia
◊

Laboratory Analysis using a Photometer

Photometric measurement, or photometry, is a technique that can be used to measure the concentration of organic and inorganic compounds in solution by determining the absorbance of specific wavelengths of light. Integral to water quality analysis, photometry instruments go beyond simple testers by allowing users to develop a chemical profile of the sample rather than just simple detection of the presence of a chemical compound.

Photometers are designed to measure multiple ion types and are thus equipped with filters able to isolate multiple (often up to 5) wavelengths of light. Beyond the multiple wavelengths, photometers operate much like colorimeters. In a cuvette, test samples are combined with reagents which colorize specific ions. Certain wavelengths of light are passed though the cuvette. Some of the light is absorbed by the colorized test sample depending upon which ions are present and their concentration. Any light that passes through the solution is measured by photodiode or photocell. According to the Beer-Lambert law, the quantity of light absorbed by a substance dissolved in solution is directly proportional to the concentration of the substance.

Figure 4.5 EcoSense 9300 and 9500 Photometer

Preparing your workspace

- Before you get started with the colorimetric water analysis, prepare your workspace.
- Get a data sheet and fill in date, time and place of collection, and start time of analysis.
- Prepare the photometer (Figure 4.5) and check batteries (replace if necessary) and test kits:
    - ◊ Nitrite
    - ◊ Nitrate

- ◊ Phosphate
- ◊ Alkalinity (Alkaphot, Alkaphot M, Alkaphot P)
- ◊ pH
- ◊ Ammonia

- Get out photometer tubes (10 ml) with caps and the rack to stand the tubes, make sure they are clean and dry.
- Get out 20 ml Nitrate-test tubes.
- Get out seawater conditioning reagent (for the Ammonia test) and the small blue spoon
- Get out pistils for crushing and mixing the reagents
- Get out tweezers for handling the chemicals
- Get out pipettes to remove excess water over the 10 ml mark of the test tubes
- Get out the wiper tissue to clean the test tubes from outside
- Get out stop watch for stopping time during the tests
- Gloves for the ammonia test

Always…

- Handle the photometer carefully and with dry hands only
- Use clean and dry test tubes for the water analysis
- Handle test tubes at the upper end only
- Wipe clean the outside of test tubes before inserting them into the photometer
- Use the blank tube on each test before taking a reading of a sample
- Use a new pistil for each test
- Follow test instructions closely, if you forget a point, just repeat the analysis
- Clean up all lab equipment after you have finished the analysis
- Do not let the chemicals dry in the test tubes

Do not…

- Eat or smoke in the laboratory
- Leave chemicals lying around
- Do not eat or drink chemicals
- Do not use scratched test tubes

Completing the analyses

The following analysis takes approximately 2 hours because of the incubation times. This time cannot be shortened and it is best to avoid distractions.

- Fill one test tube with the collected water to the 10 ml mark and close with cap with the 'B' for blank. This tube will be needed before every photometer test.

Nitrite (Nitricol)

- Fill test tube with water sample to 10 ml mark, remove excess water with a clean pipette
- Add 1 nitricol tablet, crush and mix to dissolve using pistil
- Leave the tube to stand for 10 minutes
- Select photometer test 24, by typing 24 on the photometer and confirm by pressing enter.
- Wipe off test tubes from outside
- Read the blank and then the sample (as instructed by the photometer)
- Note down the two values on data sheet, by pressing the arrow key down

Nitrate

- Fill the (special) nitrate-test tubes to 20 ml mark
- Add one level spoon of grey Nitrate test powder (there is a spoon in container)

- Add 1 nitrate-test tablet (from brown bottle). Do not crush.
- Screw cap on test tube and shake well for 1 minute
- Stand for one minute, the gently invert tube 3 times
- Stand for another 10 minutes to ensure chemicals settle, check and stand longer if needed
- Remove cap and wipe, and clean the top of the tube (inside and outside)
- Decant clear solution at the top into a 10 ml test tube without shaking
- Remove excess water with new pipette
- Add 1 nitricol tablet
- Crush and mix to dissolve and then leave it to stand for 10 min
- Select Photometer test 23 by typing 23 on the photometer and confirm by pressing enter.
- Wipe off test tubes from outside
- Read the blank and then the sample (as instructed by the photometer)
- Note down the two values on data sheet, by pressing the arrow key down

Phosphate

- Fill test tube to 10 ml mark
- Add 1 Phosphate No.1 tablet
- Crush and mix to dissolve (approximately 4 minutes)
- Add one Phosphate No.2 tablet
- Crush and mix to dissolve (approximately 4 minutes)
- Leave test tube to stand for 10 minutes
- Select Photometer test 28 by typing 28 on the photometer and confirm by pressing enter.
- Wipe off tubes from outside
- Read the blank and then the sample (as instructed by the photometer)
- Note down the two values on data sheet, by pressing the arrow key down

Alkalinity (Alkaphot)

- Fill test tube to 10 ml mark
- Add 1 Alkaphot tablet, crush and mix until all particles have dissolved
- Leave test tube to stand for 10 min, then remix
- Select Photometer test 2 by typing 2 on the photometer and confirm by pressing enter.
- Wipe off tubes from outside
- Read the blank and then the sample
- Record the three values on data sheet, by pressing the arrow key down

Alkalinity M (Alkaphot M)

- Fill test tube to 10 ml mark
- Add 1 Alkaphot M tablet, crush and mix until dissolved
- Select Photometer test 37 by typing 37 on the photometer and confirm by pressing enter.
- Wipe off tubes from outside
- Read the blank and then the sample
- Record the three values on data sheet, by pressing the arrow key down

Alkalinity P (Alkaphot P)

- Fill test tube to 10 ml mark
- Add 1 Alkaphot P tablet and crush and mix until dissolved
- Leave test tube to stand for 2 minutes
- Select Photometer test 38 by typing 38 on the photometer and confirm by pressing enter
- Wipe off tubes from outside

- Read the blank and then the sample
- Record the two values on data sheet, by pressing the arrow key down

PH (Phenol Red)

- Fill test tube to 10 ml mark
- Add 1 Phenol red tablet, crush and mix until dissolved
- Select Photometer test 27 by typing 27 on the photometer and confirm by pressing enter
- Wipe off tubes from outside
- Read the blank and then the sample
- Record the value on data sheet

Ammonia

- Always use gloves for this test
- Fill test tube to 10 ml mark
- Add 2 level spoons of seawater conditioning reagent with blue spoon, mix to dissolve
- Add 1 Ammonia No.1 tablet and then add 1 Ammonia No.2 tablet
- Crush and mix both tablets until dissolved
- Leave test tube to stand for 10 minutes
- Select Photometer test 4 by typing 4 on the photometer and confirm by pressing enter
- Wipe off tubes from outside
- Read the blank and then the sample
- Note down the three values on data sheet, by pressing the arrow key down

Cleaning up

- Wipe off photometer and store away in the case
- Store away test kits in plastic box
- Rinse off pistils, tweezers, pipettes, ammonia spoon in distilled water and dry
- Pour test solutions in the sink with water running from the tap, rinse each tube twice then put in bowl with freshwater
- Rinse off tube rack
- Clean tubes with small brush, check that there is no chemicals residues
- Rinse out every test tube with deionised water
- Place test tubes in rack with open end facing down
- Enter the data from the analysis into the computer
- Store away the original test sheets in a dry place
- On the next day store away all the dry test tubes, pistils tweezers etc.

4.4 References

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4.5 Annexes

Annex 4.1 Water Quality Monitoring (Level 1) **Sheet number**_________

Country:	Location:	Date:		Time start	:	Time end	
Surveyors:	Weather:	Wind strength (1-5):		Wind direction (NSEW):			

Parameters	**Surface 1**	**Surface 2**	**Surface 3**	**Depth 1**	**Depth 2**	**Depth 3**
GPS waypoint						
Depth (m)						
Temperature (°)						
Salinity (*‰*)						
Turbidity (Secchi)						
Water sample?						
Sediment sample?						
Other information: include details of habitat types, presence of marine life and disturbances e.g. algal bloom.						
Parameters	**Surface 1**	**Surface 2**	**Surface 3**	**Depth 1**	**Depth 2**	**Depth 3**
GPS waypoint						
Depth (m)						
Temperature (°)						
Salinity (*‰*)						
Turbidity (Secchi)						
Water sample?						
Sediment sample?						
Other information: include details of habitat types, presence of marine life and disturbances e.g. algal bloom.						
Parameters	**Surface 1**	**Surface 2**	**Surface 3**	**Depth 1**	**Depth 2**	**Depth 3**
GPS waypoint						
Depth (m)						
Temperature (°)						
Salinity (*‰*)						
Turbidity (Secchi)						
Water sample?						
Sediment sample?						
Other information: include details of habitat types, presence of marine life and disturbances e.g. algal bloom.						
Parameters	**Surface 1**	**Surface 2**	**Surface 3**	**Depth 1**	**Depth 2**	**Depth 3**
GPS waypoint						
Depth (m)						
Temperature (°)						
Salinity (*‰*)						
Turbidity (Secchi)						
Water sample?						
Sediment sample?						
Other information: include details of habitat types, presence of marine life and disturbances e.g. algal bloom.						

Annex 4.2 Water Quality Monitoring (Level 2) **Sheet number_________**

COLORIMETRIC LABORATORY ANALYSIS OF WATER SAMPLES

LOCATION:		SITE	Surface	Bottom
START TIME OF ANALYSIS:				
P 24 NITRITE:	mg/l N			mg/l NO_2
P 23 NITRATE:	mg/l N			.mg/l NO_3
P 28 PHOSPHATE	mg/l PO_4			mg/l P
P 02 ALKALINITY T	mg/l $CaCO_3$	mg/l HCO_3		mg/l CO_3
P 37 ALKAPHOT M	mg/l $CaCO_3$	mg/l HCO_3		mg/l CO_3
P 38 ALKAPHOT P	mg/l $CaCO_3$			mg/l OH_3
P 27 pH				
P 04 AMMONIA:	mg/l N	mg/l NH_3		mg/l NH_4
STOP TIME OF ANALYSIS:				

LOCATION:		SITE	Surface	Bottom
START TIME OF ANALYSIS:				
P 24 NITRITE:	mg/l N			mg/l NO_2
P 23 NITRATE:	mg/l N			.mg/l NO_3
P 28 PHOSPHATE	mg/l PO_4			mg/l P
P 02 ALKALINITY T	mg/l $CaCO_3$	mg/l HCO_3		mg/l CO_3
P 37 ALKAPHOT M	mg/l $CaCO_3$	mg/l HCO_3		mg/l CO_3
P 38 ALKAPHOT P	mg/l $CaCO_3$			mg/l OH_3
P 27 pH				
P 04 AMMONIA:	mg/l N	mg/l NH_3		mg/l NH_4
STOP TIME OF ANALYSIS:				

LOCATION:	SITE	Surface		Bottom
START TIME OF ANALYSIS:				
P 24 NITRITE:	mg/l N			mg/l NO_2
P 23 NITRATE:	mg/l N			.mg/l NO_3
P 28 PHOSPHATE	mg/l PO_4			mg/l P
P 02 ALKALINITY T	mg/l $CaCO_3$	mg/l HCO_3		mg/l CO_3
P 37 ALKAPHOT M	mg/l $CaCO_3$	mg/l HCO_3		mg/l CO_3
P 38 ALKAPHOT P	mg/l $CaCO_3$			mg/l OH_3
P 27 pH				
P 04 AMMONIA:	mg/l N	mg/l NH_3		mg/l NH_4
STOP TIME OF ANALYSIS:				

5

Seagrasses

5. SEAGRASSES

5.1 Background

Seagrasses are the only group of flowering plants (monocotoledynous angiosperms) adapted to live entirely immersed in seawater and brackish water, that can withstand changes in salinity, immersion and occasional desiccation. Seagrass beds are one of the world's most productive coastal habitats and extremely important ecologically and economically (Short and Wyllie-Echeverria 1996). Seagrass meadows are in a perilous state across the world and are being lost at an alarming rate due to anchoring, pollution, mining, dredging and other coastal modifications that change water movement patterns. More recently, climate change has been recognized as a significant global threat as it may alter local and regional environmental conditions needed for seagrasses to thrive.

Seagrass beds in the Red Sea and Gulf of Aden region may occur in the intertidal or subtidal zone up to 70 m depth (El Shaffai 2016). The original PERSGA SSM manual (PERSGA/GEF 2004) reported on previous studies into the seagrasses and macroalgae in the Red Sea and Gulf of Aden region. A catalogue and bibliography of macroalgal research in the Red Sea was compiled by Papenfuss (1968). Previous studies into ecology of seagrasses in the Red Sea were completed by Walker (1987), Price et al. (1988), Ormond and Banaimoon (1994) and Atweweberma (1997). The United Nations Development Programme (UNDP) Socotra Archipelago Biodiversity project resulted in various publications relating to the seaweeds and seagrasses of these islands (e.g. Leliaert 1999; Schils 2000, Wynne & Leiliaert 2000, Schils 2002, Schils & Coppejans 2002, 2003a, 2003b, Schils et al. 2003a, 2003b). The seaweeds and seagrasses on the north coast of Somalia still remain largely unstudied.

More recently, El Shaffai (2016) produced a field guide to the seagrasses of the Red Sea. The guide followed Den Hartog (1970) identification of seagrasses and reported the presence of 12 seagrass species. There are differences in the distribution of seagrasses in the Red Sea with 7 species reported from the Gulf of Aqaba, 5 species reported from the Gulf of Suez (Green & Short 2003), 8 species species reported from the northern part of the Red Sea (north of 25° and south of the Gulfs), and between 10 to 12 species reported from the central Red Sea (18°-25° N) (Jones et al. 1987). There are lower number of species found in the southern Red Sea may be due to limited sampling in remote areas of Yemen, Eritrea and Djibouti. The highest diversity of seagrass species in the central Red Sea is most likely be due to the greater diversity of habitats and environmental conditions.

All species in the Red Sea originated from the Indian Ocean, and at least one species, *Halophila stipulacea*, has spread into the Mediterranean Sea via the Suez Canal. A recent study investistigated the phylogeography and phylogenetics of the two dominant seagrass species in the Red Sea (*Halophila stipulacea* and *Halophila ovalis*). The study revealed that *H. ovalis* collected from the Red Sea does not group with *H. ovalis* worldwide, and it is a sister clade of *H. major* and *H. ovalis* collected worldwide. The results suggest that vicariant evolutionary diversification of *H. ovalis* may have occurred in the Red Sea from South East Asia, which is considered as the centre of origin of tropical seagrasses, including *H. ovalis*.

5.2 Overview

5.2.1 General approach

Seagrass monitoring programmes can be used to determine the current status of seagrass beds within an area and to detect changes due to man-made or other natural perturbations. Before setting up a long term seagrass monitoring programme, the distribution, composition and the spatial extent of the seagrass beds within the area should be determined using rapid assessment surveys and habitat mapping. The results of these surveys can then be used to select representative and well distributed seagrass beds for inclusion in the monitoring programme.

Seagrass monitoring is typically achieved by visually assessing the percent cover of seagrass using replicate quadrats, often positioned along replicate transect lines within each seagrass bed. Where there are intertidal seagrass beds, surveys may be completed on foot during low tide. If the seagrass beds are subtidal, surveys may be completed by snorkelling in shallow water or by SCUBA diving on deeper seagrass beds. Other parameters that can be monitored include the ambient conditions at the site, seagrass cover, canopy height and epiphyte coverage, and seagrass biomass.

The original PERSGA Standard Survey Methods Manual (PERSGA/GEF 2004) included a chapter on the assessment and monitoring methods for macroalgae and seagrass. Since then two protocols for the monitoring of seagrass have emerged as potential global standards. The first protocol, SeagrassWatch (www.seagrasswatch.org), is similar to ReefCheck in that it is designed to easily accessible and intended to be used by communities and volunteer groups, as well as by research scientists. The second protocol, SeagrassNet (www.seagrassnet.org), is marginally more complicated, and the techniques better suited to more experienced researchers.

PERSGA currently recommends the use of the SeagrassWatch method, as this method is a robust minimally-destructive technique to visually assess seagrass cover and the data collected can be shared with the larger global monitoring programme. The method is relatively easy to implement and suitable for use by a broad range of surveyors. The field method is also compatible with fish surveys which can be implemented along the same transect lines.

PERSGA also recommends the use of "SeagrassSpotter", which is a new mobile application to record sightings of seagrasses species worldwide. The mobile application can be installed on a mobile phone (Android and IOS) and used to record the location of seagrass beds and to capture photos. The application is designed to increase the information available on the global distribution of seagrass beds and seagrass species worldwide. PERSGA recommends the use of this tool as a means to increase knowledge about the occurrence and distribution of species seagrass within the RSGA region.

5.2.2 Target

Seagrass monitoring measures the percent cover of all seagrass species, and macroalgae that often co-occur within seagrass beds. Other parameters measured include the ambient conditions at the site, seagrass canopy height and epiphyte coverage.

5.2.3 Field equipment

- Survey forms, slates, clips and pencils (one form per transect)
- Species identification guides, laminated for use in the field.

- 0.5 m x 0.5 m quadrat and a system for numbering.
- Transect tape measures (3 x 50 m tapes).
- Spare dive weights to attach to both ends of the transect tapes.
- Marker pegs (either plastic tent pegs, star-pegs or iron rebar, with t-bar welded ends)
- Good shoes for use in intertidal areas.
- Personal snorkelling and scuba equipment.
- Underwater mesh bag.
- Medical kit and oxygen (if SCUBA diving required).

5.2.4 Field personnel

Surveyors need to be familiar with the survey method and able to identify the species. For intertidal surveys, the surveyors must be physically fit, whereas for subtidal surveys the surveyors need to be physically fit, able to swim, snorkel and be certified in SCUBA diving if required.

5.2.5 Training / experience

Training in the field survey methods and seagrass identification is necessary before the surveyors participate in the monitoring programme. The field guide by El Shaffai (2016)[10] is the most appropriate species identification reference document for use in the RSGA region.

5.3 Field Procedure

5.3.1 Sampling Design

The sites included in a seagrass monitoring programme will depend on the purpose of the monitoring programme, the characteristics of the area to be monitored, and the resources available. National monitoring programmes are designed to follow a stratified sampling protocol (see Figure 5.1). The sites selected for the programme should be representative of the range of seagrass bed types and levels of exposure to human activities. There should be replication of sites within different seagrass bed types, which may or may not also require replication at different depths. If there are protected areas, then sites should be selected that are both inside and outside the protected area, as the results can then be used to help determine if the MPAs are effective at reducing impacts. The number of transects (i.e. replication) used within each site should remain consistent between sites (i.e. 3 transects per site).

10 https://www.researchgate.net/publication/317400329_Second_Edition_-_Field_Guide_to_Seagrasses_of_the_Red_Sea

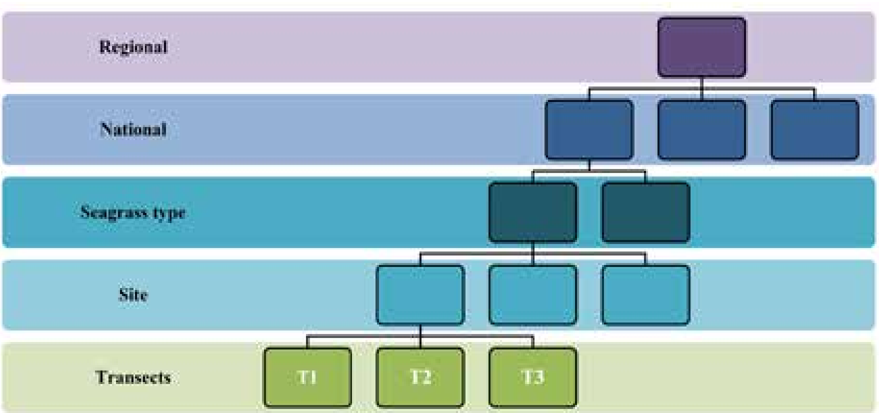


Figure 5.1 Example of stratified sampling regime for seagrass monitoring programme (adapted from English et al. 1997).

5.3.2 **Site Layout**

The SeagrassWatch Manual (McKenzie et al. 2001) suggests several alternative site layouts that can be used for monitoring seagrass beds. The transect based method is the preferred method that is recommended here, as it is suitable for use in most shallow seagrass beds that are accessible either by walking or snorkeling or SCUBA diving (Figure 5.2). Alternative layouts for use on small seagrass beds (<50 m across) or deeper subtidal seagrass beds are presented in SeagrassWatch manual. These include the use of circular layouts and single 50m, 100m or 150m transects. These layouts do not involve within site replication, which reduces the utility of the data.

To prepare a site, the survey team lays out 3 replicate 50m transects, in parallel at a spacing of 25m apart (Figure 5.2). Depending on the bathymetry of the site, the transects may be laid perpendicular to the shore or in parallel. If the monitoring station is to become a permanent long-term monitoring site, the middle transect is permanently marked. The seagrass along each transect is sampled by visual observations using 11 quadrats positioned every 5m along the 50m transects. The quadrats are positioned to the right of the transect, and the surveyors work along the left-hand side so as to avoid disturbing or damaging the substrate. The quadrats are photographed to ensure standardization / calibration of observers and to provide a permanent record.

The step by step instructions in how to complete the SeagrassWatch transect based surveys are provided below:

- Before scheduling the surveys, check the tide timetables. If the site is an intertidal site, the best time to plan to conduct surveys is during the low tide, as it is easier to estimate seagrass cover, investigate dugong trails and identify traces of leaves bleaching or burning.
- Prepare three survey slates one for each transect (T1, T2 and T3), each with a copy of the survey form (see Figure 5.3 Annex 5.1).
- On arriving at the site, record the site location using a GPS and complete the site description part of the survey form. The GPS waypoint can be recorded or the coordinates can be written out in full (use geographical coordinates in decimal degrees).
- The survey team lays the first 50m transect tape perpendicular to the shore and the bearing taken. The transect tape may need to be pegged down or weighted to stop it moving. This first transects will become T2 (see Figure 5.2).
- The next two 50m transects are laid parallel to T2 at a distance of 25m either side, these will be T1 and T3 (see Figure 5.2).
- On transect T1, position a quadrat at 0m to the right of the transect tape and complete the following:
    - ◊ Place the photo quadrat label next to the quadrat and take a photograph of the quadrat. The photograph should be vertical (or as close to vertical as possible) and it should show the whole quadrat frame, label and tape measure. Try to avoid shadows or reflection off the water surface. Tick the ‘photo’ box on the survey form for that quadrat.
    - ◊ Assess the sediment composition by digging your fingers into the top couple of centimetres of substrate and feel the texture. Record the sediment type by noting the grain sizes present in

order of dominance (e.g., Sand, Fine sand, Fine sand/Mud).

◊ Observe and describe other features within the quadrat, identify and count any associated macrofauna (e.g. number of shellfish, sea cucumbers, sea urchins, evidence of turtle feeding), and record these in the comments column. For intertidal quadrats, note if more than 50% of the quadrat is covered by water, measure and record the water depth in cm.

◊ Observe and estimate the total percent cover of seagrass in the quadrat as accurately as possible (e.g. 27%). Use the Percent Cover Standards provided in Annex 5.3 to 5.5.

◊ Identify the species of seagrass within the quadrat using the seagrass species identification keys and determine the percent contribution of each species to the total cover. The total composition of should equal 100%.

◊ Using a ruler, measure the canopy height of the dominant species, ignoring the tallest 20% of leaves. Measure from the sediment to the leaf tip of at least 3 mature leaf blades (strap leaved species). Record the 3 measures on the datasheet.

◊ Observe and estimate the percent cover of macroalgae within the quadrat. Macroalgae percent cover is independent of seagrass cover. The algae may fully or partially cover or overlay the seagrass, so it may be possible to have 100% seagrass and 100% algae if the algae is floating / drifting on top of the seagrass.

◊ Observe and estimate epiphyte/epibiota percent cover and density on seagrass blades. (Figure 5.4). Epiphytes and epibiota are flora and fauna that are directly attached to seagrass blades that can give the blade a furry appearance. Estimate how much of the blade surface is covered in epiphytes / epibiota, and then how many of the blades in the quadrat are covered (e.g. if 20% of the blades are each 50% covered by epiphytes, then quadrat epiphyte cover is 10%).

◊ Take a voucher seagrass specimen if required for identification. This might include a specimen of a new seagrass species is present; or if you are unsure of the seagrass identification. Place the samples inside a labelled plastic bag with seawater and a waterproof label. Select a representative specimen of the species and ensure that you have all the plant part including the rhizomes and roots.

◊ Collect plants with fruits and flowers structures if possible.

- Move to the 5m mark on the transects and repeat the above steps, for the remaining 9 quadrats on T1. A total of 11 quadrats at 5m intervals will be completed on each 50m transect.
- Record the GPS position at the 50m end of the transect, if this is possible.
- Move onto T2 and repeat the above steps.

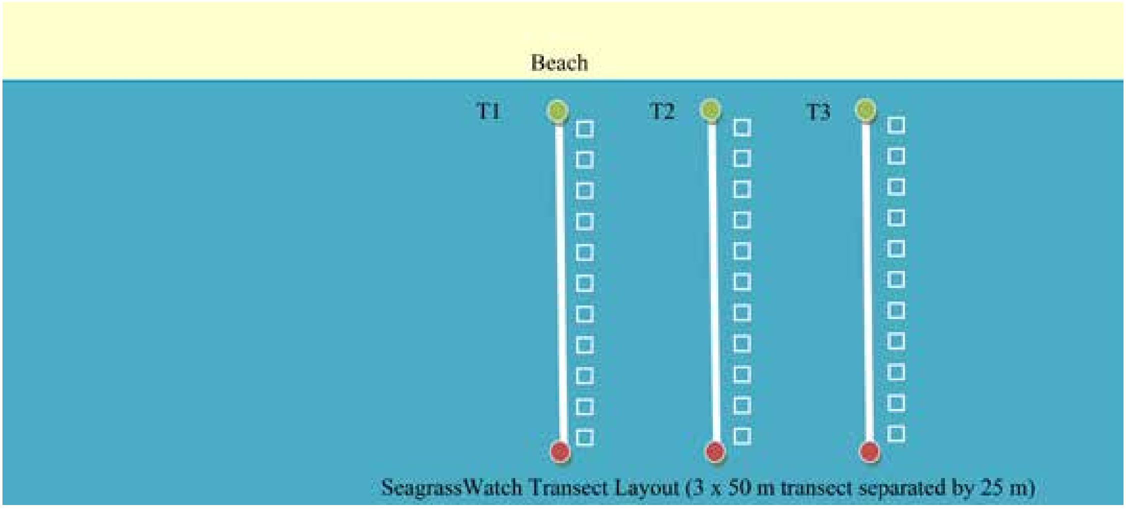
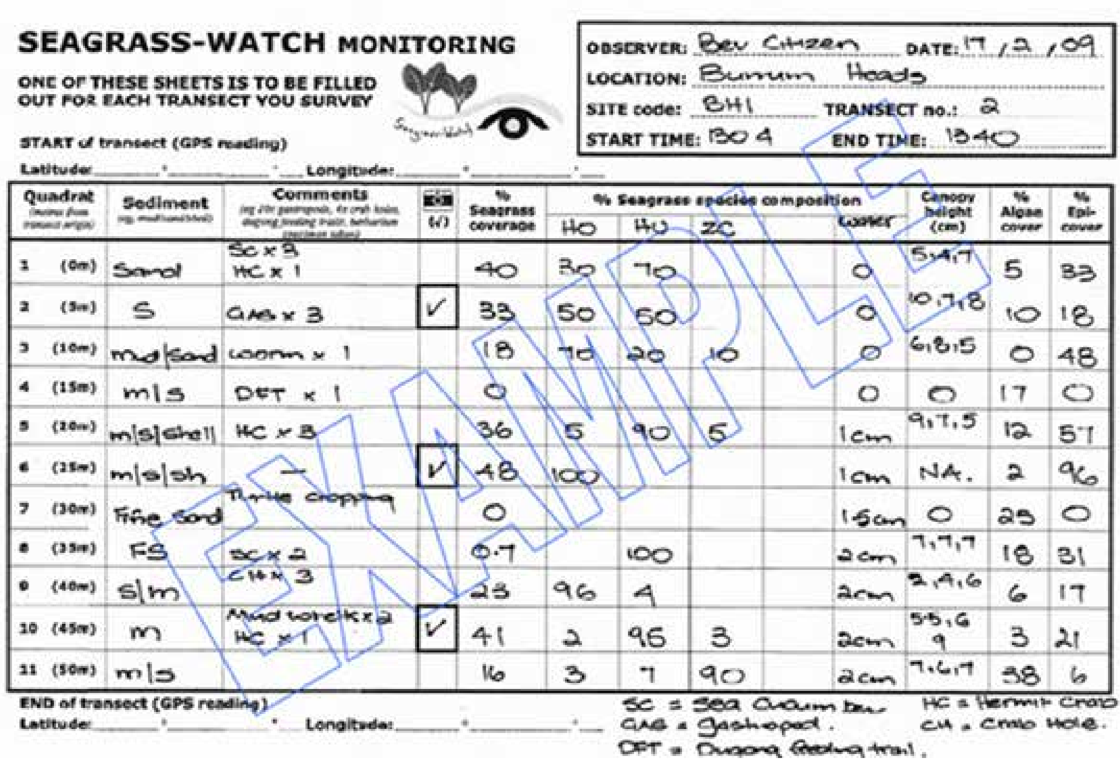


Figure 5.2 Layout of sites for seagrass monitoring using SeagrassWatch.



SEAGRASS-WATCH MONITORING

ONE OF THESE SHEETS IS TO BE FILLED OUT FOR EACH TRANSECT YOU SURVEY

OBSERVER: Bev Citizen DATE: 17 / 2 / 09
LOCATION: Burrum Heads
SITE code: BH1 TRANSECT no.: 2
START TIME: 1304 END TIME: 1340

START of transect (GPS reading)
Latitude: ___°___' ___ Longitude: ___°___' ___

Quadrat	Sediment	Comments	(✓)	% Seagrass coverage	HO	HU	ZC		Cover	Canopy height (cm)	% Algae cover	% Epi-cover
1 (0m)	Sand	SC x 9 HC x 1		40	30	70			0	5,4,7	5	33
2 (5m)	S	GAS x 3	✓	33	50	50			0	10,7,8	10	18
3 (10m)	mud/sand	worm x 1		18	70	20	10		0	6,8,5	0	48
4 (15m)	m/s	DFT x 1		0					0	0	17	0
5 (20m)	m/s/shell	HC x 3		36	5	90	5		1cm	9,7,5	12	57
6 (25m)	m/s/sh	—	✓	48	100				1cm	NA.	2	96
7 (30m)	fine sand	Turtle cropping		0					1.5cm	0	25	0
8 (35m)	FS	SC x 2		0.7		100			2cm	7,7,7	18	31
9 (40m)	s/m	CH x 3		23	96	4			2cm	2,4,6	6	17
10 (45m)	m	Mud worksx2 HC x 1	✓	41	2	96	3		2cm	5,5,6,9	3	21
11 (50m)	m/s			16	3	7	90		2cm	7,6,7	38	6

END of transect (GPS reading)
Latitude: ___°___' ___ Longitude: ___°___' ___

SC = Sea Cucumber. HC = Hermit Crab
GAS = Gastropod. CH = Crab Hole.
DFT = Dugong feeding trail.

EXAMPLE

Figure 5.3 Example of a completed SeagrassWatch survey form.

Figure 5.4 High percent cover of zoo- and algal epiphytes on a seagass bald

(Source: Amgad El Shaffai)

5.4 References

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5.5 Annexes

Annex 5.1 SeagrassWatch Monitoring

SEAGRASSWATCH MONITORING	
SURVEY INFORMATION	
Observer	Record the name and / or initials of the surveyors involved in the survey.
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Site code	Record the site code / number.
Start time	Record the time in 24 hr format HH:MM e.g. 10:30
End time	Record the time in 24 hr format HH:MM e.g. 12:30
SITE INFORMATION	
Start of transect	Record the GPS waypoint number, . You can use the original waypoint number as shown in the GPS or you can write out the latitude and longitude.
Site description	Record the site description, such as the life forms present and the benthic composition
Sketch profile	Draw the profile of the site, recording any notable features, such as buildings within the 500m by 500m quadrat.
Quadrats (positioned every 5m to the right of transect)	
Sediment	Assess sediment composition by digging your fingers into the top couple of centimetres of substrate and feel the texture. Record the sediment composition, by noting the grain present size in order of dominance (e.g., Sand, Fine sand, Fine sand/Mud).
Comments	Record comments about if herbarium samples are taken, and if there are specific observations such as dugong feeding trails, presence of molluscs, burrows.
Photo	Place a photo quadrat label next to the quadrat and take a photograph of the quadrat. The photograph should be vertical (or as close to vertical as possible) and it should show the whole quadrat frame, label and tape measure. Try to avoid shadows or reflection off the water surface. Tick the 'photo' box on the survey form for that quadrat
Seagrass coverage	Record the total percent cover of seagrass within the quadrat. This is recorded separately from the macroalgal cover. Use the percent cover standards provided.
% Seagrass species composition	Record the percent contribution of each species to the total seagrass cover in the quadrat. Write the species code in the blank square at the top of each column and the percent contribution below. The total for each quadrat should equal 100%. For example: Quadrat 1 has 50% total seagrass cover, which is all *Halophila ovalis.* So the percent contribution of *H. ovalis* would be 100%. Quadrat 2 has 50% total seagrass cover, which is equally composed of *H. ovalis* and *H. stipulacea.* So the percent contribution of both species would be 50%.
Canopy height	Using a ruler, measure the canopy height of the dominant species ignoring the tallest 20% of leaves. Measure from the sediment to the leaf tip of at least 3 mature leaf blades (strap leaved species). Record the 3 measures on the datasheet
% algae cover	Record the percent cover of algae in the quadrat. Macroalgae percent cover is recorded independent of seagrass cover. The algae may fully or partially cover or overlay the seagrass, so you can have 100% seagrass and 100% algae if the algae is floating / drifting on top of the seagrass
% epi-cover	Record the percent cover of epiphytes. First estimate how much of the blade surface is covered, and then how many of the blades in the quadrat are covered (e.g. if 20% of the blades are each 50% covered by epiphytes, then quadrat epiphyte cover is 10%). Use the matrix for estimating epiphyte cover provided.

SEAGRASS-WATCH MONITORING

ONE OF THESE SHEETS IS TO BE FILLED OUT
FOR EACH TRANSECT YOU SURVEY

OBSERVER:______________ DATE:____ /____ /______

LOCATION:______________________________

SITE no.: ____________ TRANSECT no: __________

Start TIME:____________ End TIME:______________

START of transect (GPS reading)

Latitude:……………°…………………………'S Longitude:………………°……………………………'E

Quadrat *(metres from transect origin)*	Sediment *(eg, mud/sand/shell)*	Comments *(eg 10x gastropods, 4x crab holes, dugong feeding trails, herbarium specimen taken)*	(✓)	% Seagrass coverage	Canopy height (cm)	% Seagrass species composition (*must total 100%*)				% Algae cover	% Epi-cover
						ZC	HU	HO			
1 (0m)											
2 (5m)											
3 (10m)											
4 (15m)											
5 (20m)											
6 (25m)											
7 (30m)											
8 (35m)											
9 (40m)											
10 (45m)											
11 (50m)											

END of transect (GPS reading)

Latitude:……………°…………………………'S Longitude:………………°……………………………'E

Annex 5.2 SeagrassWatch Matrix for estimating cover of epiphytes (Source: McKenzie et al. 2001)

Seagrass-Watch

Matrix for estimating cover of epiphytes

Epiphytes are algae attached to seagrass blades (often giving the blade a furry appearance).

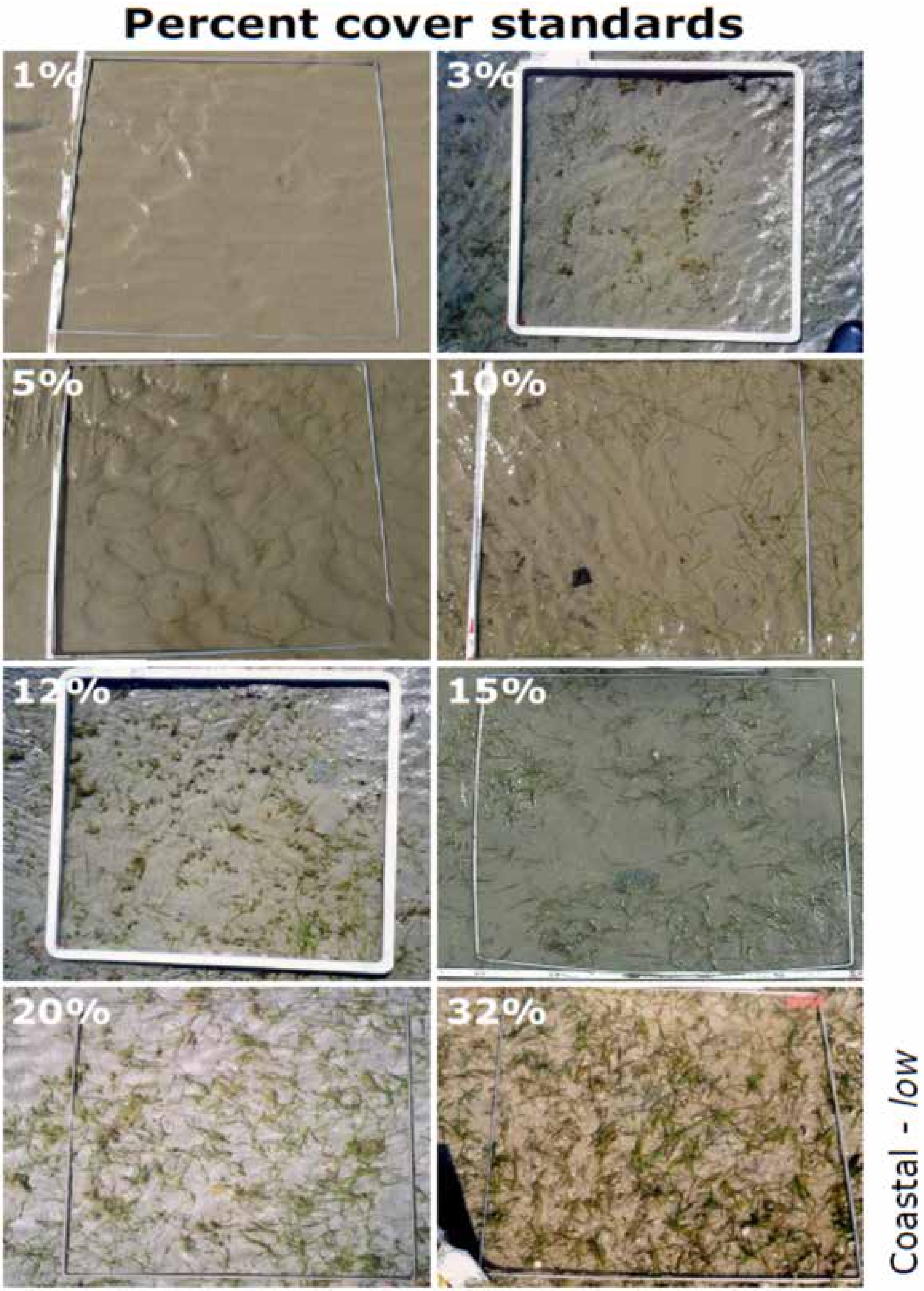
First estimate how much of the blade surface is covered, and then how many of the blades in the quadat are covered (e.g., if 20% of the blades are each 50% covered by epiphytes, then quadrat epiphyte cover is 10%).

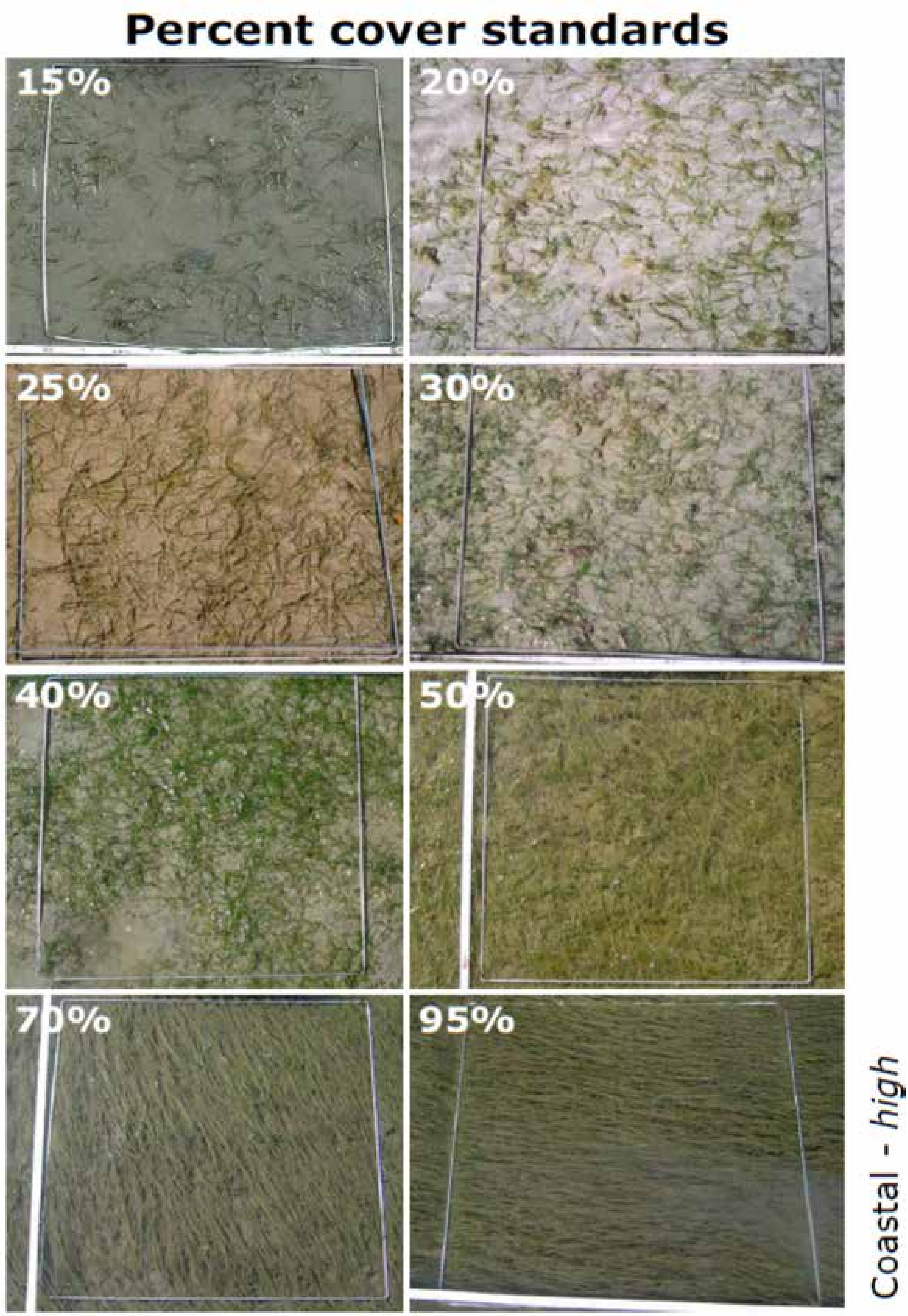
Epibionts are sessile animals attached to seagrass blades –record % cover in the comments or an unused/blank column – do not add to epiphyte cover

% of leaves in quadrat with ephipytes (columns); **average epiphyte cover on a leaf** (rows)

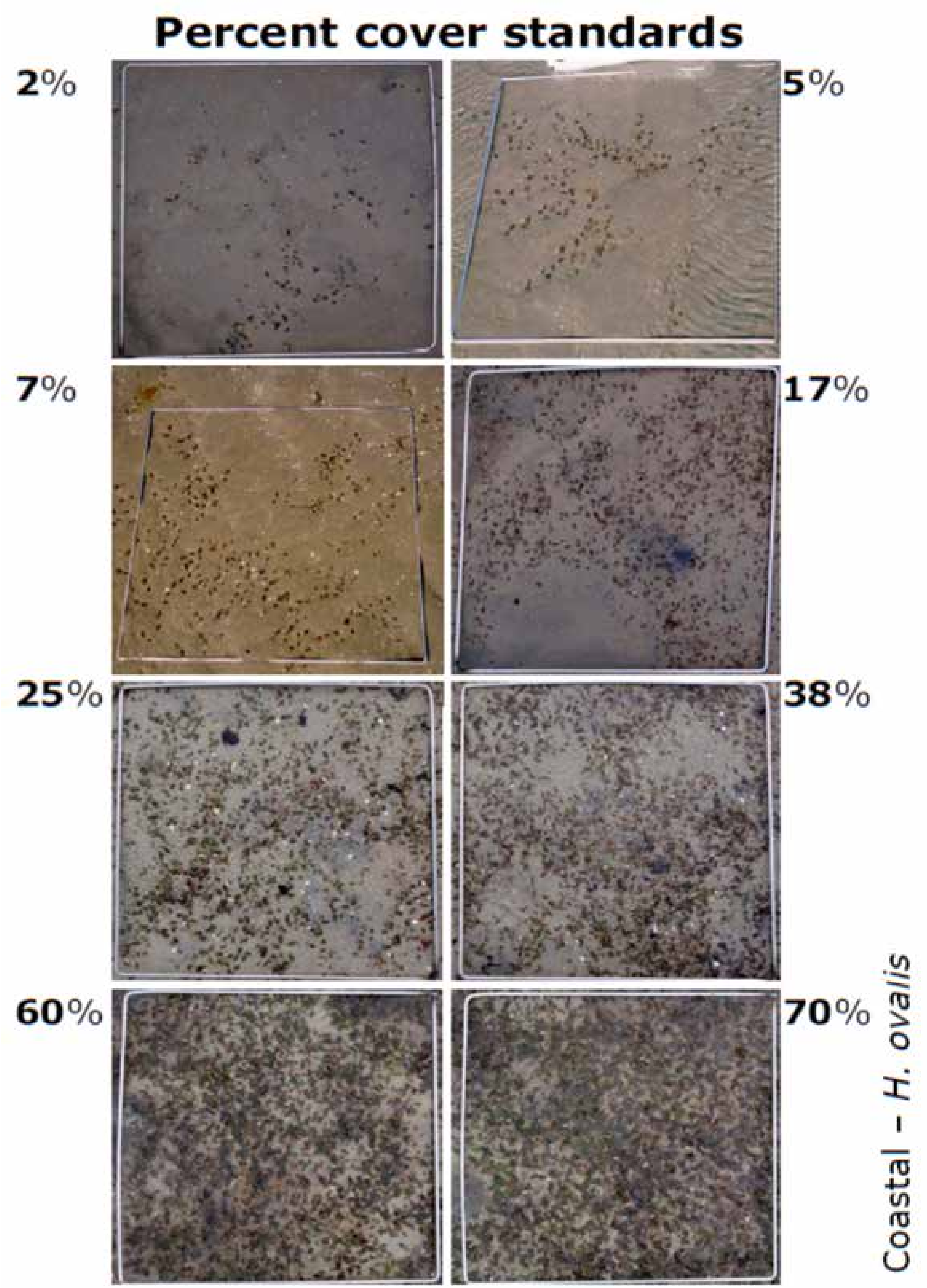
0	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5
10	1	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10
15	1	1	2	2	3	4	5	5	6	7	8	8	9	10	11	11	12	13	14	14	15
20	1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
25	1	1	3	4	5	6	8	9	10	11	13	14	15	16	18	19	20	21	23	24	25
30	1	2	3	5	6	8	9	11	12	14	15	17	18	20	21	23	24	26	27	29	30
35	1	2	4	5	7	9	11	12	14	16	18	19	21	23	25	26	28	30	32	33	35
40	1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
45	1	2	5	7	9	11	14	16	18	20	23	25	27	29	32	34	36	38	41	43	45
50	1	3	5	8	10	13	15	18	20	23	25	28	30	33	35	38	40	43	45	48	50
55	1	3	6	8	11	14	17	19	22	25	28	30	33	36	39	41	44	47	50	52	55
60	1	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
65	1	3	7	10	13	16	20	23	26	29	33	36	39	42	46	49	52	55	59	62	65
70	1	4	7	11	14	18	21	25	28	32	35	39	42	46	49	53	56	60	63	67	70
75	1	4	8	11	15	19	23	26	30	34	38	41	45	49	53	56	60	64	68	71	75
80	1	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
85	1	4	9	13	17	21	26	30	34	38	43	47	51	55	60	64	68	72	77	81	85
90	1	5	9	14	18	23	27	32	36	41	45	50	54	59	63	68	72	77	81	86	90
95	1	5	10	14	19	24	29	33	38	43	48	52	57	62	67	71	76	81	86	90	95
100	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100

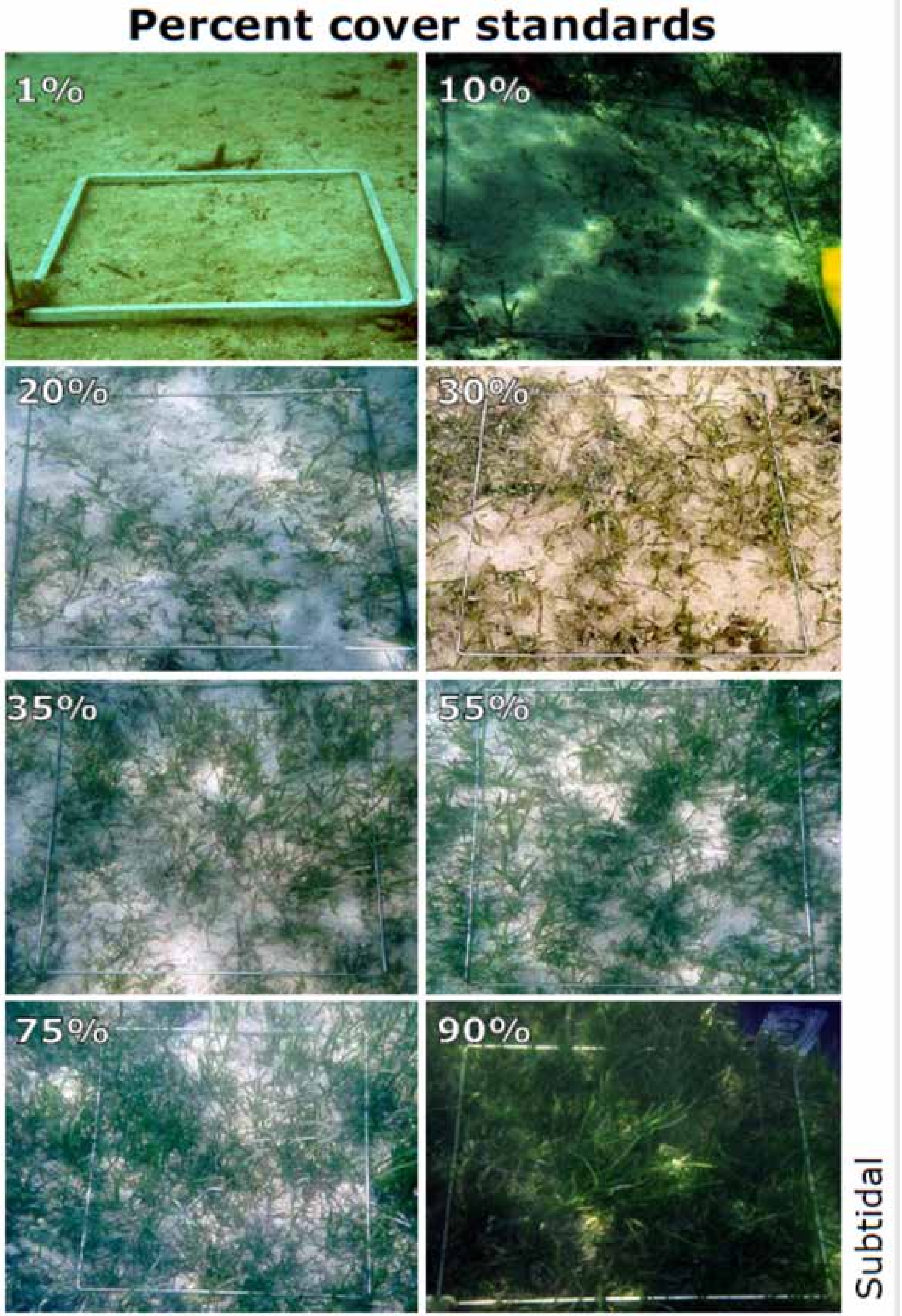
Annex 5.3 SeagrassWatch Percent Cover Standards (Source: McKenzie et al. 2001)



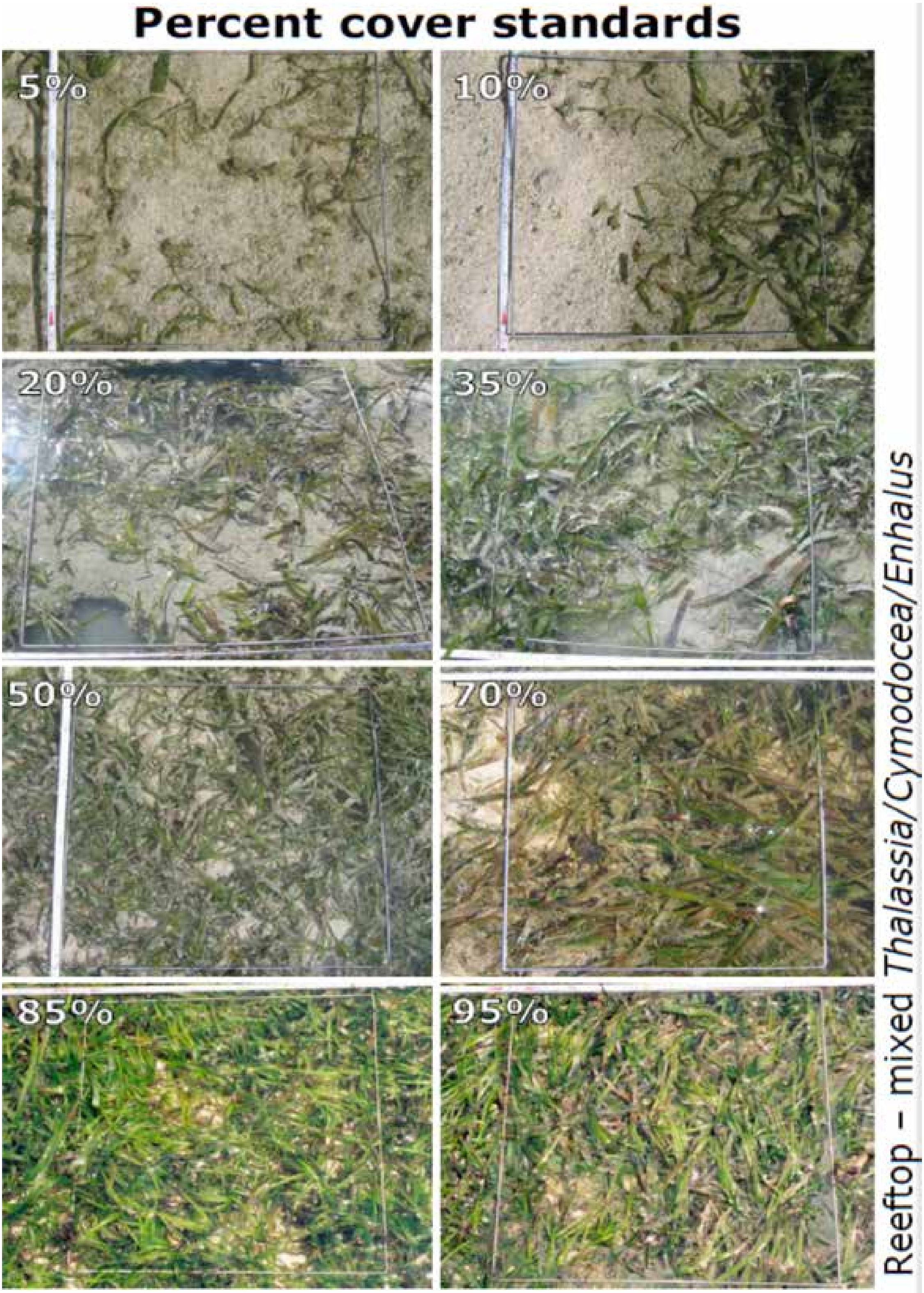

Percent cover standards
15%
20%
25%
30%
40%
50%
70%
95%
Coastal - *high*

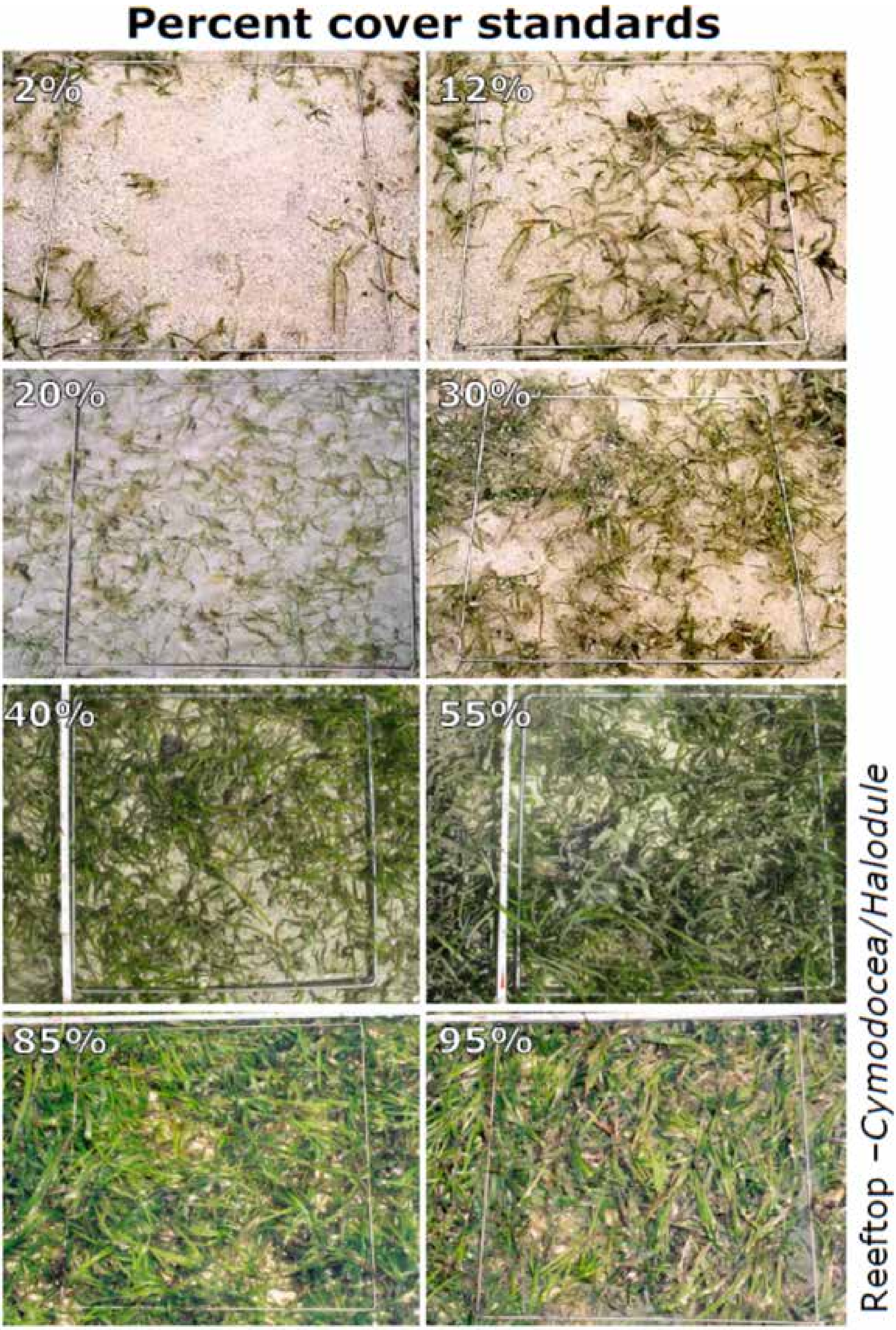
Annex 5.4 SeagrassWatch Percent Cover Standards (Source: McKenzie et al. 2001)



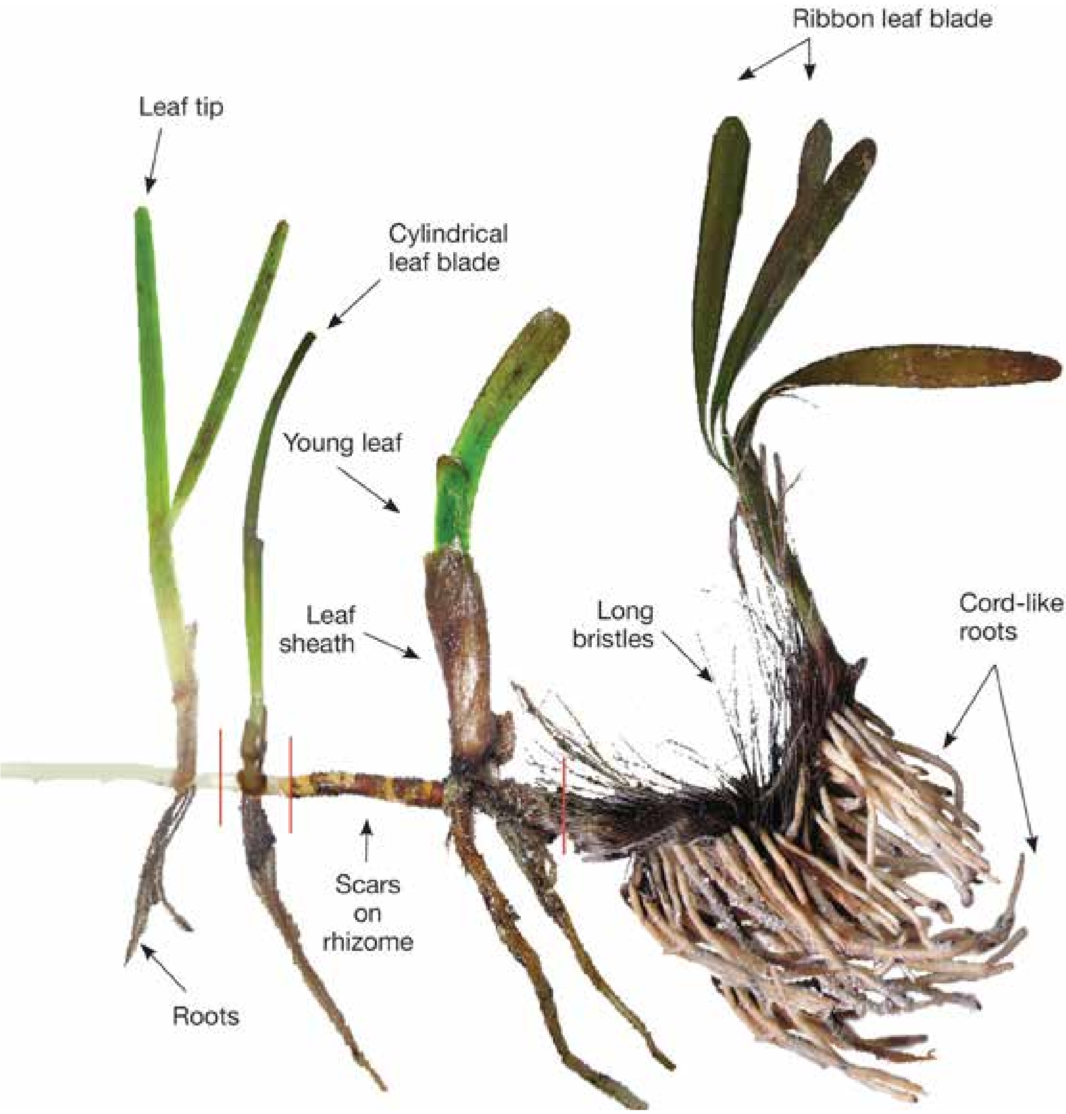

Percent cover standards
1%
10%
20%
30%
35%
55%
75%
90%
Subtidal

Annex 5.5 SeagrassWatch Percent Cover Standards (Source: McKenzie et al. 2001)



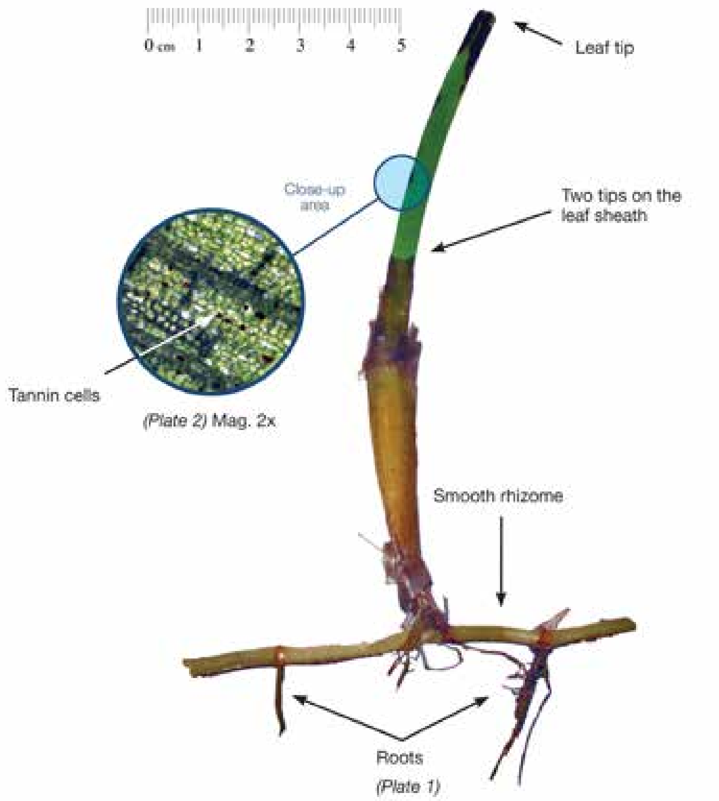

Percent cover standards
2%
12%
20%
30%
40%
55%
85%
95%
Reeftop –*Cymodocea/Halodule*

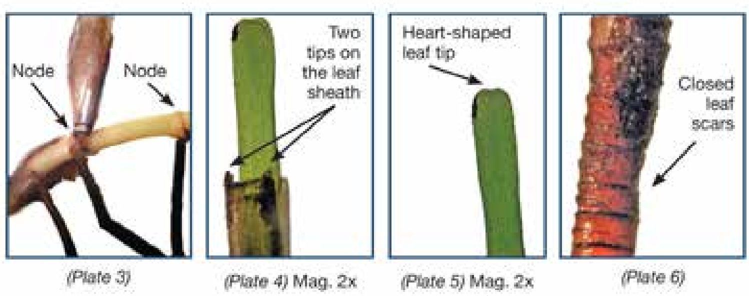
Annex 5.6 Seagrass Morphology (source: El Shaffai, 2016)



Annex 5.7 Seagrass Identification Guide (Source: El Shaffai, 2016)

Family: Cymodoceaceae





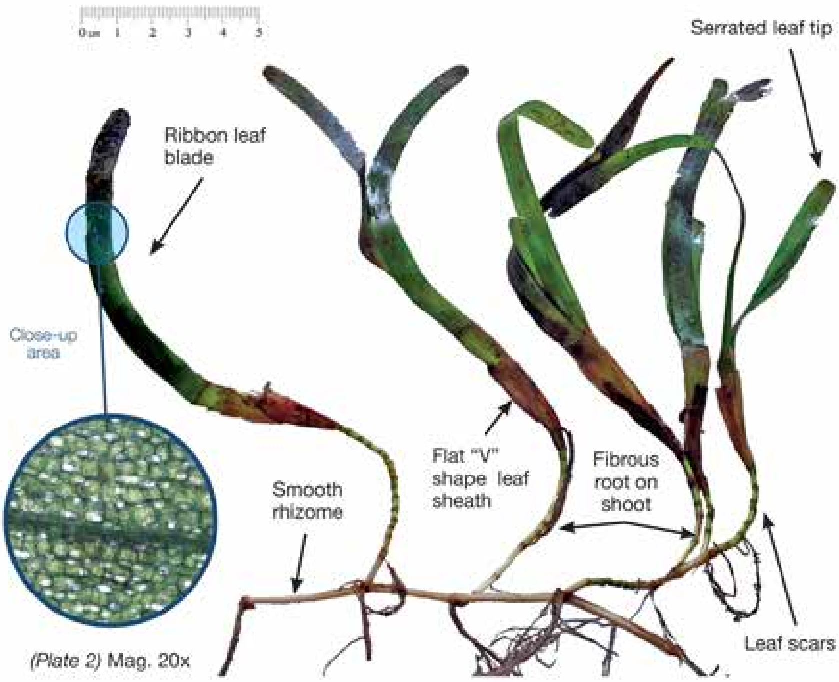
Cymodocea rotundata (plate 1)

Leaf: The leaf blade of this species is 7-15 cm long and 0.2-0.4 cm wide, linear and flat. The leaf sheath is well developed and ranges from 1.5-5.5 cm in length. The leaf sheath may be pale purple in color and is not shed along with the blade. When a leaf sheath sheds, closed circular scars are left on the stem. There are 9-15 longitudinal leaf veins. The leaf margin may have small serrations. The leaf tip sometimes appears slightly heart-shaped to the naked eye. Note that the dark color of the upper section of the leaf in Plate 1 is due to dead or old tissue. A healthy leaf is green all over.

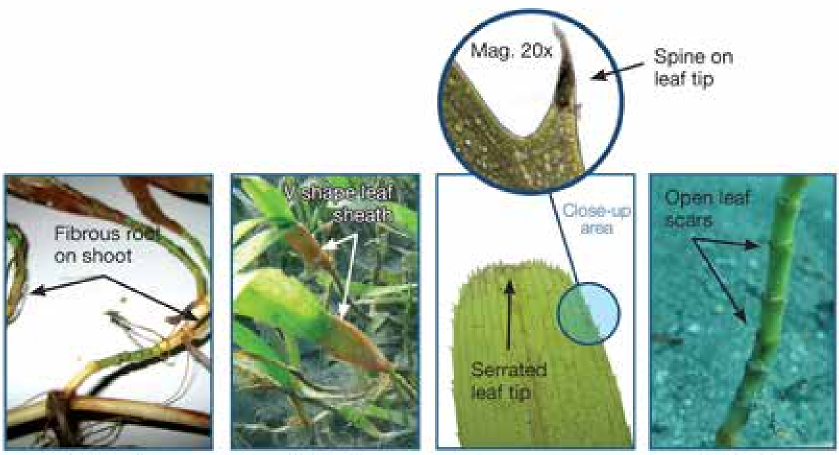
Stem: This species has a short erect lateral stem at each node, bearing 2-7 leaves.

Rhizome: The rhizome is smooth, with 1-3 irregularly branched roots at each node.

Microscopic Leaf Anatomy: Cells are round to angular. Tannin (black colored) cells can be seen in round to rectangular groups (Plate 2).



(Plate 1)



(Plate 3) (Plate 4) (Plate 5) Mag. 2x (Plate 6)

Cymodocea serrulata (plate 1)

Leaf: The leaf blade is up to 15 cm long, 0.4-0.9 cm wide and can be linear or slightly curved. The leaf sheath is purple, broadly triangular, and narrows at the base. When the leaf sheaths are shed, they leave open, semi-circular scars on the stem. There are 13-17 longitudinal leaf veins and the leaf margin is serrated with obvious tooth-like projections. The leaf tip is bluntly rounded and also serrated.

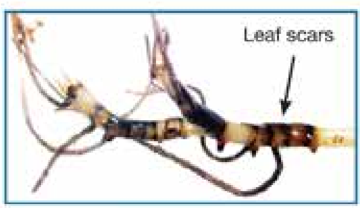
Stem: This species has a short erect vertical stem often with fibrous roots at each node.

Rhizome: The rhizome is smooth. The color can be yellow, green or brown depending on its health and exposure to light.

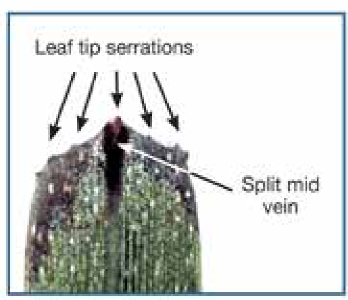
Microscopic Leaf Anatomy: Cells are generally angular in shape (Plate 2).

(Plate 2) Mag. 20x

(Plate 1)



(Plate 3) Mag. 2x



(Plate 4)

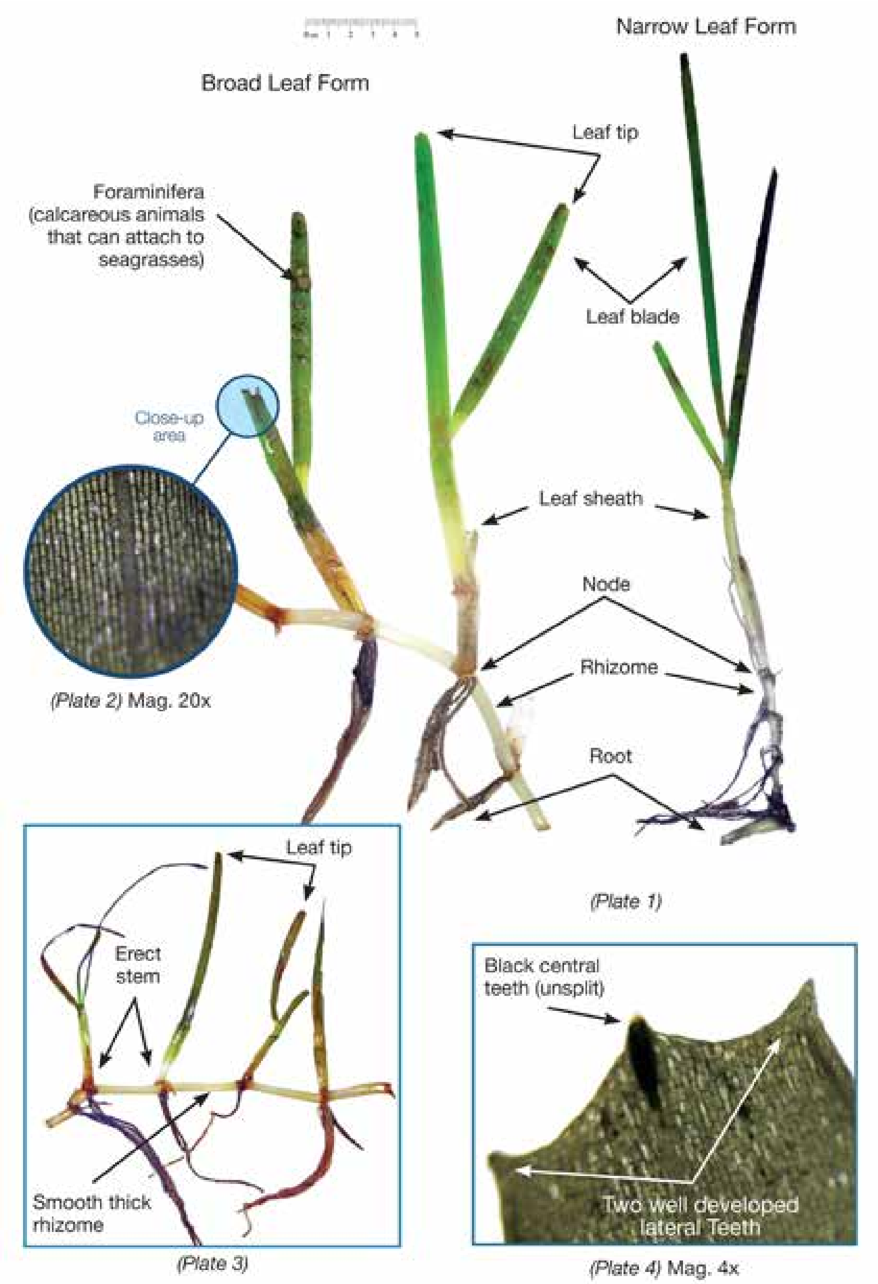
Halodule pinifolia (plate 1)

Leaf: The leaf blade is less than 20 cm long and 0.02-0.1 cm wide, linear and flat. The leaf sheath is well developed and there are three longitudinal leaf veins. Leaf margin is mostly smooth but finely serrated at the tip. The most distinctive feature is the black central vein at the leaf tip, which splits into two at the apex.

Stem: The stem of this species is short, erect, vertical and bearing 1-2 leaves. It is often covered by dense leaflets and looks like leaves develop directly from the rhizome.

Rhizome: The rhizome is thin and often covered by leaf scars.

Microscopic Leaf Anatomy: Cells are small, regular and rectangular in shape (Plate 2).



(Plate 3)

(Plate 4) Mag. 4x

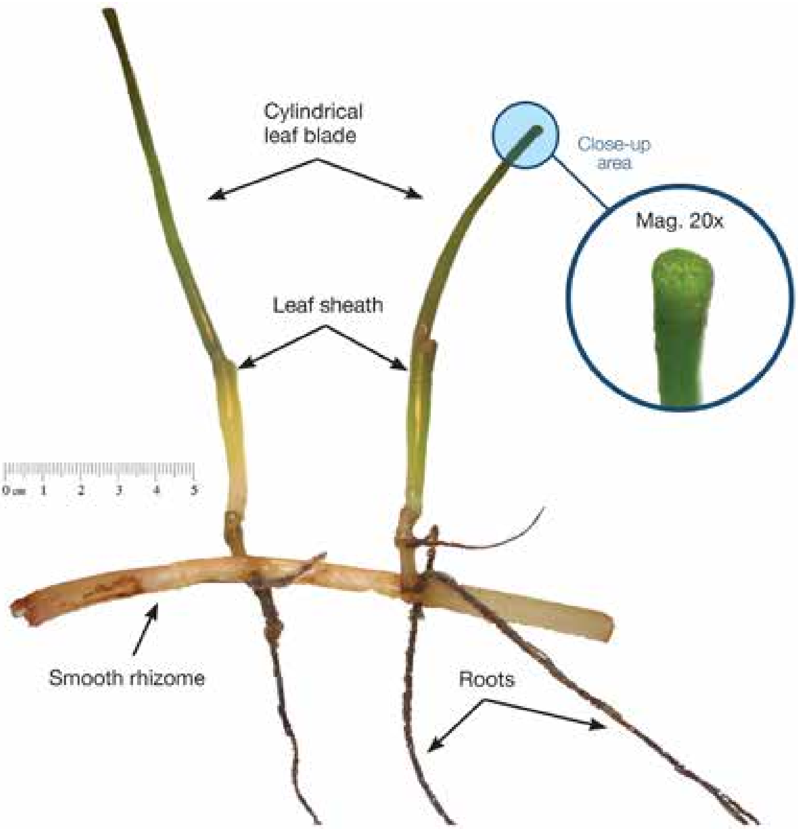
Halodule uninervis (plate 1)

Leaf: Leaf dimensions of this species are highly variable. The leaf blade is up to 15 cm long, but typically much shorter. The leaf width ranges from 0.05-0.5 cm, and has a linear shape and is flat. The leaf sheath is well developed and remains long after the blade is shed. The leaf has three longitudinal veins, the mid vein being the most obvious and easiest to identify. The leaf margin is smooth and the leaf tip has three distinct tips (sometimes called “teeth”), one in the middle and one on each side (see Plate 5).

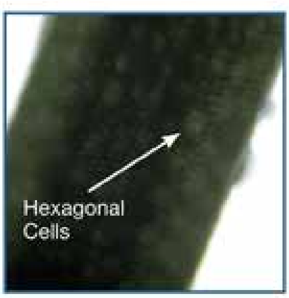
Stem: The stems are short, erect and vertical at each node and can bear 1-4 leaves.

Rhizome: The rhizome is typically smooth.

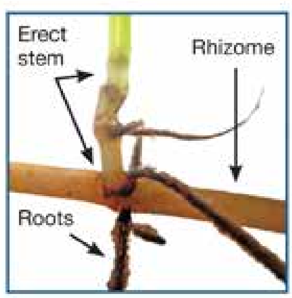
Microscopic Leaf Anatomy: Cells are regular and rectangular in shape (Plate 2).



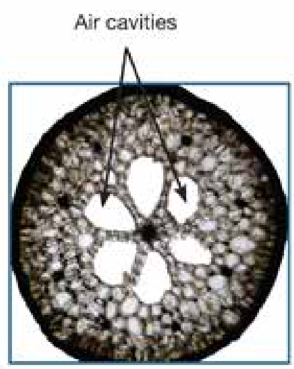
(Plate 1)



(Plate 2) Mag. 20x



(Plate 3) Mag. 2x



(Plate 4) Mag. 20x

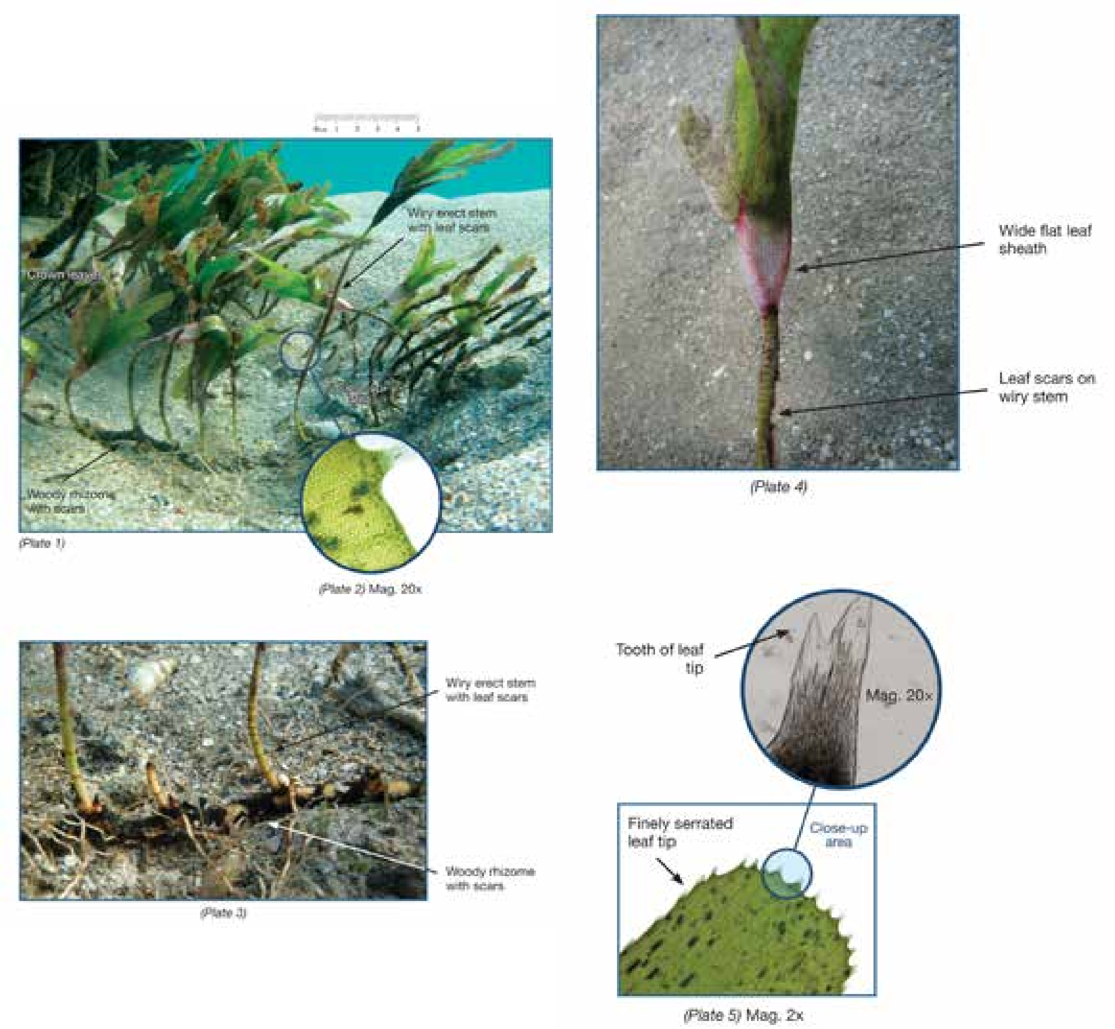
***Syringodium isetofolium* (plate 1)**

Leaf: The leaf blade is up to 30 cm long and 0.1-0.2 cm wide. The leaf sheath ranges from 1.5-4.0 cm in length. There are no obvious leaf veins. The leaf margin is smooth and the leaf tip tapers off to a point (Plate 1).

Stem: This species has an erect stem at each node bearing 2-3 leaves.

Rhizome: The rhizome is smooth and has 1-3 small branched roots.

Microscopic Leaf Anatomy: Cells are hexagonal in shape and are closely packed (Plate 2).



Thalassodendron ciliatum (plate 1)

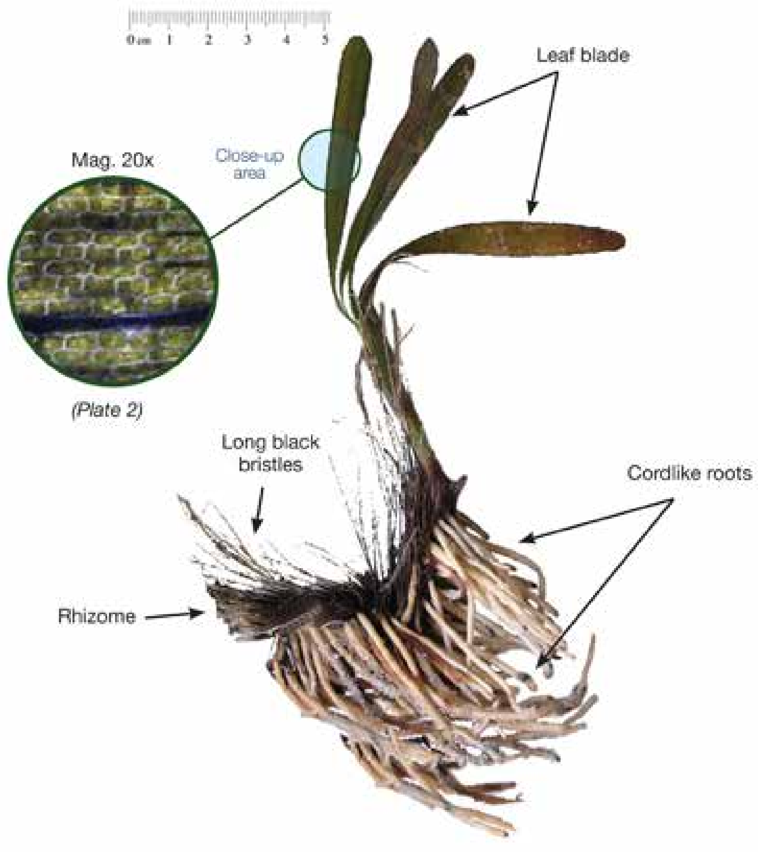
Leaf: The leaf blade is up to 15 cm long and 0.5-1.5 cm wide, and linear in shape. The leaf sheath is wide (1.5-3.0 cm), flat and often purple in color, and curved at the base of the leaves. Leaves have between 17-27 longitudinal veins. The margin of the leaf has irregular serration and the leaf tip is rounded, with obvious numerous teeth.

Stem: This species has a long erect and wiry stem that can be up to 65 cm (but usually much shorter) with numerous leaf scars along its length. The stem bears a cluster of leaves (called crown leaves).

Rhizome: The rhizome of this species is woody and tough, up to 0.5 cm thick and covered by scars along the length of rhizome. The roots are generally well attached to the seafloor.

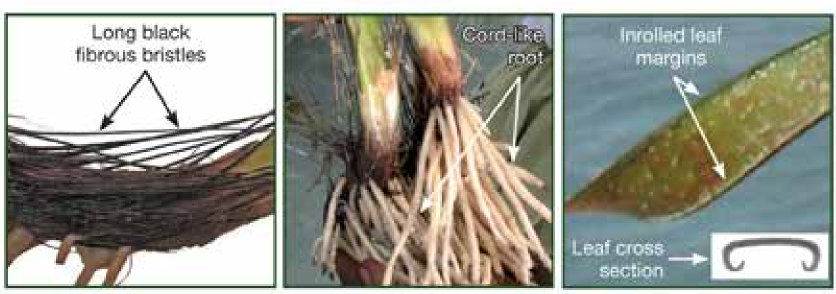
Microscopic Leaf Anatomy: Cells are square to angular and are placed in well-spaced rows (Plate 2).

Family: Hydrocharitaceae



(Plate 2)

(Plate 1)



(Plate 3) (Plate 4) (Plate 5)

Enhalus acroides (plate 1)

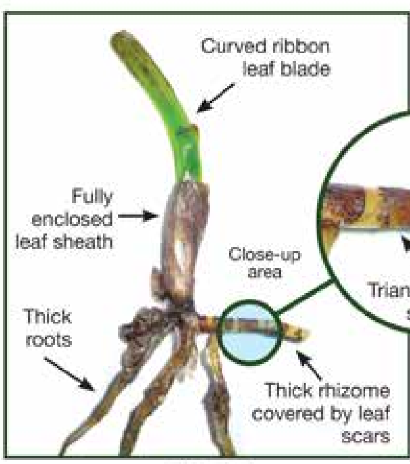
Leaf: The blade of the leaf is ribbon-like, and can be 200 cm long and nearly 2 cm wide. The remnants of the leaf sheath form long black fibrous bristles. There are up to 30 longitudinal parallel leaf veins. The leaf margins are thick and inrolled. Young leaves have slight serrations with a rounded and smooth leaf tip.

Stem: The leaves develop directly from the rhizome.

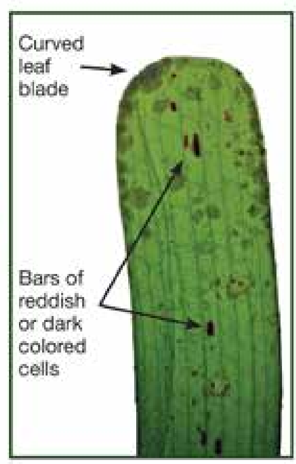
Rhizome: The rhizome is thick (up to 1 cm in diameter). The roots are cordlike, 0.3-cm thick.

Microscopic Leaf Anatomy: Cells are mostly brick-shaped, usually two to three times longer than they are broad (Plate 2).

(Plate 1)



(Plate 3)



(Plate 4) Mag. 2x

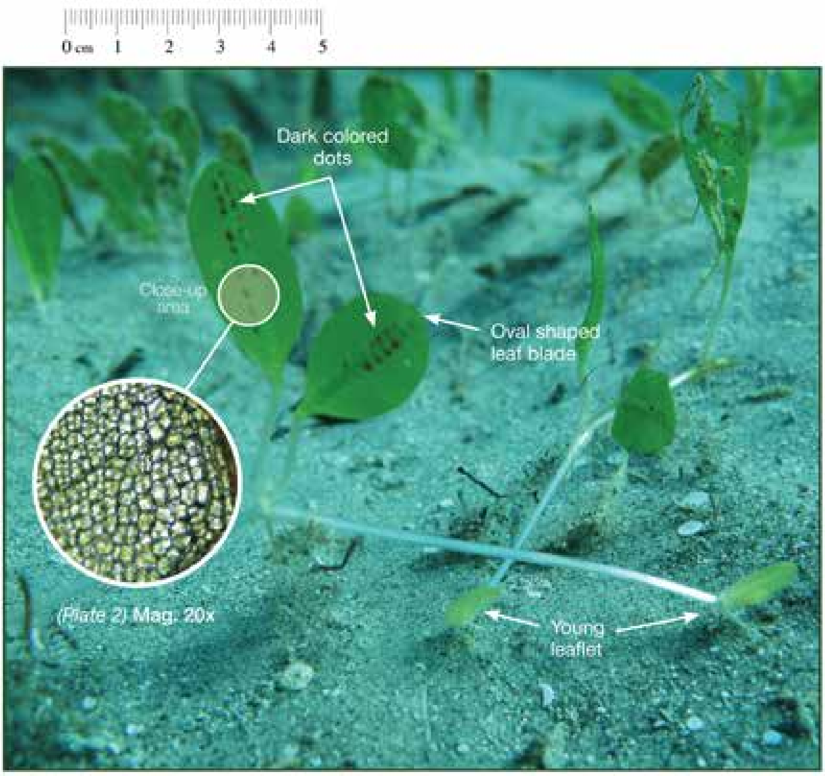
Thalassia hemprichii (plate 1)

Leaf: The blade of the leaf is up to 40 cm long, but typically much shorter, and 0.4-1.0 cm wide. The leaf blade is ribbon-like and often slightly curved with obvious large cells grouped in red or black bars. The leaf sheath is well developed and there are 10-17 longitudinal leaf veins (Plate 1). The margin of the leaf is smooth except for the leaf tip, which has fine serrations and is rounded.

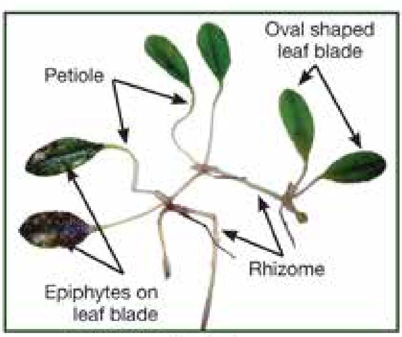
Stem: The stem is short and erect, bearing 2-6 leaves.

Rhizome: The rhizome is thick and covered with triangular shaped leaf scars.

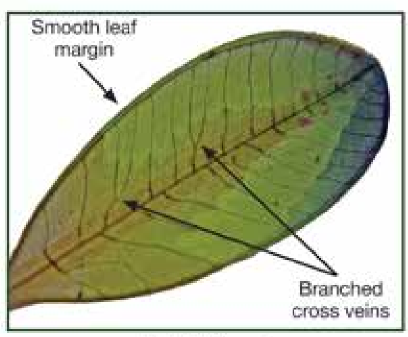
Microscopic Leaf Anatomy: Cell shape can range from circular to rectangular with red or black colored cells arranged in regular bars (Plate 2).



(Plate 1)



(Plate 3)



(Plate 4) Mag. 2x

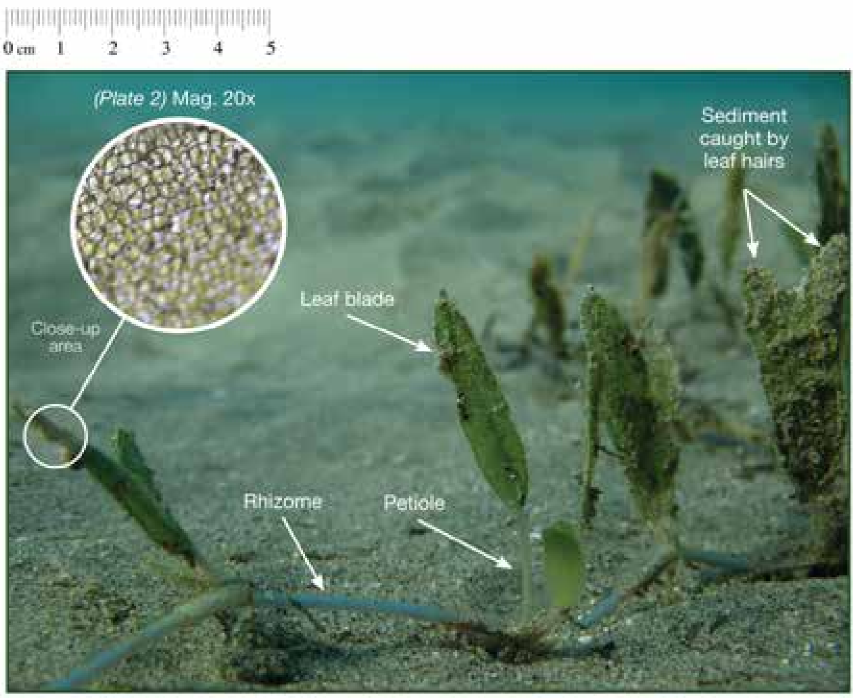
Halophila ovalis (plate 1)

Leaf: The leaf blade is typically >1.2 cm long and >0.6 cm wide, and is oval shaped. The leaf has no sheath, but two scales cover the base of the petiole. There are usually 12-28 (uncommonly <12) cross veins and in some specimens there are small dark colored dots beside the mid vein (Plate 1). The leaf margin is smooth and there are no hairs on the leaf surface.

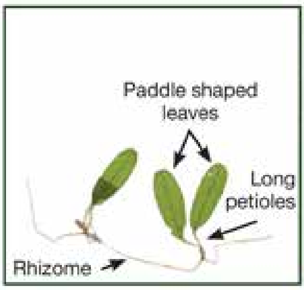
Stem: Petioles are 0.4-8.0 cm in length and arise directly from the rhizome. Pairs of leaves on petioles.

Rhizome: Rhizome is smooth, thin and light colored.

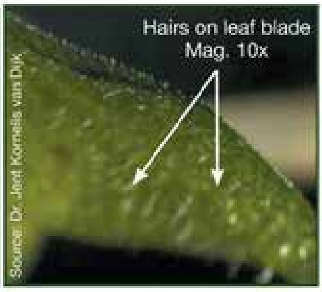
Microscopic Leaf Anatomy: The cells are not in clear rows but irregular in arrangement and shape. Cells sometimes have a “jigsaw” like appearance (Plate 2).



(Plate 1)



(Plate 3)



(Plate 4)


(Plate 5)

Halophila decipiens (plate 1)

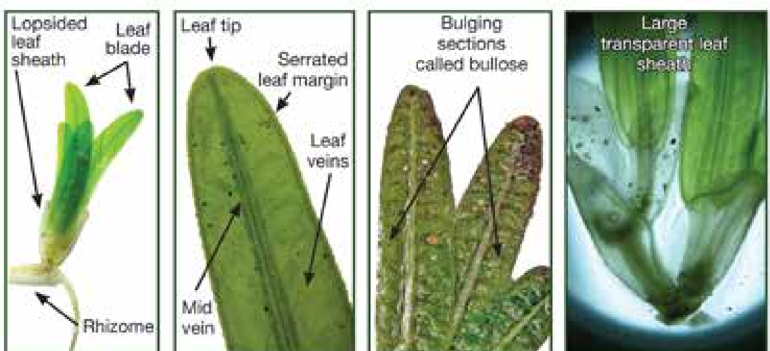
Leaf: The leaf blade is up to 2.5 cm long, 0.5 cm wide and paddle-shaped. It has hairs on both side of the leaf blade. There are 6-9 unbranched cross leaf veins. The margin of the leaf is finely serrated and the leaf tip is rounded.

Stem: The petioles are 3-15 mm long, each bearing pairs of leaves. Petioles develop directly from the rhizome.

Rhizome: The rhizome is smooth, thin and elongated.

Microscopic Leaf Anatomy: Cells angular to hexagonal in shape (Plate 2).

(Plate 1)



(Plate 3) (Plate 4) Mag. 4x (Plate 5) Mag. 2x (Plate 6) Mag. 2x

Halophila stipulacea (plate 1)

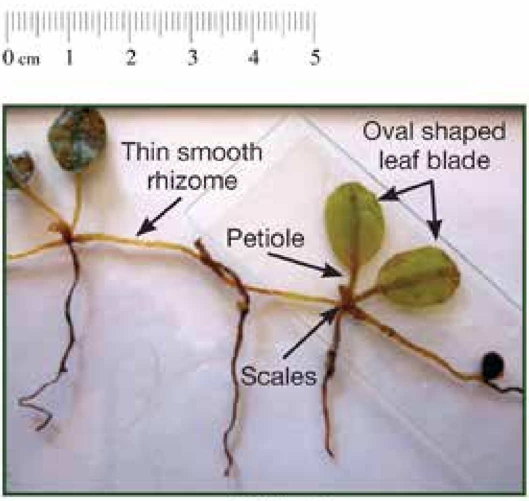
Leaf: The leaf blade is up to 6 cm long and 0.8-1.0 cm wide, and is linear to oblong in shape. The leaf sheath is a large transparent scale covering a short petiole. Leaf veins consist of 10-40 branched cross veins with a clear and obvious mid vein (Plate 1). An unusual leaf structure observed in the Red Sea is called 'bullose', which is a bulging section on the leaf surface (Waycott, et al., 2004). The leaf margin is serrated and minute hairs may be present on one side of the leaf surface. The leaf tip is rounded, and distinctly serrated.

Stem: Two short stems, each carrying two leaves.

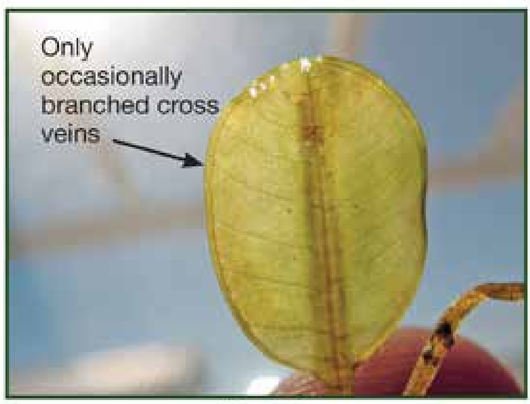
Rhizome: The rhizome is smooth with long internodes and the rhizome is always covered by leaf scars at the stem base.

Microscopic Leaf Anatomy: The leaf contains large cells that are angular to hexagonal in shape (Plate 2).

(Plate 1)



(Plate 2)



(Plate 3)

Halophila minor (plate 1)

Leaf: The leaf blade is oval shaped (Plate 2), and ranges between 0.6-1.2 cm in length and 0.35-0.6 cm in width. There is no leaf sheath, but two scales cover the petiole base. There are typically <12 cross veins, with a wide space between the cross veins that are occasionally branched. The leaf margin has smooth edges with no hairs on the leaf surface.

Stem: The petioles arise directly from the rhizome.

Rhizome: The rhizome is smooth, thin and light-colored.

Microscopic Leaf Anatomy: Similar to *H. ovalis*, cells are not in rows and irregular in arrangement

6

Corals and Coral Communities

6. CORALS AND CORAL COMMUNITIES

6.1 Background

Coral reefs together with their associated fish and macroinvertebrate communities are threatened globally by human activities in the coastal zone and by climate change. From the 1960s onwards, coral reef researchers around the world developed a variety of survey methods to measure different parameters on corals reefs (DeVantier 2004). The use of different methods however limited both the comparability of results and the identification of trends in the status of coral reefs at the national, regional and international scale (Connell, 1997). In response to this, coral reef researchers recognised that there was a need to develop standard protocols that could be equally applied in nations with different levels of finance, human capacity and expertise (Aronson et al. 1994). This led to the development of regional reef assessment programmes, including CARICOMP (Ogden et al. 1997), the ASEAN–Australia Living Coastal Resources Project (Chou & Wilkinson, 1992), ReefCheck (Hodgson, 1999) and the Global Coral Reef Monitoring Network (GCRMN) (Wilkinson, 2000, English et al. 1997). These programmes aimed to collect data with the purpose of producing status reports to raise regional and global awareness at both governmental and intergovernmental levels.

The original PERSGA SSM manual (PERSGA/GEF 2004) included two chapters related to monitoring coral reefs and coral communities and their associated fish and macroinvertebrate communities (DeVantier 2004, Gladstone 2004). The chapters provided an overview of research completed within the region together with the rationale, advantages and disadvantages of various methods for coral reef management-related research. The chapters also presented a minimum set of methods for site description and survey of benthic cover, coral and fish biodiversity, fish abundances and biomass together with recommendations for training, quality assurance, data archival, analysis and presentation, training materials, references. PERSGA also supported the implementation of two regional coral reef surveys. The first was prepared following the preparation of the SSM in 2002 and second in 2009 during which national teams completed monitoring surveys and the results were presented in the PERSGA Status Reports (PERSGA/GEF, 2003; PERSGA, 2010). The surveys in 2002 covered 52 sites while the surveys in 2008 included a total of 36 sites (5 in Djibouti, 8 in Egypt, 3 in Jordan, 9 in Saudi Arabia and 7 in Yemen). The sites surveyed in 2009 were selected taking into consideration accessibility for future surveys, safety measures, national capabilities of team member and logistics required in relation to national facilities available.

Since the development of PERSGA SSM other standard protocols have been developed to assess coral bleaching and coral reef resilience.

The purpose of this Chapter is to describe the preferred PERSGA methods to monitor corals and associated organisms. The main aim is to have a standard method that is used across the region in order to unify the data collected and in order to ease analysis process and long term monitoring

6.2 Overview

6.2.1 General approach

There are several standard coral reef monitoring protocols that have been developed to assess benthos, macroinvertebrates and fish community composition associated with coral reefs and coral communities. The two global standards are the ReefCheck protocol (Hodgson 1999, ReefCheck 2006) and the Global Coral Reef Monitoring Network (GCRMN) protocol (English et al. 1997). Both protocols employ transect based methods where benthos, macroinvertebrates, fish and impacts are surveyed using SCUBA diving along the same transect lines at a fixed number survey sites usually across two survey depths. Both protocols are described in in the PERSGA SSM Manual in the chapters by DeVantier (2004) and Gladstone (2004). The ReefCheck method is an appropriate entry level monitoring method that is well suited for use by community and voluntary groups following training. The GCRMN methods are more advanced and require a higher level of expertise and knowledge. In the RSGA region both protocols have been employed although the majority of national teams are still using ReefCheck (PERSGA 2010). Recommendations arising from the PERSGA SSM and reiterated following the 2009 surveys were that countries aimed to establish a two-tiered monitoring programme, whereby ReefCheck is used at a larger number of sites and national teams progress onto using the GCRMN methods (PERSGA 2010). The GCRMN methods are more detailed and requires certain level of qualification for data collection and is useful for detailed long term monitoring.

Both of the standard protocols are presented below together with several additional complimentary methods that can be used to increase the amount of data collected in the field surveys and the potential scope for analyses. These additional methods include the use of video belt transects and photoquadrats for monitoring benthic communities and the use of baited and unbaited remote underwater video for fishes. These methods make use of wider availability of very affordable underwater camera systems that can be used to collect data by national teams. The advantage of these methods is that they do not require much additional field time. So even if the national teams do not currently have the capacity to analyse these types data, they can collect the data which can then be archived and analysed later at the regional level and used to provide more in-depth training.

6.2.2 **Objective**

The main objective is to monitor the ecological state of marine ecosystems in the Red Sea and Gulf of Aden. The survey methods are intended to collect information about the percentage cover and composition of benthic communities and the abundances of fishes and macroinvertebrate communities, as well as assessment of the types and levels of impacts found associated with coral reefs and coral communities. The different methods use different targets that range from simple benthic cover categories to more detailed species and genera level surveys.

6.2.3 **Field equipment**

- Survey forms, slate, clips and pencils
- Transect tape measures (3 x 100 m or 6 x 50 m tapes)
- Spare dive weights to attach to both ends of the transect tapes
- Marker pegs (either starpegs or iron rebar with t-bar welded ends)
- Plastic cable ties or markers to attach to pegs.
- Surface marker bouyes to mark the survey and transects locations during surveys
- GPS (preferably differential GPS)
- Boat for the off-shore sites

- Four wheel Drive Vehicle for shore sites
- Large weighted hammer.
- Personal SCUBA equipment.
- Underwater mesh bag
- Dive oxygen and medical kit.
- Underwater camera to take photographs to aid identification of unknown species or record specific impacts.
- Field laptop for data entry.

Additional equipment required if more methods are used in parallel with standard protocols

- 0.25 m x 0.25 cm quadrat for coral recruitment studies
- 0.5 m x 0.5 m quadrat or 1 m x 1 m quadrat to assist in quantifying densities of macroinvertebrates when abundances are particularly high.
- Tetrapod photoquadrat frame, underwater camera and lights
- Baited underwater camera frames and cameras.

6.2.4 Field personnel

The surveys require SCUBA diving. All survey teams should therefore be composed of properly qualified and suitably experienced SCUBA divers. The survey team should ideally be composed of buddy pairs with a boat man. The divers need to work within the safe diving limits at all times. Ideally survey teams will be composed of at least six divers, including one surveyor for benthos plus a buddy, another for fishes plus a buddy, and a third surveyor for macroinvertebrates plus a buddy. Often it is not possible to have six qualified surveyors participating in monitoring programmes, however the buddies can be experienced divers that can assist the surveyors and help ensure diving safety.

6.2.5 Training / experience

All survey teams should be composed of properly qualified and suitably experienced SCUBA divers. Each buddy pair should have at least one advanced diver (BSAC Advanced, PADI Dive Master, CMAS3*). The surveyors should be familiar with Reef-Check or GCRMN survey methods the team members who will collect data must participate in training before surveys . ReefCheck has a certification scheme (Ecodiver training course) details of which are available on the ReefCheck website.

6.3 Field Procedure

Survey Sites and Sampling Design

The sites selected for inclusion in national monitoring programmes should reflect the range of habitat types and levels of exposure to human impacts. Programmes are normally designed so that they follow a stratified sampling protocol (see Figure 6.1). Ideally two depths (0-5m and 5-10m)are surveyed within each site, and transects are positioned within a relatively homogeneous area of habitat at each depth. The number of transects (i.e. replication) should remain consistent between sites and between depths, and generally 5 transects are surveyed per site. The transects are normally laid parallel to the reef / shoreline within the depth ranges. In some areas (e.g. Socotra Islands and Gulf of Aden, Yemen), the coral communities are quite patchy and only extend across a limited depth range. On these types of habitats, all transects can be positioned in parallel, rather than aligned linearly along the reef. Parallel transects must to be separated by at least 10 m and should not overlap.

Site Maps and Layouts

The position of sites and the layout of the transects should be mapped to aid relocation. This entails recording a GPS waypoint at the start of the first transect, and other transects if these are particularly far apart. Creating a sketch map to show conspicuous features coastline and underwater features can also assist in the relocation of sites (e.g. position of transects in relation to large massive corals). Some monitoring programmes use sub-surface marker floats to mark transect sites. But can be problematic and often lost in areas where there are strong currents or where fishermen are active. It is important to minimize the damage caused during the marking of transects.

Permanent or Random

For long term monitoring programmes the transects should ideally be permanently marked using steel pegs made from rebar or star-type fencing pegs, which can be hammered or cemented into the reef substrate and marked with fishing float fixed to the substrate with short line (see Figure 6.2). Pegs can be labelled to indicate the transect number by using plastic marker tags, punched with holes to indicate the number (e.g. 1–4 holes for Reef Check, 1–5 holes for GCRMN). Alternatively, cable ties can be used to indicate the peg number by attaching the correct number of ties to each peg. These can also be used to indicate the transect direction. Although the amount of work involved in marking a site may appear onerous, the benefits pay off in the end as the variability that needs to be accounted for between the surveys is reduced.

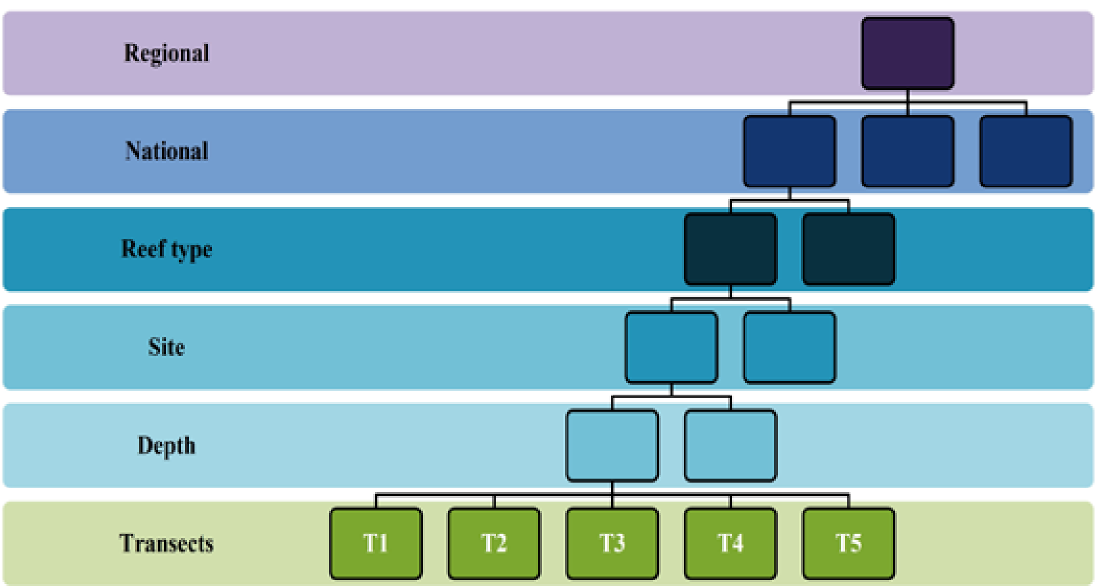


Figure 6.1 Example of stratified sampling regime for coral reef monitoring (after English et al. 1997, Oxley 1997 and DeVantier 2004).

(a) (b)

Figure 6.2 (a) Transect marker peg made from rebar (with Onset Hobo temperature logger attached) and (b) hammering marker pegs into the reef substrate using a heavy sledge hammer.

6.3.1 **ReefCheck (Level 1 & 2)**

Survey sites

Survey sites should be selected to be representative of the range of coral reefs and coral communities present within the survey area. Surveys are normally conducted at two depth range per site, between 0-5 m and 5-10 m below the chart datum of low water.

Transect layout

Surveys are completed along a 100 m long transect tape that is normally laid along the selected depth contour from a randomly selected starting point on the reef slope. Each 20 m transect is separated by a 5 m space (see Figure 6.3). The first transect (T1) extends between 0 to 20m, the second transect (T2) extends between 25 to 45 m, the third transect (T3) extends between 50 to 70 m and the fourth transect (T4) extends between 75 to 95 m. In parts of the southern Red Sea, Gulf of Tadjourah and Gulf of Aden, it may not be possible to survey two depths within each site or arrange the transects end-to-end. In this case one survey depth may be assessed and transects can be laid in parallel to one another.

To permanently mark the transect marker pegs would be fixed into the substrate 10 m intervals along the transect for T1 (0 m, 10 m, 20 m), T2 (25 m, 35 m, 45 m), T3 (50 m, 60 m, 70 m) and T4 (75 m, 85 m 90 m). Thus a minimum of 12 pegs would be needed per depth, and 24 pegs per site, assuming that two depths are surveyed.

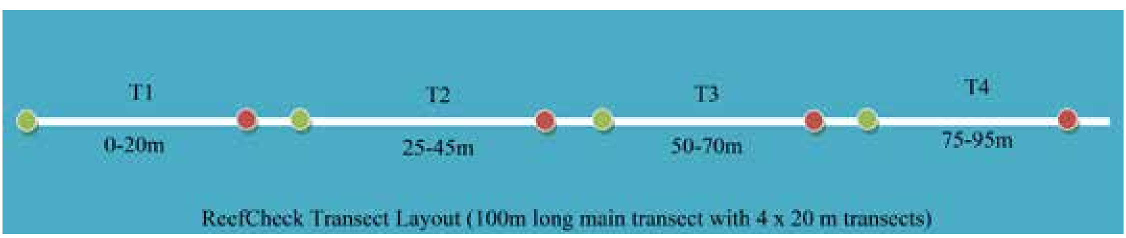


Figure 6.3 Standard layout of a ReefCheck monitoring sites. Red circles indicate the start and end point of each transect T1 to T4, which extend between 0-20 m, 25-45 m, 50-70 m and 75-95 m.

Benthos

The benthos is surveyed along four 20 m transects along the main 100 m transect line using the point intercept transect method. The benthic surveys are completed as follows:

- Prepare a survey slate and pencil, together with the Reef Check point intercept transect survey form, and personal SCUBA kit.
- Starting on T1, observe the benthic cover immediately beneath the transect tape at position 0 cm on the transect tape, and record this cover type on the survey form.
- Add a D or B to indicate if the hard coral is diseased or bleached (e.g. HC/D or HC/B)
- Move along T1 to the 50 cm mark on the transect tape, observe the benthic cover type under the tape and record this on the survey form.
- Repeat these observations every 50 cm until reaching the end of T1 at the 20 m mark.
- Swim along the transect tape by 5 m to the 25 m mark which is the start of T2 and repeat the process, by recording the benthic cover type at 50 cm point intervals until reaching 45 m mark.
- Repeat the above process until all four transects have been completed.

The benthic categories to be recorded using the ReefCheck method are listed in Table 6.1. Further details on ReefCheck method, identification guides and photographs of the species are provided at www.reefcheck.org.

Table 6.1 ReefCheck benthic cover categories (ReefCheck 2010)

Code	**Substrate**	**Description**
HC	Hard coral	All forms of hard coral, including blue coral *Heliopora,* fire coral *Millepora* and organ pipe coral.
SC	Soft coral	All forms of soft corals, including zoanthids.
RDC	Recently dead coral	Any recently dead coral where the corallite structures are still visible.
BC	Bleached Coral	Any bleached or partially bleached coral colonies.
NIC	Nutrient indicator algae	All macroalgae except coralline, calcareous and turf algae, which are recorded as the substrate beneath. The exception is *Halimeda* which is record as 'Other'.
SP	Sponge	All sponges.
RC	Rock	Any substrate surface where coral could settle onto including rock covered with turf algae, bivalves, coralline algae and dead coral
RB	Rubble	Pieces of dead broken coral between 0.5 to 15 cm diameters.
SD	Sand	Sand includes particulate matter typically less than 0.5cm in diameter that settle rapidly out of the water column when disturbed.
SI	Silt/clay	Silt is fine particulate matter that does not settle out of the water column rapidly when disturbed.
OT	Other	All other living and non-living substrata not accounted for above, including hydroids, anemones, gorgonians, ascidians.

Macroinvertebrates

The abundance / density of macroinvertebrate organisms is assessed along four belt transects 20 m long and 5 m wide (100 m^2) centred along on the main ReefCheck line transects at two survey depths within each survey site. The macroinvertebrate surveys are completed as follows:

- Prepare a survey slate and pencil, together with the macroinvertebrate survey form, and personal SCUBA kit.
- Starting on T1, swim along the main transect, looking 2.5 m either side of the tape for the macroinvertebrates listed on the survey form (see Figure 6.4). Swim slowly and take time to look under corals head and in crevices to check for macroinvertebrates.
- Record the number of each type of macroinvertebrate observed on the survey form. Using tally marks instead of number can help with the accurate recording of numbers.
- If a particular species is very abundant, it may be necessary to use replicate 1 m x 1 m quadrats to estimate the abundance of that species within the survey area. 10 quadrats per transect would provide a good enough estimate of density.
- Once the survey on T1 is completed swim along the transect tape by 5 m to the 25 m mark which is the start of T2 and repeat the process.
- Repeat the above process until all four transects have been surveyed.

The organisms listed on the survey form include: giant clams (*Tridacna* spp.), pencil urchins (*Heterocentrotus mammillatus*, *Eucidaris* spp.), long-spined urchins (*Diadema* spp.), sea cucumbers (*Holothuria scabra, H. fuscogilva, Stichopus chloronotus*), crown-of-thorns starfish (*Acanthaster planci*), giant triton (*Charonia tritonis*), flamingo tongue (*Cyphoma gibbosum*), banded coral shrimps (*Stenopus hispidus*) and lobsters (*Panulirus* spp.). Broken coral and items of human litter (trash) are also recorded. Further details on ReefCheck method, identification guides and photographs of the species are provided at www.reefcheck.org.

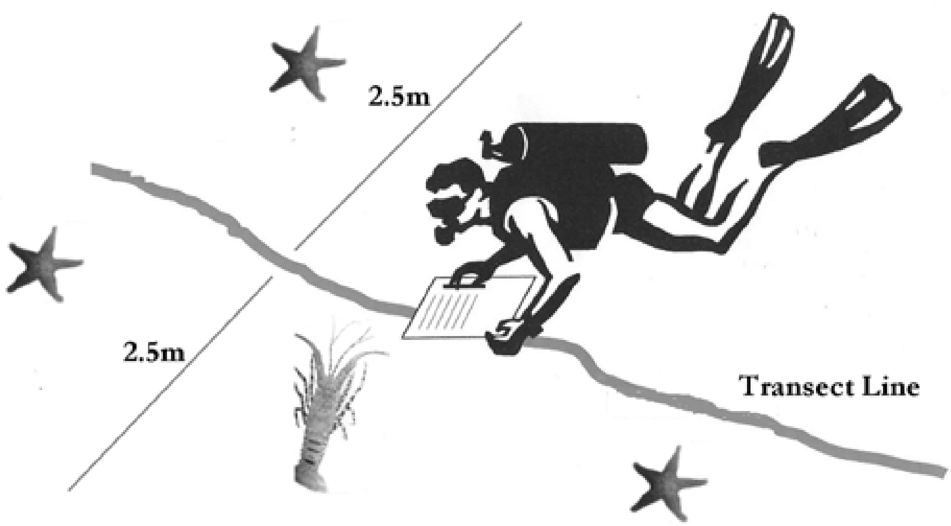


Figure 6.4 Belt transects for monitoring invertebrates, indicating the surveyor observing 2.5 m either side of the transect line.

Fish

Fish are surveyed along four replicate 20 m long x 5 m wide belt transects (100 m^2) centred on the main ReefCheck transects at two depth ranges (7–12 or 2–6 m) within each survey site. The fish surveys are completed as follows:

- Prepare a survey slate and pencil, together with the fish survey form, and personal SCUBA kit.
- After the transects have been laid, wait for approximately 15 minutes before starting the survey to allow the fishes to resume their normal behaviour.
- Starting on T1, swim slowly along the main transect looking for the fishes listed on the survey form 2.5 m either side of the tape and 5 m off the substrate. Swim slowly and count the abundance of fishes.
- Record the number of each type of fish observed on the survey form. Using tally marks instead of number can help with the accurate recording of numbers.
- Once the survey on T1 is completed swim along the transect tape by 5 m to the 25 m mark which is the start of T2 and repeat the process.
- Repeat the above process until all four transects have been surveyed.

The target fish species counted in each transect include: grouper (*Cephalopholis* and Epinephelus spp.) and coral trout (*Plectropomus* spp.) over 30 cm in total length (all species), barramundi cod (*Cromileptes altivelis*), sweetlips (family Haemulidae – *Plectorhynchus* spp.), humphead (Napoleon/ Maori) wrasse (*Cheilinus undulatus*), bumphead parrotfish (*Bolbometopon muricatum*) and butterfly fish (all species of family Chaetodontidae). Further details on ReefCheck method, identification guides and photographs of the species are provided at www.reefcheck.org.

Data entry

ReefCheck also provides standard Excel datasheets for data entry and preliminary analysis. Entering the data from the field data sheets into the spreadsheet at the end of every survey day is preferable if logistics permit. For QAQC (quality assurance quality control) purposes, the team will check their data and check that it has been entered correctly onto a spreadsheet. Data may then be sent to ReefCheck.

6.3.2 Global Coral Reef Monitoring Network (Level 2 & 3)

Survey sites

As with ReefCheck, survey sites should be selected to be representative of the range of coral reefs and coral communities present within the survey area. Surveys are normally conducted at two depth range per site, between 2-6 m and 7–12 m below the chart datum of low water.

Transect layout

Surveys are completed along three or preferably five replicate transect tapes that are laid within a depth range starting from a randomly selected point on the reef slope. The transects used are 50 m long, although only the first 20 m of each transect is surveyed for benthos and macroinvertebrates.

The transects should be laid end to end as is done in ReefCheck, but more commonly the transects are laid in parallel separated by a minimum of 10 m to allow for the completion of fish and macroinvertebrate belt transects. Laying the transects end to end does not work where reef habitats are patchy such as in the Gulf of Aden or Gulf of Tadjourah. Laying all five 50 m transects in parallel on steep reef slopes is also problematic as the deepest transects can end up being a lot deeper than the rest if the correct spacing is to be maintained.

An appropriate alternative layout is shown in Figure 6.5. This layout works well both on forereef slopes and on small patchy reefs. The first 50 m transect (T1) extends is laid parallel to shore, and the second transect (T2) and third 50 m transect (T3) are laid a further 10 m and 20 m away. The fourth transect (T4) is then laid in is laid 5 m from T1 and T2 running in the opposite direction. The fifth transect (T5) is laid 10 m from T2 and T3 also running in the opposite direction.

If the sites are permanently marked pegs would need to be hammered into the substrate at 5 m intervals along the first 20 m of each transects and then 10 m intervals up to 50 m (0 m, 5 m, 15 m, 20 m, 30 m, 40 m and 50 m). So 7 pegs are needed per transect, which is equivalent to 35 pegs per depth, and 70 pegs per site.

Numbering the transects in a consistent manner makes it easier for the surveyors to correctly identify which transect they are working on and in re-locating the transects for repeat surveys. For safety reasons it is however always safer to work on the deeper transects first.

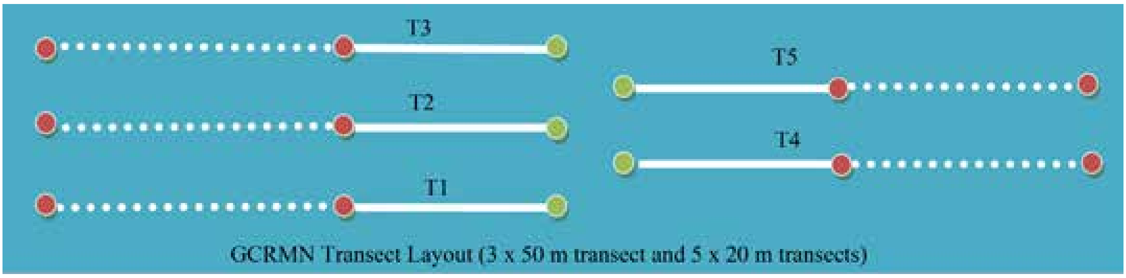


Figure 6.5 Standard layout of a GCRMN monitoring sites. Red circles indicate the start and end point of each transect T1 to T4, which extend between 0-20 m, 25-45 m, 50-70 m and 75-95 m. Green circles indicates distance should be left between transects.

Benthos

The benthos is recorded along five 20 m long transects are surveyed using the line intercept transect method by scuba at one or two depths (2–6 m and 7–12 m where appropriate) at survey site. The method is similar to ReefCheck in that the data is recorded in-situ and along replicate transects. However, it differs from ReefCheck in that the benthic cover is measured by recording the distances along the transect line instead of at point intervals, and there are more different benthic cover types recorded (Bradbury et al. 1986; De Vantier 1986; English et al. 1997, De Vantier 2004). The benthic line intercept transects are completed as follows:

- Prepare a survey slate and pencil, together with the line intercept transect survey form, and personal SCUBA kit.
- Starting on T1, observe the benthic cover immediately beneath the transect tape starting at position 0 cm on the transect tape and record this cover type on the survey form.
- Move along T1 until the substrate type changes and record the distance alongside the substrate type recorded on the survey form.
- Record the new substrate type on the survey form, then move along T1 again until there is another change in the substrate type. Again record the distance on the survey form.

- Repeat these observations until reaching the end of T1 at the 20 m mark.
- Swim back along the transect tape to the start of T2 and repeat the process by recording the benthic cover types and the changes until reaching 20 m mark.
- Repeat the above process for all five transects.

Macroinvertebrates

The abundance / density of macroinvertebrate organisms is assessed along five 20 m long and 5 m wide belt transects (100 m^2) at one or two survey depths within each survey site. The macroinvertebrate surveys are completed as follows:

- Prepare a survey slate and pencil, together with the macroinvertebrate survey form, and personal SCUBA kit.
- Starting on T1, swim along the main transect, looking 2.5 m either side of the tape for all mobile macroinvertebrates. Swim slowly and take time to look under corals head and in crevices to check for macroinvertebrates.
- Record the number of each type of macroinvertebrate observed on the survey form. Using tally marks instead of number can help with the accurate recording of numbers.
- Take photographs of unknown species for identification purposes.
- If a particular species is very abundant, it may be necessary to use replicate 1 m x 1 m quadrats to estimate the abundance of that species within the survey area. 10 quadrats per transect would provide a good estimate of density.
- Once the survey on T1 is completed swim to the start of T2 and repeat the process.
- Repeat the above process until all five transects have been surveyed.

These surveys are similar to the ReefCheck methods but instead of limiting the surveys to key indicators species, instead these survey aim to record all the macroinvertebrate species encountered.

Table 6.2 Lifeform categories recorded on line intercept transect surveys (after DeVantier 2004).

Lifeform	Group	Code
Acropora tabular	Scleractinia, *Acropora*	ACT
Acropora branching	Scleractinia, *Acropora*	ACB
Acropora encrusting	Scleractinia, *Acropora*	ACE
Acropora digitate	Scleractinia, *Acropora*	ACD
Acropora submassive	Scleractinia, *Acropora*	ACS
Coral massive	Scleractinia, non-*Acropora*	CM
Coral branching	Scleractinia, non-*Acropora*	CB
Coral submassive	Scleractinia, non-*Acropora*	CS
Coral foliose	Scleractinia, non-*Acropora*	CF
Coral encrusting	Scleractinia, non-*Acropora*	CE
Coral mushroom	Scleractinia, non-*Acropora*	CMR
Heliopora	Alcyonaria, blue coral	CHL
Millepora	Hydrozoa, fire coral	CME
Tubipora musica	Alcyonaria, organ pipe coral	CTU
Soft coral	Alcyonaria, gorgonians, sea whips etc.	SC

Dead coral	Recently dead corals with no visible algae	DC
Dead coral with algae	Dead standing corals with algae	DCA
Sponge	Porifera	SP
Zoanthid	e.g. *Palythoa, Protopalythoa, Zoanthus* spp.	ZO
Other living benthos	Anemones, ascidians etc.	OT
Mixed algal assemblage	Various algae	AA
Coralline Algae	Crustose coralline algae	CA
Turf Algae	Short turf algae	TA
Macro-Algae	Large fleshy algae	MA
Halimeda	Calcareous green algae	HA
Sand	Reefal origin	SD
Rubble	Dead broken coral etc.	RB
Silt	Terrestrial origin	SI
Rock	Rock not covered by other benthos	RCK
Water	Fissures deeper than 50 cm	WA
Other	Missing data	DDD

Fish

Detailed assessments of fish populations involve surveying the fish along replicate 50 m by 5 m wide belt transects along the same transect lines as surveyed for benthos and macroinvertebrates (Figure 6.6). The fish surveys are completed as follows:

- Prepare a survey slate and pencil, together with the fish survey form, and personal SCUBA kit.
- Starting on T1, swim slowly along the main transect, recording fish encountered within 2.5 m on either side of the tape and 5 m above the substrate level.
- Count and record the abundance of all fish species included on the survey forms. Using tally marks instead of number can help with the accurate recording of numbers, or use log abundance scales.
- Surveyors will be able to record all fish species observed within the belt transects.. Two survey forms are included at the back of the chapter with a proposed list of core species (the list is modified to suit local needs). The first list include those that can be surveyed within a 5 m x 50 m belt transect. The others are species that can be surveyed within a 1 m x 50 m belt transect. These surveys could be done by an experienced individual or as buddy pairs, where one buddy focusses on counting the species in 5 m x 50 m belts and the other focusses on counting the 1 m x 50 m belts.
- At the end of on T1 complete a 5 minute timed swim. The timed swim allows for the recording or larger schooling or more mobile food fishers that are often not well accounted for in transects. Swim slowly and record the abundance of all fishes in a 180 degree radius at a distance of approximately 5 m counting all fish encountered.
- Once the survey on T1 is completed swim to the start of T2 and repeat the process.
- Repeat the above process until all three to five transects have been surveyed.

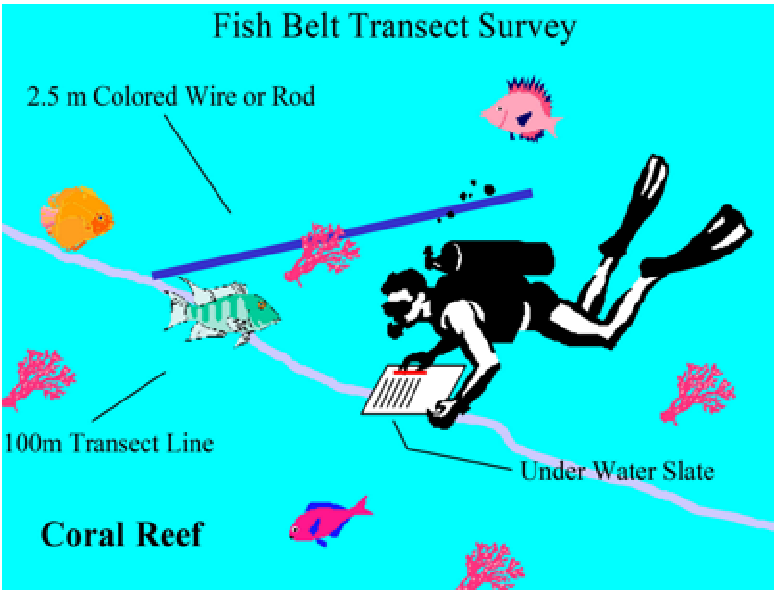


Figure 6.6 Belt transects for monitoring coral reef fishess, indicating the surveyor observing 2.5 m either side of the transect line.

6.3.3 Benthos – Advanced methods

Benthos - Video Belt Transects (Data collection Level 1/2 & Data analysis Level 3)

The use of video belt transects can be used to supplement the in-water benthic survey methods. The wider availability of underwater video cameras and increased affordability has increased the use of this field method. The video transects can be recorded along the full length of ReefCheck transects and along the full 50 m length of GCRMN transects which increases the comparability of the data with the fish survey methods (Klaus and Turner 2004). A series of five replicate transects are filmed depending on the local reef characteristics and the discretion of the local survey team.

- The video operator swims slowly at a constant speed (ca. 5–10 m per minute such that a 50 m transect takes 5 minutes to film) and height (ca. 25–30 cm) above the transect line. The camera is held perpendicular to the benthos with outstretched arms.
- At the start and end of each transect, the general site characteristics are also filmed by the surveyor slowly rotating to film seascape. Keeping a scale (e.g. measuring tap, diver, measuring stick, etc.) within the frame to be appear in the film, and use for measuring assessment when playback

A detailed description of the method is provided in Christie et al. (1996), Oxley (1997) and Klaus & Turner (2004). The data can be collected by qualified SCUBA divers but the analysis requires additional training in the software.

Benthos – Photoquadrats (Data collection Level 1/2 & Data analysis Level 3)

As with the use of video, the use of photoquadrats to supplement in water benthic survey methods has increased in popularity in line with the increased availability and affordability of underwater digitial cameras. Photoquadrats are taken using a camera attached to a fixed tetrapod frame constructed from metal or plastic tubing. The frame consists of two rectangular ‘frames’ connected at the mid-point along each of the four arms of the frame by four legs. The camera is attached to the top smaller frame, by using a an underwater camera tray, and positioned so that the lens faces vertically downwards. The frame thus holds the camera at a fixed distance from the substrate so that each shot captures the same area of substrate within the bottom photoframe (see Figure 6.7). The bottom photoframe is often marked with alternating black and white marks at 5 cm intervals for scale. Video lights can also be attached to the top frame to increase the lighting available for each photograph.

Replicate photoquadrats can be taken at random either side or centered on the transect, at fixed distances along the transect (e.g. 0 m, 5 m, 15 m and 20 m) or continuously along the first 10 m of each transect, which can then be used to create a photomosaic. The data can be collected by qualified SCUBA divers but the analysis requires additional training in the software.

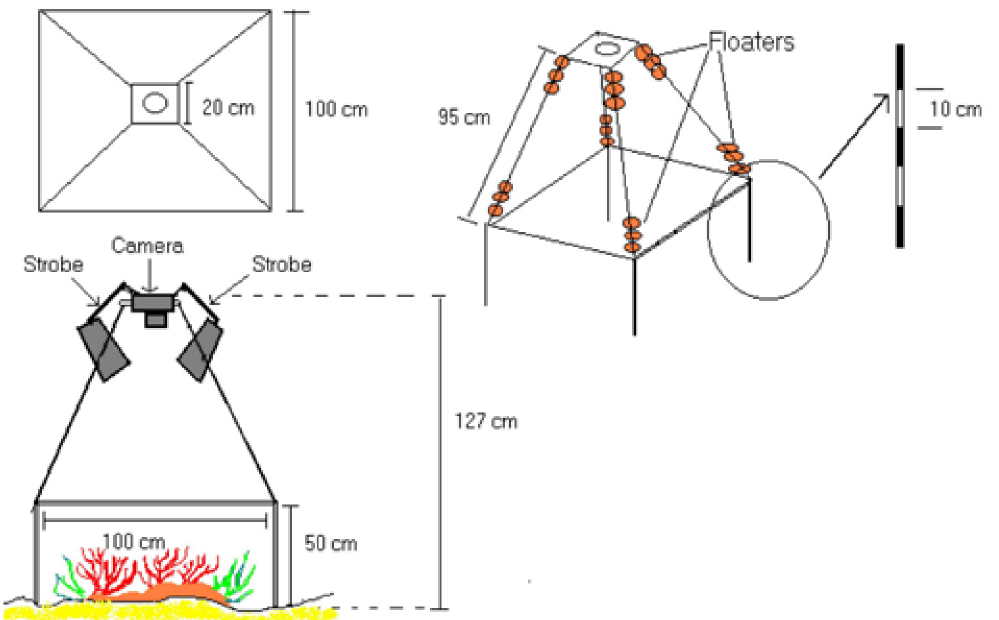


Figure 6.7 Diagram showing the design of photoquadrat (modified by Kotb, 2001).

6.3.4 **Fish – Advanced method**

Fish – Biomass Methods (Level 3)

An additional method that complements the GCRMN methods is for fish surveyors to record the lengths of individual fishes. Data on fish length provides managers and scientists with information that is useful for understanding natural differences in population demographics between areas. The information is also useful for evaluating biomass and the impacts of fishing and management strategies designed to allow recovery of fish stocks after exploitation.

Before surveyors attempt to undertake surveys that incorporate fish length they need training in how to estimating fish length underwater. Surveyors are trained using plastic or wooden model fish cut to various lengths covering the size range of species to be surveyed. Each model fish is individually numbered with a random number, and the numbers, and corresponding fish length, are recorded on a separate sheet of waterproof paper. The model fish are laid out in a random order in a line on the substrate or the bottom of a swimming pool with their numbers visible. Trainees swim with the information sheet, comparing the actual fish lengths to the appearance of the models. Trainees repeat the process in the opposite direction, again comparing each model fish's actual length to its appearance. Trainees then return the waterproof sheet of fish lengths to the trainer and undertake a trial by swimming back along the line attempting to estimate the length of each model fish to the nearest centimetre.

After the trial, trainees compare their estimated length to the actual length of each model fish and test the significance of the differences by a paired t-test. Trainers can then inform the trainee if they are over- or under- estimating the model lengths.

Fish - Baited and Unbaited Remote Underwater Videos (Level 2 & 3)

Fish assemblages can also be monitored using video systems which is another technique that allows for the safe non-destructive monitoring of fish fauna within sensitive habitats. Remote underwater video (RUV) systems can be either unbaited (RUVs) or baited (BRUVs). Investigations to compare baited and unbaited methods found that while the use of bait increases the abundance and species richness of carnivores it does not influence herbivorous fish (Langlois *et al.,* 2010). The use of BRUVs is not dissimilar to other fish sampling techniques that also incur a level of bias. RUVs/BRUVs can be set up using a single camera or two cameras. With the two-camera systems, the cameras are positioned so that the field of view is overlapping which permits the recording of stereo video and allows for measurement of fish sizes. The camera or stereo-cameras are attached to a weighted metal frame that holds them at a height of approximately 30 to 50 cm off the seabed. The frame is weighted using additional dive weights if needed to ensure that it is stable underwater. RUV/BRUVs frames also have a bait pole that holds the bait out in front of the camera. Bait fish is crushed and placed in a bait box or similar container and attached to the end of the bait pole. The bait may be left for 24 hours to develop greater pungency and increase the attractiveness of the bait to target fish species (Dorman *et al.,* 2012). The RUV/BRUVs camera rigs are light enough that they can be deployed by hand off the side of a small boat. The rig is tethered to a floating surface marker buoy by a 6mm floating rope which also aids retrieval. Three or more BRUV rigs are then deployed on a survey site for a fixed period of time between 30 minutes to 1 hour.

6.4 Strengths / Weaknesses

Strengths	Weaknesses
ReefCheck	
ReefCheck provides a rapid means of acquiring quantitative estimates of the percentage cover of the main benthic groups on coral reefs without requiring taxonomic knowledge, and is thus an appropriate entry level survey method where little capacity exists. The method requires minimal logistical support other than the essential items listed above.	The method provides no information on coral community structure and, because of the limited number of sampling points (40 points per 20 m transect). The data is prone to large variances in heterogeneous habitats. This potential for imprecision can limit the statistical power of the method for detection of significant trends in cover.

Global Coral Reef Monitoring Network	
This method requires little logistical support and thus is suitable for isolated locations. Survey observers can be trained to collect accurate data in a short time period (ca. 1 week training course). The method provides data with greater taxonomic resolution and usually higher levels of precision than does Reef Check. As observers' levels of taxonomic expertise increase, more detailed data can be collected, initially at family-genus level and ultimately at genus-species level.	The method is more time consuming and requires a greater level of taxonomic expertise than ReefCheck. For collection of demographic data, quadrat and belt transect methods are more appropriate. As with other methods, great care must be taken to ensure all observers are well trained and consistent in recording the standard 31 benthic categories (English *et al*. 1997).
Video belt transects	
Video belt transects are very fast to implement underwater in comparison with PITs and LITs which can take an experienced observer more than 30 minutes per transect. The method is also cost-effective in terms of laboratory analysis, and provides a permanent archive-able record of the site, which is useful for training and for showing to decision makers. The results are compatible with the in-water methods, and transects lengths can be completed that match the fish transect lengths. The data can also be used for demographic analysis, by mapping of the individual corals present on the transects.	Although cost-effective in the field and laboratory, the method is reliant on camera equipment, which although more affordable does require maintenance. The analytical method uses software that is available for free but requires additional training or skilled personnel.
Photoquadrats	
Photoquadrats are an extremely useful additional method to combine with either of the transect based methods described above. Photoquadrats allow for the rapid collection of field data that can be used for more detailed quantitative demographic analysis and for monitoring specific colony level impacts and recovery processes through time.	Although cost-effective especially when used in combination with either of the transect based methods, the analytical techniques require additional training.
BRUVs/RUVs	
Allows for the recording of fish communities undisturbed by divers. Baited and unbaited RUVs are rapidly becoming the new standard method for assessing fish abundances.	The analytical techniques require specialist software that needs to be purchased.

6.5 References

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6.6 Annexes

Site Description Form **Survey Sheet_______**

SITE INFORMATION				
Site:	Coral	Coral (channel)	Coral (fringing)	Seagrass
Site:	Coral	Coral (channel)	Coral (fringing)	Seagrass
GPS Waypoint:	Lat (deg dmin): º ‘S		Lon (deg dmin): º ‘E	
Date:	Start Time:		End Time:	
ReefCheck: PIT		ReefCheck Fish		ReefCheck Invertebrate	
GCRMN LIT		GCRMN Fish		GCRMN Invertebrate	
Photoquadrats		Video transects:			
Biomass		BRUV/RUVs			

PHYSICAL ENVIRONMENT & SITE STRUCTURE		
Weather:		**Air Temp (C)**
Depth (m) Min:	**Depth (m) Max:**	**Slope:**
Exposure:	**Aspect:**	**Salinity ppt:**
Current direction (NSEW):	**Visibility (m) horizontal:**	**Water Temp(ºC) surface:**
Current rating (1-5):	**Visibility (m) depth:**	**Water Temp(ºC) deep:**
Substrate complexity (1-5):	**Sediment texture (1-5):**	
Topographic complexity (1-5):	**Sediment depth (1-5):**	
Largest coral & genera:	**Dominant coral genera:**	**Dominant size class:**

SITE MAPS	
PROFILE: (*depth of transects and features*)	**PLAN:** (*sketch of transect layout and orientation*)

ACTIVITIES NEAR SITE					
Sources of Pollution		**Fisher Activities**		**Other Resource Use**	
Distance to nearest town		Fishing Nets		Tourist diving / hotel	
Population size		Fishing Traps		Agriculture	
Distance to nearest river		Fishing Other		Sand mining	
Other		Harvest inverts		Other	
		Aquaculture			
IMPACTS					
Bleaching (%)		**Disease & Infestations**		**Physical Damage**	
White		COTS		Rubbish	
Partial				Fish trap	
Dead (recent)				Fish nets	
Dead (old)				Anchor	
Recovery				Other	
Other organisms					
NOTES:					

ReefCheck Benthic Transects **Survey Sheet_______**

Country:	**Site:**	**Depth:**	**Date**
GPS Waypoint:	**Surveyor:**		**:**

Transect 1				**Transect 2**				**Transect 2**				**Transect 4**			
Depth = (start)		Depth = (end)		Depth = (start)		Depth = (end)		Depth = (start)		Depth = (end)		Depth = (start)		Depth = (end)	
0		1050		2500		3550		5000		6050		7500		8550	
50		1100		2550		3600		5050		6100		7550		8600	
100		1150		2600		3650		5100		6150		7600		8650	
150		1200		2650		3700		5150		6200		7650		8700	
200		1250		2700		3750		5200		6250		7700		8750	
250		1300		2750		3800		5250		6300		7750		8800	
300		1350		2800		3850		5300		6350		7800		8850	
350		1400		2850		3900		5350		6400		7850		8900	
400		1450		2900		3950		5400		6450		7900		8950	
450		1500		2950		4000		5450		6500		7950		9000	
500		1550		3000		4050		5500		6550		8000		9050	
550		1600		3050		4100		5550		6600		8050		9100	
600		1650		3100		4150		5600		6650		8100		9150	
650		1700		3150		4200		5650		6700		8150		9200	
700		1750		3200		4250		5700		6750		8200		9250	
750		1800		3250		4300		5750		6800		8250		9300	
800		1850		3300		4350		5800		6850		8300		9350	
850		1900		3350		4400		5850		6900		8350		9400	
900		1950		3400		4450		5900		6950		8400		9450	
950		2000		3450		4500		5950		7000		8450		9500	
1000				3500				6000				8500			

ReefCheck Fish Transects **Survey Sheet_______**

Country:	**Site:**	**Depth:**	**Date**
GPS Waypoint:	**Surveyors:**		**:**

Fishers	**T1**	**T2**	**T3**	**T4**
Butterflyfishes (Chaetodontidae)				
Sweetlips (Haemulidae)				
Broomtail wrasse (*Cheilinus lunalatus*)				
Humphead wrass *(Cheilinus undulatus)*				
Bumphead parrotfish (*Bolpometopon muricatum*)				
Other parrotfishes (Scaridae >20 cm)				
Moray eel (Muraenidae)				
Grouper (Serranidae) >30 cm only				
30-40 cm				
40-50 cm				
50-60 cm				
>60 cm				
Total number of grouper				
Other significant species				

ReefCheck Invertebrate Transects Survey Sheet_______

Macroinvertebrates (5 m x 20 m belt transects)	**T1**	**T2**	**T3**	**T4**
Banded coral shrimp (*Stenopus hispidus*)				
Black spined urchins (*Diadema* and *Echiniothrix*)				
Pencil urchins (*Hetercentrocus mammilatus*)				
Collector urchins (*Tripnuestes* sp.)				
Sea cucumbers (Holothuridae)				
Crown-of-thorns (*Acanthaster plancii*)				
Triton (*Charonia tritonis*)				
Lobster (Palinuiridae)				
Giant clams				
<10 cm				
10-20 cm				
20-30 cm				
30-40 cm				
40-50 cm				
>50 cm				
Giant clam total				

Impacts ***0 = none, 1 = low (1 piece), 2 = medium (2-4 pieces) and 3 = high (5+ pieces)***	**Coral Damage / Disease/ Bleaching / Trash**			
	T1	**T2**	**T3**	**T4**
Coral damage: boat /anchor				
Coral damage: dynamite				
Coral damage: other				
Trash: fish nets				
Trash: general				
Bleaching (% of coral population):				
Bleaching (% per colony):				
Coral disease (% colonies affected)				
Black band				
White band				
Other				
Rare animals sighted (type/#/size):				
Sharks				
Turtles				
Mantas				
Dugong				
Others				

Line Intercept Transects **Survey Sheet_______**

Country:			Location	Site:			Depth:		
GPS waypoint			Surveyor						
T1		T2		T3		T4		T5	
Depth		**Depth**		**Depth**		**Depth**		**Depth**	
Benthos	Distance	Benthos	Distance	Benthos	Distance	Benthos	Distance	Benthos	Distance

Macroinvertebrate Belt Transects **Survey Sheet_______**

Country:	**Location**	**Site:**	**Depth:**
GPS waypoint	**Surveyor**		

Species	**T1**	**T2**	**T3**	**T4**	**T5**

Fish Belt Transects (5 m x 50 m belt) **Survey Sheet_______**

Country:	**Location**	**Site:**	**Depth:**
GPS waypoint	**Surveyor**	**Transect**	

Family	**Species**	**No.**	**Family**	**Species**	**No.**
Serranidae	*Cephalopholis hemistiktos*		Scaridae	*Hipposcarus harid*	
	Cephalopholis miniata			*Cetoscarus bicolor*	
	Aethaloperca rogaa			*Bolbometopon muricatum*	
	Epinephelus fasciatus			*Scarus sordidus*	
	Epinephelus fuscoguttatus			*Scarus gibbus*	
	Epinephelus summana			*Scarus ghobban*	
	Epinephelus malabaricus			*Scarus ferrugineus*	
	Epinephelus aerolatus			*Scarus niger*	
	Epinephelus chlorostigma		Chaet-odontidae	*Chaetodon fasciatus*	
	Plectropomus maculatus			*Chaetodon lineolatus*	
	Plectropomus truncates			*Chaetodon austriacus*	
	Pseudanthias squamipinnis			*Chaetodon melapterus* *	
Lutjanidae	*Lutjanus ehrenbergi*			*Chaetodon mesoleucos*	
	Lutjanus kasmira			*Chaetodon paucifasciatus*	
	Lutjanus bohar			*Chaetodon v pictus* *	
	Macolor niger			*Chaetodon lunula* **	
Haemulidae	*Plectorhinchus pictus*			*Chaetodon semilarvatus*	
	Plectorhinchus schotaf			*Chaetodon kleinii* ***	

Lethrinidae	*Lethrinus harak*			*Gonochaetodon larvatus*	
	Lethrinus elongates			*Heniochus intermedius*	
	Lethrinus lentjan			*Heniochus acuminatus* **	
	Lethrinus mahsena		Poma-canthidae	*Pomacanthus maculosus*	
	Lethrinus nebulosus			*Pomacanthus imperator*	
Sparidae	*Acanthopagrus bifasciatus*			*Pomacanthus asfur*	
Labridae	*Cheilinus mentalis*			*Pygoplites diacanthus*	
	Cheilinus digrammus			*Apolemichthys xanthotis*	
	Cheilinus undulatus		Acanthu-ridae	*Zebrasoma veliferum*	
	Cheilinus lunulatus			*Zebrasoma xanthurum*	
	Cheilinus abudjubbe			*Acanthurus dussumeri* **	
	Labroides dimidiatus			*Acanthurus leucosternon* **	
	Larabicus quadrilineatus			*Acanthurus nigricans*	
	Halichoeres hortulanus			*Acanthurus sohal*	
	Halichoeres scapularis			*Acanthurus nigrofuscus*	
	Novaculichthys taeniourus			*Acanthurus triostegus* ***	
	Coris gaimard			*Ctenochaetus striatus*	
	Coris variegate			*Naso lituratus*	
	Hemigymnus fasciatus		Siganidae	*Siganus rivulatus*	
	Hemigymnus melapterus			*Siganus argenteus*	
	Anampses twistii			*Siganus luridus*	
	Thalassoma klunzingeri			*Siganus stellatus*	
	Thalassoma lunare		Balisti-dae	*Balistapus undulatus*	
	Gomphosus caeruleus			*Balistoides viridescens*	
	* restricted to southern Red Sea, Gulf of Aden, Socotra Island Group			*Pseudobalistes flavimarginatus*	
				Pseudobalistes fuscus	
	** restricted to Gulf of Aden, Socotra Island Group			*Sufflamen chrysopterus* **	
	*** restricted to Socotra Island Grou			*Sufflamen fraenatus* **	

Fish Belt Transects (5 m x 50 m belt) **Survey Sheet_______**

Country:	**Location**	**Site:**	**Depth:**	
GPS waypoint	**Surveyor**			

Family	**Species**	**T1**	**T2**	**T3**	**T4**	**T5**
Cirrhitidae	*Paracirrhites forsteri*					
Pseudochromidae	*Pseudochromis fridmani*					
	Pseudochromis flavivertex					
Pomacentridae	*Amphiprion bicinctus*					
	Dascyllus trimaculatus					
	Dascyllus marginatus					
	Dascyllus aruanus					
	Chromis ternatensis					
	Chromis dimidiata					
	Chromis caerulea					
	Pristotis cyanostigma					
	Pomacentrus sulfureus					
	Pomacentrus aquilus					
	Pomacentrus albicaudata					
	Pomacentrus trilineatus					
	Stegastes nigricans					
	Neopomacentrus xanthurus					
	Plectroglyphidodon lacrymatus					
	Paraglyphidodon melas					
	Chrysiptera unimaculata					
	Amblyglyphidodon leucogaster					
	Amblyglyphidodon flavilatus					

Reef fishes commonly collected for aquaria and recommended for monitoring in the Red Sea and Gulf of Aden region (after Edwards 2002).

Family	**Genus**	**Species**	**Common names**
Acanthuridae	*Acanthurus*	*sohal*	Sohal, Red Sea surgeon fish
	Naso	*lituratus*	Orangespine/Lipstick unicorn-fish
	Zebrasoma	*veliferum*	Sailfin tang
	Zebrasoma	*xanthurum*	Yellowtail/Purple tang
Balistidae	*Balistapus*	*undulatus*	Orange-striped/Undulate trigger fish
	Balistoides	*viridescens*	Titan trigger fish
	Rhinecanthus	*assasi*	Picasso trigger fish
Chaetodontidae	*Chaetodon*	*auriga*	Threadfin butterfly-fish
	Chaetodon	*austriacus*	Exquisite/Melon butterfly-fish
	Chaetodon	*fasciatus*	Red Sea racoon/Striped butterfly-fish
	Chaetodon	*larvatus*	Orangeface butterfly-fish
	Chaetodon	*mesoleucos*	Whiteface/Red Sea butterfly-fish
	Chaetodon	*paucifasciatus*	Redback butterfly-fish
	Chaetodon	*semilarvatus*	Golden/Redlined/Masked butterfly-fish
	Chaetodon	*trifascialis*	Chevroned butterfly-fish
	Heniochus	*intermedius*	Red Sea bannerfish
Cirrhitidae	*Paracirrhites*	*forsteri*	Blackside/Forster's hawkfish
Labridae	*Anampses*	*twistii*	Yellow-breasted wrasse
	Bodianus	*anthioides*	Lyretail hogfish
	Cheilinus	*lunulatus*	Broomtail wrasse
	Coris	*Aygula*	Clown/Twin-spot coris/wrasse
	Gomphosus	*Caeruleus*	Red Sea bird/Green-bird wrasse
	Labroides	*Dimidiatus*	(Bluestreak) Cleaner wrasse
	Larabicus	*quadrilineatus*	Arabian/Four-line cleaner wrasse
	Novaculichthys	*taeniourus*	Rockmover/Dragon wrasse
	Paracheilinus	*octotaenia*	Eight-stripe/Eight-line wrasse
	Thalassoma	*klunzingeri*	Klunzinger's/Rainbow wrasse
	Thalassoma	*lunare*	Moon/Lunare wrasse
Ostraciidae	*Ostracion*	*cubicus*	Yellow boxfish
Pomacanthidae	*Pomacanthus*	*asfur*	Arabian angelfish
	Pomacanthus	*imperator*	Emperor angelfish
	Pomacanthus	*maculosus*	Yellow-bar/Bluemoon angelfish
	Pygoplites	*diacanthus*	Royal/Regal angelfish
	Amphiprion	*bicinctus*	Two-banded anemone fish
	Dascyllus	*aruanus*	Humbug dascyllus
	Dascyllus	*marginatus*	Black-banded dascyllus
	Dascyllus	*trimaculatus*	Three-spot/Domino dascyllus
	Chromis	*viridis*	Blue-green chromis
Pseudochromidae	*Pseudochromis*	*fridmani*	Orchid/Fridman's dottyback

Scorpaenidae	*Pterois*	*miles*	Soldier turkeyfish, lionfish
	Pterois	*radiata*	Clearfin turkeyfish, Tailbar lionfish
Tetraodontidae	*Arothron*	*diadematus*	Masked puffer
Serranidae	*Pseudanthias*	*squamipinnis*	Scalefin/Lyretail anthias

7

Marine Turtles

7. MARINE TURTLES

7.1 Background

Marine turtles are charismatic keystone species and an important indicator of marine ecosystem health. Five species of marine turtle occur in the PERSGA region including the green turtle (*Chelonia mydas*) (see Figure 7.1), the hawksbill (*Eretmochelys imbricata*), the loggerhead (*Caretta caretta*), the olive–ridley turtle (*Lepidochelys olivacea*) and the leatherback turtle (*Dermochelys coriacea*) (Pilcher 2004; Mancini *et al.* 2015). Although all species occur in the region, only four species are known to nest, with the green and hawksbill turtles being the most widely reported (Pilcher 2004; Mancini et al. 2015). The loggerhead turtle is known to nest on the Gulf of Aden coast of Yemen (Saad 2002) and in significant numbers on Socotra (Baldwin et al. 2003), and there is one record of an olive-ridley turtle nesting in Eritrea (Pilcher *et al*. 2006). Different turtle species have different life cycles, feeding habits and serve different ecosystem functions. For example, green turtles are herbivorous and often found feeding on seagrass meadows, although they can also help promote reef health and coral growth by grazing on algal films and macroalgae. Hawksbill turtles are invertivores typically feeding on sponges and hard and soft corals (Léon and Bjorndal 2002). This species can help sculpt the reef framework in a way that supports other keystone and reef building species and create space for coral recruitment (WWF 2004).

Drastic declines in marine turtle populations have been reported globally and all species are classified as threatened on the IUCN Red List (Table 1) (WWF 2004). Efforts to conserve turtles have meant some sub-populations have begun to show signs of recovery although not in all regions (Wallace et al. 2010; Mazaris et al. 2017). The main threats to marine turtles within the PERSGA region include the collection of eggs and capture of adult females on nesting beaches for consumption or trade, mortality from accidental capture in fishing gear, degradation and loss of nesting and foraging habitats due to coastal development, water pollution, entanglement and consumption of marine debris and climate change (Pilcher 2004; PERSGA/GEF 2004; Hanafy 2012, Mancini et al. 2015, El Kafrawya 2018). Monitoring of turtle populations began in the 1970s (WWF 2004; Southeast Ecological Science Centre 2013) and various methods have since been developed to assess populations including site-based monitoring at nesting sites and foraging grounds, genetic analyses, mark and recapture and telemetry. The most widely adopted method for site-based monitoring of turtle populations involves recording observations of female turtles as they come ashore to nest on beaches during the nesting season. It is well known that often there can be considerable interannual variability in marine turtle nesting numbers. These types of turtle monitoring programmes therefore need to be maintained over the long term to ensure that the data provides reliable insights into annual variations in populations which can be used in future predictive models and conservation management efforts.

Figure 7.1 Marine turtle

Table 7.1 Threatened marine turtles reported from the RSGA region and IUCN Red List status.

Common name	Species name	IUCN Status
Hawksbill turtle	*Eretmochelys imbricata*	Critically Endangered
Green turtle	*Chelonia mydas*	Endangered
Loggerhead turtle	*Caretta caretta*	Vulnerable
Leatherback	*Dermochelys coriacea*	Vulnerable
Olive ridley	*Lepidochelys olivacea*	Vulnerable

7.2 Overview

7.2.1 General Approach

The general approach to establishing a national turtle monitoring programme can be achieved in three phases. The same approach can be applied to designing monitoring programmes for smaller study areas, such as Marine Protected Areas. The three phases are as follows:

- **Phase 1** involves a desktop study to identify the species previously reported from the study area and any known nesting sites. This can be achieved through reviewing the scientific literature, and other reports and through using interview-based methods such as the participatory mapping methods described in Chapter 13.
- **Phase 2** involves reviewing the resources available for baseline reconnaissance surveys and long-term monitoring in terms of personnel, survey equipment and means of transport, and preparation of the draft monitoring programme;
- **Phase 3** is the field phase, during which the design of the monitoring progamme is finalised and implemented. This phase involves a reconnaissance survey, using aerial surveys or ground-based methods to identify the distribution of nesting beaches, if these are not already known. The findings from the reconnaissance survey can then be used to prioritise the sites to be included in the more detailed long-term monitoring programme and to finalise the design.

Turtle monitoring programmes typically involve collecting information at nesting sites and foraging grounds (Pilcher 2004). Turtles can be most easily studied when they emerge onto a beach to nest, so most monitoring programmes involve surveys of nesting beaches. Nesting beach surveys involve collecting information about turtle tracks, sightings of female turtles coming ashore to nest, location and or numbers of nests, clutch sizes, nest depth and hatchling success. Other methods used include morphological measurements and tagging to determine movement patterns individual return rates and hatchling success. Turtle monitoring programmes can also provide an opportunity to collect information about the status of habitats (e.g. beach dynamics, coastal erosion or accretion, and anthropogenic and other natural threats).

7.2.2 Target

The target for these surveys is marine turtles and their critical feeding and nesting habitats. If resources are limited, the monitoring programme should prioritise the most important nesting sites and species of highest conservation concern.

7.2.3 Field equipment

- Species identification card printed in colour and laminated (Annex 7.1 and Annex 7.2).
- Species morphology and morphometric

guide printed in colour and laminated (Annex 7.3 and Annex 7.4).

- Survey forms, waterproof notebooks/ dive slates to record data *in situ*.
- GPS unit to record nesting occurrences and foraging areas.
- Camera to record habitat and species photographs.
- Maps of the study area showing nesting beaches and foraging areas.
- Torches for beach surveys at night-time, preferably with a red lens.
- Mechanical counter to measure clutch size.
- Snorkelling (snorkel, mask and fins) or SCUBA gears (BCD, regulator, dive tank, dive computer, mask and fins) for foraging area or in-water tagging surveys.
- Fibre glass measuring tape to measure nest depth, track size (if there is any) and turtle size (carapace length and width, head and tail lengths etc.) in nesting beach surveys.
- Callipers to be used for straight measurements.
- Saltwater-resistant spring balance to measure weight.
- Titanium tags + tag applicator to tag turtles in both nesting beach and foraging area surveys.

7.2.4 **Field personnel**

At least two surveyors are needed to undertake turtle nesting beach and foraging area surveys to ensure that the data is collected correctly and in a timely manner. During peak nesting season, more surveyors may be needed for nesting beach surveys, especially if the turtles are nesting over a large area or in more than one location. Long beaches can also be sub-divided into shorter sectors, approximately 1 km long, and surveyed separately by different teams. For all the surveys described below, surveyors should be trained in the method and familiar with the species and the use of basic survey equipment. For the Level 2 surveys, surveyors need to be trained in how to safely handle turtles and apply tags if relevant. Surveyors for foraging area surveys also need to be comfortable in the water and preferably able to snorkel.

7.2.5 **Training / experience**

The methods used to monitor nesting beaches and foraging areas are fairly simple and easy to follow and can be easily taught to others that would like to participate in turtle monitoring surveys. New surveyors should undertake a field survey with an experienced surveyor first to ensure that they are familiar with the protocol and can collect reliable datasets. One experienced field researcher can train a group of individuals in the nesting beach or foraging area survey methods as well as species identification and oversee the quality of the data collected.

7.3 **Field Procedure**

The following section describes the methods for the long-term monitoring of turtle nesting beaches and foraging areas. Nesting beach surveys are normally completed on foot, whereas foraging area surveys can be conducted by snorkelling, diving or on a boat. The field procedures described below are based upon those provided in the original PERSGA Standard Survey Methods Manual (Pilcher, 2004):

7.3.1 **Nesting Beach Surveys – Level 1**

The purpose of the Level 1 nesting beach survey method is to determine the presence of nesting turtles within a study area and to collect basic information about the characteristics of the site. The method is appropriate to use as part of a reconnaissance survey to inform the design of the detailed monitoring programme. The guide and survey form for the Level 1 surveys are provided in Annex 7.5.

The Level 1 method can be integrated with rapid coastal assessment surveys to provide a 'snapshot' of the current situation across a broad area or it can be used as part of a long term monitoring programme. Repeated annually over several seasons the method can provide an indication of nesting success, and give an indication of intra-annual trends in the size of nesting populations, which may be loosely correlated with overall population size. This Level 1 method is also suitable for use as citizen science method if adequate training can be delivered and data collection systems put in place.

Beach patrols are normally carried out on foot in the early morning. The survey team(s) walks the length of the beach along the high water mark looking for the presence of turtle tracks. Other information that is collected includes: the species of turtle, which can be determined by the size and type of the tracks, evidence of nesting success, predation and other threats.

The survey method as described in Pilcher (2004) is summarised below:

- Prepare the survey equipment the night before the survey including data sheets, survey slate, pencils and camera, GPS, binoculars, measuring tape and a map of the survey area.
- Start the patrol at one end of the beach shortly after sunrise when the turtle tracks are still fresh and before the sun dries the sand and the tracks become obscured.
- Walk along the latest high tide line and record the number and type of crawls, nesting pits, presence of eggshells and any evidence of slaughtered turtles.
- Record both fresh and old crawls. Fresh crawls are those resulting from turtles emerging through the previous night's tide line. Old crawls look drier and the tracks are less distinct. Recording the presence of both fresh and old crawls allows for a count of the number of turtles nesting the night before, and the total nesting attempts over the last few days.
- Record the direction of the crawl, by looking at the direction the sand is pushed. If the crawl is a fresh crawl up the beach there will be loose sand covering the crawl track.
- Record the species of turtle that made the track. Green turtle tracks have parallel flipper tracks with a tail drag as they crawl. Hawksbill turtles are lighter and leave a shallower track with alternating comma-shaped flipper marks as they crawl. If the species is unknown then this should be recorded.
- Record if the crawl resulted in successful nesting. Follow the crawl track and to find if it ends in a nest, which will be evident if there is a loose sand 'plume' where the turtle has finished filling-in the chamber and a secondary body pit.
- Also count and record the number of unsuccessful nesting attempts, which will be indicated by an unfinished primary pit, with a partially excavated egg chamber.
- Record the length of the crawl up and down the beach. If the returning crawl is longer than the emerging crawl it is probable that the turtle may have spent a long time on the beach and there is a good chance she nested. She might have only been wandering or digging unsuccessfully.

- Note if there are any signs of disturbance or predators on the beach or around the nest. If predators have excavated the nest, these nests should be recorded as successful, with an additional comment on predation (as the turtle did indeed lay eggs).
- If nesting success is uncertain, then record nesting success as unknown.
- On high density nesting beaches, tracks can easily get confused. So be careful when following the tracks of turtles that have attempted to nest, moved a few metres, and attempted to nest again.
- Once a track has been recorded, the surveyors mark each track by scraping a line through it with a stick, to help avoid duplicating counts of the same track.
- At the end of the survey, finish completing the top of the survey form by recording the other beach characteristics including:
  - ◊ Location name and GPS
  - ◊ Vegetation type
  - ◊ Beach length, width, slope
  - ◊ Beach composition (grain size and type)
  - ◊ Wave conditions and direction
  - ◊ Presence/absence of rivers
  - ◊ Presence/absence of man-made structures
  - ◊ Any other potential threats

7.3.2 **Foraging area survey – Level 1**

The purpose of the Level 1 foraging area method to collect information about the distribution of foraging marine turtles. The surveys are conducted during daylight hours and preferably during calm weather for ease of sightings and logistics. The method can be completed from a small boat or while snorkelling or diving. The guide and survey form for these surveys are provided in Annex 7.6.

The method involves recording turtle observations within a foraging area, together with behaviour and habitat characteristics (water temperature, depth, habitat and current). If the surveys are carried out from a small boat, the area surveyed and location of the foraging turtles can be recorded using a GPS. If conducting the survey while snorkelling or diving, the start and end location of the survey and duration of the survey can be used to calculate an encounter rate within an approximate area. Or the surveyors can tow a GPS in a waterproof container at the surface. In-water surveys should be conducted by pairs of observers for safety reasons. The survey pairs can swim transects in parallel at an agreed distance apart over a foraging ground recording their individual observations. The surveyors can then compare and consolidate their observations at end of the survey.

- Prepare the survey equipment before the survey including data sheets, slate, pencils and camera, GPS, binoculars.
- Record the name of the start location for the survey and the start time.
- If a GPS is available, record the start position as well as well as the position of each turtle encountered
- If no GPS is available, record the time at which each turtle is encountered
- Record the species of the turtle if known and try to take a photograph
- Record whether the turtle was actively foraging, swimming or resting when encountered.
- Record the habitat (water depth, temperature, current speed and direction and substrate type) where the turtles was observed to establish habitat utilisation.

- At the end of the survey, record the name of the end location and the end time.
- If a GPS is available record the end position.

7.3.3 **Nesting Beach Surveys – Level 2**

The purpose of the Level 2 nesting beach survey method is to determine the success of nesting turtles as they come ashore and to collect additional morphological information about the individual animals and characteristics of the site. The method is appropriate to use as part of a detailed long term monitoring survey. The guide and survey form for the Level 2 surveys are provided in Annex 7.7.

These types of surveys are typically completed at night just after sunset, with the exception of surveys for hawksbill turtles, which can be surveyed during the day as they nest during daylight hours. Survey intensity needs to be increased during the peak nesting season, both in terms of the frequency of surveys and the number of surveyors participating in the monitoring (Pilcher, 2004).

The survey method as described in Pilcher (2004) is summarised below:

- On the day before of the survey, prepare the survey equipment including data sheets, pencils and camera, GPS, binoculars, measuring tape and a map of the survey area.
- Start the patrol at one end of the beach shortly after sunset.
- Walk along the latest high tide line and record the number and type of crawls, evidence and location of nesting pits, eggshells and any evidence of slaughtered turtles.
- If a turtle is found coming ashore to nest or nesting, remain still to avoid disturbing the animal. Allow the turtle to finish chambering before approaching. Avoid making loud noises or sudden movements and avoid the use of flash photography.
- Once the turtle has finished chambering, attempt to record clutch size. Approach the turtle very slowly from behind, find a position that allows for the counting of eggs, then use a mechanical counter to count number of eggs as they are laid.
- Record a GPS position for the nest to aid relocation for emergence assessments to determine incubation success at the end of the nesting period.

Only once nesting has been completed and the turtle has finished infilling the chamber, is it possible to take measurements in the nest and to tag and take morphological measurements (see below).

7.3.4 **Foraging area survey – Level 2**

Foraging area surveys are conducted as per the methods described under Level 1, but also involve morphometric measurement and tagging, as described in the sections below. The Level 2 foraging area survey method needs to be completed from a small boat. The guide and survey form for these surveys are provided in Annex 7.8.

7.3.5 **Mark and Recapture Methods– Level 2 & Level 3**

Tagging of turtles with numbered titanium tag can be completed during turtle nesting or foraging area surveys. Using mark and recapture methods allows for the tracking of turtle movements through several nesting seasons, for the determination of site fidelity, growth rates and demographics, abundance, size class, migration patterns and feeding habits within the wider survey area.

Capturing marine turtles while they are on the beach is much easier than in the water, as the animals are large and much slower moving on land. Both methods should only be carried out by experienced surveyors or following training so as to minimise the stress caused to the animal.

The methods to capture turtles as described in Pilcher (2004) are summarised below:

Capturing post-nesting females during nesting beach surveys (Level 2)

During nesting beach surveys, post-nesting female turtles can be captured after they have finished egg laying by placing a large open topped wooden box over the turtle before she returns to the sea. This prevents the turtle from being able to progress down the beach allowing the surveyors time to tag and take morphometric measurements. Measurements and tagging should be completed calmly but as quickly as possible so as to minimise any stress that might be caused to the animal.

Capturing marine turtles during foraging surveys (Level 3)

During foraging surveys, it is possible to capture turtles from the side of a small boat using a method, known as Rodeo Capture. The Rodeo Capture method requires practice and should only be carried out by experienced surveyors or following training.

The method requires a minimum of two surveyors and an experienced boat handler. The boat driver should be safety-conscious and remain at the controls the entire time. The first surveyor is the person who enters the water and does the turtle rodeo and the second surveyor stays on the boat to assist.

There are risks to the first surveyor from jumping overboard from a moving boat, including collisions, propeller cuts and hitting the seabed or the turtle with great force. So this method should only be attempted by an experienced surveyor who is also a very good swimmer, and with a competent boat driver.

The methods as described in Pilcher (2004) are outlined below:

- The boatman follows the turtle until they tire and slow down.
- The second person jumps into the water slightly ahead of the turtle to tries to grab it. They hold the turtle carapace at the nuchal scales behind the neck and under the posterior end of the carapace, then tilts the turtle upward. The turtle will attempt to swim away, headed upward until they break the water, after which they can go no further.
- The boatman returns to the first surveyor and turtle. The second surveyor on-board the boat helps to secures the turtle and brings it on board the boat.
- Once on board, the turtle can be tagged, weighed, measured and then released.
- The surveyors can then record the exact location of the capture site with a GPS receiver and record water depth and substrate type at point of capture.

7.3.6 Morphometric measurements - Level 2

Morphological measurements of turtles taken during nesting site surveys can be used to relate body size to reproductive output and measurements taken during foraging ground surveys can be used to determine frequency of size classes (to determine demographic structure), and to monitor growth rates (in subsequent recaptures) (Pilcher 2004).

The morphology of a turtle and the most common morphometric measurements recorded for turtles are illustrated in Annex

7.3 and Annex 7.4, respectively. The guide and survey forms to record these measurements during nesting surveys are provided in Annex 7.7 and in Annex 7.8 for foraging ground surveys.

It is advisable for one surveyor to take all measurements to help ensure consistency. If this is not practical, all surveyors should practice and standardise methods prior to actual data collection. Individuals can practice measuring on a turtle carcass or a sample turtle. The sample size should also always be reported so that one can determine the validity of the summary data. An average taken among four individuals will not be as precise as an average taken from 100 individuals.

Curved measurements over the carapace are taken using a fibreglass tape measure (±1 mm), while straight length measurements are taken with callipers (± 0.1 mm). The length of the calipers should only be slightly larger than the maximum expected size to help ensure accuracy. All records should be taken in a single measuring attempt. Any barnacles or other organisms growing where measurements are to be taken should be removed with pliers beforehand.

7.3.7 **Tagging methods (Level 3)**

Turtles captured during nesting beach or foraging ground surveys can be tagged using a numbered titanium tag, which is applied to the proximal trailing edge on either side of the front flippers. The application of these types of tags to turtles requires specialist equipment and should only be attempted by experienced surveyors or following proper training.

Tagged individuals should be recorded if observed during other surveys, even if no new tags are being applied, and the tag records added to the national and regional database.

The methods that can be used to capture turtles and apply tags, as described in Pilcher (2004) are as follows:

- Practice tagging with several tags on a piece of cardboard prior to working with turtles.
- Mark one side of the applicator with paint to identify the top position.
- Tape tags together on their cardboard sleeves to reduce tag loss and maintain tag order.
- Check turtles for presence of previous tags or signs of tag loss prior to placing new tags and keep notes.
- Replace old tags only if they appear heavily corroded and might be lost easily.
- Record all previous tags to maintain a long-term history of the turtle.
- Turtles that show signs of having been tagged previously but which have lost their tags should also be recorded as such, as this provides information on the rate of tag loss.
- Tag new turtles on the proximal trailing edge of each front flipper (Figure 7.8) to reduce the chances of abrasion, entanglement and tag dislocation.
- Tagging is a two-step process:
  - ◊ clamp applicator so that the sharp point pierces the flipper and
  - ◊ apply greater force to ensure the tag point bends over and securely locks into rear of tag
- Check the tag is securely attached, and that the sharp point of the tag has looped through the receiving hole and curved into a locking position. It is possible that the sharp point curves back under the receiving side of the tag, or outside of it.
- Leave a 0.5–1.0 cm gap between the trail-

ing edge of the flipper and the rear edge of the tag when tags are applied to adult turtles (Figure 7.2).

- Leave a 1.0 cm gap between the trailing edge of the flipper and the rear edge of the tag when tags are applied to juveniles.
- Tag number and placement (i.e. which flipper) should only be recorded after tagging has been completed successfully. Tags can break on application and must be discarded, and it is possible to forget to change the number if it is pre-recorded. Only the tag that is actually placed on the turtle should be recorded.

Only tag turtles when they have completed covering the nest cavity with the rear flippers to minimise the possibility of disturbing the turtle, causing her to abandon the nesting effort.

Tag turtles that emerge but fail to nest when they are returning to the sea, as they will usually return to nest at a later time or date.

Copies of the tagging records should be submitted to PERSGA by the researcher at the conclusion of each research period, so that PERSGA can maintain an up-to- date database of tagged turtles in the RSGA region.

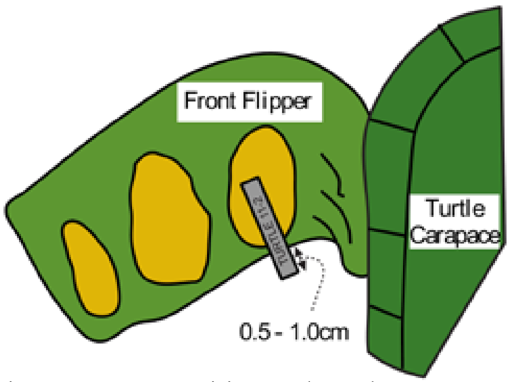

Figure 7.2 Tag position and gap between outer edge of the tag and the trailing edge of the flipper (source: Pilcher 2004).

7.4 References

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7.5 Annexes

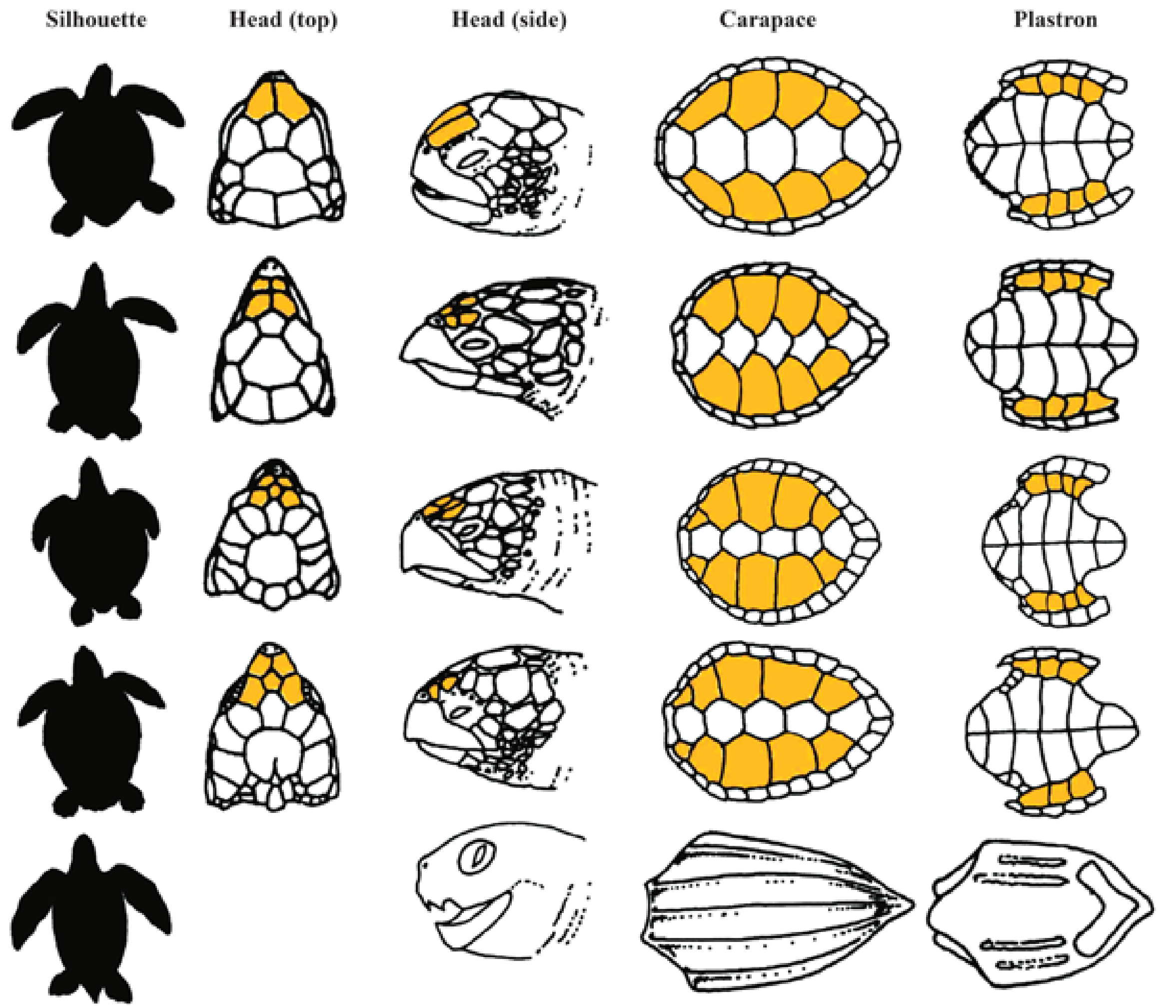
Annex 7.1 Marine Turtles of the Red Sea Gulf of Aden

(Source: Pilcher 2004 pictures courtesy of: Queensland Department of Environment and Heritage)

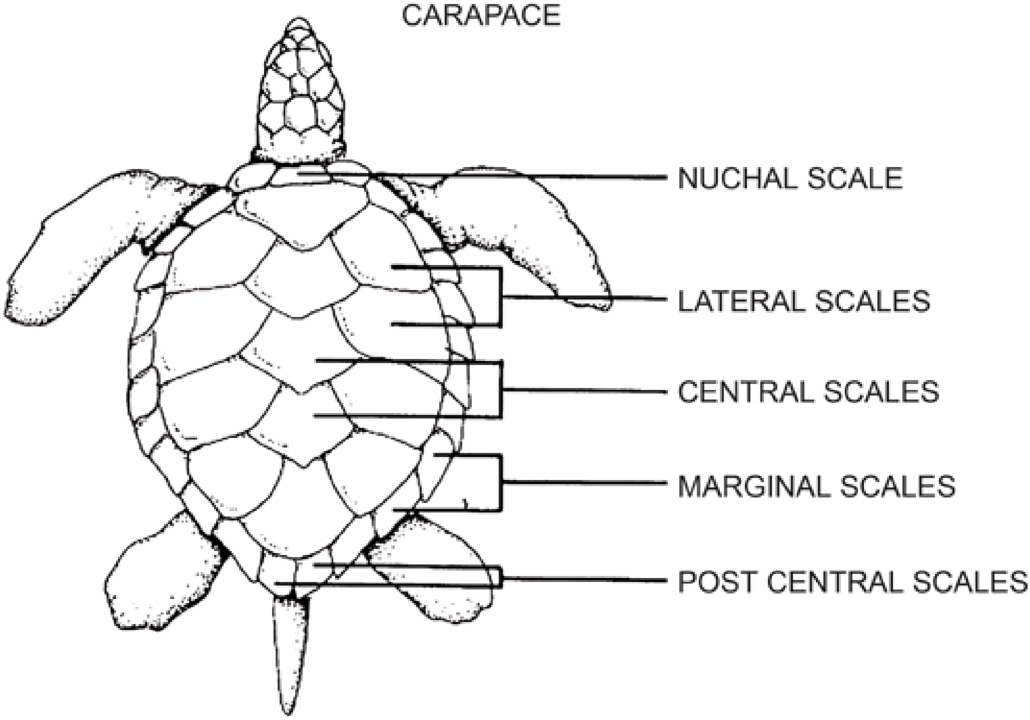
***Chelonia mydas* (Green turtle)** 	***Eretmochelys imbricata* (Hawksbill turtle)** 	***Lepidochelys olivacea* (Olive ridley turtle)** 
***Dermochelys coriacea* (Leatherback turtle)** 	***Caretta caretta* (Loggerhead turtle)** 	

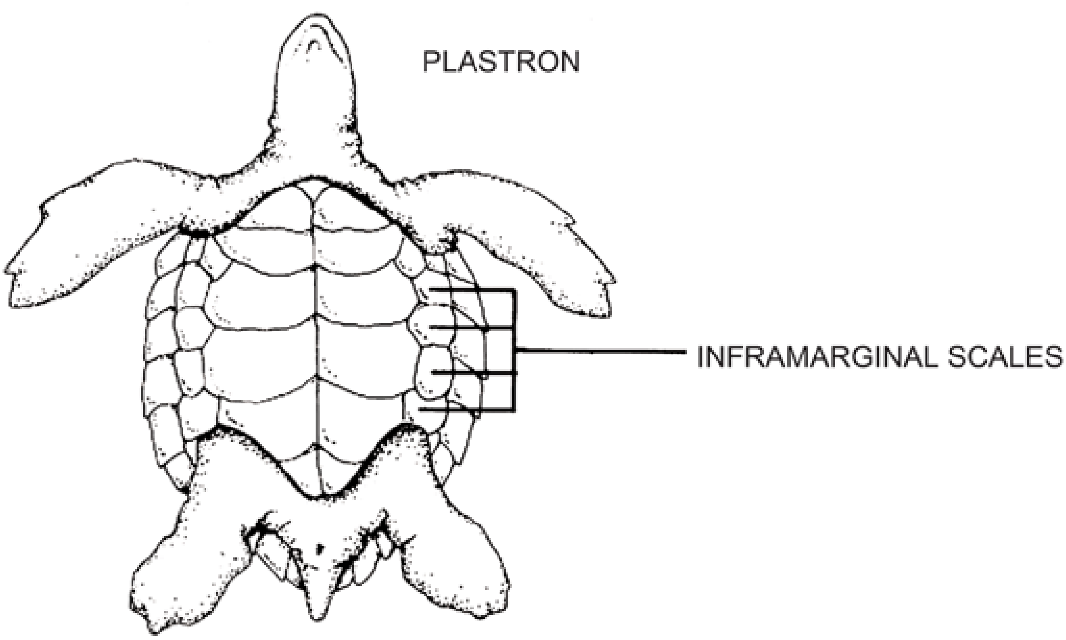
Annex 7.2 Marine Turtles Identification Key (source: Pilcher 2004; Diagrams not to scale. Modified from Miller 1989 and Eckert et al. 1999).

Description
***Chelonia mydas* (Green turtle)** Head with one pair prefrontal scutes. Carapace with four lateral scutes, domed, light to dark green and mottled. Plastron with four inframarginal scutes without pores.
***Eretmochelys imbricate* (Hawksbill turtle)** Head with two pairs prefrontal scutes. Carapace with four lateral scutes, scutes imbricated (overlapping). Plastron with four inframarginal scutes without pores.
***Lepidochelys olivacea* (Olive ridley turtle)** Head with more than one pair of prefrontal scutes. Carapace with five, six or more lateral scutes, nearly circular, colour grey green. Plastron with four inframarginal scutes with pores.
***Caretta caretta* (Loggerhead turtle)** Head with more than one pair of prefrontal scutes. Carapace with five lateral scutes, longer than wide, colour red–brown. Plastron with three inframarginal scutes without pores.
***Dermochelys coriacea* (Leatherback turtle)** Head with no scales. Carapace with five distinct ridges and no scales.



Annex 7.3 Marine Turtle - Key Identifying Characteristics (Source: Pilcher 2004, Miller, 1989).





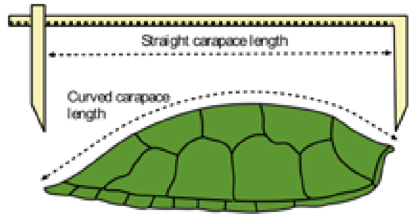
Annex 7.4 Marine Turtles Morphometric Measurements (source: Pilcher 2004; Diagrams not to scale.).

Straight Carapace Length (SCL):

Measured as a straight-line distance between the anterior point at the midline of the nuchal scute to the posterior tip of the surpacaudal scute

Curved Carapace Length (CCL):

Measured over the curve of the carapace along the midline from the anterior point at the midline of the nuchal scute to the posterior tip of the surpacaudal scutes

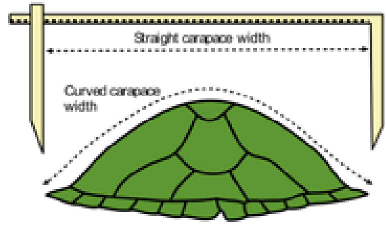


Straight Carapace Width (SCW):

Measured as a straight-line distance between the outer edges of the marginal scutes at the widest portion of the carapace perpendicular to the midline

Curved Carapace Width (CCW):

Measured over the curve of the carapace perpendicular to the midline across the widest portion of the carapace

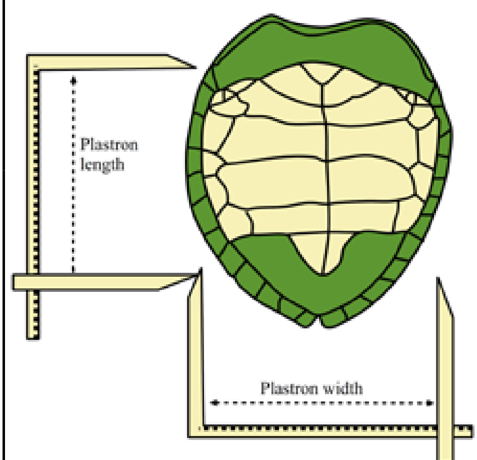


Plastron Length (PL):

Measured along the midline from the joining of the skin and plastron at the anterior edge to the posterior-most projection of the bone. If the turtle is not turned over for weighing, this length need not be taken.

Plastron Width (PW):
Measured across the plastron at its widest point perpendicular to the length. If the turtle is not turned over for weighing, this measure need not be taken.

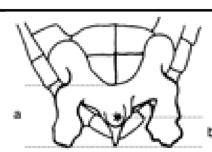
NB: For leatherbacks: curved measurements are not taken on the top of the carapace ridges due to shape irregularities. The curved measurement is taken as in the case of hard- shelled turtles, but the tape is allowed to run along one side of the dorsal ridge. Curved width is recorded from side to side over the tops of the ridges, at the widest point. Straight length is measured from the anterior edge of the carapace at the midline to the furthest point on the caudal peduncle. Plastron measurements are not practical and are therefore not taken.



Head Width (HW):
A straight distance across the widest portion of the skull. Care should be taken when taking this measurement as the turtle's ears are hidden behind the large lateral scales posterior to the eyes.

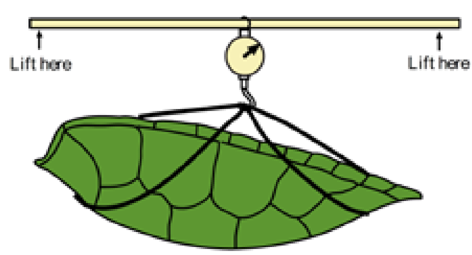
Tail Length (TL):

Measured from the tip of the tail to the trailing edge of the plastron (a) and from the tip of the tail to the cloaca (b).



Weight Turtles

Should be weighed with a saltwater-resistant spring balance (±0.5 kg). The easiest way to weigh turtles is to form a figure of eight with a sturdy piece of rope measuring about 2 m in length. One end of the loop should be slightly larger than the other and the cross point should be tied tight. After carefully flipping a turtle onto its back, the smaller loop can be placed over the front flippers and head to support the anterior portion of the carapace. The larger loop is looped over the rear flippers and tail and supports the posterior of the carapace. A balance is positioned at the cross point and supported with a sturdy brace, which is then lifted by two people.



Annex 7.5 Marine Turtle Nesting Beach Survey - Level 1

MARINE TURTLE NESTING BEACH SURVEY – LEVEL 1	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti, etc.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 20150312 for the 12th March 2015.
Time	Record the time the survey was conducted.
Surveyors	Record the initials for the surveyors involved in the survey.
Weather	Record the weather using the following scale: **1**= Sun, no cloud; **2**= Sun part cloud (<50% cloud); **3**= Sun and cloud (50% and 50%); **4**= Cloud (full cloud); **5** = Cloud and rain
Wind strength	Record the wind strength using the following scale: 1= none (<4kn) 2= slight (4-6kn), 3= moderate (7-10kn), 4= strong (11-15kn), 5= very strong (>16kns)
Wind direction	Record wind direction using the compass rose to describe which direction the wind is coming from (e.g. SE or SSE)
NESTING BEACH CHARACTERISTICS	
Water temperature	Record the water temperature (in °C)
Vegetation type	Describe the type of vegetation on the beach. If the plant species are unknown take a photograph of the plant and any distinguishing features.
Beach type	Record the type of beach by circling the dominant substrate type (pebble, coarse sand, medium sand and fine sand)
Beach length	Record the length of the beach, this can be measured using a measuring tape or survey wheel, or by measuring the beach from a map.
Beach width	Record the width of the beach, by using a measuring tape or survey wheel.
Beach slope	Record the slope of the beach in degrees relative to the horizontal, with flat being equal to zero, and vertical being equal to 90^{o}.
Wave exposure	Record the wave exposure. Use the following scale: 1= none, 2= slight, 3= moderate, 4= strong, 5= very strong.
Wave direction	Record the wave direction use the compass rose to describe which direction the wind is coming from (e.g. SE or SSE)
Man-made structures	Record if there are man-made structures on the beach.
Other threats	Record potential threats present during survey that may hinder successful nesting and/or survey.
TURTLE NESTING BEACH SURVEY	
GPS waypoint	Record the GPS waypoint number where nesting / tracks were observed. You can use the original waypoint number as stored in the GPS.
Age of track (Fresh / Old)	Record the presence of any nesting tracks sighted, and whether the track is fresh (F) or old (O).
Species?	Record the species of turtle that made the track. If not recognised, record as unknown.
Successful nesting (Y/N)	If the nesting attempt was successful, and there is evidence of a pit at the end of the track enter Y for yes or if not N for no.
Predation?	Tick if there was evidence of predation.
No. false pits	Count and record the number of false pits if any.

Track width	Record the width of the track
Track length	Record the length of track
Old nest?	Tick this box to record the presence of an old nest
Egg shells	Tick this box to record the presence of discarded egg shells.
Dead carcass	Tick this box to record the presence of a turtle carcass.
Emergence tracks	Record the presence of any emergence tracks sighted within the survey area.
Emergence presence	Record any sightings of emergence within the survey area.
Photo?	Record the start and end number of the photographs. There are different ways to help distinguish between the photographs from different sites. You can write the GPS waypoint number on a sheet of paper and photograph the number. You can photograph the survey form between sites, your watch or the GPS screen showing the waypoint.
Notes	Write a brief description of what you observe, mentioning any human activities that are occurring or are known to take place within close proximity to the survey area, old tags or bruises on turtles or any other relevant information that can be used in long term monitoring.

TURTLE NESTING SURVEYS (LEVEL 1)

Survey Sheet No______________

(adapted from Pilcher 2004)

Country:	Location:	Date:	Start time:	End time:
Surveyors:	Weather:	Wind strength (1-5):	Wind direction (NSEW):	

Vegetation type		Beach type (circle below)			
		Pebble	Coarse sand	Medium sand	Fine sand
Wave exposure	Wave direction	Beach length (cm)	Beach slope (cm)	Beach width (cm)	
Rivers?	Man made structures?	Other threats?			

GPS Way-point	**Track age? (Fresh / Old)**	**Track width**	**Track length**	**Species?**	**Successful nesting (Y/N)**	**No. false pits**	**Old nest?**	**Predation?**	**Egg shells?**	**Emergence track**	**Emergence presence**	**Dead carcass**	**Photo?**	**Notes**

KEY: Species: Green =**Cm**, Hawksbill= **Ei**, Loggerhead = **Cc**, Olive Ridley = **Lo**

Annex 7.6 Turtle Foraging Area Survey - Level 1

TURTLE FORAGING AREA SURVEY	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti, etc.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 20150312 for the 12th March 2015.
Start Time	Record the time the survey started.
End Time	Record the time the survey ended.
GPS Start:	Record the GPS position where the survey started.
GPS End	Record the GPS position where the survey ended.
Surveyors	Record the initials for the surveyors involved in the survey.
Weather	Record the weather using the following scale: **1**= Sun, no cloud; **2**= Sun part cloud (<50% cloud); **3**= Sun and cloud (50% and 50%); **4**= Cloud (full cloud); **5** = Cloud and rain
Wind strength	Record the wind strength using the following scale: 1= none (<4kn) 2= slight (4-6kn), 3= moderate (7-10kn), 4= strong (11-15kn), 5= very strong (>16kns)
Wind direction	Record wind direction using the compass rose to describe which direction the wind is coming from (e.g. SE or SSE)
TURTLE FORAGING INFORMATION	
Number/ GPS waypoint	If the survey is being used as a citizen science method, this column can be used to record a sequential number for each individual turtle observed. If the survey is being conducted from a boat and there is access to a GPS, record the waypoint number of the location the turtle was encountered. You can use the original waypoint number as stored in the GPS.
Species	Record the turtle species encountered during foraging area survey.
Activity	Record what the turtle was doing when encountered.
Water temperature	Record the water temperature (in °C)
Water depth	Record the water depth where the turtle was encountered
Habitat	Record the site description, such as the main benthic cover and life forms present and the composition
Current strength	Record the current strength of the survey area, Use the following scale: 1= none 2= slight, 3= moderate, 4= strong, 5= very strong.
Current direction	Record the current direction use the compass rose to describe which direction the wind is coming from (e.g. SE or SSE)
Tag visible	Record if the turtle has a tag “Yes” or “No”
Photograph	Record the start and end number of the photographs. If this is not possible, there are different ways to help distinguish between the photographs from different sites. You can write the GPS waypoint number on a sheet of paper and photograph the number. You can photograph the survey form between observations, or your watch or the GPS screen showing the waypoint.
Comments	Record potential noticeable scars or damage to the turtle.Or record any threats observed.

TURTLE FORAGING SURVEYS (LEVEL 1 **Survey Sheet No____________**

(adapted from Pilcher 2004)

Country:	Location:	Entry point:	Exit point:
Date:		Time start:	Time end
Surveyors:	Weather:	Wind strength (1-5):	Wind direction

Number / GPS Waypoint	Species	Time (24hr)	Water temp	Depth	Habitat	Current direction	Current strength	Activity	Tag visible?	Photograph	Notes

KEY: Activity: **S =** swimming; **Rsu =** resting surface; **Rse** = resting seabed; **F =** foraging.

Species: Green =**Cm**; Hawksbill= **Ei**; Loggerhead = **Cc**; Olive Ridley = **Lo;** Leatherback = **Dc**

Annex 7.7 Turtle Nesting Beach Survey - Level 2

TURTLE NESTING BEACH SURVEY – LEVEL 2	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti, etc.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 20150312 for the 12th March 2015.
Time	Record the time the survey was conducted.
Surveyors	Record the initials for the surveyors involved in the survey.
Weather	Record the weather using the following scale: **1**= Sun, no cloud; **2**= Sun part cloud (<50% cloud); **3**= Sun and cloud (50% and 50%); **4**= Cloud (full cloud); **5** = Cloud and rain
Wind strength	Record the wind strength using the following scale: 1= none (<4kn) 2= slight (4-6kn), 3= moderate (7-10kn), 4= strong (11-15kn), 5= very strong (>16kns)
Wind direction	Record wind direction using the compass rose to describe which direction the wind is coming from (e.g. SE or SSE)
NESTING BEACH CHARACTERISTICS	
Water temperature	Record the water temperature (in °C)
Vegetation type	Describe the type of vegetation on the beach. If the plant species are unknown take a photograph of the plant and any distinguishing features.
Beach type	Record the type of beach by circling the dominant substrate type (pebble, coarse sand, medium sand and fine sand)
Beach length	Record the length of the beach, this can be measured using a measuring tape or survey wheel, or by measuring the beach from a map.
Beach width	Record the width of the beach, by using a measuring tape or survey wheel.
Beach slope	Record the slope of the beach in degrees relative to the horizontal, with flat being equal to zero, and vertical being equal to 90^{o}.
Wave exposure	Record the wave exposure. Use the following scale: 1= none, 2= slight, 3= moderate, 4= strong, 5= very strong.
Wave direction	Record the wave direction use the compass rose to describe which direction the wind is coming from (e.g. SE or SSE)
Man-made structures	Record if there are man-made structures on the beach.
Other threats	Record potential threats present during survey that may hinder successful nesting and/or survey.
TURTLE NESTING INFORMATION	
GPS waypoint	Record the GPS waypoint number where the nest was observed. You can use the original waypoint number as stored in the GPS.
Time	Record the time the nest / observation was made
Activity	Record what the turtle was doing when observed, using the following codes: E= Emerging, W= Wandering, D= Digging, C= Chambering, L= Laying, F= Filling, R= Returning.
Successful nesting (Y/N)	If the nesting attempt was successful, enter Y for yes or if not N for no.
Number of pits	Record the number of pits dug.
Number of eggs	Record the number of eggs counted in the pit.

Number deformed	Record the number of deformed eggs.
Clutch Size	Record the number of eggs laid during each successful nesting
TURTLE TAG	
Tag number	Record the tag number if the turtle is already tagged, or the new tag number if the turtle was tagged after nesting.
New tag? (Y/N)	Record whether the tag was newly applied.
TURTLE MEASUREMENTS	
	Only to be completed after the turtle has finished nesting, record the following measurements to the nearest centimetre:
Curved Carapace Length (CCL)	Measure and record the distance following the curve of the carapace along the midline from the anterior point at the midline of the nuchal scute to the posterior tip of the surpacaudal scutes.
Curved Carapace Width (CCW)	Measure and record the distance following the curve of the carapace perpendicular to the midline across the widest portion of the carapace
Straight Carapace Length (SCL)	Measure and record the straight-line distance between the anterior point at the midline of the nuchal scute to the posterior tip of the surpacaudal scute.
Straight Carapace Width (SCW)	Measure and record the straight-line distance between the outer edges of the marginal scutes at the widest portion of the carapace perpendicular to the midline.
Plastron Length (PL)	Measure and record the distance along the midline from the join between the skin and plastron at the anterior edge to the posterior-most projection of the bone. If the turtle is not turned over for weighing, this length need not be taken.
Plastron Width (PW)	Measure and record the plastron at its widest point perpendicular to the length. If the turtle is not turned over for weighing, this measure need not be taken.
Head Width (HW)	Measure and record the straight-line distance across the widest portion of the skull. Care should be taken when taking this measurement as the turtle's ears are hidden behind the large lateral scales posterior to the eyes.
Tail Length (TL)	Measure and record the distance from the tip of the tail to the trailing edge of the plastron and from the tip of the tail to the cloaca.
Weight	Measure and record the weight of the turtle if possible.
Photographs	Record the start and end number of the photographs. If this is not possible, there are different ways to help distinguish between photographs taken from different sites / observations. You can write the GPS waypoint number on a sheet of paper and photograph the number. You can photograph the survey form between sites, or your watch showing the time or the GPS screen showing the waypoint.
Other information	Write a brief description of what you observe, mentioning any human activities that are occurring or are known to take place within close proximity to the survey area, old tags or bruises on turtles or any other relevant information that can be used in long term monitoring.

TURTLE NESTING SURVEYS (LEVEL 2) **Survey Sheet No____________**

(adapted from Pilcher 2004)

Country:	Location:	Date:	Start Time:	End Time
Surveyors:	Weather:	Wind strength (1-5):	Wind direction (NSEW):	

Vegetation type		Beach type (circle below)			
		Pebble	Coarse sand	Medium sand	Fine sand
Wave exposure	Wave direction	Beach length (cm)	Beach slope (cm)	Beach width (cm)	
Rivers?	Man made structures?		Other threats?		

Species	GPS Waypoint	Time (24hr)	Activity	Successful nesting (Y/N)	No. pits	No. eggs	No. deformed	Tag number	New tag?(Y/N)	CCL	CCW	SCL	PL	PW	HW	TL	WGT	Notes

KEY: Activity: **E**merging, **W**andering, **D**igging, **C**hambering**, L**aying, **F**illing, **R**eturning. **Species**: Green =**Cm**, Hawksbill= **Ei**, Loggerhead = **Cc**, Olive Ridley = **Lo**

Measurements: record size in centimetres (**cm**) and weights in kilograms (**kg**).

Annex 7.8 Turtle Foraging Area Survey - Level 2

TURTLE FORAGING AREA SURVEY	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti, etc.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 20150312 for the 12th March 2015.
Start Time	Record the time the survey started.
End Time	Record the time the survey ended.
Surveyors	Record the initials for the surveyors involved in the survey.
Weather	Record the weather using the following scale: **1**= Sun, no cloud; **2**= Sun part cloud (<50% cloud); **3**= Sun and cloud (50% and 50%); **4**= Cloud (full cloud); **5** = Cloud and rain
Wind strength	Record the wind strength using the following scale: 1= none (<4kn) 2= slight (4-6kn), 3= moderate (7-10kn), 4= strong (11-15kn), 5= very strong (>16kns)
Wind direction	Record wind direction using the compass rose to describe which direction the wind is coming from (e.g. SE or SSE)
TURTLE FORAGING INFORMATION	
GPS waypoint	Record the GPS waypoint number of the location the turtle was encountered. You can use the original waypoint number as stored in the GPS.
Species	Record the turtle species encountered during foraging area survey.
Activity	Record what the turtle was doing when encountered.
Water temperature	Record the water temperature (in °C)
Water depth	Record the water depth where the turtle was encountered
Habitat	Record the site description, such as the main benthic cover and life forms present and the composition
Current strength	Record the current strength of the survey area, Use the following scale: 1= none 2= slight, 3= moderate, 4= strong, 5= very strong.
Current direction	Record the current direction use the compass rose to describe which direction the wind is coming from (e.g. SE or SSE)
Tag visible	Record if the turtle has a tag “Yes” or “No”
TURTLE INFORMATION	
	If the foraging turtle is captured during the survey record the following information:
Tag Number	Record the tag number of the existing tag or the new tag number applied to the captured turtle
Tag new	Record if the tag is new “Yes” or “No”
Curved Carapace Length (CCL)	Measure and record the distance following the curve of the carapace along the midline from the anterior point at the midline of the nuchal scute to the posterior tip of the surpacaudal scutes.
Curved Carapace Width (CCW)	Measure and record the distance following the curve of the carapace perpendicular to the midline across the widest portion of the carapace
Straight Carapace Length (SCL)	Measure and record the straight-line distance between the anterior point at the midline of the nuchal scute to the posterior tip of the surpacaudal scute.

Straight Carapace Width (SCW)	Measure and record the straight-line distance between the outer edges of the marginal scutes at the widest portion of the carapace perpendicular to the midline.
Plastron Length (PL)	Measure and record the distance along the midline from the join between the skin and plastron at the anterior edge to the posterior-most projection of the bone. If the turtle is not turned over for weighing, this length need not be taken.
Plastron Width (PW)	Measure and record the plastron at its widest point perpendicular to the length. If the turtle is not turned over for weighing, this measure need not be taken.
Head Width (HW)	Measure and record the straight-line distance across the widest portion of the skull. Care should be taken when taking this measurement as the turtle's ears are hidden behind the large lateral scales posterior to the eyes.
Tail Length (TL)	Measure and record the distance from the tip of the tail to the trailing edge of the plastron and from the tip of the tail to the cloaca.
Comments	Record potential noticeable scars or damage to the turtle.Or record any threats observed.

TURTLE FORAGING SURVEYS (LEVEL 2) **Survey Sheet No_____________**

(adapted from Pilcher 2004)

Country:	Location:	Date:	Time start:	Time end
Surveyors:	Weather:	Wind strength (1-5):	Wind direction (NSEW):	

GPS Way-point	Species	Time (24hr)	Water temp	Depth	Habitat	Current direc-tion	Current strength	Activity	Tag visible?	Turtle cap-tured (Y/N)	Tag number?	New tag?(Y/N)	CCL	CCW	SCL	PL	PW	HW	TL	Notes

KEY: Activity: **S =** swimming; **Rsu =** resting surface; **Rse** = resting seabed; **F =** foraging.

Species: Green =**Cm**; Hawksbill= **Ei**; Loggerhead = **Cc**; Olive Ridley = **Lo;** Leatherback = **Dc**

Measurements: record size in centimetres (**cm**) and weights in kilograms (**kg**).

8

Seabirds

(Source: Ahmad Ghallab, Egypt)

8. SEABIRDS

8.1 Background

The PERSGA region is recognised internationally as an important area for a large number of resident and migratory bird species many of which breed, rest, roost and forage in coastal and marine habitats throughout the region (PERSGA/GEF 2004). Seabirds are good indicators of ocean health as they are often long-lived and spend most of their time in coastal and marine environments, foraging on the sea surface, and roosting and breeding in the coastal zone. Monitoring of seabird populations can thereby also provide information about productivity and threats that may be detrimental to the entire ecosystem.

The PERSGA region is one of the worlds important flyways, where several migration routes collide resulting in significant bottlenecks, where hundreds of thousands of migrating soaring birds, particularly large birds of prey, storks and pelicans can be seen together, particularly in the northern and southern Red Sea. The PERSGA region also has a suite of endemic resident taxa such as the white-eyed gull (*Larus leucophthalmus*), red-billed tropicbird (*Phaeton aethereus indicus*), spoonbill (*Platalea leucorodia archeri*) and brown noddy (*Anous stolidus plumbeigularus*). Species and sub-species endemic to the northwest Indian Ocean also breed within the region including Jouanin's petrel (*Bulweria fallax*), sooty gull (*Larus hemprichii*), swift tern (*Sterna bergii velox*), white-cheeked tern (*Sterna repressa*), the Socotra cormorant (*Phalacrocorax nigrogularis*) and sooty falcon (*Falco concolor*).

Seabirds within the Red Sea and Gulf of Aden are threatened by human exploitation, human disturbance and habitat degradation, as well as water pollution and marine debris. Some of the regional endemic species are classified as threatened on the IUCN Red List. For example, the Socotran cormorant, which breeds on Socotra, and in Somalia and Eritrea, is classified as 'Vulnerable' while the white-eyed gull and sooty falcon are both classified as 'Near-threatened'. There are however many other species that are classified as "Data Deficient", which is in part due to a lack of knowledge and the limited number of systematic surveys on the breeding colonies of the region (Newton 2004).

Seabird species nest (Figure 8.1) at different times of the year and non-breeding species may occur at any time (Newton 2004). So seabird monitoring can be a year-round activity. National monitoring programmes therefore often focus on the highest priority sites and vulnerable and threatened species of greatest conservation concern. The methods presented below are based upon the original methods described by Newton (2004) in the PERSGA Standard Survey Methods Manual (PERSGA/ GEF 2004).

Figure 8.1 Seabird (Source: Ahmad Ghallab, Egypt)

8.2 **Overview**

8.2.1 **General approach**

The general approach to establishing a national inventory of seabirds including regular monitoring programme can be achieved in three phases, as previously outlined in Newton (2004). The same approach can be applied to designing monitoring programmes for smaller study areas, such as Marine Protected Areas. The three phases are as follows:

- Phase 1 involves a desktop study to identify the species previously reported from the study area and any known nesting, roosting and foraging sites. This can be achieved through reviewing the scientific literature, and other reports and through using interview-based methods such as the participatory mapping methods described in Chapter 13.
- Phase 2 involves reviewing the resources available for baseline reconnaissance surveys and long-term monitoring in terms of personnel, survey equipment and means of transport, and preparation of the draft monitoring programme;
- Phase 3 is the field phase, during which the design of the monitoring progamme is finalised and implemented. This phase involves a reconnaissance survey, using aerial surveys or ground-based methods to identify which islands, coastal areas are used by seabirds, which species are present and if they are nesting. The findings from the reconnaissance survey can then be used to prioritise the sites to be included in the more detailed long-term monitoring programme.

If resources are limited the monitoring programme should prioritise the most important sites and species of highest conservation concern.

Seabird monitoring is typically focused on coastal areas or islands where birds are known to congregate during the nesting or non-nesting seasons. Monitoring of seabird populations could be a year round activity but as this is not practical, it is normally conducted at least twice a year (summer and winter season) so as to increase the likelihood of recording more species with different breeding and nesting seasons. Surveys often involve both aerial and ground-based methods (carried out on foot or onboard a boat) and these are often used in combination if resources permit. The suitability of ground-based or aerial methods varies depending on the species, nesting behaviour, habitat and accessibility of the terrain.

During ground-based surveys, surveyors typically observe the birds from a stationary vantage point or conduct surveys on from a boat or on foot, walking through the survey area in search of birds and nests. Ground-based survey methods may be combined with other methods such as genetic analyses, disease studies and bird ringing, which can provide additional information on survival and fledgling rates, breeding site fidelity and distribution patterns. Aerial count surveys can cover a greater area in a shorter timeframe but because they require the use of a light aircraft or drones they are more expensive than ground methods. Aerial surveys can however and may be the only available method where access on foot is difficult or where nests are above the canopy and so not visible from the ground. Aerial surveys should be validated by ground-truthing to assess the accuracy of the aerial counts.

8.2.2 **Target**

Seabird monitoring programmes typically target the following main species groups:

- True seabirds (e.g. petrels and shearwaters, tropicbirds, boobies, cormorants, gulls and terns) which are dependent on the marine environment for the whole annual cycle:
- Other seabirds (e.g. pelicans, some herons and egrets, spoonbills) that are associated with the marine environment for the breeding season and much of the annual cycle:
- Raptors and waders: (e.g. the osprey, *Pandion haliaetus* and crab plover, *Dromas ardeola)* are dependent on the marine environment. Sooty falcons *Falco concolor* nest on marine islands, and feed on migrant passerine and near-passerine birds. Kentish plover *Charadrius alexandrinus* nest on mainland beaches and islands and utilise intertidal areas for feeding on invertebrates; some nest inland around freshwater bodies).

Specific monitoring programmes may be designed to prioritise the monitoring of ecologically important species or species of conservation concern.

Monitoring programmes designed to collect information to inform the production of a national inventory of seabird colonies record the following:

- species present, breeding status, number of pairs (or individuals), habitats utilised
- size, topography and habitats of each island/colony
- timing of nesting or occupation of islands/colonies
- human activities on or around each island/colony, direct and indirect threats to seabirds;
- conservation actions where needed especially in areas where human occupation has been noted or sensitive species are present.

Preparing a national inventory will normally entail a combination of aerial and/or ground-based methods to count one or more of the following:

- Individual birds or pairs: used for

non-breeding birds or aerial counts where nests are hidden in the sub-canopy.

- Occupied nests (where the adult is present)
- Active nests (where egg or chick present).
- Vacant nests (where contents not visible and present breeding status thus indeterminate).

Such information can be shared with regional or even international ornithological organisations such as BirdLife International.

8.2.3 **Field equipment**

The following survey equipment is required in seabird monitoring:

- Survey form, clip board and pencil.
- Species identification guide to identify species *in-situ*.
- Binoculars
- Telescope and tripod.
- Mechanical counter.
- GPS and compass.
- Laminated map of survey area.
- Camera for photographic information.
- Boat if surveying on and around islands.
- Surveyors tape (50m or 100m) or rope / string knotted at fixed intervals
- 1 m x 1 m quadrat
- Bamboo canes

8.2.4 **Field personnel**

A minimum of two surveyors with good bird identification and survey skills are needed to conduct aerial, boat based or ground seabird monitoring surveys. Surveyors should also be able to swim in case of island hopping during the surveys. It is also crucial to have someone with boat handling skills when travelling between islands during seabird breeding seasons. Bird ringing requires specialist training as it involves handling fragile chicks and the application of metal or coloured rings to the birds' legs.

8.2.5 **Training / experience**

Surveyors should be familiar with seabird species identification, bird counting and census techniques. Surveyors should also be able to swim and comfortable with using the equipment needed to conduct bird monitoring.

8.3 **Field Procedure**

The following methods are based upon the breeding seabird monitoring methods that were presented in the original PERSGA Standard Survey Methods Manual (Newton 2004). Species specific guidance on the appropriate methods is also provided in Annex 8.1. The survey forms for each of the data collection methods presented below are provided in Annex 8.2. As many of these methods use the same terminology, these are presented together in the same guide in Annex 8.2. A separate guide and survey form are provided for the habitat monitoring part of the seabird survey methods in Annex 8.3.

8.3.1 **Aerial counts (Level 2 & 3)**

There are two aerial survey methods that can be used for monitoring seabirds: direct counts taken onboard an aircraft (fixed wing or helicopter), or counts derived from aerial photography (drone or aircraft). These methods can be used in combination or independently. The advantage with the photography is that the data can be collected by inexperienced surveyors and then analysed together with experts and it provides an archival record.

Counts from aerial surveys (Level 3)

Aerial count surveys require a minimum of two surveyors with previous experience in conducting these types of surveys as they must be familiar with and able to accurately record the species found within the area and types of nest.

The aerial count method described in Newton (2004) is summarised below. A survey form and guide to completing the form for aerial counts is provided in Annex 8.2. A survey form to record habitat information during the surveys is provided in Annex 8.3.

- Prepare a draft survey plan and route and discuss this with the pilot several weeks in advance. The pilot can then advise about restricted areas, range and flying time, and prepare flight plans.
- If the pilot has not supported aerial surveys before, explain the following key points:
  - ◊ Surveys are conducted at 30–90 m above sea level and as slowly as possible (probably about 90 knots)
  - ◊ Several overpasses of each colony/island are likely to be required to cover the range of species.
  - ◊ Surveys on small islands need to be limited to 5 minutes overhead or less.
  - ◊ Aerial surveys in summer should be in the early morning (0600–1030) or late afternoon (1500–1830) to minimise heat stress on adult birds or their eggs and chicks. During winter, a longer part of the day may be used.
- Once the route is agreed provide the pilot a list of coordinates of locations to be surveyed along the route.
- On the day before the flight, prepare survey equipment (survey forms, clipboards, pencils, binoculars and mechanical counters) and agree on responsibility for different data collection tasks. For example, if there are two surveyors one may record bird and nest counts while the other records habitat information (size, substrate, signs of human occupation, habitats etc.). If there are more than two surveyors, one can count birds, the other nests, or species counts can be split.
- Complete the bird and nest counts using a mechanical tally (clicker) counter if needed. If numbers are very high counts can be completed in increments of 10 or 50.
- During the first overpass, try to identify which species flush first and disperse furthest and those that stay together in more detectable flocks. This can provide an indication of breeding status as non-breeding birds tend to be the first to flush, whereas nesting birds with eggs and/or chicks are slower to fly off. Several overpasses may be needed to flush species that nest under thick cover e.g. brown boobies.
- Once bird counts have been made, if time and fuel permit, make a further overpass to photograph dense colonies.
- At the end, complete the survey form and habitat information record the estimated size of the survey area, substrate composition (e.g. percentage sand and rock, vegetation cover, vegetation height and mangrove cover) and evidence of human activities, including huts, fishing camps and boats within 2 km of coast.

Counts from aerial photography (Level 2)

Aerial photography is an appropriate method for certain species, and it is also useful if surveyors are relatively inexperienced in counting techniques. Photographs obtained using a light fixed wing aircraft, helicopter or drone can be analysed after the survey in the presence of a more experienced surveyors. It is important to choose a good quality camera and lens with a good resolution. During the surveys it is important to record GPS waypoints together with information about photographs for each of the islands coastal sub-sections photographed. Once back at base, the photographs are downloaded and used to create a photomosaic of the whole study area. The study area can then be divided into sub-sections and each nest counted. The counting exercise should be repeated several times and the average count used.

8.3.2 **Ground counts (Level 2)**

Ground counts can be used to estimate seabird numbers and nest densities within different habitats types within a survey area. The data can be used to extrapolate densities to the whole study area (e.g. island) covered by that habitat type. The ground methods for counting individual birds and pairs include vantage point and flush counts. The ground methods for counting nests and clutch sizes are walk-throughs, belt transects and quadrats. The suitability of these methods depends upon the type of colony, in terms of the size and density of nesting, as well as the terrain and accessibility. Each colony/site may need a different approach and a combination of methods may be needed.

Vantage point surveys are suitable for both seabird numbers and nests for semi-colonial species, with small to medium sized nesting sites. The method may not always be possible as it requires the presence of elevated terrain from which to observe the colony. All the other methods are better suited for more compact colonies.

Flush counts are suitable for estimating bird numbers in dense colonies, whereas walk throughs, belt transects and quadrats are suitable for recording the number of nests and clutch sizes. Belt transects and quadrats are more time-consuming than walk-throughs as they involve the use of more equipment (ropes, tape measures, compass and bamboo canes) to mark out and measure the survey area.

Vantage point counts (Level 2)

Semi-colonial species (e.g. bridled terns) can be assessed from vantage points if there is suitable high terrain in the survey area from which to observe the birds.

A survey form and guide to completing the form for vantage point counts is provided in Annex 8.2. A survey form to record habitat information at the end of the surveys is provided in Annex 8.3. The field procedure is summarised below:

- Prepare the survey equipment on the day before the survey and agree data collection tasks.
- Travel to the survey location and set up equipment on vantage point.
- If the birds are disturbed wait on the vantage point until after the birds have resettled.
- Record a GPS waypoint and start time for the survey.
- Use binoculars or a telescope to count the number of individuals, and occupied / active / vacant nests.
- If the colony is fairly large split the colony into sections using landmarks and complete the counts within several sections.
- During the incubation period, one member of a pair often incubates while the second frequently perches above the nest on the top of a bush. A count of the total number of perched birds can be used to approximate the number of pairs.
- If the birds are very densely packed or the colony is very large, a different sampling

method should be used to validate the counts.

- At the end of the survey, record the estimated size of the survey area, substrate composition (e.g. percentage sand and rock, vegetation cover, vegetation height and mangrove cover) and evidence of human activities, including huts, fishing camps and boats within 2 km of coast.

Flush counts (Level 2)

When a human approaches a seabird colony the disturbance causes the birds to rise up and fly above the colony in a flock. This process is called ‘flushing’ and it is a method that can be used to aid the counting of individual bird numbers that is particularly suitable for dense colonies (e.g. tern numbers).

A survey form and guide for use in collecting flush count data is provided in Annex 8.2. A survey form to record habitat information during the flush surveys is provided in Annex 8.3. The field procedure is summarised below.

- Prepare the survey equipment the day before and agree on data collection tasks.
- Travel to the survey location and stay at a suitable distance from the colony to avoid disturbing the birds until ready to start the survey.
- Record a GPS waypoint and start time for the survey.
- Approach the colony, just close enough to cause the birds to fly up.
- Count and record the number of individual birds in flight above the colony.
- Retreat and allow the birds to settle before repeating the count. Flush counts are repeated three to five times so that the mean count of individuals can be calculated.
- At the end of the survey, complete the habitat survey form recording the estimated size of the survey area, substrate composition (e.g. percentage sand and rock, vegetation cover, vegetation height and mangrove cover) and evidence of human activities, and other threats within the area.

The flush count method is normally paired with other ground-based methods (walk-throughs, belt transect or quadrat methods) to count nests or clutch sizes so that the relationship between the number of individual birds and nests can be determined. Flush counts should be completed first before using the other methods to count nests.

Walk-though Counts (Level 2)

Walk through counts are suitable for estimating nest densities within small to medium sized tern or gull colonies. The survey is conducted by a pair of surveyors walking through the colony in parallel at a fixed distance apart.

A survey form and guide to completing the form for walk-through nest counts is provided in Annex 8.2. A survey form to record habitat information at the end of the surveys is provided in Annex 8.3. The field procedure is summarised below.

- Prepare the equipment on the day before the survey and agree on data collection tasks.
- Travel to the survey location and remain at a suitable distance away from the colony until ready to start to avoid unnecessarily disturbing the birds.
- Prepare the GPS and check that GPS track mode is enabled.
- Record a GPS waypoint and start time at the beginning of the survey.
- Complete the flush count, as described above, before starting the walk through.
- Start the walk through survey with two

surveyors walking in parallel 3 to 5 m apart, counting nests on either side, to within half the distance between the next person;

- Continue to walk through the colony until entire colony has been counted.
- Use ropes, string or footprints in sandy areas to prevent double counting.
- At the end of the survey remove any materials used to mark out the area
- Complete the survey form and habitat survey form recording the estimated size of the survey area, substrate composition (e.g. percentage sand and rock, vegetation cover, vegetation height and mangrove cover) and evidence of human activities or other threats.

Belt Transects (Level 2)

Belt transect data can be used to estimate nesting densities per meter square, and total populations for each island or colony can then be extrapolated. The method is suitable for seabird species that do not nest at extremely high densities, such as the white-cheeked tern and bridled tern (see Annex 8.1).

Belt transects are typically conducted at regularly spaced intervals (e.g. 50m, 100m or 500 m) across the shortest axis of the colony or island. Surveyors should decide how best to lay out, and mark the transects before arriving on site as each site / colony may require a slightly different approach. For example:

- For smaller colonies / islands, transects can be measured and temporarily marked out using a long surveyors tape (50 m or 100 m), or rope or coloured string. The rope or string can be knotted at fixed intervals to indicate distance. Bamboo canes can also be used as markers at fixed intervals (e.g. 20m) or start or end points so that surveyors have a reference point to walk towards.
- For larger colonies, it may be more appropriate to just measure out and mark the start and/or end points of all the transects and then survey the transects along an agreed compass bearing. All the starting points can be measured out and temporarily marked using bamboo canes before the survey starts.

A survey form and guide to completing the form for belt-transects is provided in Annex 8.2. A survey form to record habitat information at the end of the surveys is provided in Annex 8.3. The field procedure is summarised below:

- Prepare the survey equipment the day before the survey and agree on how belt transects will be measured and marked out and data collection tasks.
- Travel to the survey location and remain at a suitable distance away from the colony until ready to start to avoid unnecessarily disturbing the birds.
- Prepare the GPS and check that GPS track mode is enabled.
- Record a GPS waypoint and start time at the beginning of the survey.
- Complete the flush count, as described above, before starting the belt transects.
- Set out and mark the transects at regular intervals using the agreed method.
- Each surveyor should carry a GPS, and the GPS should be set to track mode.
- Record a GPS waypoint and start time at the beginning of the survey.
- Record a GPS waypoint and start time at the beginning of the first transect.
- Walk slowly along the transect recording

nests either side of the transect, within a fixed distance of the rope, string or tape (e.g. 2.5m either side).

- For each nest found, record the species, clutch size and location along the transect.
- At the end of the transect record the total transect length and a GPS position.
- Repeat the above procedure for each transect until all transects are completed.
- Remove any materials used to mark out the site at the end of the survey.
- Record the estimated size of the survey area, substrate composition (e.g. percentage sand and rock, vegetation cover, vegetation height and mangrove cover) and evidence of human activities (e.g. buildings, roads, huts, fishing camps and boats) or other threats.

Quadrats (Level 2)

Quadrat surveys are suitable for use with species that nest at extremely high densities, such as swift and lesser-crested terns. For these species replicate quadrat counts can be used to estimate nest densities per meter square within the colony and the data extrapolated to estimate total populations for each island or colony. The method can be used in a similar way to walk-throughs and belt transects. Surveyors should decide how best to survey the site before arriving as each site / colony may require a slightly different approach.

A survey form and guide to completing the form for belt-transects is provided in Annex 8.2. A survey form to record habitat information at the end of the surveys is provided in Annex 8.3. The field procedure is summarised below:

- On the day before the survey, the surveyors should gather and prepare the survey equipment and agree on data collection tasks.
- On arriving at the survey location, surveyors should stay at a suitable distance until they are ready to start to avoid unnecessarily disturbing the birds;
- Surveyors should then set out the transects at regular intervals and begin the surveys;
- The GPS should be set to track mode
- A GPS waypoint and start time is recorded at the beginning of each transect;
- Surveyors start to walk through the colony carrying a 1 m x 1 m lightweight quadrat.
- The quadrat is carefully positioned on the ground at regular intervals throughout the colony (e.g. every 5 m to the right of the transect).
- The number of nests within each quadrat is recorded;
- An approximate map of the area can be prepared so that quadrat densities can be extrapolated to the entire colony area.
- GPS positions can be used to record the location of each quadrat and used to prepare a more accurate map of survey and nesting density.
- At the end of the survey, surveyors should remove any materials used to mark out the site.
- Surveyors should also record the estimated size of the survey area, substrate composition (e.g. percentage sand and rock, vegetation cover, vegetation height and mangrove cover) and evidence of human activities (e.g. buildings, roads, huts, fishing camps and boats) within 2 km of coast.

8.4 References

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8.5 Annexes

Annex 8.1 Species Specific Guidance on Survey Methods for Breeding Seabirds in the RSGA region (after Newton 2004)

Species	Area	Habitat / colony type	Nesting season	Ground	Aerial	Survey method	References
Jouanin's petrel *Bulweria fallax*	Socotra and neighbouring islands	Caves in coastal cliffs of soft lime-stone.	Summer – Autumn (eggs July, fledg-lings November).	(✓)	(✓)	None described; the nesting cliffs are treacherous and would requires competent rock climbers with ropes. Sampling caves (of different depth, diameter of entrance etc.) may yield a mean number of pairs per cave type. A colony size may then be estimated by multiplying the total number of each cave type by the appro-priate mean number of pairs and summing them. .	Taleb 2002, Ratcliffe et al. 2000; [Tape playback meth-odology described in James & Robertson 1985 For other Puffinus species Ratcliffe et al. 1998 For Small Petrels].
Persian shearwater *Puffinus (lhermin-ieri) persicus*		This species has been discovered nesting on Socotra in similar habitat to Jouanin's petrel		(✓)	(✓)		
Red-billed tropic-bird *Phaethon aethereus*	Whole RSGA region	Dispersed; holes and crevices in cliffs.	Probably April to August, possibly lat-er in Gulf of Aden.	✓		Direct counts of occupied holes, but usually can only be detected if bird seen entering or departing. Adults flying around cliffs during the prob-able nesting season may be an indication of local breeding.	Hansbro & Sargeant 2000; Clapham 1964; North 1946
Masked booby *Sula dactylatra*	Scarce; south-ern Red Sea, Gulf of Aden.	Not well described; rocky islands, possibly use trees on occasions.	Summer – autumn?	✓ Vantage	✓	Direct count of nests from air, sea or vantage point.	Morris 1962; Newton & Al Suhaibany 1996b

Species	Area	Habitat / colony type	Nesting season	Ground	Aerial	Survey method	References
Brown booby *Sula leucogaster*	Widespread, whole RSGA region	Very varied including sandy beaches and islands, under medium sized bushes, open rocky islands, occasionally cliffs	Very variable; possibly a prolonged season commencing in summer in the south but with colonies active until January; in north may start earlier (possibly April).	✓ Vantage	✓	Direct counts of nests from air or vantage point. Do not disturb colony during incubation as gulls will rapidly prey upon unguarded eggs.	Newton & Al Suhaibany 1996a; Hoath et al. 1997; Clapham 1964.
Socotra cormorant *Phalacrocorax nigrogularis*	Islands off Yemeni coast in Gulf of Aden.	Large dense colonies on sandy or rocky substrate	In Arabian Gulf, September to April with peak laying October to January.	✓ Vantage	✓	Direct counts of nests from a distance in colonies of size B to low D. For large colonies, high D to E, aerial counts of "apparently occupied nests".	Symens et al 1993.
Pink-backed pelican *Pelecanus ufescens*	Southern Red Sea.	Usually on top of tall mangroves *Avicennia marina,* occasionally *Rhizophora mucronata*, or lower bushes and exceptionally on the ground.	Winter, possibly November to March		✓	Direct counts from air or aerial photographs, virtually impossible to see nests from ground or sea level.	Newton & Symens 1996.
Little green heron *Butorides striatus*	Widespread, whole RSGA region	Usually concealed in or under dense vegetation (e.g. mangroves) but also in more isolated thickets of *Euphorbia*. Sometimes under nests of other species (such as western reef heron, spoonbill), occasionally in holes and crevices in fossil coral.	Spring, probably commencing in March to April.	✓		None known except through searches of dense vegetation; presence/absence possibly only data that can be gathered.	Newton & Al Suhaibany 1996a; Goodman & Meininger 1989.
Cattle egret *Bubulcus ibis*	Southern Red Sea.	This species may nest on nearshore islands in tall vegetation; however, it does not utilise the marine environment as a food.	Throughout the year, perhaps dependent on rains	✓	✓	Direct nest counts of small colonies; aerial counts for large colonies	Jennings 1995.
Western reef heron *Egretta gularis*	Whole RSGA region	Usually small to medium colonies (A–B) in dense vegetation, both mangroves and trees, often sub-canopy; occasionally low cliffs.	Spring – summer (March to August).	✓		None described; thorough searches on foot of suitable habitat on smaller islands.	Jennings 1995; Newton & Al Suhaibany 1996a; Goodman & Meininger 1989.

Standard Survey Methods

Species	Area	Habitat / colony type	Nesting season	Ground	Aerial	Survey method	References
Purple heron *Ardea purpurea*	Local, southern Red Sea.	Probably dense mangrove, unlikely to be colonial, compare JENNINGS 1995.	Not known, possibly spring to summer.	✓		None described, thorough searches necessary to prove breeding. Presence outside winter (April to August) may indicate local breeding.	Jennings 1995.
Goliath heron *Ardea goliath*	Local, whole Red Sea.	Usually areas with plenty of mangrove; nests solitarily, sub- canopy or on ground under cover.	Probably winter – spring.	✓		Thorough searches necessary to prove breeding.	Newton & Al Suhaibany 1996a.
Spoonbill *Platalea leucorodia*	Whole Red Sea, most common in south.	Usually small colonies (B) on top of dense vegetation, both mangroves and thickets, often associated with western reef heron.	Spring – summer.	(✓)	✓	Aerial counts, though ground counts feasible if nesting in thickets of medium height shrubs.	Jennings 1995; Newton & Al Suhaibany 1996a; Evans 1989.
Osprey *Pandion haliaetus*	Widespread, whole RSGA region.	Usually well- spaced, large nest structure in open situation, found in all habitats though rarely directly in or on vegetation; occasionally semi-colonial.	Winter (November to April).	✓	✓	Easily detectable on ground; aerial counts necessary to get meaningful data.	Jennings 1995; Fisher 1996.
Sooty falcon *Falco concolor*	Scarce, whole length of Red Sea.	Variable, crevices or caves, on ground under mangroves.	Spring – summer.		✓	Pairs usually flushed if landings made on island; usually detectable by aerial survey.	Gaucher et al. 1995.
Crab plover *Dromas ardeola*	Local along length of Red Sea.	Nests underground in burrows; in colonies (B–C) on sandy islands.	Summer (commencing May/June).	✓		Colonies can be quite easy to overlook; direct counts of burrows straightforward but not easy to prove occupancy. If possible, do not walk through colony, as burrows are very easy to collapse	Goldspink et al. 1995; Nikolaus 1987; Morris 1992.
Kentish plover *Charadrius alexandrinus*	Widespread, probably whole RSGA region.	Dispersed nests on open shore just above high water mark in seaweed, flotsam or broken coral rubble.	Spring, mostly February to May.	✓		Nests difficult to find, but adults frequently employ distraction displays that are sufficient proof of breeding.	Jennings 1995.

Species	Area	Habitat / colony type	Nesting season	Ground	Aerial	Survey method	References
Sooty gull *Larus hemprichii*	Widespread, probably whole RSGA region.	Dispersed or loose colonies on both sandy and rocky islands. Nests usually in shade of rock or small bush.	Commences April/ May in north, June/ July in south.	✓	✓	Flush counts of adults emerging from nests can be made from air; loose colonies usually small, so nests can be counted directly during ground work.	Jennings 1995; Niko-laus 1987; Goodman & Meininger 1989; Newton & Al Suhaibany 1996a.
White-eyed gull *Larus leucophthal-mus*	Widespread, probably whole of RSGA region.	Small colonies (B), often in open sand, occasionally more rocky sub-strate.	Summer, probably commences June in north and July in south.	✓	✓	As for sooty gull.	
Caspian tern *Sterna caspia*	Widespread but scarce, probably whole of RSGA region.	Solitary or dispersed loose colonies, usually fairly open sandy areas. Occa-sionally nests on mainland coasts, e.g. sand-spits.	Spring, usually Feb-ruary to April/May.	✓	✓	Nests can be detected from air if few other species present; otherwise detailed groundwork is needed.	Jennings 1995.
Swift and less-er-crested tern *Sterna bergii, S. bengalensis*	Widespread, whole of RSGA region.	: Large dense colonies of both species often found side by side; often on edge of larger sandy islands or more centrally on smaller ones.	Summer, usually June to August, swift terns possibly earlier than less-er-crested terns.	✓ Quadrat	✓	Aerial counts can yield ac-ceptable estimates of numbers of individuals and nests; pho-tographs could be useful for more accurate counts. Other-wise, nest density needs to be measured in sample quadrats or belt transects and extrapo-lated to measured/estimated area covered by colony.	Symens & Al Suhaibany 1996; Symens & Evans 1993; Newton & Al Su-haibany 1996a; Moore & Balzarotti 1983.

Standard Survey Methods

Species	Area	Habitat / colony type	Nesting season	Ground	Aerial	Survey method	References
White-cheeked tern *Sterna repressa*	Common and widespread, whole of RSGA region.	Usually medium sized (B to low C) colonies, frequently in open sandy areas or coral rubble; may be several discrete sub-colonies even on quite small islands.	Summer, usually June to August.	✓ Walk / Flush		Often difficult to detect during aerial counts as colonies are amongst larger numbers of bridled terns or brown noddies. However, the number of nests can usually be counted by two or more observers walking in parallel through a colony. Care should be taken not to trample eggs, as nests can be quite cryptic. Flush counts of adults attending nests are satisfactory if time limited.	As for Swift Tern, Simmons 1994.
Bridled tern *Sterna anaethetus*	Common and widespread, whole RSGA region.	Colonies will often stretch over whole islands with moderate to dense vegetation cover. Nests fairly well dispersed under bushes (although there may be more than one nest under any one bush) or small rocky overhangs.	Summer, usually May/June to August.	✓ Quadrat	✓	Numbers of adults flushed from nests can be estimated during aerial counts. On the ground, counts of adults perched on bushes following flushing during the incubation period may give approximation of numbers of pairs. If more detail required, then sample quadrats or belt transects are necessary. Make sure sampling covers the range of vegetation types, bush densities and heights.	As for Swift Tern, Sweet 1994.
Sooty tern *Sterna fuscata*	Occasionally recorded breeding on the African coastline of the Gulf of Aden.	In other parts of the world, nests in the open in very large dense colonies similar to swift and lesser-crested terns. However, colonies in RSGA region probably relatively small.	Possibly June	✓	✓	Detailed methodology given in paper.	Ratcliffe et al. 1999.

Species	Area	Habitat / colony type	Nesting season	Ground	Aerial	Survey method	References
Saunder's tern *Sterna saundersi*	Widespread but local on Arabian side of the Red Sea, apparently scarcer on the African side.	Small loose colonies (A–B) in sandy areas; may nest on mainland coasts.	Spring, first eggs usually April.	✓	✓	Very seldom detected during aerial surveys; detailed ground work needed to prove presence of nests.	Jennings 1995
Brown noddy *Anous stolidus*	Widespread, southern Red Sea and Gulf of Aden, usually on islands well offshore (>20 km).	Colonies usually large (C–D) on well-vegetated islands often covered with Suaeda fruticosa; rarely mangrove Avicennia marina. Nests sub- canopy on branches of trees or bushes.	Probably summer, May to August.		✓	Several aircraft overpasses usually flush adults from vegetation, although some adults may remain in situ. However, aerial counts are probably easier to undertake than ground counts, as it is very difficult to count nests in dense vegetation. More validation work urgently required on this species.	Moore & Balzarotti 1983; Newton & Al Suhaibany 1996a

Annex 8.2 Seabird Monitoring Surveys (All methods)

NOTE: The seabird survey forms for the different survey methods mostly use the same terminology. So the following guide provides an explanation for all the terms used in all survey forms.

SEABIRD MONITORING SURVEYS	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Start time / End time	Record the start and end time for the survey.
Weather (1-5)	Record the weather using the following scale: 1= Sun, no cloud 2= Sun part cloud (<50% cloud), 3= Sun and cloud (50% and 50%), 4= Cloud (full cloud), 5 = Cloud and rain.
Surveyors	Record the initials of the surveyors
SEABIRD HABITAT INFORMATION	
Island / colony ID	Record the location reference used on field maps and recording forms, which may be different from final code number.
Alternative Name	Record the local name of the island / islet if known or the nearest named landmark on maps available.
GPS Waypoint Start / End	Record the GPS waypoint number at the start of the survey and end of the survey (you can use the original waypoint number as stored in the GPS).
Start and End time	Record the start and end time of the survey or transect if relevant
Count method	Separate survey forms are provided for aerial and ground based counts
Count Type	Record the type of aerial or ground based count method being used whether it is photographic survey, direct count, or ground based flush count, vantage point count or walk through method, belt transects or quadrats.
SEABIRD AND NEST COUNTS	
Pass #	On the form for aerial survey, separate columns are provided to allow for the recording of the number of individuals of each species observed on each overpass. Circle the species that rise up and fly first during the first overpass as this can provide an indication of breeding / non-breeding status. More than one form may be needed if more than two passes are needed to complete the survey of the whole colony.
Flush #	On the form for flush surveys, separate columns are provided to allow for the recording of the number of individuals of each species observed on each repeat flush. The survey form allows for the completion of 3 flushes. If more flushes are needed a second survey form can be used. Circle the species that rise up and fly first as this can provide an indication of breeding status.
Count sector #	Duringe vantage point surveys, if densities are high it may be necessary to sub-divide the area and count the birds / nests within each sector. The vantage point survey form has separate count sector columns which can be used to record counts for each sectors. If the colony is large and needs to be divided into more than two sectors, separate survey forms can be used.
Transect #	Record the transect number for walk through, belt transect or quadrat. Use more forms as necessary to complete the survey.

#Individ-uals	Use the first column to record the number of individuals of each seabird species observed during the first over pass / flush / walk through/ belt transect. In the second column, record the number of individuals of each seabird species observed during the second over pass / flush / walk through/ belt transect
Nest #	Record the number of nests for each species present
Occupied Nests #	Record the number of nests where adults are present.
Active Nests #	Record the number of active nests where chicks or eggs are present (and note chick number and/or clutch size where possible)
Vacant Nests #	Record number of vacant nests where breeding status is indeterminate
Quad #	On the quadrat survey form, the quadrats are numbered sequentially (i.e. 1,2,3,4 etc) within each transect / walk through. The quadrat number can be recorded in the Quad # column then the species with nests present within the quadrat are recorded in the species column followed by the number of occupied, active and vacant nests. Each new quadrat within the same transects is numbered sequentially then the numbering re-started for each new transects / walk through.
Photo-graphs	Record the start and end number of the photographs if there are any. To help distinguish between the photographs from different sites you can write the GPS waypoint number on a sheet of paper and photograph the number or photograph the survey form between sites.

SEABIRD MONITORING - AERIAL SURVEYS **Survey Sheet_________**

Country		Date	
Location		Weather	
Sector ID		Surveyors	

Island / Colony ID:			
Alt name/Local name			
GPS waypoint Start		GPS waypoint End	
Start time		End time	
Count type	Photo	Direct count	

	# Indivi	**Occupied Nest**	**Active Nest**	**Vacant nest**	**# Indivi**	**Occupied Nest**	**Active Nest**	**Vacant nest**
Pass #								
Red-billed tropicbird								
Brown booby								
Pink-backed pelican								
Little green heron								
Cattle egret								
Cattle egret nest								
Western reef heron								
Gray heron								
Purple heron								
Goliath heron								
Spoonbill								
Osprey								
Sooty falcon								
Crab plover								
Sooty gull								
White-eyed gull								
Gulls								
Caspian tern								
Swift tern								
Lesser-crested tern								
White-cheeked tern								
Bridled tern								
Saunder's little tern								
Terns								
Brown noddy								

Notes

SEABIRD MONITORING – VANTAGE POINT SURVEYS Survey Sheet_________

Country		Date	
Location		Weather	
Sector ID:		Surveyors	

Island / Colony ID:								
Alt name/Local name								
GPS Waypoint								
Start time / End Time								
Sector #								
Species (NB: record number of adults & chicks on occupied and active nests)	**Indiv.**	**Occupied Nest**	**Active Nest**	**Vacant nest**	**Indiv.**	**Occupied Nest**	**Active Nest**	**Vacant nest**

Notes

SEABIRD MONITORING – FLUSH COUNTS **Survey Sheet_________**

Country		Date	
Location		Weather	
Surveyors		Survey Sector:	

Island / Colony ID:									
Alt name/Local name									
GPS Waypoint									
	#Individuals			**#Individuals**			**#Individuals**		
Flush #	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**

Notes

SEABIRD MONITORING – WALK THROUGH / BELT **Survey Sheet**__________

Country		Date	
Location		Weather	
Surveyors		Survey Sector:	

Island / Colony ID:									
Alt name/Local name									
GPS Waypoint									
	# Nest								
Transect #	**1**			**2**			**3**		
Start Time GPS WPT									
End Time GPS WPT									
Species (NB: record number of adults & chicks on occupied and active nests)	**Occupied Nest #**	**Active Nest #**	**Vacant nest #**	**Occupied Nest #**	**Active Nest #**	**Vacant nest #**	**Occupied Nest #**	**Active Nest #**	**Vacant nest #**

Notes

SEABIRD MONITORING – QUADRAT SURVEYS

Survey Sheet_________

Country		Date	
Location		Weather	
Surveyors		Survey Sector:	

Island / Colony ID:	
Alt name/Local name	
GPS Waypoint	

Transect #			
Start Time GPS WPT			
End Time GPS WPT			

# Nest														
Transect # =					**Transect # =**					**Transect # =**				
Quad#	**Species**	**O**	**A**	**V**	**Quad#**	**Species**	**O**	**A**	**V**	**Quad#**	**Species**	**O**	**A**	**V**

Notes

KEY: O = occupied, A = active and V = vacant

Annex 8.3 Seabird Monitoring – Habitat Surveys (Level 2)

SEABIRD MONITORING – HABITAT SURVEYS	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Start time / End time	Record the start and end time for the survey.
Weather (1-5)	Record the weather using the following scale: 1= Sun, no cloud 2= Sun part cloud (<50% cloud), 3= Sun and cloud (50% and 50%), 4= Cloud (full cloud), 5 = Cloud and rain.
Surveyors	Record the initials of the surveyors
SEABIRD HABITAT INFORMATION	
Island / colony ID	Record the location reference used on field maps and recording forms, which may be different from final code number.
Alternative Name	Record the local name of the island / islet if known or the nearest named landmark on maps available.
Start and End Time (GPS Waypoint)	Record the start and end time of the survey and the GPS waypoint number (you can use the original waypoint number as stored in the GPS).
No. islets	Record the number of islets included in count unit;
Count method	Record if the count is an aerial or ground based count
Count Type	Record the type of aerial or ground based count method being used whether it is photographic survey, direct count, or ground based flush count, vantage point count or walk through method, belt transects or quadrats.
Size	Record the size of the study area, colony, island / islet as follows: A: 50-500 m (longest axis); B: 501–5,000 m (longest axis); C: >5,000 m (longest axis).
Survey Area	Record the (estimated size) of the survey area and habitat utilisation of the seabird species found within the survey area.
% Sand	Record the percentage of island surface (above high water mark) covered by soft substrates: sand, silt, mud, loose soil; includes most land covered in mangroves.
% Rock	Record the percentage of island surface (above high water mark) composed of hard substrate: coral rock, volcanic rock, and boulders.
% Vegetation	Record the percentage of island surface covered by vegetation: mangroves, bushes and shrubs, graminoids.
Vegetation height	Record the vegetation height using the following scale: 0 = mangrove or sand and rock only; 1 = low bushes (<1 m) and graminoids; 2 = tall bushes, shrubs and trees (>1 m, but usually 2–3 m).
Mangrove	Record the percentage coverage with mangroves using the following scale: 0 = none; 1 = 1–33% of surface area covered by mangroves; 2 = 34–66% of surface area covered by mangroves; 3 = 67–100% of surface area covered by mangroves

Relief	Record the relief using the following scale: 0 = flat; 1 = undulating or some low cliffs or dunes; 2 = relatively hilly 3= mountainous / cliffs.
Huts	Record the number of fishing huts/camps/shelters present on the island (R = ruins/ remains, CGS = coastguard station).
Boats	Record the number of boats on or within 2 km of island; primarily refers to fishing boats but also includes dhows, larger vessels and coastguard boats.
Other threats	Record any other threats including evidence of human activities within close proximity to the survey area, or evidence of predators.
Notes	Record any other information, such as the presence of turtle pits.
Photographs	Record the start and end number of the photographs if there are any. To help distinguish between the photographs from different sites you can write the site ID and GPS waypoint number on a sheet of paper and photograph the number or photograph the survey form between sites.

SEABIRD MONITORING - HABITAT SURVEYS   Survey Sheet_________

Country		Date	
Location		Weather	
Surveyors		Survey Sector:	

Island / Colony ID:																					
Alt name/ Local name																					
Start & End Time / GPS WPT																					
Count	Aerial		Ground					Aerial		Ground					Aerial		Ground				
Count type	Photo	Direct	V A	F L	W T	B T	Q U	Photo	Direct	V A	F L	W T	B T	Q U	Photo	Direct	V A	F L	W T	B T	Q U
No. isles																					
Size of island / study area																					
% Sand																					
%Rock																					
Vegetation																					
Vegetation height																					
Mangrove																					
Relief																					
Huts																					
Boats																					
Other threats																					
Photographs																					
Notes																					

KEY: **Island / colony ID**: location reference used on field maps and recording forms, which may be different from final code number. **Alt. names**: other names for island or nearest named landmark on maps available. **Count and type**: Tick method(s) used. **No. isles**: number of islands included in count unit; **Code No.**: sector reference (A–G) followed by unique number. **Size**: A: 50-500 m (longest axis); B: 501–5,000 m (longest axis); C: >5,000 m (longest axis). **% Sand**: percentage of island surface (above high water mark) covered by soft substrates: sand, silt, mud, loose soil; includes most land covered in mangroves. **% Rock**: percentage of island surface (above high water mark) with hard substrate: coral rock, volcanic rock, and boulders. **% Veg**: percentage of island surface covered by vegetation: mangroves, bushes and shrubs, graminoids. **Veg. Height**: 0 = mangrove or sand and rock only; 1 = low bushes (<1 m) and graminoids; 2 = tall bushes, shrubs and trees (>1 m, but usually 2–3 m). **Mangrove**: 0 = none; 1 = 1–33% of surface area covered by mangroves; 2 = 34–66% of surface area covered by mangroves; 3 = 67–100% of surface area covered by mangroves. **Relief**: 0 = flat; 1 = undulating or some low cliffs or dunes; 2 = relatively mountainous. **Huts**: number of fishing camps/shelters present on the island (R = ruins/remains, CGS = coastguard station). **Boats**: number of boats on or within 2 km of island; primarily refers to fishing boats but also includes dhows, larger vessels and coastguard boats at sea. **Other threats:** e.g. jettys, other structures, predators dogs, cats, rats. **Note:** Record other information such as the presence of turtle pits.

9

Marine Mammals


(Credit @ Ahmad Shawky)

9. MARINE MAMMALS

9.1 Background Rationale

There are 21 species of marine mammal reported to occur in the PERSGA region, with 19 species recorded from the Gulf of Aden, and 17 species from the Red Sea (Notarbartolo di Sciara et al., 2017, Costa et al., 2018). Globally, marine mammals are threatened by several growing anthropogenic impacts. In the PERSGA region threats include prey depletion, direct or indirect (bycatch) caught, loss of habitats due to coastal development (including noise), mortality or injury due to entanglement or ingestion in marine debris, contamination by oil or xenobiotic compounds, disturbance due to tourism (whale/dolphin watching or swimming with), collision due to maritime traffic, and climate changes. Three of the species that occur in the PERSGA region are listed as Endangered on the IUCN Red List.

Assessing the status of marine mammal populations and establishing long term monitoring programmes is often challenging due to the high mobility and longevity of these large animals and the high cost associated to the research at sea. As a result, the marine mammal fauna and in particular the cetacean fauna is still among the least known worldwide in the PERSGA region. Knowledge about the species composition, distribution and population status in the northern part of the Red Sea has increased in the past decades due to dedicated research and citizen science programmes. However little is known in the central and southern parts of the Red Sea, and in the Gulf of Aden, where there has been limited monitoring to date. The aim of a marine mammal monitoring programme is to provide information on species composition, abundance and distribution, population dynamics, migratory patterns and foraging and breeding behaviours. Monitoring the status of species together with their associated habitats provides a more holistic understanding of their ecology.

9.2 Overview

A range of methods have been developed to monitor marine mammals as reviewed by Preen (2004). These include: i) interviews with fishermen or members of the local community; ii) opportunistic sighting report from citizen science program; and iii) field surveys over relatively small areas using photo-identification methods, or over large region using observation platforms such as vessels or aircrafts.

Harvesting local ecological knowledge (LEK) from residents could provide information about species presence, population trend, and seasonal distribution patterns. Informal interviews are often used allowing respondents to be more relaxed and at ease with the surveyor. Opportunistic marine mammal reports have been proved very effective to monitor animal presence and distribution in areas where tourism is developed (in particular diving areas in the Egyptian waters). Information from interviews and opportunistic sightings are often essential to support researchers for survey planning suggesting areas where animals are present in high density. These methods also allow gathering information at relatively low cost.

Vessel and aerial surveys provide quantitative information including population size and trend (if survey is repeated over years) and habitat preferences. However, these methods are relativity expensive and require trained observers. Small-scale surveys using photo-identification methods are effective for resident populations in areas close to coast.

9.2.1 **Target**

The data recorded during marine mammal monitoring include:

- Species presence / absence (see Table 9.1)
- Distribution patterns and relative abundance of marine mammal species.
- Human activities within the survey area to assess potential threats, causes of mortality or conservation priorities.
- Habitat utilisation, migratory patterns, dietary preference and breeding season of the various species recorded during the survey.

9.2.2 **Field equipment**

The following survey equipment is required for marine mammal monitoring:

- Survey form, clipboard, pencil and eraser
- Binoculars for boat surveys.
- Boat with depth sounder and/or GPS.
- GPS and map of the survey area.
- Compass
- Species identification guide with annotations (Annex 9.4).

Table 9.1 List of marine mammals considered as present in the PERSGA region, International Union for the Nature Conservation (IUCN) assessment status of the risk of extinction (undated at 2018), list of publications reporting the species presence in the Gulf of Aden and Red Sea.

Common name	**Species**	**IUCN**	**Gulf of Aden**	**Red Sea**
Dugong	*Dugong dugon*	VU	1	5
Blue whale	*Balaenoptera musculus*	EN	2,4	
Bryde's whale	*Balaenoptera edeni*	DD	2	
Omura's whale	*Balaenoptera omurai*			
Humpback whale	*Megaptera novaeangliae*			
Sperm whale	*Physeter macrocephalus*	VU	2,4	
Dwarf sperm whale	*Kogia sima*			
Melon-headed whale	*Peponocephala electra*		2	
False killer whale	*Pseudorca crassidens*		2	3,4
Killer whale	*Orcinus orca*	CD	2	4
Short-finned pilot whale	*Globicephala macrorhynchus*	CD	2,4	
Indian Ocean humpback dolphin	*Sousa plumbea*	DD	2	3,4
Short-beaked common dolphin	*Delphinus delphis*		2	4
Indo-Pacific common dolphin	*Delphinus delphis tropicalis*			
Indo-Pacific bottlenose dolphin	*Tursiops aduncus*			
Common bottlenose dolphin	*Tursiops truncatus*	DD	2	3,4
Risso's dolphin	*Grampus griseus*	DD	2	3,4
Pantropical spotted dolphin	*Stenella attenuata*	CD	2	3,4
Striped dolphin	*Stenella coeruleoalba*	CD	2	4
Spinner dolphin	*Stenella longirostris*	CD	2	4
Rough-toothed dolphin	*Steno bredanensis*	DD		4

1. Robineau & Rose 1982. 2. Small & Small 1991. 5. Preen 1989, Notarbartolo di Sciara et al., 2017, Costa et al., 2019.

9.2.3 Field personnel

For interview based surveys, one surveyor can conduct interviews which can either be formal or informal. Several surveyors can also partake in the surveys in order to cover a larger survey area within a shorter time-frame. A minimum of three surveyors are required when conducting boat surveys for marine mammal monitoring to ensure that each surveyor can position themselves on both the port and starboard side of the boat. The third surveyor remains at the bow of the boat to help identify sightings and to act as the data the recorder.

9.2.4 Training / experience

Surveyors need to be able to be familiar with and able to identify the marine mammal species known to occur within the PERSGA Region, which can be difficult when out at sea, especially when large groups are encountered. Surveyors conducting interview surveys must have good communication skills and be able to engage with and gain observers' and fishermen's trust. Surveyors participating in boat based surveys should be able to swim, for safety reasons, and not be prone to motion/sea sickness. The use of both interviews and boat based surveys when combined, can provide a larger pool of data which can be more accurate and be used for long term monitoring.

9.3 Field Procedure

9.3.1 Interview surveys (Level 1 & Level 2)

See Chapter 13 Participatory Mapping – Local Knowledge for a more detailed description on how to complete these types of informal interviews for monitoring marine mammals. The survey form and a description as to how to complete these forms for marine mammals is presented at the end of this chapter (Annex 9.1, 9.2 & 9.3).

9.3.2 Boat Surveys (Level 2 & 3)

- Survey area must be defined using a map and the survey route planned.
- Boat should be travel at a low speed during survey and surveyors must be at least 3 m above the sea surface level for ease of accurate sighting.
- Three surveyors position including two observers and one data recorder position themselves so that one observer looks over the starboard and the other over the port side of the boat. The third surveyor positions themselves at the bow to act as spotter and data recorder.
- The start time of survey is recorded.
- Other information to be collected during the boat survey include: species identification, group size, GPS coordinates of sighting location, sighting angle, estimated distance from the boat, basic behaviour observations and weather conditions.
- When conducting boat surveys, it is essential that surveyors take rest periods as the survey can last for several hours, involving exposure which can be tiring. Additionally, have extra surveyors can help to have a survey rota system.
- Surveys should also be conducted several times in the year and on an annual basis for records of long term trends as well as establishing breeding season and foraging areas.

9.4 Strengths and Weaknesses

Strengths	Weaknesses
Use of experienced researchers ensures that good quality and appropriate data sets are collated.	Boat and aerial surveys are logistically expensive.
Boat surveys allow for up-close encounters with the marine mammals.	Sightings are not always guaranteed.
Interview surveys are cheap to conduct and provide the most information from key informants which can assist in identifying priority marine mammal conservation areas.	Aerial surveys require ground- truthing which is both costly and time-consuming.
Method provides brief overview of status; however it is not often 100% accurate due to various degree of experience among surveyors/ interviewees.	Boat surveys require several surveyors and often due to long trips to cover large survey areas, surveyors experience fatigue.
	Difficult to properly survey marine mammals due to low encounters and high mobility.

9.5 References

Costa, M; Fumagalli, M; and Cesario, M (2019) Review of Cetaceans in the Red Sea. In N.M.A. Rasul and I.C.F. Stewart (eds.), Oceanographic and Biological Aspects of the Red Sea, Springer Oceanography, 281-304.

Notarbartolo di Sciara G., Kerem D., Smeenk C., Rudolph P., Cesario A., Costa M., Elasar M., Feingold D., Fumagalli M., Goffman O., Hadar N., Mebrathu Y.T., Scheinin A. (2017) Cetaceans of the Red Sea. CMS Technical Series 33, 86 p.

Preen, A. (1989) The Status and Conservation of Dugongs in the Arabian Region. MEPA Coastal and Marine Management Series Report No. 10, Vol. 1, Meteorology and Environmental Protection Administration, Jeddah. 200 pp.

Preen, A. (2000) Dugongs, boats, dolphins and turtles in the Townsville-Cardwell region and recommendations for a boat traffic management plan for the Hinchinbrook Dugong Protection Area. Great Barrier Reef Marine Park Authority Report, 70 pp.

Preen, A. (2004) Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden, PERSGA Technical Series No. 10, PERSGA, Jeddah.

Robineau, D. & and Rose, J.M. (1982) Le Dugong (Dugong dugon (Muller, 1776) Sirenia, Dugongidae) en Republique de Djibouti. Biological Conservation 24: 233–238.

Small, J.A. and Small, G.J. (1991) Cetacean observations from the Somali Democratic Republic, September 1985 through May 1987. In: Cetaceans and Cetacean Research in the Indian Ocean Sanctuary. (Leatherwood, S. & Donovan, G.P. eds). UNEP Marine Mammal Technical Report Number 3: 179–210. Nairobi, Kenya.

9.6 **Annexes**

Annex 9.1 Marine mammals interview survey

MARINE MAMMALS INTERVIEW SURVEY	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti etc.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Time	Record the start and end time for the survey.
Interviewers	Record the initials for the surveyors involved in the survey.
Informants	Record the name of the informants being interviewed
SITE INFORMATION	
Number (as on map)	Ask the informant to draw on the map where they made the observation. Number the area on the map and record the number of the area drawn on the map on the survey form.
Location name	Ask the informant if the area has a local name. Record the location name where the observation was made.
What is special about this area?	Ask the informant to say which species they observed in the area or what behaviour was observed in the area, why it is special. Record why the area is special. Use the species identification key to see if the informant can recognise the species.
Habitat characteristics	Ask the informant to describe the habitat where the observation was made (e.g. is coral, sand, sea grass, mangrove etc.)
Time of year	Ask the informant if these observations were made at a specific time of year. E.g. is the species present all year round or only during certain months. Record which months the observations were made.
Has there been any changes in the past 5 years?	Ask the informant if they have notices any changes in the past 5 years, in terms of the presence or abundance of the species.
Additional comments	Ask the informant if they noticed the animals behaving in a certain way (feeding, mating etc.).or if there was any damage to the animals (scars, fishing line hooks etc.).
Notes	Use this space to record any additional information reported by the informants. Such as observations reported by

Marine Mammal Interview Surveys (Level 1 & 2) **Sheet number______________**

Country:	Location:	Date:	Time:
Interviewer 1:		Informants and age:	
Interviewer 2:			

Number. (on map)	**Location name**	**What is special about this area?** (e.g. species found, spawning, nesting, feeding ground)	**Habitat characteristics** (e.g. sand/algae/ coral/ sea grass)	**Time of year**												**Has the area / number of animals changed in the last 5 years?** (yes or no and what changes have been observed)	**Additional comments** (behaviour e.g. foraging, mating, aggregation? calves or adults or both)
				January	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**		

NOTES

Annex 9.2 Additional Interview Questions about Dugong (source Preen 2004, Preen 1989)

How long have you lived/fished in this area? What is the range of the area in which you fish? Do you know the dugong?
Can you describe it?
Do you recognize it in any of these photos? (series of photos of marine animals) What do they feed on?
Do you see them often? How often?
Do you think dugongs are more common, less common, or about the same as 10 years ago, 20 years ago, 30 years ago?
Do they get caught in your fishing nets? What season do you see/catch the most? In which area do you see/catch the most?
What happens to dugongs caught in your nets? Do you release them or kill them or do they accidentally drown?
Do you eat them? Do you use any other parts of the animal? What for?
Do you hunt dugongs or did you in the past? If so, how do/did you catch them? How many do you catch (accidentally or deliberately) in a year?
When was the last time you caught one? Do other fishermen in this area catch them?
How many would get caught by the whole village in a year? When was the last one caught?
Do you sell any dugongs?
If so, where do you sell them and how much do you get per kilogram/for the whole animal?

Annex 9.3 Marine mammals boat-based survey

MARINE MAMMALS BOAT-BASED SURVEY	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti etc.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Start time	Record the start time for the survey.
End time	Record the end time for the survey.
MARINE MAMMAL INFORMATION	
GPS Waypoint	Record the GPS waypoint number of the sighting location (you can use the original waypoint number as stored in the GPS).
Species Identification	Record the marine mammal species reported during survey and where sighting occurred (e.g. while boat was on anchor or travelling).
Number in group	Record the number of individuals in the species group reported in the survey.
Number of calves	Record the number of calves in the group or presence of calves
Seen from?	Record whether the observation was made from shore, sailing boat, powerboat at anchor, powerboat travelling, large survey vessel.
Distance (m)	Record the estimated distance between the observation platform and animals
Confidence	Record the confidence of the observation using the following: **C**= Certain, **P** = Probable, **G**= Guess
Weather (1-5)	Record the weather. Usually this will not change much while surveying, so can be recorded at the top of the survey sheet. Use the following scale: 1= Sun, no cloud 2= Sun part cloud (<50% cloud), 3= Sun and cloud (50% and 50%), 4= Cloud (full cloud), 5 = Cloud and rain
Wind direction (NSEW	Record the wind direction using the compass rose to describe which direction the wind is coming from (e.g. SE or SSE)
Wind strength (1-5)	Record the wind strength. Usually this will not change while surveying, so can be recorded at the top of the survey sheet. Use the following scale: 1= none (<4kn) 2= slight (4-6kn), 3= moderate (7-10kn), 4= strong (11-15kn), 5= very strong (>16kns)
Wave height (m)	Record the estimated wave height in metres.
Current direction (NSWE)	Record the current direction using the compass rose to describe which direction the wind is coming from (e.g. SE or SSE)
Current strength (1-5)	Record the current strength using the following scale: 1= none, 2= slight, 3= moderate, 4= strong, 5= very strong
Photographs	Record the start and end number of the photographs if there are any. There are different ways to help distinguish between the photographs from different sites. You can write the GPS waypoint number on a sheet of paper and photograph the number. You can photograph the survey form between sites, or the GPS screen showing the waypoint.
Other information	Write a brief description of what you observe, mentioning any human activities that are occurring in the area, or take place within close proximity to the sighting area or any other relevant information that can be used in long term monitoring.

Marine Mammal Boat Based Surveys (adapted from Preen, 2004) (Level 2 &3) **Sheet number______________**

Country:	Location:	Date:	Start time:	Surveyors

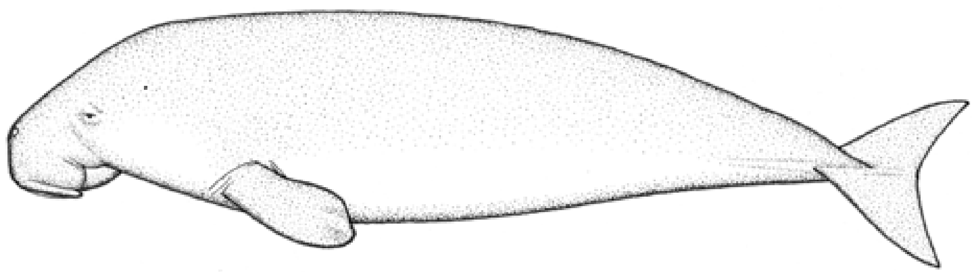
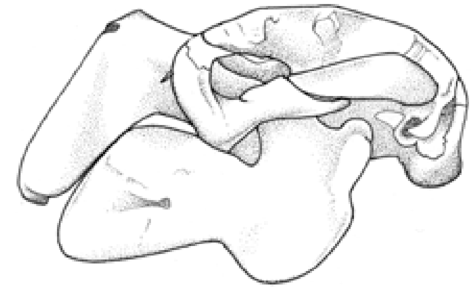
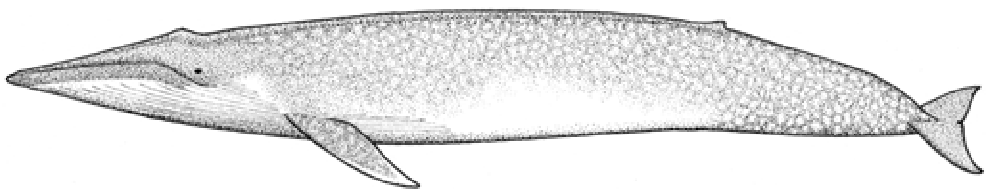
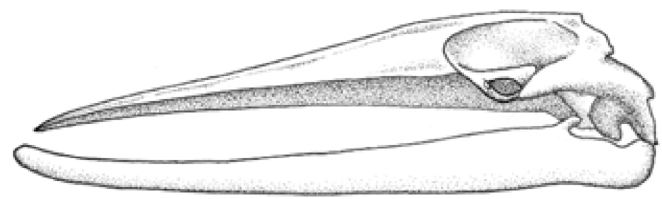
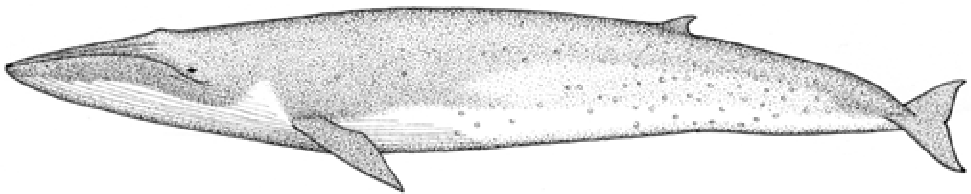
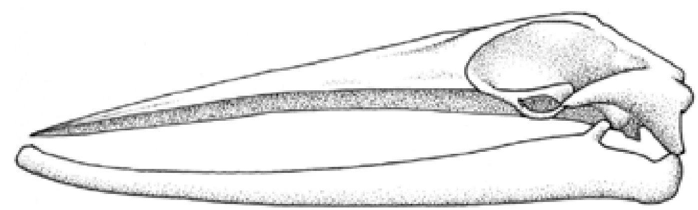
GPS waypoint	Species	No. in group	No. of calves	Seen from:	Distance (m)	Confidence?	Weather	Wind direction (NSEW)	Wind strength (1-5)	Wave height (m)	Current direction (NSEW)	Current strength (1-5)	Photographs	Comments (e.g. basic behaviour observations, sighting angle, estimated distance from the boat

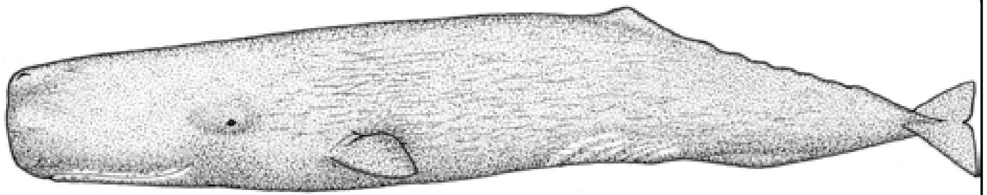
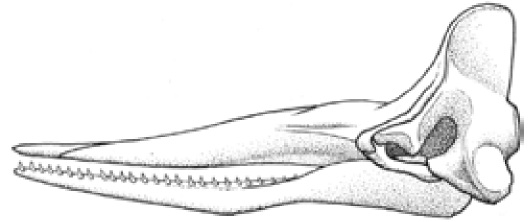
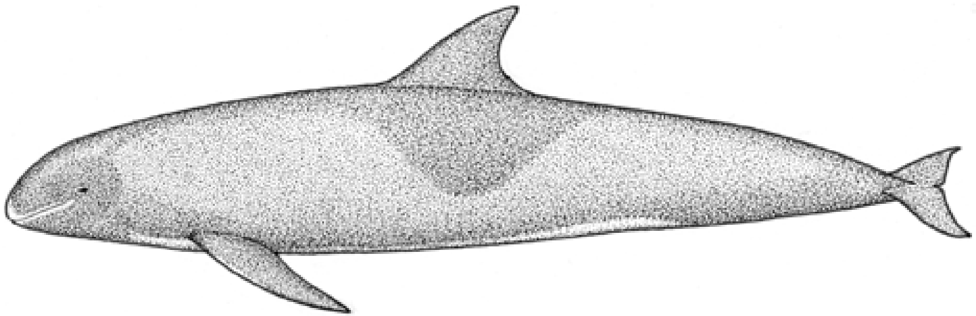
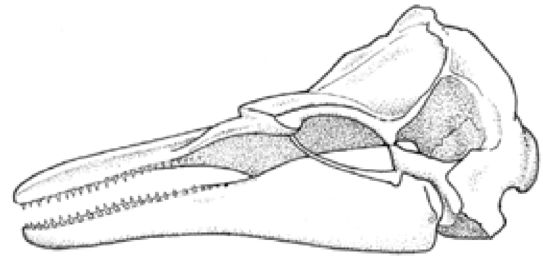
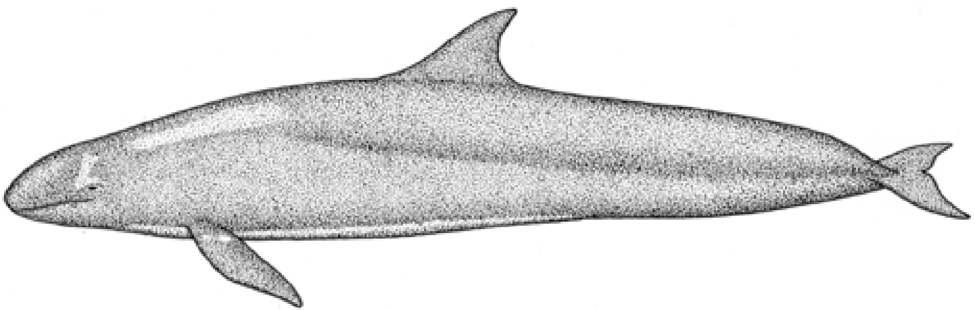
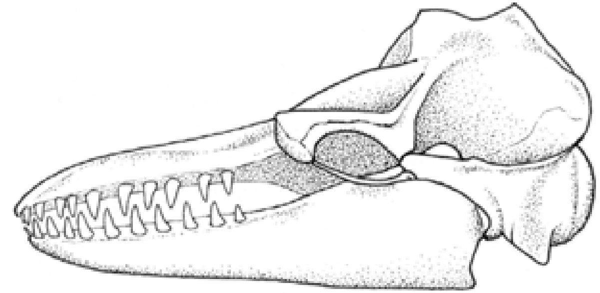
SPECIES: **DG** = Dugong, **BLW** =Blue Whale, **BRW** = Brydes Whale, **MHW** = Melon headed whale, **FK** =False Killer whale, **KW** =Killer whale, **BD**=Bottlenose dolphin, **CD** = Common dolphin, I**HD**= Indo-Pacific Humpback dolphin, **RD**= Risso's dolphin, **PSD** = Pantropical spotted dolphin, **STD** = Striped dolphin, **SPD** = Spinner dolphin, **RTD** =Rough-toothed dolphin.

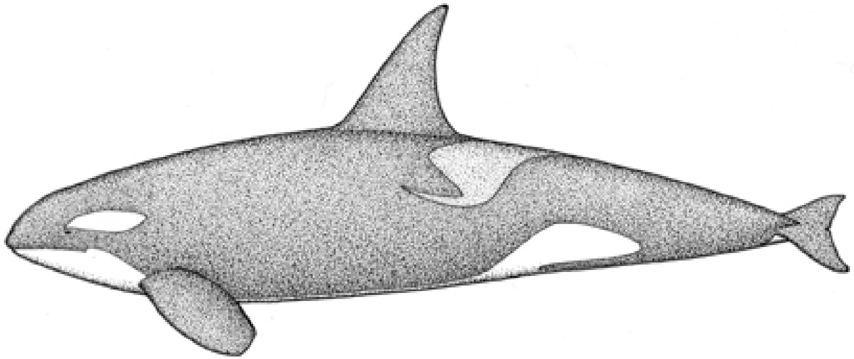
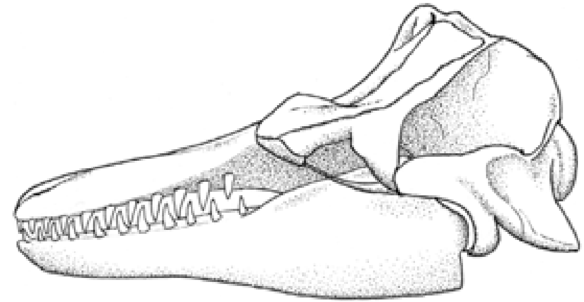
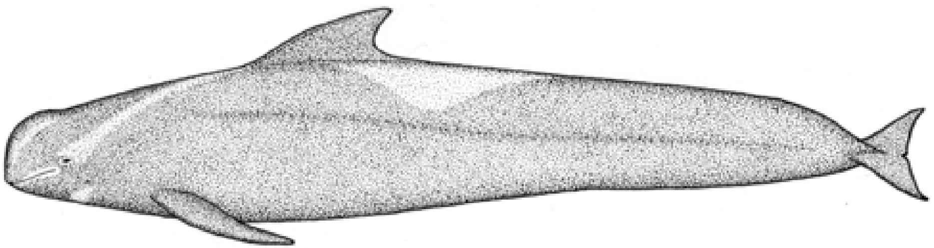
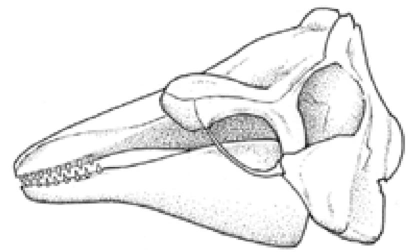
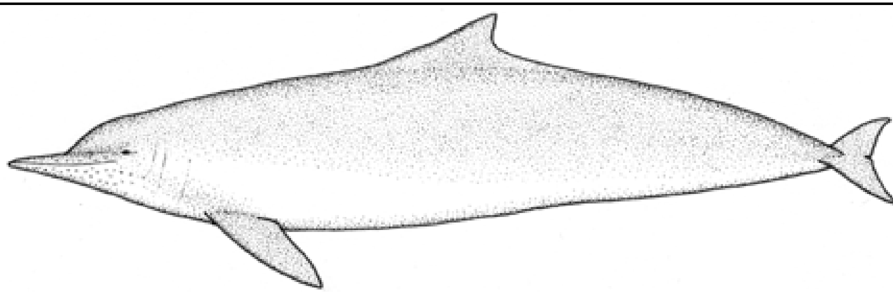
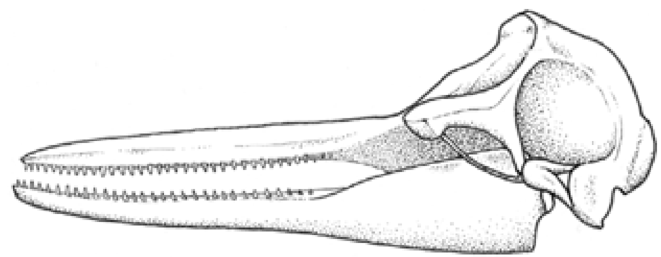
CONFIDENCE OF IDENTIFICATION: **C**= Certain, **P** = Probable, **G**= Guess

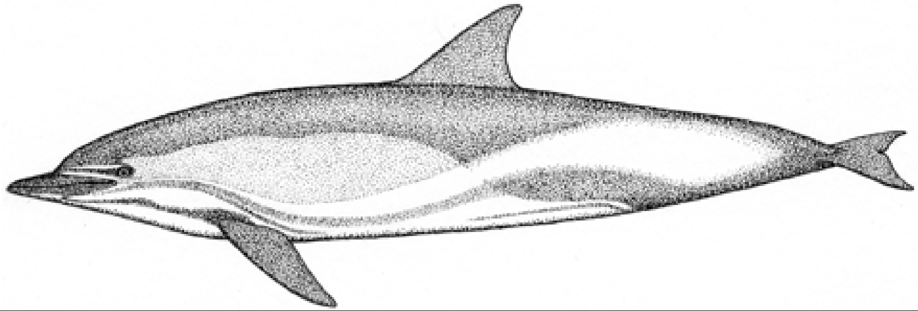
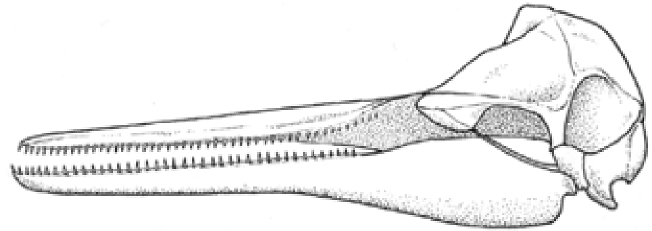
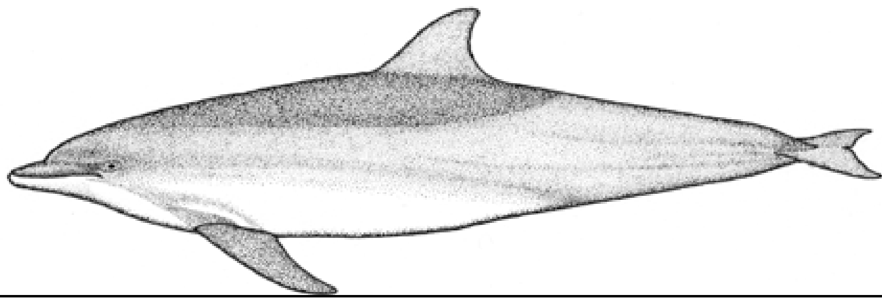
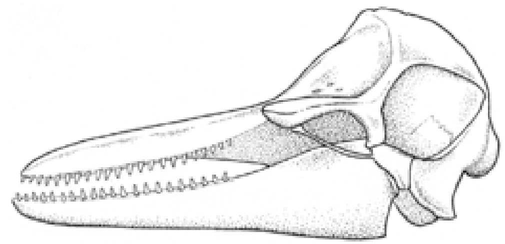
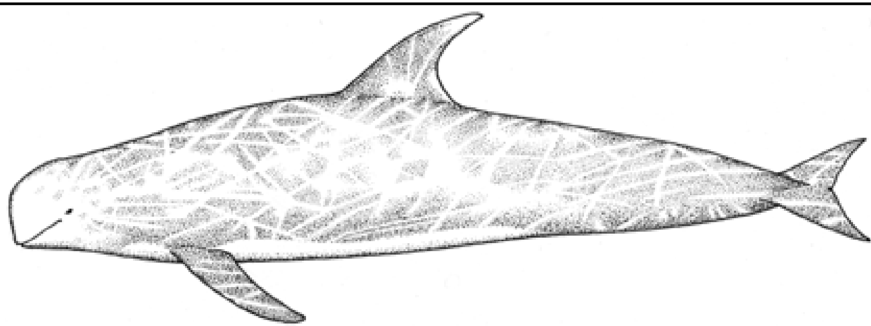
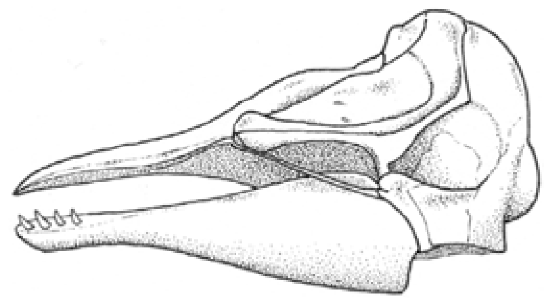
LOCATION OF SURVEYOR: Shore / Sailing Boat / Powerboat at anchor / Powerboat travelling

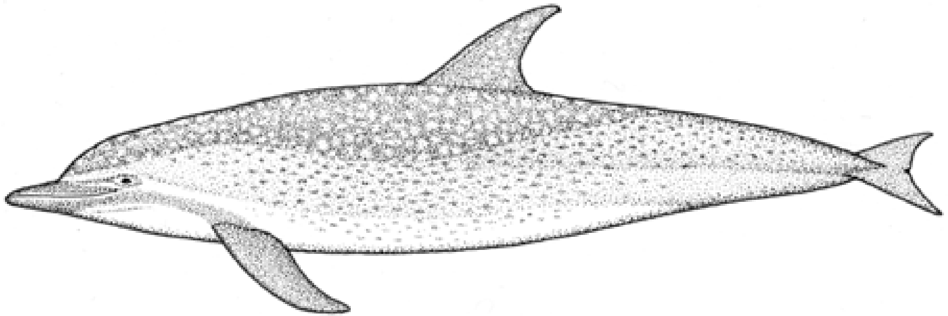
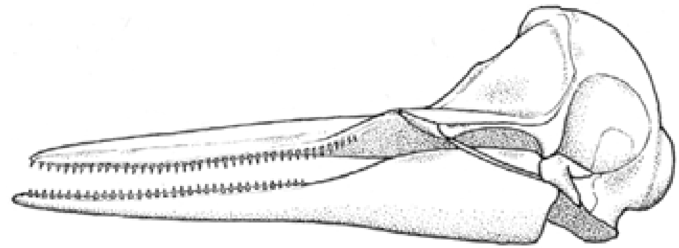
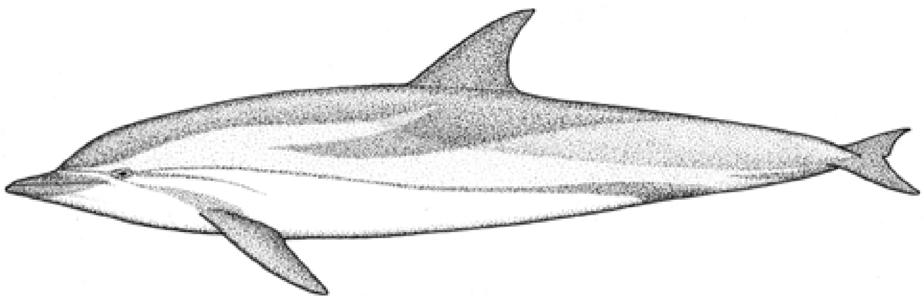
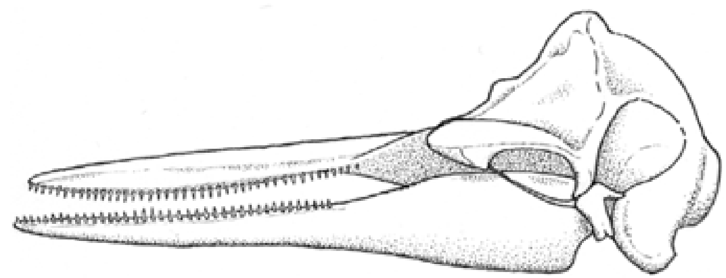
Annex 9.4. Marine mammal guide to identification

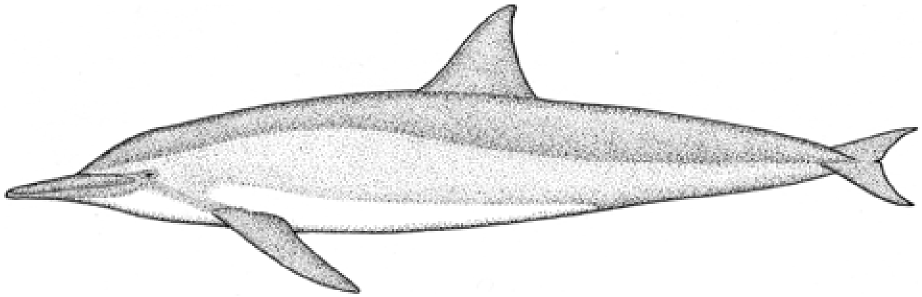
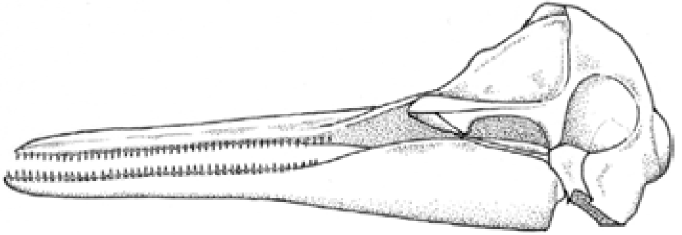
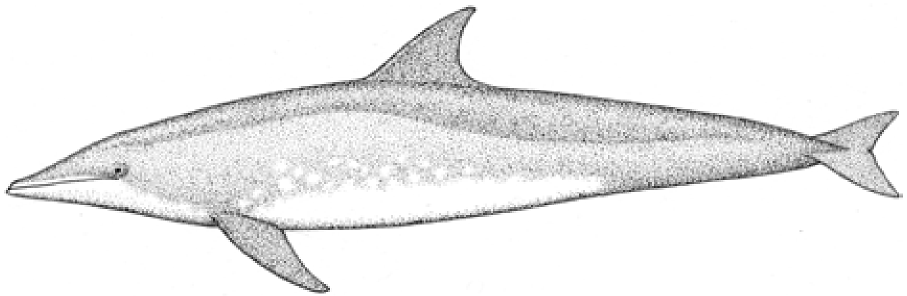
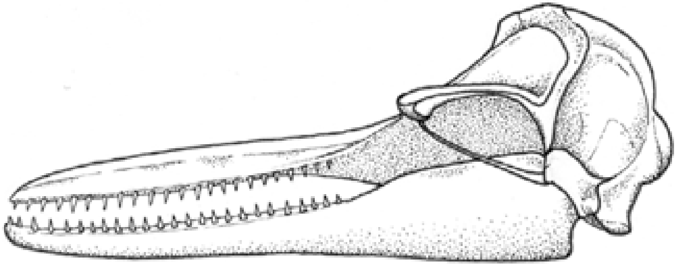
Dugong *Dugong dugong*	**Skull**
	
Blue whale Balaenoptera musculus	
	
Bryde's whale Balaenoptera edeni	
	

Sperm whale Physeter microcephalus	
	
Melon–headed whale Peponocephala electra	
	
False killer whale Pseudorca crassidens	
	

Killer whale Orcinus orca	
	
Short–finned pilot whale - Globicephala macrorhynchus	
	
Indian Ocean humpback dolphin Sousa plumbea	
	

Short-beaked common dolphin Delphinus delphis	
	
Common bottlenose dolphin Tursiops truncatus	
	
Risso's dolphin Grampus griseus	
	

Pantropical spotted dolphin Stenella attenuata	
	
Striped dolphin Stenella coeruleoalba	
	

Spinner dolphin Stenella longirostris	
	
Rough–toothed dolphin Steno bredanensis	
	

10

Fisheries Monitoring

10. FISHERIES MONITORING

10.1 Background

The fisheries of the Red Sea and Gulf of Aden are socio-economically important to the majority of member states within the PERSGA Region, both in terms of food security and income generation, particularly for rural coastal communities. Fisheries within the region target invertebrates, demersal and pelagic finfish, and include subsistence and small-scale commercial fisheries and foreign industrial fisheries, and an expanding sports and recreational fishing sector. Many of the species targeted within the region span national boundaries and are essentially shared stocks between two or more countries (PERSGA 2003). Despite the importance of the fisheries sector, the direct impacts of fishing on fish stocks, vulnerable species such as dugong, shark, turtle, shrimp, sea cucumber and rock lobster, and other direct or indirect impacts on marine habitats are largely unknown. The main reason for this is a lack of reliable information on the fisheries and the environmental interaction of fisheries within the region.

Applied fisheries research and stock assessments have been neglected within the RSGA region for many years. No stock assessments have been undertaken since the 1970s and 1980s after the cessation of the collaborative research programmes by the former Soviet Union and international organizations, such as the Food and Agriculture Organization of the United Nations (FAO). The national capacity for fisheries data collection, analysis and dissemination has declined and current national capacity varies greatly between the countries. While Egypt, Djibouti and Saudi Arabia have systems to monitor catches at major landing sites, Yemen, Sudan, Somalia and Jordan only have ad-hoc monitoring. Generally, there is more data available for the industrial fisheries compared to the subsistence or small-scale commercial fisheries. Data recording by fisheries cooperatives and fish buyers / traders is often inconsistent or absent. The types of data that are collected are often aggregated higher level data for the purposes of producing annual catch summaries. Information on catch location, catch per unit effort and biological parameters, is generally not recorded. Information on fish processing is also often unrecorded. So most national authorities do not have access to reliable data of sufficient quality to allow proper stock assessments or economic evaluation of fisheries activities.

The socio-economic importance of the small-scale commercial and subsistence fisheries underscores the need to increase monitoring of this part of the sector within the region (PERSGA 2003). The following chapter presents two survey methods that are orientated toward sampling the small scale commercial and subsistence fisheries, but can also be applied to recreational and/or sports fisheries.

10.2 Overview

10.2.1 General approach

There are two main approaches to monitoring fisheries: the first involves the collection of data about the catches landed by the different types of fishery and; the second is to collect independent scientific data, either through scientific fishing or by using underwater visual census methods or alternative techniques to assess fish abundance and biomass *in-situ*.

The survey methods included here focus on the methods that can be used to sample small-scale commercial, subsistence, recreational or sports fisheries. There are four main methods that can be used to assess these types of fisheries which include:

- **Frame surveys** which are completed to establish a baseline, to determine sampling locations, frequency and identify sampling techniques before setting up a long-term monitoring programme.
- **Onboard surveys** which surveys where the data are collected with the fishermen, while they are fishing. These methods permit the accurate recording of time spent fishing using different gear type, as well as catch and location data.
- **Creel surveys** are conducted at landing stations or locations where it is known that fishers come ashore with the catch.
- **Questionnaire**-based surveys may be used as an alternative to creel surveys and involve interviewing fishers about their catches after they are back onshore.

Creel surveys are generally considered to produce the most comprehensive data, as they permit the sampling of much larger quantities of fish and allow for the collection of biological samples for analysis in the laboratory (e.g. otoliths, stomach contents, etc). Implementing creel survey for monitoring small-scale commercial and subsistence coral reef fisheries can be challenging as fishers may land their catches unpredictably at random locations and times along the coast. So the amount of data that can be collected may be limited unless the fishers are required to come ashore at specified fish landing stations, which is always monitored. Observer-based methods can address this challenge, as the observer remains onboard with the fisher, but they are time consuming and the amount of data obtained is limited by the number of observers that can participate in the surveys. Questionnaire-based surveys also address this issue as the data is collected from fishers at an agreed location after they have come ashore, although the data will not necessarily be as accurate as could be obtained were the observers to be onboard. Creel based surveys that engage local community members in the monitoring programmes and train them in how to collect the data can help to address the issue as the local communities will often know better where and when fishers will land their catches.

10.2.2 Target

Creel surveys can be designed to estimate total catch, total fishing effort, catch per unit effort, catch composition, length frequency of the fish in the catch, gear numbers and gear types. The surveys are generally designed to collect all of this information over a period of time at more than one location, and the data is then pooled to characterise the fishery.

10.2.3 Field equipment

- Survey forms, slate / clipboard / clips
- Pencils (at least 2), pencil sharpener and rubber
- Map of the study area, preferably laminated.
- Fine permanent black marker pen (to write on maps)
- GPS and spare batteries
- Watch / mobile phone with a clock
- Fish measuring board
- Weighing scales
- Camera

10.2.4 Field personnel

Fisheries monitoring is best undertaken by a team of two trained surveyors. For creel methods, the surveyors need to wait at or near the where the fishers will come ashore for the entire survey day and measure the catch of all fishers who return, including those who have not caught anything. For observer based methods, the surveyors need to remain onboard the boat for the whole fishing trip.

10.2.5 **Training/experience**

An experienced fisheries surveyor should be involved during the initial phase of setting up a fisheries monitoring programmes. These initial frame surveys can engage the local community and fishers in the surveys to familiarise them with monitoring and to introduce the concept of monitoring their own fisheries. Once the design of the fisheries monitoring programme has been agreed, fishers and local community members can be trained in how to collect the data and employed to undertake the surveys on a regular basis.

10.3 **Field Procedure**

10.3.1 **Fish Landing Station Surveys**

Catch assessments surveys using the creel method are normally completed at Fish Landing Stations, or known locations where fishers land their catches, for a fixed number of days per month. The sampling locations, frequency and duration of these surveys will first need to be determined through a frame survey and adjusted to accommodate for the different types of fisheries in the study area and any particular cycles related to the moon or tidal state. For example, some fisheries may only be undertaken during the full moon, on low spring tides, while others may be completed when there is a new moon. These types of issues will be identified during a frame survey. Once the fisheries monitoring programme design has been decided upon, the observers need to be trained. Surveys can then be completed as follows:

- On the evening before each survey day, the surveyors will contact some of the fishers to find out roughly what time they are going out fishing and what time they expect to be back onshore.
- On the survey day, the surveyors prepare their equipment and go to the sampling location or Fish Landing Station at least 1 hour before the fishers are due back to shore.
- The surveyors approach each fisher as they return and complete one survey form per fisher (if an individual) or per fishing boat.
- The first section of the form includes general information about the survey, which the surveyor can fill in before approaching the fisher.
- The surveyor then asks the fisher for more information about the type of fishing they have just undertaken.
- The second section on the form requests information about the boat type, means of propulsion, whether the boat had an inboard or outboard engine, the size of the engine.
- The next section focuses on the type of gear that has been used.
- The fourth section focuses on the fishing trip and clarifies the amount of time the fisher has spent fishing (effort required) total fishing days or fishing hours per day.
- The final section of the form is where the surveyors record the catch. In this final section, the surveyors record the species, measure the length of the fish and the weight. This entails weighing each fish individually to the nearest gram using a

spring balance and measuring the total length to the nearest millimetre or 0.5 cm.

- There are three measures of fish length, which are: standard length, fork length and total length. The total length of a fish is the maximum length of the fish, with the mouth closed and the tail fin pinched together.
- The correct way to measure the total length is to lay the fish flat on a measuring board and push the fish's snout up against a vertical surface on the board with the mouth closed. If the tail is rounded, the measure is to the rounded tip of the tail. If the tail is forked, pinch the tail fin closed and measure the total length, ignoring any streamers.
- The species, length and weight, are recorded on the form.
- If the surveyors do not recognise the species of fish, then they can take a photograph of the fish and tick the box on the survey form.

If the fishers are very impatient and unwilling to allow the surveyors to measure each fish, then it might be necessary to use an alternate quicker method to record the catch. Under these circumstances, the surveyors can quickly separate the fish into the main groupings (e.g. by family or genera), record the weight per group and take photographs of each group. An alternative option would be to take photographs and weigh the whole catch without separating out the fish into any groupings. With both these options, the usefulness of the data is less than if each fish were to have been weighed, but it does still provide useful data.

Another option is to just measure the total length of each fish and then use L-W relationship equation to calculate the weight of the fish. This method depends on their being sufficient information about the L-W relationship for all species in the catch, which in tropical multi-species fisheries is unlikely.

10.3.2 Fisher Tracking Surveys

The Fisher Tracking survey is an onboard observation survey method used to better understand the distribution of effort for a specific fishery. Surveyors join a fisher or group of fishers for the full duration of a fishing trip, recording where they fish and what they catch. Surveys are undertaken either from a boat or on foot, depending on the mode of transport being used by the fisher. It is important to liaise with the fisher beforehand to ascertain the time they will be leaving the shore to go out fishing. For each fisher, the surveyors complete form FS02.

- On the evening before each survey day, the surveyors will contact some of the fishers to find out roughly what time they are going out fishing and where to meet.
- On the survey day, the surveyors prepare their equipment and go to the agreed meeting point, arriving early if possible so as not to delay the fishers depature.
- On arrival at the fishing ground, a GPS position should be recorded, each time the fisher deploys and recovers their gear (net, line, trap etc.).
- When the gear is deployed the surveyor records the GPS position, date and time and information about the type of gear deployed (lines, traps, nets).
- When the gear is recovered the surveyor records the GPS position and information about the gear type (lines, traps, nets), the duration the gear has been left and the catch. Remember to record the details about the gear such as the mesh size of nets or hook size and type of handlines, or type of trap.

- To record the catch, record the "Total Length" of each fish caught in centimetres (to the nearest 0.5cm) (see Figure 10.1 and 10.2). Lay the fish flat on the measuring board, placing the snout of the fish against the end of the board, close the mouth of the fish, and hold the tail flat. For fish with forked tails, pinch the two ends of the tail together before measuring.
- If the fisher deploys gear in more locations, then the catch should be recorded each time gear are deployed / recovered. Use additional survey forms as required.
- If no fish are caught, then this should also be recorded.
- Once back at the shore, the total number of fishing locations should be recorded and the combined weight of all fish caught should be measured using the scales and recorded on the data sheet.

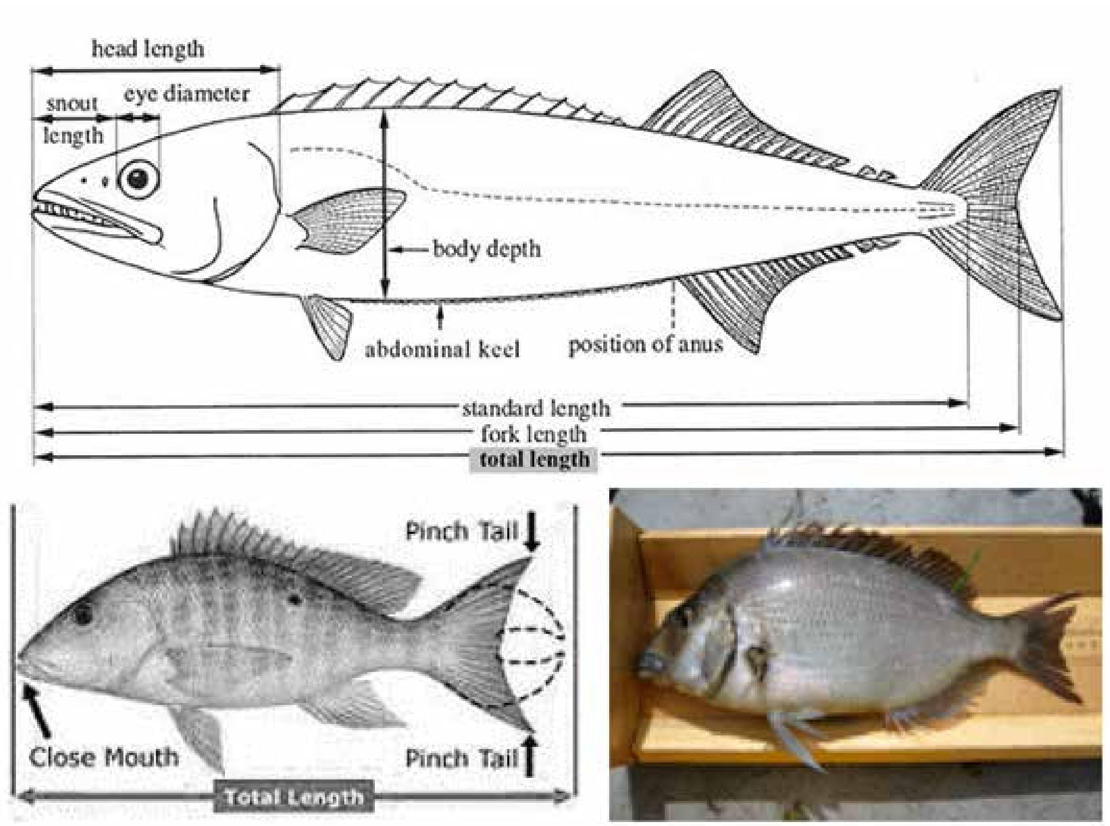


Figure 10.1 Measuring the Total Length of a fish.

Sources: www.fishbase.org; www.nefsc.noaa.gov and www.fishingregulations.org.

Figure 10.2 Fish on a measuring board made of wood with a measuring tape (note mouth should be closed). (Source: https://teacheratsea.wordpress.com/tag/reef-fish/page/2/)

10.4 Annexes

Annex 10.1 Fisheries Landing Station Surveys

FISHERIES LANDING STATION SURVEYS FS01	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti, Etc
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, the orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day), e.g. 20150312 for the 12th March 2015.
Surveyors	Record the initials for the surveyors involved in the survey.
Weather	As weather will not usually change much while surveying, it can be recorded at the top of the survey sheet, using the following scale: **1**= Sun, no cloud, **2**= Sun part cloud (<50% cloud), **3**= Sun and cloud (50% and 50%), **4**= Cloud (full cloud), **5** = Cloud and rain.
Wind strength	As wind strength will not usually change much while surveying, so can be recorded at the top of the survey sheet, using the following scale: **1**= none (<4kn), **2**= slight (4-6kn), **3**= moderate (7-10kn), **4**= strong (11-15kn), **5**= very strong (>16kns)
Wind direction	As the wind direction will not usually change much while surveying, it can be recorded at the top of the survey sheet. Use the compass rose (NSEW) to describe which direction the wind is coming from (e.g. is the wind coming from the SE or NW etc.).
Moon state	Use the following scale: **1**= new moon, **2**= half moon (waxing); **3**= full moon; **4**=. half moon (waning)
BOAT TYPE	
Boat type	If not obvious, ask the fishers which type of boat they were using and does it have an engine or sail? If they were fishing on foot tick 'No Boat'.
Means of propulsion	If not obvious, ask the fisher(s) whether the boat has an inboard or outboard engine, or if they used a sail. Tick the relevant box
Engine	If not obvious, ask the fisher(s) the size of the engine.
No. fishers on boat	If they used a boat, ask how many fishers were on the boat.
Boat type?	Tick which type of boat was used, or if no boat was used tick the boat
Boat own or rent?	If the fisher(s) used a boat, ask who owns the boat. Record the name of the boat owner.
Boat owner?	Ask for the name of the boat owner
Number of fishers	Ask the number of fishers on the boat
Registered / Non-Registered	Ask whether the number of registered or non-registered fishers.
FISHING TYPE	
Gear type	Ask what type of fishing has been carried out and tick which methods have been used (there may be more than 1). If 'Other' is ticked, please describe the fishing method used. Remember to record the mesh size of nets and hook type and size, and trap type.
FISHING TRIP	
Time left shore	Ask the fisher(s) what time they left shore and went out fishing
Time returned to shore	Record the time that they returned to the shore
Time spent fishing	Ask the fisher(s) roughly how much time they actually spent fishing. This does not include the time it took them to get out to the fishing ground or return to shore.

Fishing Location	Ask where the fisher(s) went fishing. Ask them to be as specific as possible. Ask for the name of the fishing ground and ask them to show you the area on the laminated map of the study area. If they draw on the map, then label the area with consecutive numbers and record this number in the 'Fishing Location' box on the survey form.
Fishing Habitat	Ask what habitat type they were fishing on? Tick the boxes that are most relevant in terms: sand, seagrass, algae, coral, open deep water.
Depth	Ask at which depth they were fishing?
Time spent fishing	Ask how long they were fishing in each location.
Target	Ask the fisher(s) if they were targeting any particular species in this trip.
CATCH INFORMATION	
Species	Record the fish species. If the species is not known, record the local name and write a description, including as much detail as possible, and take a photograph if you have a camera.
Length	Record the length of the fish in centimetres to the nearest 0.5cm.
Weight	Weigh the fish and record the weight in grams (to the nearest 1g).
Photographs	Take photographs of the catch, particularly unknown species. Record the start and end number of the photographs. There are different ways to help distinguish between the photographs from different sites. You can write the GPS waypoint number on a sheet of paper and photograph the number. You can photograph the survey form between sites, or the GPS screen showing the waypoint.

FISH LANDING STATION SURVEYS – FS01 **Sheet No_______** **(page 1 of 2)**

SURVEY INFORMATION			
Country:	Survey Sector:	Location:	Date:
Surveyors:	Weather:	Wind strength (1-5):	Wind direction (NSEW):
Moon state (1-4)			

BOAT TYPE (tick)							
No boat (foot)		Dugout		Houri		Sambuk	
Inboard engine		Outboard engine		Sail		Paddle	
Engine size? (hp)				Name of boat owner?			
Own boat?		Rented boat?		Number of Fishers on boat?			
Number of registered fishers?				Number of non-registered fishers?			

FISHING TYPE (tick all gears used)							
Handline		Trolling		Set-nets		Gill nets	
Trammel net		Shark net		Small surround net		Cast net	
Beach seine		Basket trap		Basket trap		Beach glean	
Reef glean		Spear		Spear-gun		Diving	
Line fisheries							
No. of lines		No. of hooks		Hook size?		Type of hook?	
Type of bait?							
Net fisheries							
No. of nets?		Time left (hrs)?		Size of mesh?			
Trap fisheries							
No. of traps		Time left (hrs)?		Type of bait?		Trap type?	

FISHING TRIP					
Time left shore?		Time returned to shore?		Total time fishing	
Total catch (kg)		Target (yes or no)		Target species?	

Location (name)	**Habitat** (sand,etc)	**Gear**	**Depth** (m)	**Time spent fishing** (hour)

CATCH INFORMATION			
Species (*Latin name / local name)*	Total length (cm)	Weight (grams)	Photo?

(continue on next sheet if required)

FISH LANDING STATION SURVEYS – FS01 **Sheet No_______** **(page 2 of 2)**

CATCH INFORMATION (continued)			
Species (*Latin name / local name)*	Total length (cm)	Weight (grams)	Photo?

Annex 10.2 Fisheries Onboard Surveys

FISHERIES ONBOARD SURVEYS - FS02	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti, Etc
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, the orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day), e.g. 20150312 for the 12th March 2015.
Surveyors	Record the initials for the surveyors involved in the survey.
Weather	As weather will not usually change much while surveying, it can be recorded at the top of the survey sheet, using the following scale: **1**= Sun, no cloud, **2**= Sun part cloud (<50% cloud), **3**= Sun and cloud (50% and 50%), **4**= Cloud (full cloud), **5** = Cloud and rain.
Wind strength	As wind strength will not usually change much while surveying, so can be recorded at the top of the survey sheet, using the following scale: **1**= none (<4kn), **2**= slight (4-6kn), **3**= moderate (7-10kn), **4**= strong (11-15kn), **5**= very strong (>16kns)
Wind direction	As the wind direction will not usually change much while surveying, it can be recorded at the top of the survey sheet. Use the compass rose (NSEW) to describe which direction the wind is coming from (e.g. is the wind coming from the SE or NW etc.).
Moon state	Use the following scale: **1**= new moon, **2**= half moon (waxing); **3**= full moon; **4**=. half moon (waning)
BOAT TYPE	
Boat type	Record the type of boat being used. If they are fishing on foot tick ‘No Boat’.
Means of propulsion	Record whether the boat has an inboard or outboard engine, or if they used a sail. Tick the relevant box
Engine	Record the size of the engine.
Number of fishers on boat	Record the number of fishers on the boat.
Boat own or rent?	If using a boat, ask the fisher(s) if they own the boat or rent it.
Boat owner?	Ask for the name of the boat owner.
Registered / Non-Registered	Ask if the fishers are registered and record the number of registered or non-registered fishers.
FISHING TIME	
Time left shore	Record the time the fisher(s) left shore and went out fishing
Time returned to shore	Record the time that the fisher(s) returned to the shore
Time spent fishing	Record the total amount of time the fisher(s) spent fishing. This does not include the time it took them to get out to the fishing ground or return to shore.
Total catch weight (g)	Record the total catch weight in grams at the end of the trip.
Number of locations fished	Record the number of locations fished during the whole fishing trip.
CATCH INFORMATION	
Fishing Location	Record the name of the fishing ground.
Fishing habitat	Record the habitat type the fisher(s) were fishing on (sand, seagrass, algae, coral, open deep water) at each location.
GPS waypoint – start	Record a GPS waypoint for each location where fishing gear is deployed
GPS waypoint -end	Record a GPS waypoint for each location where fishing gear is recovered

Start time	Record the time the fisher(s) started fishing in each location.
End time	Record the time the fisher(s) ended fishing in each location
Depth	Record depth at which the fisher(s) was fishing at each location
Gear type	Record the type of gear deployed/recovered at each location (e.g. net, line)
Gear number	Record the number of gear deployed/recovered ar each location
Bait type	Record the bait type used at each location
Mesh size	Record the mesh size of nets used at each location in centimetres
Hook type	Record the hook type used
Hook size	Record the size of the hook used
Species / local name	Record the fish species. If the species is not known, record the local name and write a description, including as much detail as possible, and take a photograph if you have a camera.
Total length (cm)	Record the length of the fish in centimetres to the nearest 0.5cm.
Total weight (grams)	When back onshore record the weight of total catch in (to the nearest 10g).
Photographs	Take photographs of the species caught and record the photograph number. You can photograph the survey form between sites, or the GPS screen showing the waypoint to distinguish between sites.

FISHER TRACKER SURVEYS – FS02 **Sheet No_______** **(page 1 of 2)**

SURVEY INFORMATION			
Country:	Survey Sector:	Location:	Date:
Surveyors:	Weather:	Wind strength (1-5):	Wind direction (NSEW):
Moon state			

BOAT TYPE (tick boat type and means of propulsion)							
No boat (foot)		Dugout		Houri		Sambuk	
Inboard engine		Outboard engine		Sail		Paddle	
Engine size? (hp)				Name of boat owner?			
Own boat?		Rented boat?		Number of Fishers on boat?			
Number of registered fishers?				Number of non-registered fishers?			

FISHING TRIP					
Time left shore?		Time returned to shore?		Total time fishing	
Total catch (g)		Number of locations fished			

CATCH INFORMATION					
Location name			Habitat type		
GPS waypoint start			GPS waypoint end		
Start time		End time		Depth:	
Gear type:		Gear no.		Bait type:	
Mesh size		Hook no.		Hook type	

Species (*Latin name / local name)*	Total length (cm)	Photo?

OBSERVATIONS

(if more than one location fished during the same fishing trip, continue on next sheet as required)

FISHER TRACKER SURVEYS – FS02 **Sheet No_______** **(page 2 of 2)**

CATCH INFORMATION

Location name		Habitat type	
GPS waypoint start		GPS waypoint end	

Start time		End time		Depth:	
Gear type:		Gear no.		Bait type:	
Mesh size		Hook no.		Hook type	

Species (*Latin name / local name)*	Total length (cm)	Photo?

OBSERVATIONS

CATCH INFORMATION

Location name		Habitat type	
GPS waypoint start		GPS waypoint end	

Start time		End time		Depth:	
Gear type:		Gear no.		Bait type:	
Mesh size		Hook no.		Hook type	

Species (*Latin name / local name)*	Total length (cm)	Photo?

OBSERVATIONS

(if more than one catch from same fishing trip, continue on next sheet as required)

11

Socio-Economics

11. SOCIO-ECONOMICS

11.1 Background

Human populations within the Red Sea and Gulf of Aden region have strong association with the sea. The health and welfare of human populations whose livelihoods depend upon coastal and marine resources are inextricably linked to the local environment and the ecosystem services and benefits they provide. Socio-economic assessments and monitoring programmes are used to assess and track the long term trends in social, economic, cultural and political variables. Socio-economic data can help marine protected area (MPA) managers and coastal administrators to better understand the local situation in dependent communities and how different variables influence the behaviour of resource users over time. These data can help identify the key drivers that motivate resource users, which can in turn be used to inform adaptive management and improve management effectiveness. Various protocols have been developed for socio-economic monitoring of resource users and coastal communities in relation to coral reefs, MPAs and coastal developments in different regions around the world (Bunce et al. 2000; Bunce et al. 2003, Malleret-King et al. 2006). There is no one solution fitting all situations, and socio-economic monitoring programmes need to be adapted and customised to suit the local context. The indicators to be monitored should be selected to reflect the objectives of the monitoring programme. The following chapter provides guidance on the steps involved in setting up a long-term socio-economic monitoring programme and the survey methods that can be used to collect the data. The chapter includes two standard methods. The first method can be used to register stakeholders that may be influenced by a new development or an MPA and the second which can be used for surveying households to detect changes over time. The methods presented were initially developed for use in Yemen and Sudan, but they also have wider applicability within the PERSGA region.

11.2 Overview

11.2.1 General approach

The establishment of a long term socio-economic monitoring programme normally commences with a baseline socio-economic assessment of a broad range of socio-economic variables. The baseline assessment allows the characterisation of the local community and selection of key variables for use as indicators in subsequent long-term monitoring efforts. The process starts with the compilation and review of existing information from secondary sources, followed by key informant interviews and/or focus group workshops. Other socio-economic data collection methods, including household or user group surveys and observations, are only required if there is insufficient data available from existing sources and key informant interviews and/or focus group workshops to complete the baseline data. The compilation of these datasets during the baseline normally entails visiting the local area to collect secondary source data, which is typically located in government, academic, research, civil society organisations and other offices often outside the study area. Key informant and focus group interviews, surveys and observations, would be conducted inside the study area. Once the baseline socio-economic assessment is completed, the information gathered can be used to inform the design of the long-term monitoring programme. The long term monitoring protocols may use the same survey methods as used during the baseline, or the survey questionnaire may need to be redesigned or tailored to better meet the purpose of the monitoring programme.

11.2.2 **Target**

Socio-economic monitoring programmes are normally designed to gain or improve understanding about local communities and/or a specific marine resource user group (e.g. fishers). Once the baseline assessment has been collected, monitoring surveys can be tailored towards improving understanding about the circumstances and behaviours within the local economic, cultural and political settings.

The category of people to be monitored during these surveys, depends upon the overarching objectives of the programme and the type of issues and variables to be addressed. For example, if the objective of the programme is to understand and monitor issues and variables relating to fishing, then fishers, fish-buyers/traders and consumers groups might be selected as the target population. If the issue and variables relate to the general community life, then surveys would focus on household heads.

The frequency of monitoring also needs to be determined by the monitoring team based on the anticipated socio-economic impact and/or rate of change and/or the sensitivity of the issue. Some variables may need to be monitored annually, while others may only need to be monitored every three to five years. Seasonality can also significantly affect socio-economic livelihoods, activities, actions, and perceptions and these need to be taken into consideration in deciding the specific timing of each monitoring cycle and the frequency of monitoring specific variables (Malerett-King *et. al.* 2006).

Whatever the target population and indicators selected are, it is important that the long term monitoring programme is designed in such a manner that it is repeatable and can detect changes over time. Programmes should target the same population, and use the same indicators and methods from one monitoring cycle to the next and at the same time of year. If the surveys are completed in the summer months during the first cycle, they should be measured by surveys in the summer months during subsequent monitoring cycles (Malleret-King *et. al.* 2006).

11.2.3 **Field equipment**

The field equipment required for socio-economic monitoring programme depends on the survey methods being used. If the method involves focus group meetings, then it is often useful to have survey forms, notebooks as well as flip-charts and marker pens. If the method is household surveys, then the surveyors may only need to have the survey forms and pens. A map and handheld GPS and camera are also useful. It is, however, always polite to ask before taking photographs of people, whether as individuals or in groups.

11.2.4 **Field personnel**

The number of people needed to undertake a socio-economic monitoring programme depends upon the size of the human population in the study area, the sampling plan and the methods being used to collect the data. When the monitoring programme is associated with an MPA, the team would normally include a representation from the management authority.

11.2.5 Training/experience

The initial design of socio-economic monitoring programmes will need expert input, especially during the baseline to help identify and select the key variables most appropriate for inclusion in the long term monitoring programme and to assist in the interpretation and analysis of preliminary results. Once the long term monitoring programme has been designed, the surveys can be completed by broader range of people that have been trained in the method. For example, key informant interviews and household surveys, that use structured or multiple choice questions, with or yes/no answers, and can often be completed by students or rangers, as long as they have been provided with training, can read and write and communicate in the local language. Survey teams can be coordinated by one lead surveyor who helps to organise the data collection process and the data entry. Running focus group meetings requires training and experience in facilitation technique to ensure group dynamics, interactions and outcomes.

11.3 Field Procedure

11.3.1 Preparation

Advance preparation includes identifying the study area, the purpose of the socio-economic monitoring, including defining the specific objectives, selecting appropriate indicators, defining the process by which the socio-economic monitoring will be completed, identifying and consulting with stakeholders, and identifying the monitoring team.

The preparation normally involves the steps shown in Figure 11.1.

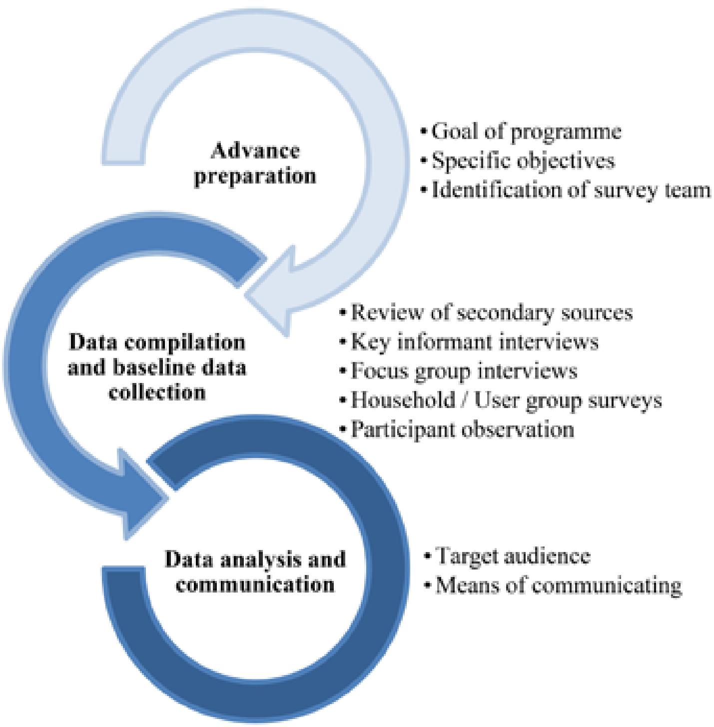


Figure 11.1 Schematic diagram illustrating the steps involved in establishing a socio-economic monitoring programme. The process is not linear and it is often iterative as new information may become available and new needed indicators are introduced.

11.3.2 Review of Secondary Sources

The team should start by reviewing all secondary sources of data. These are sources of data that have already been collected and includes items such as; census data, statistics, research studies, maps, satellite images, GIS databases, community accounts, and newspaper or project reports. Searching, compiling and reviewing relevant secondary source data is quick and simple and can reduce the financial and logistical requirements of monitoring (Macfarlane 2000). Potential sources of information include:

- National census data: this can provide relevant data for certain indicators, such as population and employment which can then be confirmed through local surveys.
- Local government and council records: provide relevant data for selected indicators such as recreation or tourism patterns.
- Historical sources: previous reports, assessments, and surveys, available from government departments, often provide useful data in easily accessible formats.

11.3.3 Field Data Collection

There are four standard methods for collecting socio-economic monitoring data if the secondary source data is insufficient to deal with some variables. Designing field data collection requires consideration of the sample size needed (see guidance below) with respect to the population size being sampled and whether that population will be sampled randomly or in a semi-structured manner.

Key Informant Interviews

Key informants are individuals who, because of their experience, knowledge or access to information, can provide information about the people being monitored. They might include, for example, the administrative head of the relevant district or community, the head of a local fisher group, a medical officer or police officer. Generally, the socio-economic variables addressed in key informant interviews focus on basic quantifiable or binary facts (e.g. the demographics of a community, the existence of a formal management body). These facts can be verified by cross-examining with the facts disclosed through other key informant interviews, through secondary data sources or through household or user group surveys. As a rule, the veracity of a fact is confirmed when the answers given by different key informants to the same question become repetitive (Macfarlane 2000, Malleret-King *et. al.* 2006). When the answers to one question become repetitive this is also a way to confirm that a sufficient number of key informant interviews have been conducted.

Focus Group Interviews

Focus group interviews involve bringing together a group of people (usually between 4 and 10 people) who share a common background or specialised knowledge due to their previous experience (e.g. common livelihood, organisational membership, interest, special knowledge, class, caste, ethnicity etc). Focus group participants can be purposefully selected, like key informants, or randomly selected from a wider group of individuals based on either their knowledge or experience of an issue, their background or affiliation. Information is obtained from the group through a process of semi-structured discussion, 'brainstorming', or problem solving. Generally, the variables addressed through focus group interviews are more subjective and qualitative (e.g. views on changes to their quality of life, perspectives on their natural resource use and yield etc.) than obtained through surveys or key informant interviews. Nevertheless, group interview techniques, like ranking or scoring, may be used to prioritise and quantify participant views and perspectives so that the monitoring results are more easily comparable and measurable over time (Macfarlane 2000, Malleret-King *et. al.* 2006).

The results of both key informant and focus group interviews can be used to refine the questions asked in household or user group surveys. Tailoring the household or user-group surveys in this manner allows ensuring that these types of surveys produce quantitative data that can be statistically analysed.

Stakeholder registration

Stakeholder registration surveys are a specific type of socio-economic survey that intends to identify and account for all the stakeholders living within a specific location that might be influenced by a particular development. These types of surveys are required in the event that a new coastal development, such as a port, or other large development, might displace or require the resettlement of all or part of a resident community.

These types of surveys may also be completed as part of planning process for a new MPA. An example of stakeholder registration survey form is provided in Annex 11.1.

Household or User Group Surveys

Surveys are a well-established method in social science and aim to give systematic and representative and preferably quantitative data from, or about, a defined population. Surveys most commonly refer to questionnaires administered to a sample population group, and generally this sample population targets the head of households or a specific group of marine resource users (e.g. sea cucumber fishers). Surveys tend to be highly structured with close-ended questions with a limited range of answers (e.g. multiple choice or yes/no) resulting in quantitative data that can be statistically analysed (Macfarlane, 2000). These types of surveys are best conducted face-to-face, although they can also be conducted through phone-calls and emails. The surveys can be completed efficiently by relatively unexperienced researchers (e.g. students, or school leavers) coordinated by a more experienced surveyor, that provides training in the method, and takes responsibility for oversight, data compilation and analysis.

An example house-hold survey form is provided in Annex 11.2.

Participant Observation

Participant observation is a well-established method in the field of ethnography. It involves the monitoring team spending time among the people being researched, sharing their experiences, customs and practices. Participant observation is carried out in a relatively unstructured, free ranging and exploratory manner. In the context of the socio-economic monitoring of MPAs, participant observation will involve qualitative or sometimes quantitative descriptions of what the team member sees by attentively watching and recording their social surroundings. For example, a team member may collect information on material lifestyle by observing a household's property and noting its construction type and materials or on natural resource use patterns by observing where people fish and what they are catching (Macfarlane, 2000; Malleret-King, *et al.* 2006).

Guidance on sampling design and size

Once the goal and objectives of the monitoring programme has been defined and the category of people to be assessed selected, it is important to decide if the people within these categories will be selected for survey or interview randomly or non-randomly.

This decision will depend on whether the results need to be statistically representative of the wider category of people. If they do, then it is important to collect information from a statistically representative sample of people from within each category (See GCRMN Manual, Appendix B p233 in Bunce *et al.*, 2000).

As a general rule, the larger the sample size, the greater the level of accuracy and the monitoring team can be more certain that the results from the sample represent the whole group. The smaller the group the greater will be the effect of biases on the results, so the sample size of the groups should be as large as possible (Bunce *et al.*, 2000). Table 11.1 below shows the minimum sample size required for a given population sizes across different confidence levels and intervals.

Table 11.1 Required sample size (http://math.tutorvista.com/statistics/sample-size.html)

	Confidence =95%				Confidence =99%			
	Margin of error				Margin of error			
Population size	5%	3.5%	2.5%	1%	5%	3.5%	2.5%	1%
10	10	10	10	10	10	10	10	10
20	19	20	20	20	19	20	20	20
30	28	29	29	30	29	29	30	30
50	44	47	48	50	47	48	49	50
75	63	69	72	74	67	71	73	75
100	80	89	94	99	87	94	96	99
150	108	126	137	148	122	135	142	149
200	132	160	177	196	154	174	186	198
250	152	190	215	244	182	211	229	246
300	169	217	251	291	207	246	270	295
400	196	265	318	384	250	309	348	391
500	217	306	377	475	285	365	421	485
600	234	340	432	565	325	416	490	579
700	248	370	481	653	341	462	554	672
800	260	396	526	739	363	503	615	763

11.3.4 **Additional tools**

- Public meetings are a useful tool during which relevant stakeholders can make presentations regarding an issue of concern and then provides opportunity for community members to provide feedback or comments.
- Cost benefit analyses can be used to assess the potential costs and benefits of a resource or activity in monetary terms to determine the most efficient use of resources.
- Multiple criteria analysis to assess the potential cross and benefits of a resource or activity using multiple data types.
- Citizen juries which involve representative members of the public acting as concerned citizens making a decision on behalf of society on a given charge.
- Modelling used to be run simulations to predict effects or identify effects that may not be intuitive

11.4 **Strengths / Weaknesses**

Strengths	**Weaknesses**
Questionnaire based techniques are simple, robust methods that can be implemented by people with minimum training and; if the surveys are well designed they produce quantitative data that is statistically analysable.	Selecting the appropriate indicators for use in a socio-economic monitoring presents a challenge. The indicators should be carefully considered to ensure that they reflect what needs to be measured. Including too many indicators means the surveys become onerous and take too long.
Socio-economic monitoring programmes increase understanding of the dependence of local communities on coastal and marine habitats and resources, which provides protection of biodiversity while minimizing impacts on local community livelihoods.	The data collection process can be challenging for both the interviewers and informants. There is a risk of consultation fatigue if the surveys need to be frequently repeated.
Increased understanding of the motivations and behaviour of local communities in relation to habitats and marine resources, which can be used to help develop adaptive management strategies to address negative influences.	Attribution of causality can present a challenge in socio-economic monitoring of impacts over time. For example, if there is an increase in income, identifying and disaggregating the reasons why incomes have increased can be problematic.

11.5 References

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11.6 **Annexes**

Annex 11.1 Stakeholder Registration Questionnaire

STAKEHOLDER REGISTRATION QUESTIONNAIRE **Survey sheet**_________

To be completed by the interviewer for individual stakeholders. If the interviewee is being interviewed in a group, the response must be that of the specified stake holding interviewee without being influenced by others		
1.0 INTERVIEWER DETAILS		
1.1	Name, age, sex and contact details of the interviewer	
1.2	Date form completed	
2.0 INTERVIEWEE DETAILS		
2.1	Address and Location	Address Coordinates: N E
2.2	Name	Name: Provide photo (optional)
2.3	Date and place of Birth	Year Place
2.4	Sex/ Marital Status	Male ☐ Female ☐ Single ☐ Married ☐ Divorced ☐
2.5	Number and nature of dependents	
2.9	Period and type of residence at the place	Period: Type: <5years ☐ 5-10 years ☐ Seasonal ☐ Permanent ☐ >10years ☐
2.10	ID number and validity	(Optional)
2.11	Original geographical location	Dungonab ☐ Mohamed Gol ☐ other ☐ *specify*-----------
2.13	Electric supply at residence	Permanent ☐ Part of the Day ☐ None ☐
2.14	Source of cooling drinking water at residence	Refrigerator ☐ *Zir* ☐ *Girba* ☐ others ☐ specify----------
2.15	Means and frequency of water supply at residence/ quantity consumed	Mean: Frequency: Quantity of *jerry-cans*/day Pipe ☐ Daily ☐ ------------------------ Tanker ☐ 2-3 days/week ☐ Less ☐
2.16	Distance to primary health care facility (km)?	Less than km ☐ 1-5 km ☐ More ☐ *specify* -------------
2.17	Distance to midwife(km)?	Less than km ☐ 1-5 km ☐ More ☐ *specify* -------------
2.18	Distance to primary education (km)?	Less than km ☐ 1-5 km ☐ More ☐ *specify* -------------

2.19	Principal type of cooking fuel (oil, gas, wood, charcoal, other)	Gas ☐ Charcoal ☐ wood ☐ *specify* source------------- Other ☐ specify ---------------
2.20	Distance to secure source of principal cooking fuel(km)?	Less than km ☐ 1-5 km ☐ More ☐ *specify* -------------
2.21	Distance to phone(km)?	Less than km ☐ 1-5 km ☐ More ☐ *specify* -------------
2 22	How often do you eat fish?	Daily ☐ 2-3 times/ week ☐ once/week ☐ less ☐

Annex 11.2 Household Survey

Socioeconomic– Household Surveys (Page 1 of 7) **Survey sheet________**

Country		**District**	
Village		**Date**	
Surveyors name		**Surveyors contact**	

Name of household head?				**Sex**	Male	Female
Education?				**Age?**		
Home village?			**If not where?**			
Type of house?	Mud	Mud-brick	Stone-brick	Rocks	Wood	Cement
Ownership of house?	Owned	Rented	Inherited	**Garden?**	Yes	No
Number of rooms?		**Number of Bedrooms?**				
Kitchen?	Inside	Outside	**Toilet?**	Inside	Outside	
Water supply in house?	Yes	No	**Number of taps in house?**			
Source of water?	House well	Village well	Tanker			
	Private network	Government network	Other			
If from a well, is it normally covered?	Yes	No				
If from a well, who brings the water?	Father	Mother	Boys	Girls	Other	
How do they bring water to the house?	Vehicle	Camel/Donkey	On foot	Other		
Who paid for the construction of well?	Personal	Government	Charity	Other		
Quality of water (all sources)?	Good	Poor	**If poor quality, why?**			
How do you dispose of waste water?	Sewage system	Pit latrine	Open space	Other		
How do you dispose of solid waste?	Collected	Dumped	**If collected, how often?**			
Who disposes of solid waste?	Government	Father	Mother	Boys	Girls	

Electricity in house?	Yes	No	**If yes, number of hours?**		per day
If no, source of lighting?	Candles		Gas		Other
Source of electricity? (tick)	Government		Local participation		Private generator
	Other?				
Electrical appliances? (tick)	Refrigerator		Freezer	Cooker	Washing machine
	TV		Satellite	Fan	Air conditioning
	Others?				

Roads and transport?	Close	Far	**Distance?**	km
Transport available?	Private	Public	**Transport types?**	

Landline phone in house?	Yes	No	**Distance to nearest landline?**	
Mobile phone coverage?	Yes	No	**Number of mobile phones?**	

Do you own land?	Yes	No	**If yes, what area?**
Other partners in land?	Yes	No	**What percentage do you own?**
Is the land farmed?	Yes	No	**If yes, what type of agriculture?**
Do you farm the land?	Yes	No	**If no, how many people do you employ?**
If the land is not farmed what is the land used for?			

<table>
<tr><td colspan="2">Do you own livestock?</td><td colspan="2">Yes</td><td colspan="4">No</td></tr>
<tr><td colspan="2">If yes, what type of livestock and how many of each? (number)</td><td colspan="2">Camels =
Sheep =</td><td colspan="2">Donkeys =
Poultry =</td><td>Goats =
Other =</td><td>Cows =</td></tr>
<tr><td colspan="3">Are there disputes about land in the village?</td><td colspan="5"></td></tr>
<tr><td colspan="3">Are there disputes about water in the village?</td><td colspan="5"></td></tr>
<tr><td>Who resolves disputes? (tick)</td><td>Court</td><td>Faqeeh</td><td>Public notary</td><td>Sheik</td><td colspan="3">Other (specify)</td></tr>
<tr><td rowspan="2">Who are the main leaders / personalities in the village? (tick)</td><td>Iman</td><td>Mamoor</td><td colspan="3">Sheik</td><td colspan="2">Teacher</td></tr>
<tr><td>Qadhi</td><td>Local Council Member</td><td colspan="3">Council of Deputies</td><td colspan="2">Others</td></tr>
<tr><td colspan="2">Are there cooperatives / civil society organisations in the village /district?</td><td colspan="6"></td></tr>
<tr><td colspan="2">What is their role?</td><td colspan="6"></td></tr>
<tr><td colspan="2">Are they successful?</td><td colspan="6"></td></tr>
<tr><td colspan="2">Are you a member of a cooperative?</td><td colspan="6"></td></tr>
<tr><td colspan="2">What is your role in the cooperative?</td><td colspan="6"></td></tr>
</table>

Socioeconomic– Household Surveys (Page 2 of 7) **Survey sheet________**

Household composition: List all the people in household by name and/or role (i.e. husband, wife, brothers, brothers in-law, sisters, sisters in-law, sons, daughters, daughters in-law, sons in-laws, nephews (M), niece (F), grand children (M), grand children (F), others												
Name / role	Age	**M**ale **F**emale	Education (number of years)	Ethnicity	Religion	Languages	Perma-nent or Seasonal resident?	How many years? (permanent or seasonal)	Seasonal resident – what months?	Sea-sonal resident – where from?	Primary occupa-tion	Secondary occupation

Socioeconomic– Household Surveys (Page 3 of 7)   Survey sheet__________

INCOME (in local currency, specify)	
Estimated household income per month?	
Primary source of household income?	
Secondary source of household income?	
Tertiary source of household income?	

Monthly expenses: Please enter the amount spent per month in local currency. **Local currency** =				
Water =	Food =	Electricity =	Clothes =	Medications =
Transport =	Telephone =	Qat =	Education =	Other =
Occasional expenses: Please estimate the amount spent per year in local currency				
Feasts =	Birth celebrations =	Other celebrations =	Funerals =	Others =

HEALTH									
What health issues do you and your family members suffer from?									
Malaria		Bilharzia		Tuberculosis		Typhoid		Dysentery	
Diarrhoea		Diabetes		Heart problems		Skin issues		Chest / coughs	
Others									
What type of medical treatment does your family most commonly seek/use when they are sick?									
Doctor		Pharmacy		Herbalist		Hospital		Other	
Distance to nearest midwife?									
Distance to nearest clinic?									
Distance to nearest hospital?									
Distance to other type of treatment?									

Do you or your family use coastal and marine habitats for livelihood? (please circle / tick those used)			Open ocean	Coral reef	Seagrass
Beach (muddy)	Beach (sandy)	Beach (rocky)	Saltmarsh	Mangrove	Algae

If yes, how?	**Use**	**Goods or service**	**Rank important** (where 1 = lowest importance)
Beach (muddy)			
Beach (sandy)			
Beach (rocky)			
Saltmarsh			
Mangrove			
Coral reef			
Seagrass			
Algae			
Open ocean / pelagic waters			

Socioeconomic– Household Surveys (Page 4 of 7) **Survey sheet__________**

Do you or your family fish / hunt for any of the following group? (please circle, tick all target groups)						Bony fish (demersal)	Bony fish (pelagic)	Shark / rays	Marine mammals
Seabird / eggs	Sea turtles	Crabs	Lobsters	Sea cucumbers	Squid	Bivalve mollusc	Gastropod molluscs	Sea turtles	Other (specify)

If yes how do you fish for each group? Please state fishing gear type used, boat, with an engine or without, and please state the importance by ranking which groups are the most important target followed by others.				
If yes how?	**Fishing gear type**	**Boat (y/n)**	**With engine (y/n)**	**Importance** (rank 1= lowest importance)
Bony fish (pelagic)				
Bony fish (demersal)				
Sharks and rays				
Marine mammals				
Seabirds / eggs				
Sea turtles				
Crabs				
Lobster				
Sea cucumber				
Squid				
Bivalve mollusc				
Gastropod mollusc				
Other (specify)				

What happens to the fish you catch? Please state the importance by ranking which groups are the most important by others.				
Type of resource	**Sold to buyer**	**Sold in village**	**Own consumption**	**Value** (high, medium, low)
Bony fish (pelagic)				
Bony fish (demersal)				
Sharks and rays				
Marine mammals				
Seabirds / eggs				
Sea turtles				
Crabs				
Lobster				
Sea cucumber				
Squid				
Bivalve mollusc				
Gastropod mollusc				
Other (specify)				

Socioeconomic– Household Surveys (Page 5 of 7) **Survey sheet__________**

Condition / Status of Habitats? Please tick the relevant box in relation to the condition of each habitats

Type	**Very good**	**Good**	**Neither good nor bad**	**Poor**	**Very poor**
Beach (muddy)					
Beach (sandy)					
Beach (rocky)					
Saltmarsh					
Mangrove					
Coral reef					
Seagrass					
Algae					
Open ocean / pelagic waters					

Threats to Habitats? Please state the top 5 threats to the habitats

Habitat type	**Threat 1**	**Threat 2**	**Threat 3**	**Threat 4**	**Threat 5**
Beach (muddy)					
Beach (sandy)					
Beach (rocky)					
Saltmarsh					
Mangrove					
Coral reef					
Seagrass					
Algae					
Open ocean / pelagic waters					

Threats to Resources? Please state the top 5 threats to resources?

Habitat type	**Threat 1**	**Threat 2**	**Threat 3**	**Threat 4**	**Threat 5**
Bony fish (pelagic)					
Bony fish (demersal)					
Sharks and rays					
Marine mammals					
Seabirds / eggs					
Sea turtles					
Crabs					
Lobster					
Sea cucumber					
Squid					
Bivalve mollusc					
Gastropod mollusc					
Other (specify)					

Socioeconomic– Household Surveys (Page 6 of 7) Survey sheet__________

Condition / Status of Resources? Please state the condition of the resources

Type	Very good	Good	Neither good nor bad	Poor	Very poor
Bony fish (pelagic)					
Bony fish (demersal)					
Sharks and rays					
Marine mammals					
Seabirds / eggs					
Sea turtles					
Crabs					
Lobster					
Sea cucumber					
Squid					
Bivalve mollusc					
Gastropod mollusc					
Other (specify)					

In addition to the threats listed above, what are the other main concerns issues affecting coastal and marine resources?

What are the solutions to this threat?

Do you and your family eat fish? Please state what type of fish and how often (per week) & time of year

Type	Frequency per week	Months of year

Does you and your family eat sharks? Please state what type and how often (per week) & time of year

Type	Frequency per week	Months of year

Socioeconomic– Household Surveys (Page 7 of 7) **Survey sheet__________**

Do you and your family eat seabirds or seabird eggs? Please state what type and how often (per week) & time of year		
Type	**Frequency per week**	**Months of year**
Do you and your family eat dugong or marine mammals? Please state what type and how often (per week) & time of year		
Type	**Frequency per week**	**Months of year**
Does you and your family eat sea turtles? Please state what type and how often (per week) & time of year		
Type	**Frequency per week**	**Months of year**

What are the top three concerns to your community?

1.

2.

3.

12

Marine Protected Area Management Effectiveness Assessments

12. MARINE PROTECTED AREA MANAGEMENT EFFECTIVENESS ASSESSMENTS

12.1 Background

Marine protected areas (MPAs) are the primary *in-situ* management tool used to protect and conserve biodiversity and practical knowledge about how to improve MPA management has increased (McLeod et al. 2008, Laffoley 2008, Warbouys et al. 2015). Methods to assess the effectiveness of protected areas were first developed in the 1990s and early 2000s (Rivero Blanco and Gabaldon 1992, Cifuentes et al. 2000, Hockings et al. 2000, Hockings 2003, Hockings et al. 2006, Stolton et al. 2003, Staub and Hatziolos 2004, Pomeroy et al. 2004; Stolton et al. 2007). Progress in the development and application of these methods was driven forward by the Convention on Biological Diversity (CBD) adopting protected area management effectiveness as one of the main indicators, alongside protected area coverage, to assess progress towards meeting the international biodiversity conservation targets (Leverington et al. 2010; Coad et al. 2013).

The World Summit on Sustainable Development (WSSD) in 2002 called for the establishment of a representative network of MPAs by 2012 (UN 2002). The following year, the Fifth International Union for Conservation of Nature (IUCN) World Parks Congress, also recommended the establishment of a global system of effectively managed, representative network of MPAs by 2012. The WSSD decision and IUCN recommendations were reinforced by the Conference of the Parties (COP) to the CBD decision to establish "*a global network of comprehensive, representative and effectively managed national and regional protected area systems*" covering at least 10 per cent of marine areas by 2012 (CBD 2004). The CBD went onto develop a specific Programme of Work on Protected Areas (PoWPA) and set a target to "*implement management effectiveness evaluations of at least 30 percent of each Party's protected areas by 2010*" (CBD 2004).

In 2010, the 10th COP to the CBD agreed to a new Strategic Plan and a new series of targets, known as the Aichi Targets. (CBD 2010). Aichi Target 11 requires that by 2020 "*at least 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through **effectively** and equitably managed, ecologically representative and well-connected systems, of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascapes*". This current target was also reflected in Sustainable Development Goal 14 (SDG14) Target 14.5 of the 2030 Agenda for Sustainable Development as agreed in September 2015.

In response to the CBD decisions, donor agencies such as the Global Environment Facility (GEF) integrated management effectiveness assessments into their regular monitoring and evaluation processes for projects supporting protected area implementation and progress towards the biodiversity targets (Belokurov et al. 2009). This resulted in an increased uptake and applied use of management effectiveness assessments across the globe (Coad et al. 2013). The results of the assessments are recorded on the Global Database on Protected Area Management Effectiveness (GD-PAME)[11], which compliments the World Database of Protected Areas (WDPA)[12], that tracks progress towards protected area coverage targets.

Protected area management effectiveness

11 https://pame.protectedplanet.net/
12 https://www.protectedplanet.net/

assessment (PAME) can be defined as "*the assessment of how well protected areas are being managed – primarily the extent to which management is protecting values and achieving goals and objectives*" (Hockings et al. 2006). There are now over 57 types of PAME methods recorded on the GD-PAME. The methods fall within three broad categories ranging from simple questionnaire-based methods to more complex evaluation methods (Hockings et al. 2006). The more complex methods usually require the collection of new field data, which takes time and requires dedicated financial inputs (Leverington et al., 2008). The simpler questionnaire or scorecard-based methods (Stolton et al., 2003; Staub and Hatziolos, 2004; Stolton et al., 2007), make use of existing information extracted from the literature, reports, ongoing monitoring programmes and inputs from local experts, site managers and independent assessors (e.g. non-governmental organisations, scientists, dive operators) that are familiar with the MPA.

PERSGA currently recommends the use of the standard questionnaire-based methods, which are quicker to complete and generally do not require additional financial inputs, apart from staff time. While these methods may not permit an in-depth analysis of the challenges and constraints faced by MPAs, they provide an entry point to help managers highlight the headline issues, and prioritise actions for inclusion in annual work plans and budget requests.

12.2 Overview

12.2.1 General approach

The evaluation of protected area management effectiveness is generally achieved by the assessment of a series of criteria (represented by indicators) against agreed objectives or standards. The World Commission on Protected Areas (WCPA) developed a 'framework' to help guide the development of protected areas management effectiveness evaluation methods and to promote standardisation in reporting (see Figure 12.1 and Table 12.1) (Hockings et al. 2006). The WCPA Framework is based on the concept that assessments have three main themes: (i) Design / planning issues related to sites or networks, (ii) Adequacy / appropriateness of management systems and processes and (iii) Delivery of protected area objectives including conservation of values.

Within these themes there are six elements which begin with understanding the background to the protected area (**context**), during which the values of the protected area and current status of these values and the threats are identified. The next element is determining the vision and the objectives for the protected area (**planning**), then what resources are required (**inputs**), what management actions are needed (**process**), to produce products and services (**outputs**) and result in impacts (**outcomes**) (Hockings et al. 2006). The different management effectiveness assessment methods that have been developed are generally all designed to assess each of the six elements within this framework.

Figure 12.1 The IUCN WCPA framework for assessing management effectiveness of protected areas

The first management effectiveness evaluation method that was developed specifically for MPAs was the MPA Scorecard (Staub and Hatziolos 2004). The MPA Scorecard method was adapted from the World Bank/World Wildlife Fund (WWF) Alliance method for assessing the management effectiveness of terrestrial protected areas (Stolton et al. 2003), alongside other methods (Hocking et al. 2000, Mangubhai 2003). The terrestrial scorecard was subsequently updated and re-branded as the World Bank/WWF Management Effectiveness Tracking Tool (METT) (Stolton et al. 2007). The World Bank, WWF and Global Environment Facility (GEF) then adopted and adapted the METT as part of their monitoring and evaluation process for GEF projects funded under the Biodiversity strategy. All GEF funded Biodiversity related projects since then are required to complete the GEF-METT three times during a project cycle (project preparation, midterm and project completion). The GEF-METT has thus become the most widely used PAME method internationally (Coad et al. 2013).

PERSGA currently recommends the use the MPA Scorecard method for assessing MPAs within the region for two main reasons: First the method was developed specifically for assessing MPAs. Second, the MPA Scorecard method is simpler to implement than the GEF METT, which requires the completion of additional sections related to project specific indicators among others. So the MPA Scorecard method provides a good standard entry point for MPA managers in the PERSGA region to use when assessing the effectiveness of their MPAs. The consistent use of this tool will thus allow PERSGA to collect comparable results at the regional level.

Table 12.1 Summary of the WCPA Framework

Elements of evaluation	**Explanation**	**Criteria that are assessed**	**Focus of evaluation**
Context	*Where are we now?* Assessment of importance, threats and policy environment	- Significance - Threats - Vulnerability - National context - Partners	Status
Planning	*Where do we want to be?* Assessment of protected area design and planning	- Protected area legislation and policy - Protected area system design - Reserve design - Management planning	Appropriateness
Inputs	***What do we need?*** Assessment of resources needed to carry out management	- Resourcing of agency - Resourcing of site	Resources
Processes	*How do we go about it?* Assessment of the way in which management is conducted	- Suitability of management processes	Efficiency and appropriateness
Outputs	*What were the results?* Assessment of the implementation of management programmes and actions; delivery of products and services	- Results of management actions; - Services and products	Effectiveness
Outcomes	*What did we achieve?* Assessment of the outcomes and the extent to which they achieved objectives	- Impacts: effects of management in relation to objectives	Effectiveness and appropriateness

12.2.2 Target

The target for these surveys are MPAs[13]. The MPA can be at any stage of the planning process when they are assessed, from proposed through different stages of implementation.

12.2.3 Purpose

Protected area management effectiveness assessment methods enable both managers and donors the opportunity to systematically identify protected area needs and constraints and to (Worboys et al. 2015):

- enable and support an adaptive approach to management by providing essential information to managers about the extent to which management interventions are being implemented and are successful
- assist in effective resource allocation by identifying gaps and areas of highest need and likelihood of success—in some cases, facilitating 'triage' where resources are scarce
- promote accountability and transparency through providing senior management, funding bodies, stakeholder groups and the public with information about how resources are being used and decisions made
- involve the community, build a constituency to support protected areas and promote protected area values at a particular site or more generally across a system of protected areas.

Many MPA managers find that evaluation process itself is as rewarding as the information the evaluation provides, as completing the assessments is an opportunity for reflection and self-learning. The timing of when the evaluation is completed can also help to inform the preparation of annual workplans and budget requests.

12.2.4 Field equipment

For the MPA Scorecard method or the GEF-METT, the only equipment that is needed to complete the surveys is the questionnaire, either in paper or soft copy format.

12.2.5 Field personnel

The MPA Scorecard and GEF METTs can be completed by anyone with a good knowledge about the MPA (e.g. MPA managers, MPA rangers, scientists, dive operators). Having more than one person help to complete the evaluation can promote discussion, stakeholder engagement and provide additional insights and opinions on the actual and perceived status and functioning of the MPA. This can be achieved through organising an interactive workshop to which protected area managers, policy makers, and other stakeholders participate fully in evaluating the protected areas, analysing the results, and identifying subsequent next steps and priorities. Asking an independent assessor who is familiar with the MPA to review the results can also help improve objectivity.

12.2.6 Training/experience

Both the MPA Scorecard and GEF METT are fairly straight forward and self-explanatory and could be completed without any formal training. Training does however help to improve the quality, consistency and com-

13 The IUCN definition of a protected area is: "A protected area is a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values." (Dudley 2008), which replaces the definition provided by Kelleher et al. (1999). The CBD definition of a protected area is: "A geographically defined area, which is designated or regulated and managed to achieve specific conservation objectives" (Article 2 of the Convention on Biological Diversity)". This definition is further expanded upon under Article 8 of the same convention. There is agreement between the CBD Secretariat and IUCN that both definitions have the same meaning (Lopoukhine and Dias 2012).

parability of the results and will ensure that the MPA management team are able to repeat the evaluation in a consistent manner.

12.3 Field Procedure

12.3.1 MPA Score Card (Level 1)

The MPA Score Card (Staub and Hatziolos, 2004) is a simple questionnaire-based method that is used to assess the current status and management effectiveness of MPAs. The form is intended to be completed by MPA administrators, managers and/or independent organisations (e.g. NGOs, dive operators) or other individuals (e.g. academics, local experts). The questionnaire requires no additional field data collection and should only take a short time to complete for those familiar with the MPA.

This method should be completed annually by an assessor, which can be the MPA Manager for the protected area, or the management committee if applicable, or an independent person that is knowledgeable about the protected area. The results of the assessment can help the protected area manager to identify areas of weakness where additional efforts are needed. This information can thereby help to inform the preparation of annual workplans as well as budget or funding requests.

There are two parts of the form to complete:

- Part I MPA Datasheet and
- Part II MPA Assessment.

Both forms are presented in Annex 12.1 and instructions on how to complete the forms are provided below:

PART I MPA Datasheet

The first datasheet is where the background details about the MPA and the person doing the assessment are provided. This datasheet requests information about the name, location and size of the MPA and the main objectives.

PART II MPA Assessment

The assessment includes a suite of questions related to the current status of the MPA, covering all six elements of management identified in the IUCN-WCPA Framework (context, planning, inputs, process, outputs and outcomes). The form includes 34 questions followed by four alternative answers, ranked from 0 (poor) to 3 (excellent). There are also supplementary questions that expand key themes and provide the opportunity to score additional points. In addition there is a comments column. It is important that both the scores and comments are completed. Properly completing the comments section is more time consuming but is important as it provides the assessor the opportunity to justify the score awarded.

- *Scores*: The assessor(s) is required to select one of the four answers that most closely describes the local situation. In some situations, none of the four answers may appear to be appropriate, in which case the assessor(s) needs to select the best nearest answer and then explain their choice in the comment section (see below). Questions that are not relevant should be omitted and the reason given in the comments section. The maximum achievable total score if all questions and supplementary questions are answered is 139, which is normally presented as a percentage.
    - ◊ If all questions were answered, the percentage is calculated using the total score of 139. e.g. A protected area scores 65 out of a maximum of 139 points the percentage can be calculated by dividing 65 ÷ 139 x 100 =. 46.8%

◊ If questions are were left out because they were irrelevant, the total score should be adjusted accordingly. e.g. A protected area scores 65 out of a maximum score of 87, the percentage can be calculated as 65 ÷ 87 x 100 = 75%.

- Scores can also be calculated as a percentage for each of the six elements of the WCPA Framework (i.e. context, planning, inputs, process, outputs and assessments). The scores for these six elements can be used to provide an alternative means of comparing effectiveness between sites or over time.
- *Comments:* The assessor(s) can use the comments section to explain the factors that influence the score (e.g. local staff knowledge, reference document, monitoring results or other external studies and assessments). These details help increase confidence in the results of the assessment and makes the process more transparent. It also provides a point of reference for use in future assessments and or explains why the question was not answered.

12.3.2 GEF Biodiversity Tracking Tool (Level 2)

The Global Environment Facility (GEF) has been utilising a protected area management effectiveness assessments as part of their monitoring and evaluation processes for projects supporting protected areas that are funded within the GEF Biodiversity Focal Area[14]. The GEF Biodiversity Tracking Tool includes a METT method that is very similar to the MPA Scorecard but requires more specific information, and it is completed alongside the Financial Tracking Tool. It should be noted that GEF produces a new Biodiversity Tracking Tool for each funding round[15]. The version described here is for projects funded under GEF-6.

The GEF-6 Biodiversity Tracking Tool has three sections:

- Section I requests background and coverage information on the protected area and project specific information to track indicators relevant to the GEF strategy.
- Section II includes five data sheets, including the METT, and all of which need to be completed.
- Section III is for assessing the financial sustainability of the protected area.

The five data sheets included in Section II of the GEF Biodiversity Tracking Tool are as follows:

- *Data Sheet 1:* Records details about the assessment and some basic information about the site, such as name, size and location etc. Each MPA that is registered on the World Database on Protected Area (WDPA) is issued with a code and this should be included. These can be found on the UNEP-WCMC database (http://www.protectedplanet.net/). Other contextual information such as local designation, i.e. national park, national reserve etc, along with the IUCN protected area management category, ownership, staff numbers and budget are also recorded plus information on who was involved in the assessment.
- *Data Sheet 2*: Provides a specific list of threats that the project is addressing. Previous versions also included a generic list of threats. The current version asks the assessors to identify the threats and rank their impact on the protected area.

14 GEF has six focal areas namely: Biodiversity, Chemicals and Waste, Climate Change, Forests, International Waters and Land Degradation.

15 A new version of the tracking tool for GEF-7 funded projects was published in August 2018 and is available to download here: https://www.thegef.org/topics/biodiversity

- *Data Sheet 3*: Is intended to assess the current condition of the biodiversity within the protected area.
- *Data Sheet 4*: Is the METT Assessment Form. The form is structured around 30 questions which are presented in table format. The METT has three columns for recording the results of the assessment, and two response boxes (score and comments and next steps), which should be completed three times during the project cycle as follows.
    - ◊ *Scores:* The METT form includes 30 questions with four alternative answers, ranked from 0 (poor) to 3 (excellent). As with the MPA Scorecard, there are also supplementary questions that expand key themes and provide additional information and points. The assessor is required to select one of the four answers that most closely describes the local situation. If none of the four answers appear to be appropriate, the assessor needs to select the best nearest answer and then explain their choice in the comment section. Questions that are not relevant should be omitted and the reason given in the comment section. The maximum achievable score if all questions and supplementary questions are answered is 99, which is more normally presented as a percentage. If all questions were answered the percentage is calculated using the total score of 99. If questions are were left out because they were irrelevant, the total score would be adjusted accordingly.
    - ◊ e.g. A protected area scores 65 out of a maximum of 99 the percentage can be calculated by dividing 65 ÷ 99 x 100 =. 65.65%

As with the MPA Scorecard, the use of "scoring" systems such as these can problematic as they assume that all the issues are of equal weight. Scores calculated as a percentage for each of the six elements of the WCPA Framework (i.e. context, planning, inputs, process, outputs and assessments) can be used to provide an alternative means comparing assessments of effectiveness between sites or over time.

- ◊ *Comment/next steps*: this can be used to explain what factors influenced the score (e.g. local staff knowledge, reference document, monitoring results or other external studies and assessments). These types of details help increase confidence in the results of the assessment and make the whole process more transparent. It also provides a point of reference for use in future repeat assessments and / or explains why the question was not answered. In addition, the GET METT for each question, respondents are asked to identify what if any actions will be undertake to improve management performance.

- *Data Sheet 5*: Data sources and methods on which above assessments of condition of biodiversity in the protected area in Question 30 are based.

Section III of the form requires detailed information about the financing of the protected area.

12.3.3 Management Effectiveness Evaluations (Level 3)

Comprehensive guidance in the development of more specific detailed MPA management effectiveness evaluation methodologies is provided in a manual called "How is your MPA doing" (Pomeroy et al., 2004)[16].

16 https://portals.iucn.org/library/sites/library/files/documents/

The manual (more than 200 pages) follows the IUCN-WCPA Framework and it provides detailed technical advice on how to assess all aspects of MPA management. The manual is intended to be used as a toolbox to enable MPA managers to create their own tailor made MPA management effectiveness monitoring and evaluation method. It has been translated into several languages and it provides examples on how the methods have been applied in field tests at 17 sites around the world.

One of the most comprehensive and in-depth site level assessment methodologies developed to date is the 'Enhancing Our Heritage' toolkit (Hockings et al. 2015)[17], which IUCN and UNESCO developed for use in natural World Heritage sites. The Enhancing Our Heritage Toolkit contains twelve practical tools, each designed to help those responsible for World Heritage site conservation to assess the elements of a comprehensive management framework, including the construction of targeted monitoring strategies.

- Tool 1: Identifying Site Values and Management Objectives
- Tool 2: Identifying Threats
- Tool 3: Relationships with Stakeholders
- Tool 4: Review of National Context
- Tool 5: Assessment of Management Planning
- Tool 6: Design Assessment
- Tool 7: Assessment of Management Needs and Inputs
- Tool 8: Assessment of Management Processes
- Tool 9: Assessment of Management Plan Implementation
- Tool 10: Work/Site Output Indicators
- Tool 11: Assessing the Outcomes of Management
- Tool 12: Review of Management Effectiveness Assessment Results

The tools are each designed as separate exercises, with tables and guidelines. The method is meant to be user-friendly, flexibile, and adaptable to local realities, although it quite complicated for new users and first time users and those unfamiliar with PAME methods are likely to require external support.

There are many other comprehensive assessment methods that have been developed by countries around the world. One other notable example is the methodology that was designed for use by countries in the western Indian Ocean (WIO) region (Wells and Maghrubi, 2004). This methodology is a potential model that PERSGA could use in the future, to develop a more comprehensive assessment method for use by countries in the region.

PAPS-012.pdf

17 https://whc.unesco.org/en/series/23/ and https://whc.unesco.org/document/100750

12.4 Strengths / Weaknesses

Strengths	Weaknesses
Level 1 MPA Scorecard	
The MPA Scorecard method is accessible entry level protected area management effectiveness tool that covers all parts of the IUCN-WCPA framework, and provides data that can help managers improve their understanding about the issues and challenges. The data also allows for comparisons between sites.	The amount of information collected is rather superficial and ratings are subjective and therefore open to interpretation. The scorecard places higher emphasis on both outputs and outcomes of management. Outcome measures are included but there is no guidance on the detailed assessment of biophysical outcomes.
The MPA scorecard creates an opportunity to provide training and initiate discussions with MPA managers about what actions might be needed to improve the effective management of the area.	There are challenges in using the data to compare between sites because of the scoring system. This can be addressed by comparing the aggregated sub-total scores for each of the six planning steps.
The MPA scorecard method is well suited for assessing progress through time and once the method has been learnt it can be repeated by managers and staff as a self-assessment tool to check on progress towards different targets.	The rapid assessment scorecard methods does not replace the need for full management effectiveness assessments if sufficient resources are available.
Level 2 GEF METT	
The GEF METT is a requirement for Biodiversity focused project and support is provided to complete the assessment at 3 stages during project implementation (project preparation, mid-term evaluation and final evaluation).	The GEF METT is often perceived to be a project specific tool and therefore may not be adopted by national protected area management staff as part of their recurrent management activities.
Level 3 "How is your MPA doing?"	
Provides guidance on the development of fuller more in-depth assessment methods that can be used to inform adaptive management.	Fuller management effectiveness assessment methods are time consuming and costly to implement and would often be considered lower priority where protected area finances are often a major constraint.
Provides a toolbox of solutions with a range of indicators that can be tailored to suit different MPAs with different capacities.	The "How is your MPA doing?" manual is not a 'ready-to-apply' methodology. It could appear intimidating if manager think they need to apply all indicators. As methods are not standardised, the data from different MPAs may not be directly comparable.

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12.6 Annexes

Annex 12.1 MPA SCORECARD METHOD

MPA SCORECARD METHOD - PART I DATA SHEET (after Staub and Hatziolus, 2004)

PART I	Question	Response
1	Country	
2	Name of marine protected area:	
3	Locality of marine protected area	
4	Geographical position	
	Latitude:	
	Longitude:	
5	Date MPA was established:	
6	Ownership details (i.e. owner, tenure rights etc):	
7	Management Authority:	
8	Contact information and web site (if any):	
9	Size of marine protected area (ha):	
10	Percent of MPA that is terrestrial (%):	
11	Number of staff (Permanent, Temporary, Volunteers)	
12	Annual budget	
13	Designations (IUCN category, World Heritage, Ramsar, etc)	
14	Reasons for designation	
15	The MPA is part of a larger management zoning plan (Yes / No):	
16	Brief Description of the primary habitats represented in the MPA (reef, sea-grass, mangrove, lagoon, estuary…):	
	Habitat 1:	
	Habitat 2:	
17	Two primary marine protected area objectives:	
	Objective 1:	
	Objective 2:	
18	Two most important threats to the MPA (and reasons why):	
	Threat 1:	
	Threat 2:	
19	Top two critical management activities:	
	Activity 1:	
	Activity 2:	
20	Top 2 stakeholder groups:	
	Stakeholder group 1:	
	Stakeholder group 2:	
21	Resources conditions: (poor, average, good)	
22	Name/s of respondent (assessor) [Optional]	
23	Role (position) [Optional]	
24	Contact email [Optional]	
25	Date(s) of previous score card assessment(s):	

MPA SCORECARD METHOD - PART II ASSESSMENT (after Staub and Hatziolus, 2004)

Part II	RANK	YOUR SCORE	COMMENT
A. Context: Where are we now? Assessment of important threats and the policy environment			
Question 1. Legal status – Does the marine protected area have legal status? Note: see fourth option for private reserves?			
The marine protected area is not gazetted	**0**		
The government has agreed that the marine protected area should be gazetted but the process has not yet begun	**1**		
The marine protected area is in the process of being gazetted but the process is still incomplete	**2**		
The marine protected area has been legally gazetted (or in the case of private reserves is owned by a trust or similar)	**3**		
Additional Point			
a. The MPA has received national and/or international recognition for its importance (in the comments column, describe the recognition in detail)	**1**		
Question 2. Marine protected area regulations – Are unsustainable human activities (e.g. poaching) controlled?			
There are no mechanisms for controlling unsustainable human activities in the marine protected area	**0**		
Mechanisms for controlling unsustainable human activities in the marine protected area exist but there are major problems in implementing them effectively	**1**		
Mechanisms for controlling unsustainable human activities in the marine protected area exist but there are some problems ineffectively implementing them	**2**		
Mechanisms for controlling unsustainable human activities in the marine protected area exist and are being effectively implemented	**3**		
Question 3. Law enforcement – Can staff sufficiently enforce marine protected area rules?			
The staff have no effective capacity/resources to enforce marine protected area legislation and regulations	**0**		
There are major deficiencies in staff capacity/resources to enforce marine protected area legislation and regulations (e.g. lack of skills no patrol budget)	**1**		
The staff have acceptable capacity/resources to enforce marine protected area legislation and regulations but some deficiencies remain	**2**		
The staff have excellent capacity/resources to enforce marine protected area legislation and regulations	**3**		
Additional Points			
a. There are additional sources of control (e.g., volunteers, national services, local communities)	**1**		
b. Infractions are regularly prosecuted and fines levied	**1**		

Part II	RANK	YOUR SCORE	COMMENT
Question 4. Marine protected area boundary demarcation – boundaries known and demarcated?			
The boundaries of the marine protected area are not known by the management authority or other stakeholders	**0**		
The boundary of the marine protected area is known by authority but is not known by other stakeholders	**1**		
The boundary of the marine protected area is known by both the management authority and other but is not appropriately demarcated	**2**		
The boundary of the marine protected area is known by the management authority and stakeholders and is appropriately demarcated	**3**		
Question 5. Integration of the MPA in a larger coastal management plan – Is the MPA part of a larger coastal management plan?			
There is no discussion about the integration of the MPA in a larger coastal management plan	**0**		
There is some discussions about the integration of the MPA into coastal management plan but the process has not yet begun	**1**		
The marine protected area is in the process of being integrated into a larger coastal management plan but the process is still incomplete	**2**		
The marine protected area is part of a larger coastal management plan	**3**		
Additional Points			
a. The MPA is part of a network of MPAs which collectively sustain larger marine ecosystem functions	**1**		
b. The MPA is part of a network of MPAs which collectively represent the range of bio-geographic variation in a marine eco-region	**1**		
Question 6. Resource inventory – Is there enough information to manage the area?			
There is little or no information available on the biophysical, socio-cultural and economic conditions associated with the marine protected area	**0**		
Information on the biophysical, socio-cultural and economic conditions associated with the marine protected area is not sufficient to support planning and decision making	**1**		
Information on the biophysical, socio-cultural and economic conditions associated with the marine protected area is sufficient for key areas of planning/decision making but the necessary survey work is not being maintained	**2**		
Information on the biophysical, socio-cultural and economic conditions associated with the MPA is sufficient for key areas of planning and decision-making	**3**		

Part II	RANK	YOUR SCORE	COMMENT
Question 7. Stakeholder awareness and concern – Are stakeholders aware and concerned about marine resource conditions and threats?			
Less than 25% of stakeholders are aware or concerned about the marine resource conditions, and threats and management efforts	**0**		
Approximately 25% - 50% of stakeholders are aware or concerned about the marine resource conditions and threats	**1**		
Approximately 50%-75% of stakeholders are aware or concerned about the marine resource conditions and threats	**2**		
Over 75% of stakeholders are aware or concerned about the marine resource conditions and threats	**3**		
TOTAL for Context (A): Max. score = 26 (less if some answers are Not Applicable NA or Don't Know DK)	**26**		
B. Planning – Where do we want to be? Assessment of marine protected area design and planning			
Question 8. Marine protected area objectives – Have objectives been agreed?			
No firm objectives have been agreed for the marine protected area	**0**		
The marine protected area has agreed objectives	**1**		
The marine protected area has agreed objectives but these are only partially implemented	**2**		
The marine protected area has agreed objectives and is managed to meet these objectives	**3**		
Question 9. Management plan – Is there a management plan and is it being implemented?			
There is no management plan for the marine protected area	**0**		
A management plan is being prepared or has been prepared but is not being implemented	**1**		
An approved management plan exists but it is only being partially implemented	**2**		
An approved management plan exists and is being implemented	**3**		
Additional Points			
a. There is also a long term master plan (at least 5 years)	**1**		
b. The planning process allows adequate opportunity for key stakeholders to influence the management plan	**1**		
c. Stakeholder participation includes representation from the various ethnic, religious and user groups as well as representation from both genders	**1**		
d. The socioeconomic impacts of decisions are considered in the planning process	**1**		

Part II	**RANK**	**YOUR SCORE**	**COMMENT**
e. The local culture, including traditional practices, social systems, cultural features, historic sites and monuments, is considered in the planning process	**1**		
f. There is an established schedule and process for periodic review and updating of the management plan	**1**		
g. The results of monitoring, research and evaluation are routinely incorporated into planning	**1**		
h. Management plan is tied to the development and enforcement of regulations	**1**		
TOTAL for Planning (B): Max. score = 14 (less if some answers are Not Applicable NA or Don't Know DK)	**14**		
C. Inputs – What do we need? Assessment of resources needed to carry out management			
Question 10. Research – Is there a program of management-oriented survey and research work?			
There is no survey or research work taking place in the marine protected area	**0**		
There is some ad hoc survey and research work	**1**		
There is considerable survey and research work but it is not directed towards the needs of marine protected area management	**2**		
There is a comprehensive, integrated program of survey and research work which is relevant to management needs	**3**		
Additional Point			
a. Carrying capacity studies have been conducted to determine sustainable use levels	**1**		
Question 11. Staff numbers – Are there enough people employed to manage the protected area?			
There are no staff	**0**		
Staff numbers are inadequate for critical management activities	**1**		
Staff numbers are below optimum level for critical management activities	**2**		
Staff numbers are adequate for the management needs of the site	**3**		
Additional Point			
a. There is additional support from volunteer programs, local communities, etc	**1**		
Question 12. Current budget – Is the current budget sufficient? (In the comments column: please detail of the sources of funding)			
There is no budget for the marine protected area	**0**		
The available budget is inadequate for basic management needs and presents a serious constraint to the capacity to manage	**1**		
The available budget is acceptable, but could be further improved to fully achieve effective management	**2**		

Part II	RANK	YOUR SCORE	COMMENT
The available budget is sufficient and meets the full management needs of the protected area	**3**		
Additional Points			
a. There is a secure budget for the marine protected area and its management needs on a multi–year basis.	**2**		
b. The budget is not entirely dependent on government funding; instead, funding also comes from NGO contributions, taxes, fees, etc.	**1**		
TOTAL for Inputs (C): Max. score = 14 (less if some answers are Not Applicable NA or Don't Know DK)	**14**		
D. Process – How do we go about management? Assessment of the way in which management is conducted			
Question 13. Education and awareness program – Is there a planned education program?			
There is no education and awareness program	**0**		
There is a limited and ad hoc education and awareness program, but no overall planning for this component	**1**		
There is a planned education and awareness program but there are still serious gaps	**2**		
There is a planned and effective education and awareness program fully linked to the objectives and needs of the protected area	**3**		
Question 14. Communication between stakeholders and managers – Is there communication between stakeholders and managers?			
There is little or no communication between managers and stakeholders involved in the MPA	**0**		
There is communication between managers and stakeholders but this is not a planned or scheduled program	**1**		
There is a planned communication program that is being used to build support for the MPA amongst relevant stakeholders but implementation is limited yet.	**2**		
There is a planned communication program that is being implemented to built support for the MPA amongst relevant stakeholders.	**3**		
Additional Point			
There is some communication with other MPA managers (and for example exchanges of good practices)	**1**		
Question 15. Stakeholder involvement and participation – Do stakeholders have meaningful input to management decisions?			
Stakeholders have no input into decisions relating to the management of the protected area	**0**		
Stakeholders have some input into discussions relating to management but no direct involvement in the resulting decisions	**1**		

Part II	RANK	YOUR SCORE	COMMENT
Stakeholders directly contribute to some decisions management	**2**		
Stakeholders directly participate in making decisions relating to management	**3**		
Additional Point			
a. There are clear financial contributions / agreements between MPA and tourism operators to recover MPA resources rents for local benefits	**1**		
Question 16. Indigenous people – Do indigenous and traditional peoples resident or regularly using the MPA have input to management decisions?			
Indigenous and traditional peoples have no input into decisions relating to the management of the protected area	**0**		
Indigenous and traditional peoples have some input into discussions relating to management but no direct involvement in the resulting decisions	**1**		
Indigenous and traditional peoples directly contribute to some decisions relating to management	**2**		
Indigenous and traditional peoples directly participate in making decisions relating to management	**3**		
Question 17. Staff training – Is there enough training for staff?			
Staff are untrained.	**0**		
Staff training and skills are low relative to the needs of the marine protected area.	**1**		
Staff training and skills are adequate, but could be further improved to fully achieve the objectives of management.	**2**		
Staff training and skills are in tune with the management needs of the marine protected area, and with anticipated future needs.	**3**		
Question 18. Equipment – Is the site adequately equipped?			
There is little or no equipment and facilities.	**0**		
There is some equipment and facilities but these are wholly inadequate.	**1**		
Most of equipment and facilities are adequate and maintained.	**2**		
There is adequate equipment and facilities and it is well maintained.	**3**		
Question 19. Monitoring and evaluation – Are biophysical, socioeconomic and governance indicators monitored and evaluated?			
There is no monitoring and evaluation the biophysical, socioeconomic and governance context of the MPA	**0**		
There is some ad hoc monitoring and evaluation, but no overall strategy and/or no regular collection of results	**1**		

Part II	**RANK**	**YOUR SCORE**	**COMMENT**
There is an agreed and implemented monitoring and evaluation system but results are not systematically used for management	**2**		
A good monitoring and evaluation system exists, is well implemented and used in adaptive management	**3**		
Additional Points			
a. The MPA participates as a site in national or international environmental monitoring programs such CARICOMP, CPACC, GCRMN, AGGRA or similar. (Provide the name of the program(s))	**1**		
b. There is an Emergency Response Capability in place to mitigate impacts from non threats	**1**		
TOTAL for process (D): Max. score = 25 (less if some answers are Not Applicable NA or Don't Know DK)	**25**		
E. Outputs – What were the results? Assessment of the implementation of management programs and actions; delivery of products and services			
N.B.: The outputs should be assessed based on progress since the last assessment. If this is the first time the Score Card is being used, respondents should assess outputs over the last 3 years. For newly establish MPAs, respondents may have to skip this section.			
Question 20. Context indicators – have context indicators been improved?			
a. Legal status has improved (refers to question 1. Legal status)	**2**		
b. Regulations have improved (refers to question 2. MPA Regulations)	**2**		
c. Law enforcement has improved (refers to question 3.Law enforcement)	**2**		
d. Boundary demarcation has improved (refers to question 4. MPA Boundary demarcation)	**2**		
e. The MPA has been integrated into ICM (refers to question 5. Integration of the MPA)	**2**		
f. The resource inventory has improved (refers to question 6. Resource inventory)	**2**		
g. Stakeholder awareness and concern has improved (refers to question 7.)	**2**		
Question 21. Products and services			
a. Signs – signs are now available, or new one have been installed	**1**		
b. Moorings – moorings are now available, or new one have been installed	**2**		
c. Education materials – education materials are available, or new one have been developed	**1**		

Part II	RANK	YOUR SCORE	COMMENT
Question 22. Mechanisms for stakeholder participation in decision-making and/or management activities (e.g. advisory council) – are mechanisms available to ensure stakeholder participation?			
There are no mechanisms for stakeholder participation in decision-making and/or management activities	**0**		
There are some mechanisms for stakeholder participation in decision-making and/or management activities, but not sufficient	**1**		
There are sufficient mechanisms for stakeholder partici-pation in decision-making and/or management activities	**2**		
Question 23. Environmental education activities for stakeholders (e.g. public outings at the MPA) – have education activities been developed for stakeholders?			
There are no education activities available for stakehold-ers	**0**		
There are some education activities available for stake-holders, but they are not sufficient	**1**		
There are sufficient education activities available for stakeholders	**2**		
Question 24. Management activities – have the two critical management activities (listed in the data sheet) been improved to address threats?			
Management activities has not been improved	**0**		
Some measures have been taken to improve management activities	**1**		
Management activities have been sufficiently improved	**2**		
Question 25. Visitor facilities – does the MPA have sufficient visitor facilities?			
There are no visitor facilities and services	**0**		
Visitor facilities and services are inappropriate for current levels of visitation or are under construction	**1**		
There are some visitor facilities and services, but they could be improved	**2**		
Visitor facilities and services are sufficient for current levels of visitation	**3**		
Question 26. Fees – If fees (entry fees - tourism, fines) are applied, do they help marine protected area management?			
Although a fee system exists, fees are not collected	**0**		
The fees are collected, but they go straight to central government and are not returned to the marine protected area or its environs	**1**		
The fees are collected, but they are disbursed to the local authority rather than the marine protected area	**2**		
There are fees for visiting the marine protected area that help to support this and/or other marine protected areas	**3**		
Question 27. Staff Training			
Staff was trained but could be further improved to fully achieve the objectives of management 2	**2**		

Part II	**RANK**	**YOUR SCORE**	**COMMENT**
Staff was trained in tune with the management needs of the marine protected area, and with anticipated future needs 3	**3**		
TOTAL for Outputs (E): Max. score = 33 (less if some answers are Not Applicable NA or Don't Know DK)	**33**		
F. Outcomes – What did we achieve? Assessment of the outcomes and the extent to which they achieved objectives			
Question 28. Objectives – Have MPA objectives (listed in the data sheet page) been addressed?			
Management objectives have not been addressed	**0**		
Management objectives have been addressed somewhat	**1**		
Management objectives have been sufficiently addressed	**2**		
Management objectives have been significantly addressed	**3**		
Question 29. Threats – Have threats (listed in the data sheet page) been reduced?			
Threats have increased	**0**		
Threats have stayed at approximately the same levels	**1**		
Threats have been reduced somewhat	**2**		
Threats have been largely reduced	**3**		
Question 30. Resource conditions– Have resource conditions improved?			
Resource conditions have declined	**0**		
Resource conditions have stayed at approximately the same levels	**1**		
Resource conditions have improved somewhat	**2**		
Resource conditions have improved significantly	**3**		
Question 31. Community welfare – Has community welfare improved? (provide examples)			
Livelihoods and standards of living in the community have declined	**0**		
Livelihoods and standards of living in the community have stayed approximately the same	**1**		
Livelihoods and standards of living in the community have improved somewhat	**2**		
Livelihoods and standards of living in the community have improved significantly	**3**		
Additional points			
a. MPA management is compatible with the local culture, including traditional practices, relationships, social systems, cultural features, historic sites and monuments linked to marine resources and uses	**1**		
b. Resource use conflicts have been reduced	**1**		
c. Benefits from the MPA are equitably distributed	**1**		
d. The non-monetary benefits of the marine resources to society have been maintained or enhanced	**1**		

Part II	**RANK**	**YOUR SCORE**	**COMMENT**
Question 32. Environmental awareness – Has community environmental awareness improved?			
Environmental awareness of resource conditions, threats and management activities has declined	**0**		
Environmental awareness has stayed approximately the same	**1**		
Environmental awareness has improved somewhat	**2**		
Environmental awareness has improved significantly	**3**		
Question 33. Compliance – Are users complying with MPA regulations?			
Less than 25% of users are complying with regulations	**0**		
25% to 50% of users are complying with regulations	**1**		
50% - 75% of users are complying with regulations	**2**		
Over 75% of users are complying with regulations	**3**		
Question 34. Stakeholder satisfaction – Are the stakeholders satisfied with the process and outputs of the MPA?			
Less than 25% of stakeholders are satisfied with the process and outputs of the MPA	**0**		
25 to 50% of stakeholders are satisfied with the process and outputs of the MPA	**1**		
50% to 75% of stakeholders are satisfied with the process and outputs of the MPA	**2**		
Over 75% of stakeholders are satisfied with the process and outputs of the MPA	**3**		
Additional points			
a. Stakeholders feel that they are able to effectively participate in management decisions	**1**		
b. Stakeholders feel that they are adequately represented in the MPA decision-making processes	**1**		
TOTAL for Outcomes (F) Max. score = 27 (less if some answers are Not Applicable NA or Don't Know DK)	**27**		

Summary Table

TOTAL for Context (A): Max. score = 26 (less if some answers are Not Applicable NA or Don't Know DK)	**26**		
TOTAL for Planning (B): Max. score = 14 (less if some answers are Not Applicable NA or Don't Know DK)	**14**		
TOTAL for Inputs (C): Max. score = 14 (less if some answers are Not Applicable NA or Don't Know DK)	**14**		
TOTAL for process (D): Max. score = 25 (less if some answers are Not Applicable NA or Don't Know DK)	**25**		
TOTAL for Outputs (E): Max. score = 33 (less if some answers are Not Applicable NA or Don't Know DK)	**33**		
TOTAL for Outcomes (F) Max. score = 27 (less if some answers are Not Applicable NA or Don't Know DK)	**27**		
TOTAL for all Max score for A+B+C+D+E+F = 139 adjusted if the maximum score has been adjusted	**139**		

Annex 12.2 GEF Management Effectiveness Tracking Tool for Protected Area

GEF 6: Objective 1: Catalyzing Sustainability of Protected Area Systems, Programs 1 and 2 SECTION I
Objective: To measure progress in achieving the impacts and outcomes established at the portfolio level under the biodiversity focal area. **Rationale:** Project data from the GEF-6 project cohort will be aggregated for analysis of directional trends and patterns at a portfolio-wide level to inform the development of future GEF strategies and to report to GEF Council on portfolio-level performance in the biodiversity focal area. **Structure of Tracking Tool:** Each tracking tool requests background and coverage information on the project and specific information required to track portfolio level indicators in the GEF-6 strategy. **Guidance in Applying GEF Tracking Tools:** GEF tracking tools are applied three times: at CEO endorsement or CEO approval for MSPs, at project mid-term, and at project completion. **Submission:** The finalized tracking tool will be cleared by the GEF Agencies as being correctly completed and submitted to the GEF Secretariat.
PLEASE NOTE THAT THIS TOOL IS ONLY FOR USE FOR GEF-6 PROJECTS.

I. General Data	Please indicate your answer here	Notes
Please complete this section for all projects under Objective 1.		
Project Title		
GEF Project ID		
Agency Project ID		
Implementing Agency		
Project Type		FSP or MSP
Country		
Region		
Date of submission of the tracking tool		Month DD, YYYY (e.g., May 12, 2010)
Name of reviewers completing tracking tool and completion date		Completion Date
Planned project duration		years
Actual project duration		years under implementation to date
Lead Project Executing Agency (ies)		

II. Total Extent by Biome	Please indicate your answer here	
Please complete this table with the total extent of protected areas targeted by the project by terrestrial, freshwater, and marine biome. Please complete this section for all projects under Objective 1.		
Terrestrial (insert total hectares for terrestrial coverage)		ha
Freshwater (insert total hectares for freshwater coverage)		ha
Marine (insert total hectares for marine coverage)		ha

III. Targeted Protected Areas	Please indicate your answer here	
Please complete the table below for the protected areas that are the target of the GEF intervention (i.e. completing a METT). Add new tables (copy/paste rows) for each protected area, as needed. Use N/A for not applicable.		
1. Protected Area		
Name of Protected Area		
Is this a new protected area that is being established through this project intervention?		Yes = 1, No = 0
Area in Hectares		
Biome type		Please select from the drop-down list.
Global designation or priority lists		Please select from the drop-down list.
Local Designation of Protected Area		(E.g, indigenous reserve, private reserve, etc.)
IUCN Category		Please select from the drop-down list.
2. Protected Area		
Name of Protected Area		
Is this a new protected area that is being established through this project intervention?		Yes = 1, No = 0
Area in Hectares		
Biome type		Please select from the drop-down list.
Global designation or priority lists		Please select from the drop-down list.
Local Designation of Protected Area		(E.g, indigenous reserve, private reserve, etc.)
IUCN Category		Please select from the drop-down list.

GEF:6 Objective 1: Catalyzing Sustainability of Protected Area Systems SECTION II: Management Effectiveness Tracking Tool for Protected Areas
Note: Please complete the management effectiveness tracking tool for EACH protected area that is the target of the GEF intervention to improve management effectiveness and create a new worksheet for each. Structure and content of the Tracking Tool - Objective 1. Section II: The Tracking Tool has five data sheets: **Data Sheet 1**: Records details of the assessment and some basic information about the site, such as name, size and location etc. **Data Sheet 2**: Provides a specific list of threats that the project is addressing. **Data Sheet 3**: Condition of biodiversity in the protected area. **Data Sheet 4**: Assessment Form: the assessment is structured around 30 questions presented in table format which includes three columns for recording details of the assessment, all of which should be completed. **Data Sheet 5**: Data sources and methods on which above assessments of condition of biodiversity in the protected area in Question 30 are based.
PLEASE NOTE THAT THIS TOOL IS FOR USE ONLY IN GEF-6 PROJECTS

Data Sheet 1: Reporting Progress at Protected Area Sites				
Questions	**Please indicate your answers here**			**Notes**
	Project Start-up	**Midterm**	**Project Completion**	
Name, affiliation and contact details for person responsible for completing the METT (email etc.)				
Date assessment carried out				Month DD, YYYY (e.g., May 12, 2010)
Name of protected area				
WDPA site code (these codes can be found on www.protectedplanet.net)				
Country				
Location of protected area (province and if possible map reference)				
Date of establishment				
Ownership details (please choose 1-4)				1: State 2: Private 3: Community 4: Other
Management Authority				
Size of protected area (ha)				

Number of Permanent staff				
Number of Temporary staff				
Annual budget (US$) for recurrent (operational) funds – excluding staff salary costs				
Annual budget (US$) for project or other supplementary funds – excluding staff salary costs				
What are the main values for which the area is designated				
List the two primary protected area management objectives in below:				
Management objective 1				
Management objective 2				
No. of people involved in completing assessment				
Including: (please choose 1-8)				1: PA manager 2: PA staff 3: Other PA agency staff 4: Donors 5: NGOs 6: External experts 7: Local community 8: Other

Data Sheet 2: Key Biodiversity Indicators Used in This Protected Area				
At project start-up, identify and list up to five key biodiversity indicators that are monitored on a regular basis in the protected area; these indicators can relate to any/all trophic levels OR using other indicators. For each identified indicator, provide the current (project start-up) status of that indicator in numerical terms or with a short description (see examples below), as appropriate. The examples are only illustrative and the protected area manager should use the indicators that currently are being monitored and/or will be monitored. At project midterm and at project completion, provide updates on the status of the same indicator(s) identified at project start. The overall condition of biodiversity -- based on the status of the indicator(s) identified here -- will be reported on in Question 30 in Data Sheet 4 (METT Assessment Form). Therefore the inputs here require focused analysis to assess whether trends are positive, negative or neutral.				
Indicator	**Project Start-up**	**Midterm**	**Project Completion**	**Comments (optional)**
Example Indicator 1: Estimated population of a key herbivore species as indicated by dung counts	*23 hectares*	*35 hectares*	*50 hectares*	
Indicator 1				
Indicator 2				
Indicator 3				
Indicator 4				
Indicator 5				

Data Sheet 3: Protected Areas Threats		
Please describe each threat that the project is directly addressing and provide the threat reduction indicator that the project is using from the project logframe to measure progress in reducing each threat. An example is provided.		
Questions	**Please enter your answers in this column.**	**Comments (optional)**
Example Threat	***Illegal hunting for bushmeat***	
Threat reduction indicator	*Quantity of bushmeant coming from Xanadu PA sold in markets*	
Baseline status	*At the start of project bushmeat sales in markets are 20 tons/per year (baseline upon which progress will be measured).*	
Target	*Quantities of bushmeat coming from "Xanadu Protected Area" sold in markets are reduced by 70% over the project period*	
Midterm status	*Bushmeat sales are recorded to be 14 tons per year.*	
End of project status	*Bushmeat sales are recorded to be 12 tons per year.*	
Threat 1		
Threat reduction indicator		
Baseline status		
Target		
Midterm status		
End of project status		
Threat 2		
Threat reduction indicator		
Baseline status		
Target		
Midterm status		
End of project status		

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter "N/A" in the comments space along with a brief explanation.				
Questions	**Project start-up**	**Mid term**	**Project Completion**	**Criteria and Scores**
1. Legal status: Does the protected area have legal status (or in the case of private reserves is covered by a covenant or similar)?				0: The protected area is not gazetted / covenanted 1: There is agreement that the protected area should be gazetted/covenanted but the process has not yet begun 2: The protected area is in the process of being gazetted/covenanted but the process is still incomplete (includes sites designated under international conventions, such as Ramsar, or local/traditional law such as community conserved areas, which do not yet have national legal status or covenant) 3: The protected area has been formally gazetted/covenanted
Comments and Next Steps				
2. Protected area regulations: Are appropriate regulations in place to control land use and activities (e.g. hunting)?				0: There are no regulations for controlling land use and activities in the protected area 1: Some regulations for controlling land use and activities in the protected area exist but these are major weaknesses 2: Regulations for controlling land use and activities in the protected area exist but there are some weaknesses or gaps 3: Regulations for controlling inappropriate land use and activities in the protected area exist and provide an excellent basis for management
Comments and Next Steps				

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter "N/A" in the comments space along with a brief explanation.				
3. Law Enforcement: Can staff (i.e. those with responsibility for managing the site) enforce protected area rules well enough?				0: The staff have no effective capacity/ resources to enforce protected area legislation and regulations 1: There are major deficiencies in staff capacity/resources to enforce protected area legislation and regulations (e.g. lack of skills, no patrol budget, lack of institutional support) 2: The staff have acceptable capacity/ resources to enforce protected area legislation and regulations but some deficiencies remain 3: The staff have excellent capacity/ resources to enforce protected area legislation and regulations
Comments and Next Steps				
4. Protected area objectives: Is management undertaken according to agreed objectives?				0: No firm objectives have been agreed for the protected area 1: The protected area has agreed objectives, but is not managed according to these objectives 2: The protected area has agreed objectives, but is only partially managed according to these objectives 3: The protected area has agreed objectives and is managed to meet these objectives
Comments and Next Steps				

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter “N/A” in the comments space along with a brief explanation.				
5. Protected area design: Is the protected area the right size and shape to protect species, habitats, ecological processes and water catchments of key conservation concern?				0: Inadequacies in protected area design mean achieving the major objectives of the protected area is very difficult 1: Inadequacies in protected area design mean that achievement of major objectives is difficult but some mitigating actions are being taken (e.g. agreements with adjacent land owners for wildlife corridors or introduction of appropriate catchment management) 2: Protected area design is not significantly constraining achievement of objectives, but could be improved (e.g. with respect to larger scale ecological processes) 3: Protected area design helps achievement of objectives; it is appropriate for species and habitat conservation; and maintains ecological processes such as surface and groundwater flows at a catchment scale, natural disturbance patterns etc
Comments and Next Steps				
6. Protected area boundary demarcation: Is the boundary known and demarcated?				0: The boundary of the protected area is not known by the management authority or local residents/neighbouring land users 1: The boundary of the protected area is known by the management authority but is not known by local residents/neighbouring land users 2: The boundary of the protected area is known by both the management authority and local residents/neighbouring land users but is not appropriately demarcated 3: The boundary of the protected area is known by the management authority and local residents/neighbouring land users and is appropriately demarcated
Comments and Next Steps				

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter "N/A" in the comments space along with a brief explanation.				
7. Management plan: Is there a management plan and is it being implemented?				0: There is no management plan for the protected area 1: A management plan is being prepared or has been prepared but is not being implemented 2: A management plan exists but it is only being partially implemented because of funding constraints or other problems 3: A management plan exists and is being implemented
Comments and Next Steps				
7.a Planning process: The planning process allows adequate opportunity for key stakeholders to influence the management plan				0: No 1: Yes
Comments and Next Steps				
7.b Planning process: There is an established schedule and process for periodic review and updating of the management plan				0: No 1: Yes
Comments and Next Steps				
7.c Planning process: The results of monitoring, research and evaluation are routinely incorporated into planning				0: No 1: Yes
Comments and Next Steps				

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter "N/A" in the comments space along with a brief explanation.				
8. Regular work plan: Is there a regular work plan and is it being implemented				0: No regular work plan exists 1: A regular work plan exists but few of the activities are implemented 2: A regular work plan exists and many activities are implemented 3: A regular work plan exists and all activities are implemented
Comments and Next Steps				
9. Resource inventory: Do you have enough information to manage the area?				0: There is little or no information available on the critical habitats, species and cultural values of the protected area 1: Information on the critical habitats, species, ecological processes and cultural values of the protected area is not sufficient to support planning and decision making 2: Information on the critical habitats, species, ecological processes and cultural values of the protected area is sufficient for most key areas of planning and decision making 3: Information on the critical habitats, species, ecological processes and cultural values of the protected area is sufficient to support all areas of planning and decision making
Comments and Next Steps				
10. Protection systems: Are systems in place to control access/resource use in the protected area?				0: Protection systems (patrols, permits etc) do not exist or are not effective in controlling access/resource use 1: Protection systems are only partially effective in controlling access/resource use 2: Protection systems are moderately effective in controlling access/resource use 3: Protection systems are largely or wholly effective in controlling access/ resource use
Comments and Next Steps				

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter "N/A" in the comments space along with a brief explanation.				
11. Research: Is there a programme of management-orientated survey and research work?				0: There is no survey or research work taking place in the protected area 1: There is a small amount of survey and research work but it is not directed towards the needs of protected area management 2: There is considerable survey and research work but it is not directed towards the needs of protected area management 3:There is a comprehensive, integrated programme of survey and research work, which is relevant to management needs
Comments and Next Steps				
12. Resource management: Is active resource management being undertaken?				0: Active resource management is not being undertaken 1: Very few of the requirements for active management of critical habitats, species, ecological processes and cultural values are being implemented 2: Many of the requirements for active management of critical habitats, species, ecological processes and, cultural values are being implemented but some key issues are not being addressed 3: Requirements for active management of critical habitats, species, ecological processes and, cultural values are being substantially or fully implemented
Comments and Next Steps				
13. Staff numbers: Are there enough people employed to manage the protected area?				0: There are no staff 1: Staff numbers are inadequate for critical management activities 2: Staff numbers are below optimum level for critical management activities 3: Staff numbers are adequate for the management needs of the protected area
Comments and Next Steps				

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter “N/A” in the comments space along with a brief explanation.				
14. Staff training: Are staff adequately trained to fulfill management objectives?				0: Staff lack the skills needed for protected area management 1: Staff training and skills are low relative to the needs of the protected area 2: Staff training and skills are adequate, but could be further improved to fully achieve the objectives of management 3: Staff training and skills are aligned with the management needs of the protected area
Comments and Next Steps				
15. Current budget: Is the current budget sufficient?				0: There is no budget for management of the protected area 1: The available budget is inadequate for basic management needs and presents a serious constraint to the capacity to manage 2: The available budget is acceptable but could be further improved to fully achieve effective management 3: The available budget is sufficient and meets the full management needs of the protected area
Comments and Next Steps				
16. Security of budget: Is the budget secure?				0: There is no secure budget for the protected area and management is wholly reliant on outside or highly variable funding 1: There is very little secure budget and the protected area could not function adequately without outside funding 2: There is a reasonably secure core budget for regular operation of the protected area but many innovations and initiatives are reliant on outside funding 3: There is a secure budget for the protected area and its management needs
Comments and Next Steps				

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter "N/A" in the comments space along with a brief explanation.				
17. Management of budget: Is the budget managed to meet critical management needs?				0: Budget management is very poor and significantly undermines effectiveness (e.g. late release of budget in financial year) 1: Budget management is poor and constrains effectiveness 2: Budget management is adequate but could be improved 3: Budget management is excellent and meets management needs
Comments and Next Steps				
18. Equipment: Is equipment sufficient for management needs?				0: There are little or no equipment and facilities for management needs 1: There are some equipment and facilities but these are inadequate for most management needs 2: There are equipment and facilities, but still some gaps that constrain management 3: There are adequate equipment and facilities
Comments and Next Steps				
19. Maintenance of equipment: Is equipment adequately maintained?				0: There is little or no maintenance of equipment and facilities 1: There is some ad hoc maintenance of equipment and facilities 2: There is basic maintenance of equipment and facilities 3: Equipment and facilities are well maintained
Comments and Next Steps				
20. Education and awareness: Is there a planned education programme linked to the objectives and needs?				0: There is no education and awareness programme 1: There is a limited and ad hoc education and awareness programme 2: There is an education and awareness programme but it only partly meets needs and could be improved 3: There is an appropriate and fully implemented education and awareness programme

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter "N/A" in the comments space along with a brief explanation.				
Comments and Next Steps				
21. Planning for land and water use: Does land and water use planning recognise the protected area and aid the achievement of objectives?				0: Adjacent land and water use planning does not take into account the needs of the protected area and activities/policies are detrimental to the survival of the area 1: Adjacent land and water use planning does not takes into account the long term needs of the protected area, but activities are not detrimental the area 2: Adjacent land and water use planning partially takes into account the long term needs of the protected area 3: Adjacent land and water use planning fully takes into account the long term needs of the protected area
Comments and Next Steps				
21a. Land and water planning for habitat conservation: Planning and management in the catchment or landscape containing the protected area incorporates provision for adequate environmental conditions (e.g. volume, quality and timing of water flow, air pollution levels etc) to sustain relevant habitats.				0: No 1: Yes
Comments and Next Steps				

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter "N/A" in the comments space along with a brief explanation.				
21b. Land and water planning for connectivity: Management of corridors linking the protected area provides for wildlife passage to key habitats outside the protected area (e.g. to allow migratory fish to travel between freshwater spawning sites and the sea, or to allow animal migration).				0: No 1: Yes
Comments and Next Steps				
21c. Land and water planning for ecosystem services and species conservation: "Planning adresses ecosystem-specific needs and/or the needs of particular species of concern at an ecosystem scale (e.g. volume, quality and timing of freshwater flow to sustain particular species, fire management to maintain savannah habitats etc.)"				0: No 1: Yes
Comments and Next Steps				

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter “N/A” in the comments space along with a brief explanation.				
22. State and commercial neighbours:Is there co-operation with adjacent land and water users?				0: There is no contact between managers and neighbouring official or corporate land and water users 1: There is contact between managers and neighbouring official or corporate land and water users but little or no cooperation 2: There is contact between managers and neighbouring official or corporate land and water users, but only some co-operation 3: There is regular contact between managers and neighbouring official or corporate land and water users, and substantial co-operation on management
Comments and Next Steps				
23. Indigenous people: Do indigenous and traditional peoples resident or regularly using the protected area have input to management decisions?				0: Indigenous and traditional peoples have no input into decisions relating to the management of the protected area 1: Indigenous and traditional peoples have some input into discussions relating to management but no direct role in management 2: Indigenous and traditional peoples directly contribute to some relevant decisions relating to management but their involvement could be improved 3: Indigenous and traditional peoples directly participate in all relevant decisions relating to management, e.g. co-management
Comments and Next Steps				

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter "N/A" in the comments space along with a brief explanation.				
24. Local communities: Do local communities resident or near the protected area have input to management decisions?				0: Local communities have no input into decisions relating to the management of the protected area 1: Local communities have some input into discussions relating to management but no direct role in management 2: Local communities directly contribute to some relevant decisions relating to management but their involvement could be improved 3: Local communities directly participate in all relevant decisions relating to management, e.g. co-management
Comments and Next Steps				
24 a. Impact on communities: There is open communication and trust between local and/ or indigenous people, stakeholders and protected area managers				0: No 1: Yes
Comments and Next Steps				
24 b. Impact on communities: Programmes to enhance community welfare, while conserving protected area resources, are being implemented				0: No 1: Yes
Comments and Next Steps				
24 c. Impact on communities: Local and/ or indigenous people actively support the protected area				0: No 1: Yes
Comments and Next Steps				

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter "N/A" in the comments space along with a brief explanation.				
25. Economic benefit: Is the protected area providing economic benefits to local communities, e.g. income, employment, payment for environmental services?				0: The protected area does not deliver any economic benefits to local communities 1: Potential economic benefits are recognised and plans to realise these are being developed 2: There is some flow of economic benefits to local communities 3: There is a major flow of economic benefits to local communities from activities associated with the protected area
Comments and Next Steps				
26. Monitoring and evaluation: Are management activities monitored against performance?				0: There is no monitoring and evaluation in the protected area 1: There is some ad hoc monitoring and evaluation, but no overall strategy and/or no regular collection of results 2: There is an agreed and implemented monitoring and evaluation system but results do not feed back into management 3: A good monitoring and evaluation system exists, is well implemented and used in adaptive management
Comments and Next Steps				
27. Visitor facilities: Are visitor facilities adequate?				0: There are no visitor facilities and services despite an identified need 1: Visitor facilities and services are inappropriate for current levels of visitation 2: Visitor facilities and services are adequate for current levels of visitation but could be improved 3: Visitor facilities and services are excellent for current levels of visitation
Comments and Next Steps				

Data Sheet 4: METT Assessment Form				
Please select a score from the drop-down list for each question. If a question is not applicable, then do not select a score and enter "N/A" in the comments space along with a brief explanation.				
28. Commercial tourism operators: Do commercial tour operators contribute to protected area management?				0: There is little or no contact between managers and tourism operators using the protected area 1: There is contact between managers and tourism operators but this is largely confined to administrative or regulatory matters 2: There is limited co-operation between managers and tourism operators to enhance visitor experiences and maintain protected area values 3: There is good co-operation between managers and tourism operators to enhance visitor experiences, and maintain protected area values
Comments and Next Steps				
29. Fees: If fees (i.e. entry fees or fines) are applied, do they help protected area management?				0: Although fees are theoretically applied, they are not collected 1: Fees are collected, but make no contribution to the protected area or its environs 2: Fees are collected, and make some contribution to the protected area and its environs 3: Fees are collected and make a substantial contribution to the protected area and its environs
Comments and Next Steps				
30. What is the overall condition of the biodiversity of the protected area in terms of the indicator(s) indicated in Data Sheet 2 above?				0: Severely degraded 1: Partially degraded 2: Mostly intact 3: Completely intact
Comments and Next Steps	**Please complete Data Sheet 5 for Question 30 that follows below.**			
Total METT Score (automatically calculated)	**0**	**0**	**0**	**Provide comments here (optional)**

Data Sheet 5: Data sources and methods used to assess the present overall condition of biodiversity in the protected area (METT Question 30, above).		
Summarize the data sources used to track the indicator(s) given in Data Sheet 2, and outline the method for assessing the indicator results. The indicator(s) will automatically appear in this table once entered in Data Sheet 2. This table (Data Sheet 5) should be updated, as appropriate, during each application of the METT. An example is provided.		
Indicator	**Summarize the data sources used to track this indicator**	**Outline the method used for assessing the indicator results and what these show about the condition of biodiversity**
Example: Average total area of grassland burnt by fire per year	*Records of fire events during the period of monitoring - showing the extent of the area burnt, as recorded by park rangers using hand-held GPS devices to plot boundaries of area and calculate total number of hectares*	*- Observation of overall trend – more, less or same amount of fire disturbance* *- Reference to scientific literature on ecosystem types to understand optimum fire intervals* *- Examination of fire record to determine historical trends in fires in the PA* *- Analysis of pattern to determine fire frequency in particular parts of PA in and beyond monitoring period*
Indicator 1		
Indicator 2		
Indicator 3		
Indicator 4		
Indicator 5		

GEF 6: Objective 1: Catalyzing Sustainability of Protected Area Systems
SECTION III: Financial Sustainability Scorecard
Note: Please complete the financial sustainability scorecard for each project that is focusing on improving the financial sustainability of a PA system or an individual PA, per outcome 1.2 in the GEF biodiversity strategy. **The Financial Sustainability Scorecard has three sections:** Part I – Overall financial status of the protected areas system. This includes basic protected area information and a financial analysis of the national protected area system. Part II – Assessing elements of the financing system. Part III – Scoring.
PLEASE NOTE THAT THIS TOOL IS ONLY FOR USE FOR GEF-6 PROJECTS.
Part I: Protected Areas System, sub-systems and networks
Part I requires financial data to determine the costs, revenues and financing gaps of the PA system both in the current year and as forecast for the future. It provides a quantitative analysis of the PA system and shows the financial data needed by PA planners needed to determine financial targets and hence the quantity of additional funds required to finance effective management of their PA system. As different countries have different accounting systems certain data requirements may vary in their relevance for each country. However, where financial data is absent, the first activity the PA authority should be to generate and collect the data.
Part 1.1 – Basic Information on Country's National Protected Area System, Sub-systems and Networks.
Please only complete the elements of the table that are germane to the scope of the project's interventions.

Protected Areas System, sub-systems and networks	Number of sites	Terrestrial hectares covered	Marine hectares covered [1]	Total hectares covered	Institution responsible for PA management
National System of Pas					
Sub-system					
PA sub-system 1 – insert name					
PA sub-system 2 - insert name					
Additional Sub-Systems					
Network					
Network 1 - insert name					
Network 2 – insert name					
Additional networks					

EXPLANTORY NOTES

[1] MPAs should be detailed separately to terrestrial PAs as they tend to be much larger in size and have different cost structures

Part 1.2 – Financial Analysis of the National Protected Area System			
Financial Analysis of the Sub-System or Network –[insert name of Sub-System or Network]	**Baseline year (US$)** [1][2]	**Year X (US$)** [3][4]	**Comments** Add the source of data and state confidence in data (low, medium, high). Please respond to explanatory notes below
Available Finances [5]			
(1) Total annual central government budget allocated to PA management (excluding donor funds and revenues generated for the PA system)			
- operational budget (salaries, maintenance, fuel etc)			
- infrastructure investment budget (roads, visitor centres etc)			
(2) Extra budgetary funding for PA management (total of A + B)	0		Specify sources of funds
A. Funds channelled through government – total			
- PA dedicated taxes			eg a conservation departure tax or water fees re-invested in PAs
- Trust Funds			Only include available funds for the year and not amounts contributed for capitalization
- Donor funds			
- Loans			
- Debt for nature swaps			
- Others			
B. Funds channelled through third party/independent institutional arrangements – total			
- Trust Funds			
- Donor funds			
- Loans			
- Others			
(3) Total annual site based revenue generation across all PAs broken down by source [6]	0		Indicate total economic value of PAs (if studies available)[7]

Part 1.2 – Financial Analysis of the National Protected Area System			
Financial Analysis of the Sub-System or Network –[insert name of Sub-System or Network]	**Baseline year (US$)** [1][2]	**Year X (US$)** [3][4]	**Comments** Add the source of data and state confidence in data (low, medium, high). Please respond to explanatory notes below
A. Tourism entrance fees			Specify the number of visitors to the protected areas in year X, international and national. Specify fee levels; Estimate % of overall fees generated by most popular PAs within the system (as often a high % of fees may be generated by only one or two PA sites); Estimate total revenues possible if fee level raised.
B. Other tourism and recreational related fees (camping, fishing permits etc)			Specify purpose and level of fees:
C. Income from concessions			Specify type of concession
D. Payments for ecosystem services (PES)			Provide examples:
- water			
- carbon			
- biodiversity			
E. Other non-tourism related fees and charges (specify each type of revenue generation mechanism)			
- scientific research fees			
- genetic patents			
- pollution charges			
- sale of souvenirs from state run shops			
(4) Percentage of PA generated revenues retained in the PA system for re-investment [8]			Specify whether PA generated revenues are retained directly in the PA system or are sent to government and then returned back to the PA system
(5) Total finances available to the PA system [line items 1 + 2]+ [line item 3 * line item 4]	0		
Available for operations			
Available for infrastructure investment			
Costs and Financing Needs			

Part 1.2 – Financial Analysis of the National Protected Area System			
Financial Analysis of the Sub-System or Network –[insert name of Sub-System or Network]	**Baseline year (US$)** [1][2]	**Year X (US$)** [3][4]	**Comments** Add the source of data and state confidence in data (low, medium, high). Please respond to explanatory notes below
(1) Total annual expenditure for PAs (all PA operating and investment costs and system level expenses) [9]			State any extraordinary levels of capital investment in a given year State degree of disbursement/ executed – total annual expenditures as % of available finances (line item 5.) If this % is low, state reasons:
- by government			
- by independent/other channels			
(2) Estimation of PA system financing needs			Where possible breakdown by terrestrial and marine sub-systems
A. Estimated financing needs for *basic* management costs (operational and investments) to be covered			Summarize methodology used to make estimate (eg costs detailed at certain sites and then extrapolated for system)
- PA central system level operational costs (salaries, office maintenance etc)			
- PA site management operational costs			
- PA site infrastructure investment costs			
- PA system capacity building costs for central and site levels (training, strategy, policy reform etc)			These system capacity building needs are additional to daily operations but critical for system development and are often covered by donors
B. Estimated financing needs for *optimal* management costs (operational and investments) to be covered			Summarize methodology used to make estimate
- PA central system level operational costs (salaries, office maintenance etc)			
- PA site management operational costs			
- PA site infrastructure investment costs			
- PA system capacity building costs for central and site levels (training, strategy, policy reform etc)			These system capacity building needs are additional to attaining basic management capacities and may entail additional scientific research, public communications, scholarships etc)

Part 1.2 – Financial Analysis of the National Protected Area System			
Financial Analysis of the Sub-System or Network –[insert name of Sub-System or Network]	**Baseline year (US$)** [1][2]	**Year X (US$)** [3][4]	**Comments** Add the source of data and state confidence in data (low, medium, high). Please respond to explanatory notes below
C. Estimated financial needs to expand the PA systems to be fully ecologically representative			Insert additional costs required for land purchase for new PAs:
- basic management costs for new PAs			
- optimal management costs for new PAs			
Net actual annual surplus/deficient (available finances - expenditure)			
Net actual annual surplus/deficit[11]	0		
Annual financing gap (financial needs – available finances)[10]			
(1) Annual financing gap for *basic* management scenarios	0		Where possible breakdown by terrestrial and marine sub-systems
Operations			
Infrastructure investment			
(2) Annual financing gap for *optimal* management scenarios	0		
Operations			
Infrastructure investment			
(3) Annual financing gap for basic management of an expanded PA system (current network costs plus annual costs of adding more PAs)	0		
(4) Projected annual financing gap for basic expenditure scenario in year X+5[12],[13]			
Financial data collection needs			
Specify main data gaps identified from this analysis:			
Specify actions to be taken to fill data gaps[14]:			

EXPLANATORY NOTES

[1] The baseline year refers to the year the Scorecard was completed for the first time and remains fixed. Insert year eg 2007.

[2] Insert in footnote the local currency and exchange rate to US$ and date of rate (eg US$1=1000 colones, August 2007)

[3] X refers to the year the Scorecard is completed and should be inserted (eg 2008). For the first time the Scorecard is completed X will be the same as the baseline year. For subsequent years insert an additional column to present the data for each year the Scorecard is completed.

[4] Insert in footnote the local currency and exchange rate to US$ and date of rate

[5] This section unravels sources of funds available to PAs, categorized by (i) government core budget (line item 1), (ii) additional government funds (line item 2), and (iii) PA generated revenues (line item 3).

[6] This data should be the total for all the PA systems to indicate total revenues. If data is only available for a specific PA system specify which system

[7] Note this will include non monetary values and hence will differ (be greater) than revenues

[8] This includes funds to be shared by PAs with local stakeholders

[9] In some countries actual expenditure differs from planned expenditure due to disbursement difficulties. In this case actual expenditure should be presented and a note on disbursement rates and planned expenditures can be made in the Comments column.

[10] Financing needs as calculated in (8) minus available financing total in (6)

[11] This will likely be zero but some PAs may have undisbursed funds and some with autonomous budgets may have deficits

[12] This data is useful to show the direction and pace of the PA system towards closing the finance gap. This line can only be completed if a long term financial analysis of the PA system has been undertaken for the country

[13] As future costs are projected, initial consideration should be given to upcoming needs of PA systems to adapt to climate change which may include incorporating new areas into the PA system to facilitate habitat changes and migration

[14] Actions may include (i) cost data based on site based management plans and extrapolation of site costs across a PA system and (ii) revenue and budget accounts and projections

13

Participatory Mapping Of Local Knowledge And Resource Use

13. PARTICIPATORY MAPPING OF LOCAL KNOWLEDGE AND RESOURCE USE

13.1 Background

Participatory mapping is a general term used to define a growing toolbox of techniques that can help communities make coastal area use decisions. These maps go beyond the physical features portrayed in traditional maps; nearly everything valued by the community can be expressed in spatial terms and represented on a participatory map, including social, cultural, and economic features. The process used to create the maps is as valuable as the maps themselves, since participants often find themselves more fully engaged than they would have otherwise (NOAA, 2009).

Coastal communities and marine resource users (e.g. fishers, traders and tourism operators) tend to be extremely knowledgeable about their local environment as this is where they live and work on a daily basis. This type of local knowledge can be invaluable when planning to establish a new MPA, work within an existing MPA, or indeed just planning to survey a new area. It is, therefore, often extremely useful to be engaged with local users to find out what they know about the local environment, if, how and when they or others use the area and associated resources, as well as any unusual observations, specific concerns or issues.

Consulting with local stakeholders is particularly useful when preparing a zoning plan for a new or existing MPA, as good up-to-date information about how the local community are using the area and resources; this can help in defining the zone types and boundaries and for developing adaptive management strategies. Understanding the current resource use patterns and the attitudes of different marine resource uses can help to minimize existing and prevent new conflicts. This information can also help to identify ways to reduce pressure on particularly sensitive marine resources as part of the planning process.

13.2 Overview

13.2.1 General Approach

The aim of participatory mapping surveys is to capture spatial data on the characteristics of an area and the distribution of habitats, species and human activities from local communities and other resource users who frequently visit the area on a regular basis. Collecting this type of local knowledge and other types of spatial data about the distribution of resource use patterns is normally done through informal interviews with individuals or focused groups, with informant groups of between 5 to 10 informants. Before conducting the interviews there is some preparatory work needed to ensure that the information obtained is as complete as possible. The preparatory steps include: (i) identifying the different coastal and marine resource user groups to ensure that all user groups are included; (ii) planning and deciding how to be engaged with different user groups and organise the interviews and; (iii) preparing survey forms and maps for use as a visual aid to promote discussion and record the information.

13.2.2 Target

The target for these types of surveys are the local marine communities and resource users. These groups will likely be different in each situation. The following list provides some examples of the types of groups that may need to be targeted:

- Coastal fisher communities/villages/settlements
- SCUBA dive operators
- Tour guides/tour operators
- Hotel owners/bed and breakfast facilities
- Traders (e.g. fish buyers, beach sellers etc.)

13.2.3 Field equipment

The equipment needed for these surveys includes:

- Maps or charts of the area of interest. Ideally these maps would be large poster sized maps (A0 or A1 sized) using satellite imagery printed in colour. The maps can show the location of the villages, but it should not show the boundaries of any marine protected area as this may bias the responses from informants. The maps would ideally be laminated (encapsulated in plastic) so that they can be reused. Laminated maps can be written on using a permanent marker pen and then photographed at the end of the interviews before being cleaned. If it is not possible to laminate the maps the alternative is to have one colour copy and then multiple black and white copies of the same maps that the interviewer can write on.
- Permanent marker pens that can be used on the laminated maps or coloured pens for use on black and white photocopies.
- Survey forms and crib sheets
- Notebook and pen

13.2.4 Field personnel

Participatory knowledge and resource use surveys ideally require a minimum of two interviewers per informant group. The surveys can be done by one person, but with two, one person can ask the questions while the other person completes the survey form and marks the areas on maps.

13.2.5 Training/experience

The interviewers, as well as being able to read and write, need to be comfortable communicating in the local dialect and they need to be trained in how to complete the surveys forms. Training in how to complete the surveys can be done in a classroom setting, with trainees practicing on each other. Ideally the trainees would then participate in an actual survey alongside a more experienced surveyor before being asked to undertake the surveys independently. These types of surveys could be conducted by recent undergraduate students following a suitable level of training.

13.3 Field Procedure

13.3.1 Identification of coastal and marine resource uses

The first step in planning for these types of participatory surveys is to identify the local resident communities and other resource user groups and the different types of extractive and non-extractive activities that these groups carry out. The scoping study to identify resident populations, resource user group and activities could be done from a desk-based literature review of secondary sources or through discussions with the local authorities or users themselves.

13.3.2 Stakeholder engagement plan

Once the local communities, different activity types and user groups have been identified the next step is to work out how best these groups can be engaged so as to maximise the amount of information that can be collected during the surveys. For example, if the purpose of the survey is to discuss resource use patterns with fishers from different settlements along a long stretch of coast, it might be best to plan a road trip to visit each settlement. If, however, the scoping study identifies that there is a cluster of marine resource users that all aggregate in a common location (e.g. fishing landing site or the local port), then it might be better to organise an informal workshop at this location.

When organising the focus group interviews or workshop it is important to try to ensure that the people in the group are representatives of the larger grouping. If, for example, the focus group meeting is to be held in a village next to where there is a new proposed protected area, it is important that the individuals in the group are representatives of the different sectors of society within that village (e.g. women, farmers, fishers, traders etc). During the focus group meeting it is essential that the interviewer makes sure that they get information from all of the representatives.

13.3.3 Conducting the Focus Group Interviews

It is important that the interviewers are well prepared so that nothing is forgotten and the interview is successful. This means that the interviewers must know what they are going to discuss with the focus group before meeting with them and how they are going to start and encourage discussion. The following provides some general guidance on how to conduct these types of interviews.

Introduction

Before starting the consultations it is always good for the interviewer to introduce themselves and the purpose of the meeting, so as to reassure the group and allay any concerns or suspicions. To do this the interviewers would:

- Introduce themselves (briefly)
- Explain the purpose of the meeting (e.g. *We are doing a survey for a project concerned with developing a zoning plan for the MPA. It is very important that we discuss this with people who live in and use the area. We would like to find out more about your activities, so that we can take better account of these when designing the plan, and to find out what you think is important about the area*).
- Tell the informants how long the meeting is expected to be (maximum of 2 hours)
- Ask the participants to introduce themselves and their activity (name, age, fishing gear used if fishers, product traded if traders etc).

The interviewers should take notes during this initial discussion to help them remember the names of the people present and their main livelihood activities.

Listen

It is always important for the interviewer to be courteous and listen to what people have to say; they know more about the area and the activities. It is also important to ensure that all of the people present in the group are encouraged to speak and listen to each other.

Prompt

The interviewer should try to make sure that the people present in the group speak on behalf of the wider group that they represent. The interviewer can help encourage this in how they ask the questions. For example, instead of asking the question "do you fish on the reef" the interviewer would ask the question "do <u>all</u> fishermen fish on the reef?", "do <u>all</u> fish traders sell their fish at the market?" etc. Then following up with a question "if they do not fish on the reef, where do they fish?". These are more open questions that encourage the participants to respond on behalf of the group they represent instead of as an individual.

Participation

Everyone should have the opportunity to speak. It is the responsibility of the interviewer to make sure that all the people in the group speak and that the persons involved in the activity being discussed are given the opportunity to speak (if the group is mixed).

Guidance on taking notes

- When completing the survey forms, the interviewer who is writing, needs to make sure that the notes are clearly written to make it easier for the person who will enter the data.
- The information should be written down in full and all forms should be double-checked at the end of the day, when the responses are still fresh in the mind of the interviewer.
- The survey forms help guide the interviewers to make sure that all the different themes are covered. The group discussion may diverge onto another topic, which may be interesting, but it is the job of the interviewer to bring the discussion back to around.
- When conducting these types of surveys, it is always useful to have a notebook as well as the survey form, so that any additional comments can be captured.

13.3.4 Participatory Mapping Resource Use - Fishers

The mapping of resource use by fishers is normally done before the mapping of local knowledge, as this minimises the risk of bias. With the map on display the interviewer should take a few minutes to explain the map to the informants, to point out distinctive features on the map so that the group can orient themselves. The interviewer then explains that they would like to find out more about the types of fishing and where these activities are carried out.

- The interviewer should ask the fishermen to draw on the map the areas where they fish. The areas should be drawn as accurately as possible. Each area should represent a different type of fishing, a different time of the year, or a different target species etc.
- When the fishermen have finished drawing on the map, the interviewer numbers each of the fishing areas by writing numbers next to each of the areas drawn on the map.
- The interviewers then need to complete the survey form. To complete the survey form the interviewer writes the number of a fishing area and asks the fishers the following questions:
    - ◊ Is there a local name for that fishing area?
    - ◊ What do they go there to fish for? (i.e. what is the target species). If there is more than one target species, then get the group to rank them according to their importance.
    - ◊ What is the characteristics of the fishing area? (e.g. is it sandy/coral/seagrass).
    - ◊ What fishing gear/method do they use? (i.e. line, basket trap, seine net etc). If they use more than one gear type, then rank them according to their importance for that fishing area.
    - ◊ How many hooks do they use / how big is the net / how many traps do they

put down in that area? What bait do they use in the trap for which fish?

◊ Do they fish there using a boat or on foot? Does the boat have an engine? What size is the engine?

◊ Which months of the year do they fish there?

◊ When do they fish there (e.g. day/night, high tide/low tide, full moon)?

- Once the survey form has been completed for all of the areas marked on the map, the interviewer then needs to ask the informants the following questions:

  ◊ Are there any conflicts between resource user groups in the area? Which groups are in conflict with them (not personal) and why?

  ◊ Any other comments?

If there are a large number of fishers in the group then it may be appropriate to subdivide the fishers according to the different gear types and to use different maps. If not, then information can go on the same map.

When the survey form is completed, the interviewers should take a photograph of the map and the survey forms. The interviewer should then thank the informants for their assistance and explain that they would like to ask them some more questions about the area.

13.3.5 **Participatory Mapping Resource Use - Others**

The mapping of resource use by other marine resource user groups is normally done before the mapping local knowledge, as this again minimises the risk of bias. With the map on display the interviewer, should take a few minutes to explain the map to the informants, to point out distinctive features on the map so that the group can orientate themselves. The interviewer then explains that they would like to find out more about their activities and where these activities are carried out. The following question are example questions that an interviewer would ask a tour operator (e.g. dive operator, hotel guest-house owner):

- Ask the tour operator to draw on the map the areas where they offer activities. Ask them to draw the areas as specifically as possible (i.e. different areas for different types of activity, different times of the year etc.)
- Once they have finished drawing on the map, the interviewer should number each of the areas on the map.
- The interviewer then needs to ask the informants the following questions:

  ◊ What is the name of the area (site)?

  ◊ What are the characteristics of the site (e.g. sand/coral/seagrass).

  ◊ What are the main activities (for diving, please say whether they are training dives or pleasure dives for experienced divers). If there are more than one, then rank them according to importance.

  ◊ How often do they take tourists to that site?

  ◊ Which months of the year do they take tourists there?

  ◊ How many people do they take in one trip (record the average and maximum)?

  ◊ Which areas are most important to them economically (or are they all the same?). If there are more than one, then rank them according to importance.

- Once the survey form has been completed for all of the areas marked on the map, the interviewer then needs to ask the informants the following questions:

◊ Are there any conflicts between resource user groups in the area? Which groups are in conflict with them (not personal) and why?

◊ Any other comments?

13.3.6 Participatory Mapping of Local Knowledge - All users

The next set of questions relate to local knowledge about the area. Using another map ask the informants the following questions:

Local knowledge

- Do they feel that there is anything special about the area? (e.g. are there lots of juvenile fish, healthy corals or species that aren't found anywhere else?)
- Can they map the areas where they would expect to find focal species/habitats?
- Have they noticed any changes in the state of the marine environment over the past 5 years – is it better or worse? (e.g. have the catches changed over the past 5 years?)
- Are there any other comments? e.g. Do they think that the area is healthy?

Protected Status

If the area is under consideration as a newly proposed MPA, the interviewers can ask the following questions:

- Have they heard about the proposal for the new MPA?
- What do they think about the potential benefits of an MPA?
- Do they have any concerns about a new MPA?
- Which areas do they think are very important and should be protected?

If the area is already protected, then the interviewer can ask the following questions:

- Have they heard about the MPA?
- What are the benefits of an MPA? What do they think is working well?
- Do they have any concerns about the MPA? What is not working well?
- What would make the MPA work better?
- What activities do you they think should be regulated inside the MPA?
- What activities would they not like to see regulated inside the MPA?
- Are they aware of the boundaries of the MPA? Ask them to draw on the map where they think the boundaries of the MPA should be.

If the informants are fishers the interviewer can ask the following questions:

- How many people from your village fish inside the MPA?
- If so where do they fish? If they use more than one MPA, get them to rank them in terms of the frequency of visits and in terms of their importance.
- Do fishers from other villages fish in the MPA? Which villages?
- What types of fishing take place inside the MPA?
- What is the most important type of fishing that takes place in the MPA? If they use more than one type of gear, get them to rank them in terms of their importance.
- Where are the fish/octopus/invertebrates sold?
- What other activities take place inside the MPA (e.g. tourists diving, snorkelling).

If the informant is another type of resource user (e.g. tourism operator) the interviewer can ask the following questions:

- Do they carry out activities inside the MPA? If so what area do they visit? If they use more than one MPA, get them to rank them in terms of the frequency of visits and in terms of their importance.
- What tourist activities take place inside the MPA?
- What is the most important type of activity that takes place in the MPA? If they do more than one activity, get them to rank them in terms of the importance.
- What other activities take place inside the MPA (e.g. tourists diving, snorkelling).
- Are there any conflicts? Which groups are in conflict with the groups represented in the Focus groups (we are not interested in personal conflicts!) and why?
- Any other comments?

13.4 Strengths and Weaknesses

Strengths	Weaknesses
◊ Marine resource users living in or near the study area often have a very good understanding and knowledge about the characteristics of the area. ◊ The method is comparatively simple to carry out following training, and delivers a large amount of information. ◊ The data collected using this method is very useful for zoning MPAs, for identifying areas of potential conflict between resource uses. ◊ The method can be easily adapted for use with different groups of marine resource users by simply adjusting the questions	◊ The boundaries of the areas drawn on the map are not always entirely accurate and may require field verification if they were to be used for zoning for example. ◊ To make best use of these data, it needs to be transferred into a digital format so the datasets can be overlaid on top of one another. This does requires some expertise in GIS.

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13.6 Annexes

PARTICIPATORY MAPPING SURVEYS – RESOURCE USE (FISHERS)	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti etc.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Time	Record the start and end time for the survey.
Interviewers	Record the initials for the surveyors involved in the survey.
Informants	Record the name of the informants being interviewed
SITE INFORMATION	
Number (as on map)	Ask the informant to draw on the map what areas they use. Number the area on the map and record the number of the area drawn on the map on the survey form.
Location name	Ask the informant if the area has a local name. Record the location name on the survey form.
Target species	Ask the informant to what type of fish they target in that area. Record the target species (e.g. Trochus) or species group (e.g. Nagil)
Habitat characteristics	Ask the informant to describe the habitat where the fishing takes place (e.g. is it coral, sand, seagrass, mangrove etc.). Record the habitat type.
Fishing method	Ask what type of gear the fisher uses to target that species. Record the gear type.
Means of propulsion	Ask the fisher what type of boat they use (e.g. dugout, houri, sambuk) and record whether or not the boat has an engine.
Time of year	Ask the informant if these observations were made at a specific time of year; e.g. is the species present all the year round or only during certain months. Record which months the observations were made by ticking the boxes.
Time of day	Ask if there is a specific time of day or state of tide when the fisher fishes in the area.
Has there been any change in the past 5 years?	Ask the informant if they have noticed any changes in the past 5 years, in terms of the presence or abundance of the species.
Additional comments	Ask the informant if they noticed the animals behaving in a certain way (feeding, mating etc), or if there was any injury to the animals (scars, fishing line hooks etc).
Notes	Use this space to record any additional information reported by the informants; such as observations reported by

PARTICIPATORY MAPPING SURVEY - RESOURCE USE (FISHERS) (Level 2) **Sheet Number_________**

Country:	Location	Date:	Time:
Interviewer 1:		Informants name and age:	
Interviewer 2:			

No. (as on map)	Loca-tion name	Target species (e.g. grouper, sea cucum-ber, lobster, shark)	Habitat characteris-tics (sand/ algae/ coral/ seagrass)	Fishing ethod(e.g. fishing gear type)	Means of propulsion (boat with engine (size) / without engine / foot)	Month of the year												Time of day or state of tide	Changes in the last 5, 10 or 20 years? (number of years and change)
						January	February	March	April	May	June	July	August	September	October	November	December		

Comments	Conflicts: Ask the fisher if there are other groups (e.g.: fishers using different gears, authorities, traders, tourist groups….) with which the fishers are in conflict with and REASON for the conflict

PARTICIPATORY MAPPING SURVEYS – RESOURCE USE (OTHERS)	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti etc.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Time	Record the start and end time for the survey.
Interviewers	Record the initials for the surveyors involved in the survey.
Informants	Record the name of the informants being interviewed
SITE INFORMATION	
Number (as on map)	Ask the informant to draw on the map what areas they use. Number the areas on the map and record the numbers on the map on the survey form.
Location name	For the first area, ask the informant if the area has a local name? Record the location name on the survey form.
Activity	Ask the informant what type of activity they do in that area. Record the type of activity (e.g. snorkelling, SCUBA diving, walking)
Habitat characteristics	Ask the informant to describe the habitat where the activity takes place (e.g. if it is coral, sand, seagrass, mangrove etc.). Record the habitat type.
Activity details	Ask for more details about the specific activity in that area, how many people do they take? etc
Means of propulasion	Ask what type of boat they use (e.g. dugout, houri, sambuk) to access the area and record the type of boat and whether or not the boat has an engine.
Time of year	Ask the informant if these activities take place at a specific time of year; e.g. snorkelling is offered to tourists between September and June. If so how often do the activities take place during each month and how big are the groups. Record the number of times the activities take place and how many people per trip in brackets.
Has there been any change in the past 5, 10, 20 years?	Ask the informant if they have noticed any changes in the past 5, 10, 20 years. Record the number of years and the changes observed.
Conflicts	Ask the informant if there are other groups (e.g.: fishers using different gears, authorities, traders, tourist groups….) with which the informants are in conflict with and the REASON for the conflict.
Additional comments	Ask the informants if they have any other comments about this area.
Notes	Use this space to record any additional information reported by the informants; such as observations reported by

PARTICIPATORY MAPPING SURVEY - RESOURCE USE (OTHERS) (Level 2) **Sheet Number_________**

Country:	Location	Date:	Time:
Interviewer 1:		Informants name and age:	
Interviewer 2:			

No. (as on map)	**Location name**	**Activity** (e.g. swim-ming, snor-kelling, diving, sailing, fishing)	**Habitat charac-teristics** (e.g. sand/ algae/ coral/sea-grass)	**Details** (e.g. gear type or other specific details)	**Means of propul-sion** (boat with en-gine (size) / without engine / foot)	**Number of trips / activity per month** + (group size)												Time of day or state of tide	Changes in the last 5, 10 or 20 years? (number of years and change)
						January	February	March	April	May	June	July	August	September	October	November	December		

Comments	Conflicts: Ask the informant if there are other groups (e.g.: fishers using different gears, authorities, traders, tourist groups….) with which the informants are in conflict with and the REASON for the conflict.

PARTICIPATORY MAPPING SURVEYS – LOCAL KNOWLEDGE (ALL USERS)	
SURVEY INFORMATION	
Country	Record the country code. e.g. SUD = Sudan, YEM = Yemen, DJI = Djibouti etc.
Location	Record the location of where the surveys are taking place (e.g. nearest village or site name, orientation of coast).
Date	Record the date using the format YYMMDD (year, month, day) e.g. 150312 for the 12th March 2015.
Time	Record the start and end time for the survey.
Interviewers	Record the initials for the surveyors involved in the survey.
Informants	Record the name of the informants being interviewed
SITE INFORMATION	
Number (as on map)	Ask the informant to draw on the map where they made the observation. Number the area on the map and record the number of the area drawn on the map on the survey form.
Location name	Ask the informant if the area has a local name. Record the location name where the observation was maded.
What is special about this area?	Ask the informant to say which species they observed in the area or what behaviour was observed in the area, why it is special. Record why the area is special. Use the species identification key to see if the informant can reocgnise the species.
Habitat characteristics	Ask the informant to describe the habitat where the observation was made (e.g. if it is coral, sand, seagrass, mangrove etc.)
Time of year	Ask the informant if these observations were made at a specific time of year; e.g. is the species present all year round or only during certain months. Record which months the observations were made by ticking the boxes.
Has there been any changes in the past 5 years?	Ask the informant if they have noticed any changes in the past 5 years, in terms of the presence or abundance of the species.
Additional comments	Ask the informants if they have noticed the animals behaving in a certain way (feeding, mating etc).or if there was any damage to the animals (scars, fishing line hooks etc).
Notes	Use this space to record any additional information reported by the informants; such as observations reported by

PARTICIPATORY MAPPING SURVEY - LOCAL KNOWLEDGE (ALL USERS)

Country:	Location	Date:	Time:
Interviewer 1:		Informants name and age:	
Interviewer 2:			

No. (as on map)	**Location name**	**What is special about this area? (e.g. species found, spawning, nesting, feeding ground)**	**Habitat characteristics (e.g sand/algae/ coral/seagrass)**	**Time of year**												Has the area / number of animals changed in the last 5, 10, 20 years? (number of years and what changes have been observed)	Additional comments (behaviour e.g. foraging, mating, aggregation? calves or adults or both)
				January	February	March	April	May	June	July	August	September	October	November	December		

NOTES