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Module 5: Assessing Mass Coral Bleaching, Resilience, and Socioeconomic Impacts

Section 1: Assessing the Ecological Impacts of Mass Coral Bleaching

Learning Objectives

By the end of this module you will have:

- An understanding of why we need to assess the ecological impacts of mass coral bleaching.
- The ability to identify bleached corals.
- The ability to assess the geographic extent and severity of a mass bleaching event.
- An understanding of how bleaching assessments differ to normal monitoring.
- In-water experience carrying out a bleaching impact assessment.

Background

In previous modules, you learned about the impacts of climate change to coral reefs and what resilience is and how to identify factors that confer resilience. This module will provide a overview of how to assess the ecological and socioeconomic impacts of mass coral bleaching and how to incorporate resilience into monitoring programs. This section deals with one of the first steps in a response strategy that managers should take when a mass bleaching event occurs. When mass bleaching occurs, managers must rapidly assess the extent and severity of bleaching in order to make timely and effective management decisions and communicate the situation to stakeholders, managers, government departments and the media. One goal of this section is to provide managers with the skills and knowledge necessary to assess the impacts of bleaching on coral communities and ecosystem processes. Certain reef areas may escape bleaching or may recover rapidly from bleaching due to underlying physical characteristics of the local reef environment or physiological attributes of the coral community present. The occurrence of a mass bleaching event provides managers with an opportunity to identify resilient reef areas, gain an understanding of the underlying causes of resilience, and incorporate these factors into management planning. To that end, another goal of this section is to provide managers with the ability to identify resilient reef areas and incorporate resilience monitoring into bleaching assessment protocols.

When a mass bleaching event occurs, reef users, other stakeholders, the media, and senior government officials will want to know: 'How bad is it? What are the impacts to the reef?' and 'What will it mean for the local stakeholder community?' Managers must rapidly assess the extent and severity of mass bleaching in order to make timely and effective management decisions and communicate the situation to others. This section details a range of methods that can be used by managers, scientists and community members to identify bleaching and assess the extent and severity of a mass bleaching event. Since mass bleaching is transitory in nature, the decision about when to conduct a rapid assessment of bleaching impacts, including which protocol can be best mobilized and used, may have significant implications for the survey results and for any conclusions made from those results. Experience from around the world during previous bleaching events has led to the development of standard set of strategies that can help with monitoring-related decisions. The World Wildlife Fund (WWF), the WorldFish Centre, and the Great Barrier Reef Marine Park Authority (GBRMPA) have compiled these experiences into *A Global Protocol for Assessment and Monitoring of Coral Bleaching* (can be downloaded from the ReefBase website: www.reefbase.org). The *Protocol* aims to provide detailed guidance for planning and implementing bleaching assessments under a range of resource settings, while ensuring that data are useful and readily integrated into a global database of coral bleaching impacts. These techniques will allow managers to gather sufficient information to report to concerned stakeholders, managers, decision makers, media and the general public.

Ongoing monitoring is also required to document the long-term ecological impacts of mass bleaching and other major disturbances on reef ecosystems. It is necessary to track changes in reef communities over longer timeframes (several years to decades) in order to estimate the probability and rate of recovery, increase the ability to determine the cause of changes in reef condition, and evaluate the effectiveness of management strategies. Maintenance of long-term monitoring programs will enable managers to detect gradual changes in coral community structure that may occur because of bleaching and mortality and to maximize their ability to attribute chronic impacts to particular stresses, including coral bleaching. Monitoring on an annual or semi-annual basis should be complemented with additional surveys timed to detect the occurrence and impact of coral bleaching at long-term monitoring sites. The data from such targeted surveys will help managers determine the relative influence of coral bleaching on the long-term dynamics of coral reef ecosystems. Coral reef monitoring protocols have been developed for a wide range of skill levels, ranging from *Reef Check* for volunteers, to the comprehensive *Survey Manual for Tropical Marine Resources*

developed by the Australian Institute of Marine Science (AIMS) and the Global Coral Reef Monitoring Network for reef scientists and managers. Rather than dictate to managers which assessment protocols should be used, this section highlights the relative benefits and weaknesses of a range of assessment approaches so that managers can make the best choice of methods to be included in a bleaching response plan.



On-the-Web

Bleaching assessment protocols:

Great Barrier Reef Marine Park Authority Coral Bleaching Response Plan:

http://www.gbrmpa.gov.au/data/assets/pdf_file/0020/13169/Coral_Bleaching_Response_Plan_2006-07_Final.pdf

Reef Check Bleaching Monitoring Protocol:

http://reefcheck.org/ecoaction/Monitoring_Instruction.php

Australian Institute of Marine Science – coral bleaching index:

<http://www.aims.gov.au/pages/search/search-coral-bleaching.html>

TNC Florida Reef Resilience Program, Expert Response Protocols

<http://www.nature.org/wherewework/northamerica/states/florida/preserves/art17499.html>

Information and databases:

ReefBase global database on bleaching threats:

http://www.reefbase.org/global_database/default.aspx?section=t4



Publications and References

Oliver, J, P. Marshall, N. Setiasih and L. Hansen 2004 *A Global Protocol for Assessment and Monitoring of Coral Bleaching*. WorldFish Center, Penang, Malaysia and WWF Indonesia, Jakarta. 35 pp.

Siebeck, U. E., Marshall, N. J., Klüter, A. and Hoegh-Guldberg O., 2006 *Monitoring coral bleaching using a colour reference card*. *Coral Reefs* 25: 453-460.

Hansen, L.J., J.L. Biringer and J.R. Hoffman . 2003 *Buying Time: A User's Manual to Building Resistance and Resilience to Climate Change in Natural Systems*.

http://www.panda.org/news_facts/publications/index.cfm?uNewsID=8678

Section 2: Monitoring for Resilience

Learning Objectives

- Knowledge of the reef characteristics that may promote resilience to bleaching.
- The ability to use bleaching events to identify resilient reef areas.
- Understand resilience protocols that are available for you to use and modify
- Understand the importance of incorporating resilience monitoring into your traditional monitoring practices.

Background

The severity of bleaching responses varies between reefs during mass bleaching events. Identification of areas that have historically had high resilience to bleaching provides the basis for a network of refuges to underpin resilience-based management of the reef ecosystem. Refuges serve as a seed bank to facilitate the recovery of areas with lower natural resilience, and will play a central role in networks of protected areas designed to maximize ecosystem resilience. The identification of resilient areas as an ecosystem management strategy is already being applied in various locations around the world. The experiences gained from these initiatives will help to refine knowledge and develop additional protocols for the identification of resilient areas. The outcomes of these early tests of resilience management strategies will also provide important information about the extent to which the factors that confer resilience on an area will remain consistent over time. As managers, you too can contribute to this knowledge through incorporating resilience monitoring into bleaching monitoring protocols.

Recently the IUCN has been working on a rapid resilience assessment protocol. The following information comes from the *IUCN Resilience Assessment of Coral Reefs: Rapid assessment protocol for coral reefs focusing on coral bleaching and thermal stress*. The need for rapid methodologies for measuring coral reef resilience and their application in assessing the effectiveness of coral reef conservation management measures is becoming increasingly acute, and especially so in the developing world. It is therefore crucial to develop monitoring and assessment protocols to build an understanding of bleaching resistance and resilience indicators for application in management, and to determine how MPA management actions can influence resilience and resistance. The IUCN Resilience Assessment Methodology is designed to provide a rapid assessment of coral bleaching resistance and resilience at an individual site level. This is intended to

facilitate assessment of any past management actions in maintaining the resilience of coral reefs, and the making of new management decisions against local MPA objectives.

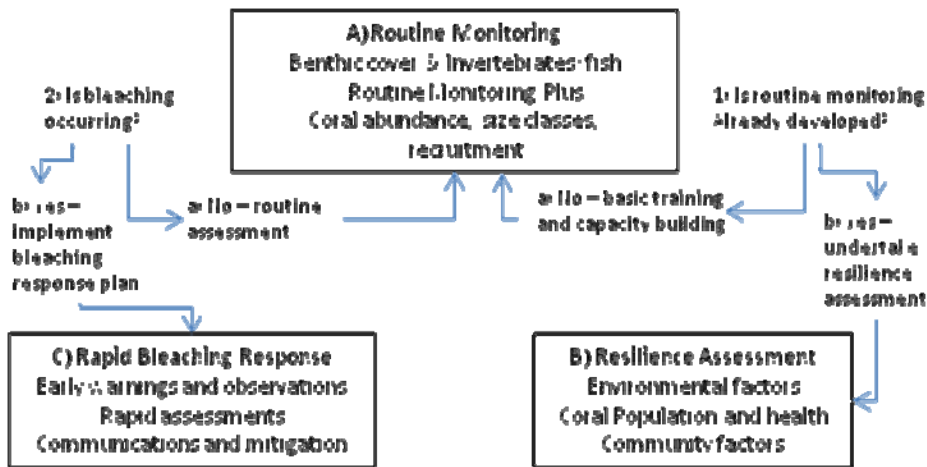
Specifically, the protocol is intended to:

- 1) Assess the factors affecting coral bleaching during a bleaching event (resistance factors).
- 2) To assess the factors affecting coral and reef recovery following a bleaching event (resilience factors).
- 3) Enable between-site comparisons at a local area/region/MPA (network) level.
- 4) Enable inter-regional comparisons at larger scales.

In a management context, the protocol should facilitate:

- 5) Building an understanding of bleaching resistance and resilience factors that can be addressed by MPA design and management.
- 6) Assessing whether MPA design and management practices to date have addressed bleaching resistance and resilience.
- 7) Designing networks of MPAs based on bleaching resistance/resilience characteristics.
- 8) Providing information to adaptively manage coral reefs in response to bleaching events and reef resilience.

While the assessment protocol can be undertaken as an independent study, it is most useful in an adaptive management structure that already incorporates annual or routine monitoring. Thus routine monitoring (A) provides background time series information on a limited set of variables that track coral reef status and function over time. Where the concern is about the effects of coral bleaching, this resilience assessment is designed to be undertaken to increase understanding of the resistance and resilience of reefs to bleaching, whether a bleaching event has occurred in the past or not (B). This need be done only once, then again after a long period (e.g. 5 years) or after a major event (e.g. bleaching, or other major pulse stress such as a cyclone, COTs outbreak, etc.) to determine whether the reef has been shifted into another phase. During a bleaching event, a separate monitoring approach is applied focused just on bleaching variables, designed to be repeated over short periods of time (e.g. monthly) to track the actual event (C).



Nested approach to monitoring resilience, building additional resilience indicators onto routine monitoring approaches (step 1b). During a bleaching event (step 2b) a subset of resilience indicators would be included in bleaching assessment protocols (Oliver et al. 2004). (Source: *IUCN Resilience Assessment of Coral Reefs: Rapid assessment protocol for coral reefs focusing on coral bleaching and thermal stress*)

The Resilience Assessment Methodology will be available in a publication from IUCN which includes survey design, field methods to assess coral condition, algae, fish and resilience factors and well as data management and analysis.

The IUCN is just one protocol of many that is available. In the Caribbean region the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol is widely used and there may be other protocols designed for your areas.

The Nature Conservancy Reef Resilience (R²) Toolkit, on which portions of this workshop are based, provides a good review of the resilience principles for and incorporating resilience into coral reef management. We will discuss the incorporation of resilient areas and into MPA design in a later module. Broader guidance beyond MPA design for increasing reef resilience can also be found in the Tropical Marine chapter of *Buying Time* which can be found at <http://assets.panda.org/downloads/6chapter6.pdf>.



On-the-Web

Florida Reef Resilience Program: www.frrp.org/

TNC Reef Resilience Toolkit: www.reefresilience.org

Atlantic and Gulf Rapid Reef Assessment Protocol: www.aggra.org

IUCN Resilience Assessment of Coral Reefs:

http://cmsdata.iucn.org/downloads/resilience_assessment_final.pdf



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Nyström, M., and Folke, C. 2001. Spatial resilience of coral reefs. *Ecosystems* 4: 406–417.

Section 3: Assessing and Predicting Socioeconomic Impacts of Climate Change

Learning Objectives

- An understanding of the why we need to assess the socioeconomic impacts of mass coral bleaching and climate change.
- An understanding of the potential socioeconomic impacts of coral bleaching and mortality, as well as other impacts from climate change.
- The ability to identify impacted populations.
- An understanding of the steps necessary to undertake a socioeconomic assessment.
- An understanding of developing and using scenarios in vulnerability and adaptation assessment
- Heard about several case studies to illustrate results of previous socioeconomic assessments in Philippines, Palau, American Samoa, Bonaire, Barbados, and the Western Indian Ocean.

Background

Climate change impacts on coral reef ecosystems may also have subsequent flow-on effects for coastal communities who depend on reefs for a range of ecosystem goods and services. When corals bleach, impacts occur not only to ecological communities but also to the human communities who depend upon coral reefs for income, food from fisheries, revenue generation from tourism, recreation, cultural traditions, and educational opportunities. If corals recover from bleaching events, these impacts may be temporary. However, if corals die as a result of bleaching, impacts may be longer-term and more severe. Ironically, social, cultural, and economic impacts can also occur as a result of management interventions aimed at promoting coral reef resilience to climate change. Managers need to understand the relationship of the communities with the coastal and marine resources. At the same time, they need to find out how climate change and management decisions related to climate change will impact the socioeconomic aspects of communities who depend upon reefs so that they can design and implement strategies that will meet both environmental and socioeconomic needs. This section aims to provide managers with basic knowledge of the components of a socioeconomic assessment and ways to perform assessments. In the following section we will discuss some specific manuals available that outline the steps for socioeconomic assessment, and for developing of socioeconomic scenarios for vulnerability and adaptive assessments. Several case studies have been provided to illustrate how other communities have undertaken such assessments and the outcomes of these assessments. These case studies show how difficult it can be to separate out the

socioeconomic impacts of bleaching from impacts from concurrent events, such as regional economic downturns, weather events, or other stresses on corals. This section aims to incorporate socioeconomic monitoring into bleaching assessment protocols.

Reef managers, policy-makers, and communities that understand the relationships people have with the adjacent coral reefs will be able to better identify both the impacts of a mass bleaching event and any impacts associated with management strategies. This knowledge can be used to design management strategies that maximize environmental outcomes while minimizing negative impacts on people. Specifically, impact assessments can:

- Identify the potential social and economic impacts of mass bleaching;
- Integrate local knowledge with technical expert knowledge;
- Evaluate the social and economic costs and benefits of various coral bleaching management strategies; and
- Increase public involvement in the monitoring of coral bleaching.

Given how difficult it can be to separate the socioeconomic impacts of bleaching from impacts from concurrent events, some communities may wish to undertake general economic valuation studies for their coral reefs, which could be used to derive impacts from bleaching with a small amount of additional data collection. These valuation studies can also be used as a baseline from which to measure socioeconomic impacts of bleaching and other damaging events.

In addition to impacts from coral bleaching, climate change and variability will catalyze other impacts as well. In the Pacific island region, the current most visible impacts from climate change also include sea level rise, inundation, salt water intrusion, and coastal erosion. Climate change is having increasingly impacts on livelihood, food security, infrastructure, human health, and the most important economic bases of the Pacific islands, namely fishery, agriculture and tourism. Quantification of these impacts to the tourism industry has been attempted in several cases, with significant economic consequences predicted for climate change.

Worksheet or Activity

Worksheet: Socioeconomic Considerations in your Bleaching Response Plan

Activity 3: Selecting Socioeconomic Indicators

SOCIOECONOMIC CONSIDERATIONS

It is important to consider the impacts to human users of coral reefs from climate change and coral bleaching. These will have both direct impacts, from the bleaching itself, especially when there is coral mortality, and indirect impacts from management measures intended.

Use this table to identify populations who may be affected by major coral bleaching events. These impacts will be important to report to the media and to elected officials. It is also important to understand up front the economic impacts of certain management measures (e.g. dredging bans during bleaching events).

Type of event	Populations who may be affected by bleaching (e.g. dive operators, fishermen, women harvesting at low tide)	Type of impact (social, cultural, economic)	Actions that may lessen impacts (examples: pre-bleaching warnings, economic mitigation, etc)
Direct impacts			
Moderate bleaching	1.		
	2.		
	3.		
Severe bleaching	1.		
	2.		
	3.		
Post-bleaching coral mortality	1.		
	2.		
	3.		
Indirect impacts			
Fishing restrictions	1.		
	2.		
Recreational use restrictions	1.		
	2.		
Restrictions on coastal development/ dredging	1.		
	2.		
Other:			

Activity 3: Defining socioeconomic assessment objectives and selecting relevant socioeconomic indicators

Given scenario: A coastal community of 10,000 people experiencing the following impacts:

- Climate: Rising sea surface temperature
- Biological impacts: Mass coral bleaching, coral mortality, decreasing abundance and availability of fish stocks
- Physical impacts: Weaken reef structure, more exposure for coastal erosion during storm surge events

Your tasks:

1. Define your socioeconomic assessment objectives:

2. From the examples of socioeconomic indicators presented in the Powerpoint presentation, select ones that are relevant and appropriate for the above objectives. Propose a data collecting method for each of the selected indicators. The methods include secondary sources, household survey, key informant interview, focus group discussion, and observation.



Socioeconomic assessment tools:

Global Socioeconomic Monitoring Initiative (SocMon):

<http://www.reefbase.org/socmon/>

Locally Managed Marine Areas Network (LMMAN): <http://www.lmmanetwork.org>

Malone, Elizabeth L., Joel B. Smith, Antoinette L. Brenkert, Brian Hurd, Richard H. Moss, and Daniel Bouille. 2004. *Developing Socioeconomic Scenarios for Use in Vulnerability and Adaptation Assessments*. New York: UNDP. <http://ncsp.undp.org/docs/653.pdf>.

Mersai, Charlene T and Craig J. Severance. No date. *Introductory Handbook for Biological and Social Monitoring of MPAs in Palau*. Koror: Palau International Coral Reef Center.

Nakalevu, Taito. 2006. *CV&A : A Guide to Community Vulnerability and Adaptation Assessment and Action*. Apia, Samoa : South Pacific Regional Environment Programme (SPREP). http://www.sprep.org/att/publication/000437_cvaguidee.pdf

Wongbusarakum, S. and R. Pomeroy. 2008. *Socioeconomic Monitoring Guidelines for Coastal Managers in Pacific Island Countries*. Silver Spring: National Oceanic and Atmospheric Administration; and Apia, Samoa: Secretariat of Pacific Regional Environment Programme. http://www.reefbase.org/socmon/pdf/SocMon_Pacific.pdf

World Wildlife Fund. 2007. *Climate Witness Community Toolkit*. Suva, Fiji: World Wildlife Fund-South Pacific Programme. http://assets.panda.org/downloads/cw_toolkit.pdf

Economic valuation studies

Cesar, H., P. van Beukering, S. Pintz, and J. Dierking. 2002. *Economic Valuation of the Coral Reefs of Hawaii*. Final report to National Oceanic and Atmospheric Administration Coastal Ocean Program. Cesar Environmental Economics Consulting, Arnhem, The Netherlands. <http://marineeconomics.noaa.gov/Reefs/HICesar.pdf> Accessed on April 24, 2008.

Socioeconomic Monitoring Program for the Florida Keys National Marine Sanctuary - Recreation/Tourism: <http://marineeconomics.noaa.gov/SocmonFK/Linking.html>

Valuing the Environment in Small Islands - An Environmental Economics Toolkit <http://www.jncc.gov.uk/page-4065>

World Resources Institute (WRI) *Economic Valuation of Coastal Ecosystems in the Caribbean*: <http://www.wri.org/project/valuation-caribbean-reefs>



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Cesar, H., L. Pet-Soede, M. C. C. Quibilan, P. M. Aliño, H. O. Arceo, I. V. Bacudo and H. Francisco, 2001. First Evaluation of the Impacts of the 1998 Coral Bleaching Event to Fisheries and Tourism in the Philippines. Pp. 41-58 in Schuttenberg, H.Z. (ed.). *Coral Bleaching: Causes, Consequences and Response*. Selected papers presented at the Ninth International Coral Reef Symposium on "Coral Bleaching: Assessing and Linking Ecological and Socioeconomic Impacts, Future Trends and Mitigation Planning." Coastal Management Report #2230, Coastal Resources Center, University of Rhode Island: 102 pp.

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Westmacott, S., H. Cesar, L. Pet-Soede and O. Lindén, 2001. Assessing the Socio economic Impacts of the Coral Bleaching Event in the Indian Ocean. Pp. 31-40 in Schuttenberg, H.Z. (ed.). *Coral Bleaching: Causes, Consequences and Response*. Selected papers presented at the Ninth International Coral Reef Symposium on "Coral Bleaching: Assessing and Linking Ecological and

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