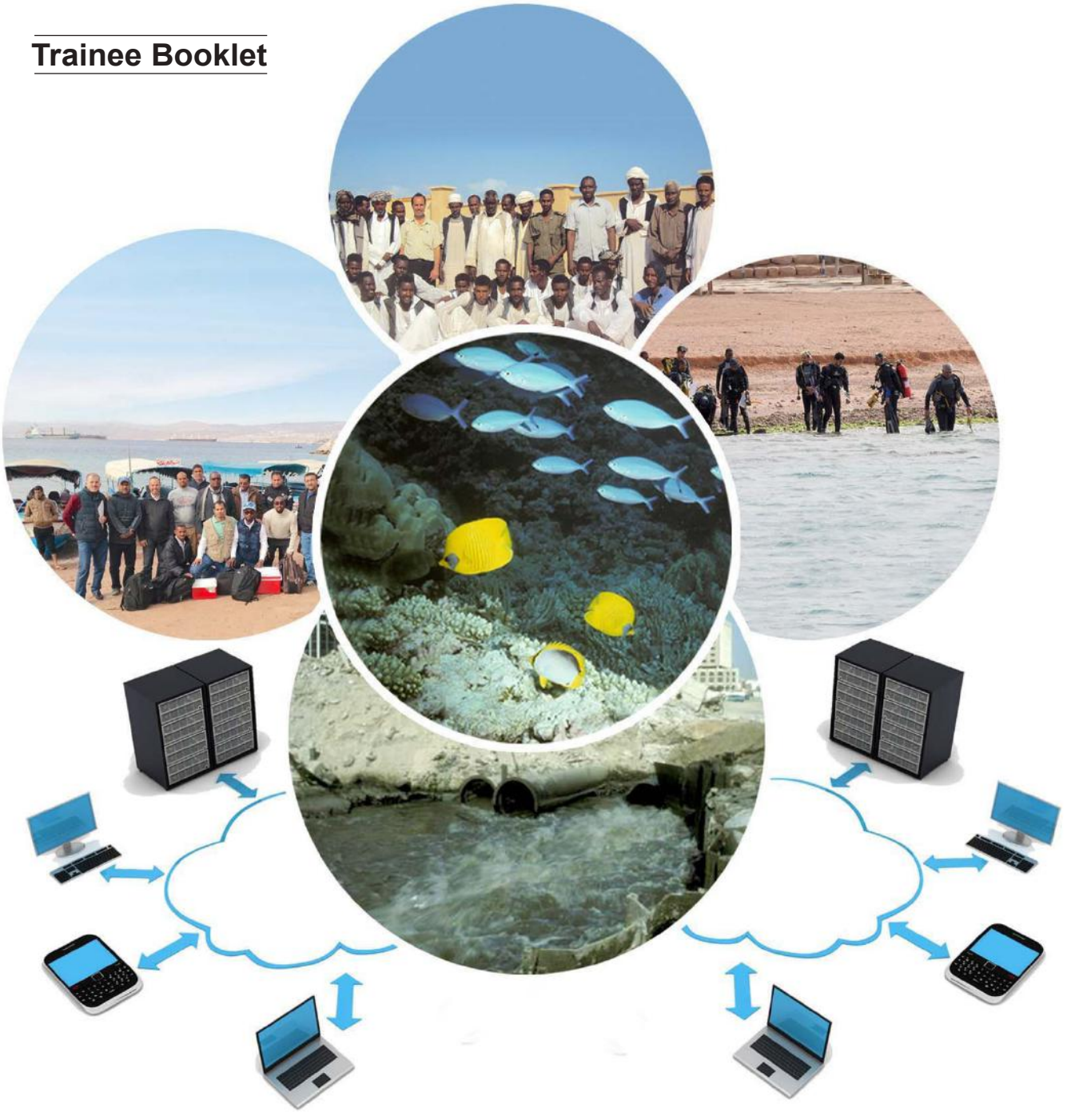
The Regional Organization for Conservation of the Environment of the Red Sea and Gulf of Aden

Trainee Booklet



Manual for Monitoring Indicators of the Impact of Wastewater Discharge on Coral Reefs

GD.0031A

Regional Organization for Conservation of the Environment of the Red Sea and Gulf of Aden "PERSGA" is an intergovernmental organization dedicated to the conservation of the coastal and marine environments in the Region.

Legal basis of PERSGA stems from Article XVI of the Regional Convention for Conservation of the Red Sea and Gulf of Aden, known as Jeddah Convention, signed in Jeddah, Kingdom of Saudi Arabia in 1982: PERSGA Member States are Djibouti, Egypt, Jordan, Saudi Arabia, Somalia, Sudan and Yemen.

This Manual is prepared by Dr. Alexander Shepherd as an independent consultant and Dr. Mohammad Badran from PERSGA. It is reviewed by Dr. Birguy Lamizana from UN Environment. The Manual is PERSGA publication number GD.0031. Preparing the Manual was supported by UN Environment through the GPA/Global Wastewater Initiative (GW2I).

Reference to this Manual is: PERSGA Guidelines (2018); GD. 0031. Printed in Saudi Arabia.

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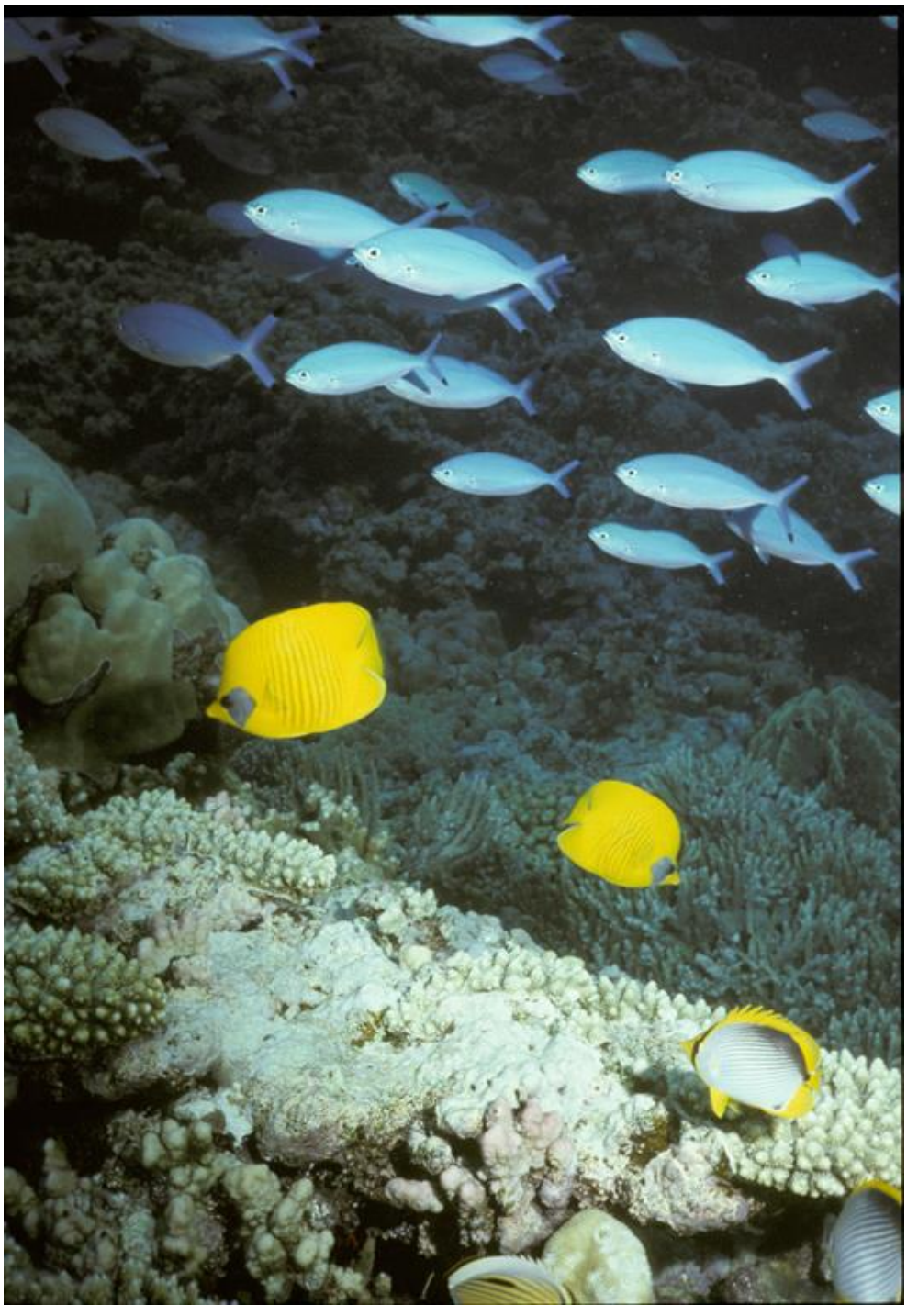
MANUAL FOR MONITORING INDICATORS OF THE IMPACT OF WASTEWATER DISCHARGE ON CORAL REEFS
MODULE 1 : PURPOSE AND KEY TERMS



Outer Farasan Bank 1980's

JUSTIFICATION FOR THIS MANUAL

Importance of Coral Reefs

Whilst there is some objective evidence of the importance of healthy coral reefs to supporting social and economic development within the Red Sea and Gulf of Aden there is more subjective evidence including the numbers employed in the fisheries sector in the countries of the region, the large size of the marine tourism sector particularly within Egypt and the level of compensation payments made for ship groundings on coral reefs[1]. Indeed the reason for collecting objective information on the value of coral reefs using this manual, and other relevant tools, is to provide evidence for advocacy for action leading to more effective management.

In global terms the importance of coral reefs can be summarized as:

- Economic

"*Economic valuation of ecosystems needs to be treated with caution but annual values per km^2 have been calculated at US$100 000-600 000 for reefs…*[2]*"*.

- Food security

"A healthy, well-managed reef can yield between 5 and 15 tons of fish and seafood per square kilometer per year.[3]*"*

- Biodiversity

"*Coral reefs are not only major storehouses of incredible biodiversity (32 of the 34 recognised animal Phyla are found on coral reefs compared to 9 Phyla in tropical rainforests)…*[4]*"*.

[1] PERSGA. 2009. Guidelines for Compensation Following Damage to Coral Reefs by Ship or Boat Grounding. Part 1. PERSGA Technical Series Number 15. PERSGA, Jeddah. Http://www.persga.org/Files///Common/Flipping_Books_Downloads/Guidelines_for_Compensation_Following_Damage_to_Coral_Reefs_by_Ship_Grounding.pdf

[2] UNEP-WCMC (2006) In the front line: shoreline protection and other ecosystem services from mangroves and coral reefs. UNEP-WCMC, Cambridge, UK 33 pp.

[3] Burke, L., K. Reytar, M. Spalding and A. Perry. 2011. Reefs at Risk Revisited. World Resources Institute. Washington DC. 114 pp

[4] Wilkinson, C.R. (Editor), 2002. Status of coral reefs of the world. Global Coral Reef Monitoring Network (GCRMN), Australian Institute of Marine Science (AIMS), Townsville, Australia.

"*Although they occupy less than one quarter of 1 percent of the marine environment, coral reefs are home to more than a quarter of all known marine fish species.* [5]".

Significance of Wastewater

There is some objective evidence of the significance of wastewater on society, economy and the environment within the Red Sea and Gulf of Aden[6]. This evidence includes the significant investment in wastewater treatment in the region to maintain human health. However, evidence of the impact of wastewater on coral reefs is more subjective. Indeed the reason for collecting objective information on the linkages between wastewater and coral reefs using this manual, and other relevant tools, is to provide evidence for advocacy for action leading to more effective management.

Policy justification

2030 Agenda for Sustainable Development

The 2030 Agenda for Sustainable Development adopted in September 2015[7] updates the millennium development goals. It contains seventeen (17) goals all have which have some relevance to this manual but two of which, goal 6 and goal 14 are of particular relevance to this manual.

Goal 6 is "*Ensure availability and sustainable management of water and sanitation for all*". The manual aims to enhance capacity to deliver all the targets for this goal but two targets, target 6.3 and 6.6, are particularly relevant. Target 6.3 includes the requirement that water quality be improved by 2030 and target 6.6 includes the requirement that water-relates ecosystems, including wetlands (though coral reefs are not mentioned) be protected and restored by 2020.

Goal 14 is "*Conserve and sustainably use the oceans, seas and marine resources for sustainable development*". The manual aims to enhance capacity to deliver all the targets for this goal but targets14.1 and 14.2 are particularly relevant. Target 14.1 requires that marine pollution of all kinds be significantly

[5] Cited in: Bryant, D., L. Burke, J. McManus and M. Spalding, 1998. Reefs at Risk: A map-based indicator of threats to the world's coral reefs. World Resources Institute. 56pp.

[6] PERSGA (2014). Regional Workshop on Wastewater Management and Pollution Loads Assessment in Coastal Cities of the Red Sea and Gulf of Aden. June 16th – 18th 2014, Jeddah, Saudi Arabia. Regional Organisation for the Conservation of the Environment of the Red Sea and Guf of Aden (PERSGA).

reduced by 2030. Target 14.2 requires that marine and coastal ecosystems be sustainably managed to avoid significant adverse impacts. As indicated above coral reefs are a significant component of tropical marine and coastal ecosystems.

The Manila Declaration 2012

The Manila Declaration 2012 identifies wastewater as a priority source category of land-based pollution in the marine environment. Coral reefs are vulnerable to wastewater pollution, which poses a threat both to coral reef ecosystem health and to the health and wellbeing of people that depend on their ecosystem services. However, awareness of wastewater pollution impacts of coral reefs are limited, monitoring of wastewater pollution and its impacts remains weak in most reef regions, and many island countries, especially in the Pacific, are on a path to miss the sanitation target of the Millennium Development Goals…...[8].

PERSGA Wastewater Management Project

This manual for monitoring indicators of the impact of wastewater discharge on coral reefs is delivered under the "*Wastewater Management and Pollution Loads Assessment in Coastal Cities of PERSGA Region Project*" which contributes to implementation of two UNEP projects: 321.2 "*Global Coral Reef Partnership*" and in particular Output A: Indicators, methods, planning tools and strategic frameworks for management of coral reefs that builds resilience in the face of climate change and Project 322 "*Managing Wastewater through a Global Partnership*" Component 1: Strengthening the normative basis for managing and monitoring the impacts of wastewater on the marine environment.

Optimal status: Wastewater

The optimal status of wastewater depends on the conditions for which it is to be used. For drinking water it should comply with the World Health Authority conditions for drinking water. Generally speaking wastewater management should comply with the principles[9] of integrated water resources management (IWRM) with no net negative impact on society, the economy and the environment.

[8] Extract from UNEP (2015). Wastewater Pollution & Coral Reefs. Science-to-Policy Brief for UNEP DRAFT September 2015. C_2O. UNEP.

[9] http://www.gwp.org/en/

Optimal status: Coral reef

The definition of what is a suitable environment for optimizing coral reef health is very wide ranging and depends on the baseline conditions the coral reef is used to and the resilience of the coral reef to impacts. GBRM water quality triggers[10] provide a basis for determining suitable conditions for maintaining coral reef health.

Other pressures on coral reefs

Other stressors can act together (cumulatively) with wastewater to adversely affect the health of coral reefs. Reducing, or removing, wastewater stressors may provide coral reefs with greater resilience to and capacity to adapt to these other stressors, some of which may become significant in the future[11].

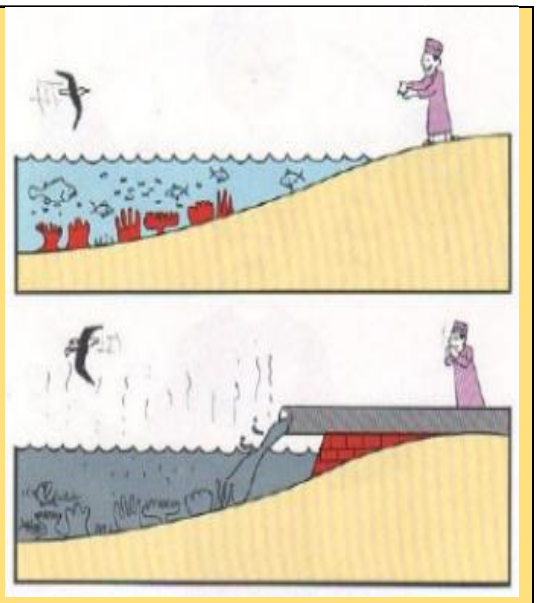
TRAINEE MATERIALS

1.1	LEARNING POINTS
1.1.01	**About this manual**: The rationale for developing this manual is presented as a preface to this module. This "*Manual for monitoring indicators of the impact of wastewater discharge on coral reefs*" comprises a sequence of 5 modules reflecting the process from problem identification to problem solution. The manual should, therefore, be used in this sequence. The purpose of this manual is to determine whether wastewater is a problem for living coral reefs using a citizen-science approach (module 2-4), to advocate for improved wastewater management and to plan for improved wastewater management if it is a problem (module 5). In general improved wastewater management will reduce the stress on coral reefs so that they may have a better chance of coping with other stresses such as increased sea-temperatures and ocean acidification resulting from the burning of fossil fuels (human induced climate change). In these respects it needs to be appreciated that the priority for investment has to be to reduce or reverse human induced climate change due to the burning of fossil fuels.

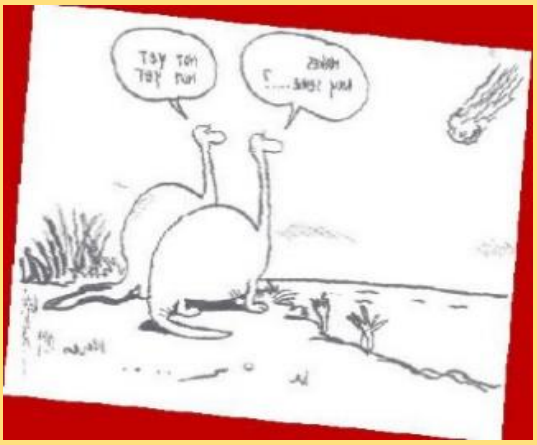
[10] Water quality guidelines for the Great Barrier Reef Marine Park 2010 [electronic resource] / Great Barrier Reef Marine Park Authority. http://www.gbrmpa.gov.au/__data/assets/pdf_file/0017/4526/GBRMPA_WQualityGuidelinesGBRMP_RevEdition_2010.pdf

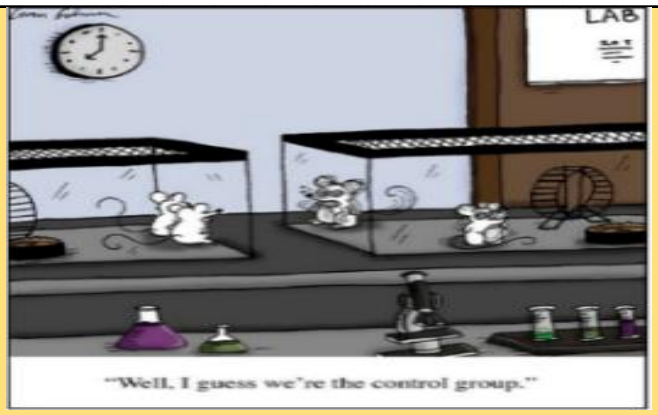
[11] ISRS (2015). ISRS Consensus Statement on Climate Change and Coral Bleaching, October 2015. Prepared for the 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change, Paris, December 2015. The International Society for Reef Studies (ISRS). http://coralreefs.org/wp-content/uploads/2014/03/ISRS-Consensus-Statement-on-Coral-Bleaching-Climate-Change-FINAL-14Oct2015-HR.pdf

1.1.02	**The target audience**: The target audience for the manual is people who have a basic secondary level foundation training in science and an interest in the subject matter. The learning points are supported by basic training for trainer notes. However, it is expected that these training notes will be adapted and expanded by trainers to meet local conditions. Local communities can participate but need to do so within a citizen science framework and using a sub-set of the indicators presented in this manual. Trainers will have to produce "community friendly" guidelines for training communities by adapting the materials in this manual.
1.1.03	**Module 1 - Purpose and key terms**: By the end of this module target group will be able to demonstrate an understanding of the key learning points presented below. Training in this module should take approximately four hours of presentation, an hour for the group exercise and 15 minutes for the test. Any fieldwork should be added to this time.
1.1.04	**Precautionary principle**: Specified in the preamble to the international convention on biological diversity "*Noting also that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat*". http://www.cbd.int/doc/legal/cbd-un-en.pdf
1.1.05	**Cumulative environmental impact**: Where two or more factors act together to create an impact that is greater than the impact if they act independently.
1.1.06	**Environmental Impact Assessment (EIA)**: Often a legal requirement EIA is "*a process of evaluating the likely environmental impact of a proposed project or development taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse*". https://www.cbd.int/impact/problem.shtml
1.1.07	**Ecosystem** means "*a dynamic complex of plant, animal and micro-organism communities interacting with their non-living environment as an ecological unit*".
1.1.08	**Wastewater** is water whose quality has been negatively affected by human activity (see training for trainer notes for other definitions).

1.1.09	**Zero discharge** means: "*Wastewater that is not directly or indirectly discharged to a navigable water (e.g., wastewater that is land disposed through spray irrigation) under CWA (USA Clean Water Act).*"	 MRME (1995). Oman.
1.1.10	**A living coral reef** is any solid structure that is maintained by living hard (calcium carbonate, hermatypic/reef building) coral.	
1.1.11	**Living coral reef sensitivity to wastewater**: Most coral reefs in the Red Sea have evolved in nutrient poor areas due to generally low water exchange with the Indian Ocean and limited freshwater inputs from the land. Wastewater introduces nutrients, sediment and low salinity water. An increasing human population in the coastal zone of the Red Sea produces increased wastewater.	
1.1.12	**Importance of coral reefs**: Coral reefs provide a source of food, living sea-defences and nature tourism.	
1.1.13	**Coral bleaching**: The disruption of the symbiotic relationship between polyps and zooxanthellae, resulting in the expulsion of zooxanthellae and loss of photosynthetic pigments (corals become white and weaken, and may ultimately die).	
1.1.14	**Eutrophic waters:** Nutrient rich waters.	
1.1.15	**Oligotrophic waters**: Nutrient poor waters.	
1.1.16	A **point source** of wastewater pollution is a source from a single identifiable location.	
1.1.17	A **dispersed/diffuse/non-point source** of wastewater pollution arises from multiple locations.	
1.1.18	**Black water, brown water, foul**	

	water, sewage: water containing faecal material and urine.	 Settlement ponds, near Hudaydah, Yemen 1986
1.1.19	**Grey water**, **sullage**: water from non-industrial processes without sewage. Sullage is an historical term for grey water.	
1.1.**20**	**Primary (mechanical) treatment**: *"The first major stage in wastewater treatment that removes solids and organic matter mostly by the process of sedimentation or flotation".*	
1.1.21	**Secondary (biological) treatment**: *"Follows primary treatment to achieve the removal of biodegradable organic matter and suspended solids from effluent. Nutrient removal (e.g., phosphorus) and disinfection can be included in the definition of secondary treatment or tertiary treatment, depending on the configuration".*	
1.1.22	**Tertiary (additional) treatment**: *"Follows secondary treatment to achieve enhanced removal of pollutants from effluent. Nutrient removal (e.g., phosphorus) and disinfection can be included in the definition of secondary treatment or tertiary treatment, depending on the configuration".*	
1.1.23	**Sewage sludge**: Sewage sludge refers to the residual, semi-solid material that is produced as a by-product of sewage treatment.	
1.1.24	**Kipling method**: "I keep six honest serving men (they taught me all I knew); their names are What and Why and When and Where and Who" http://www.kiplingsociety.co.uk/poems_serving.htm	
1.1.25	**Garbage in garbage out**: The value of information to evidence based decision-making depends on how relevant and good the information is.	

1.1.26	**Polluter pays Principle:** "*....the polluter should bear the cost of measures to reduce pollution according to the extent of either the damage done to society or the exceeding of an acceptable level (standard) of pollution*." (United Nations Statistics Division 2006 http://unstats.un.org/unsd/environmentgl/gesform.asp?getitem=902)
1.1.27	**Citizen-science** is scientific research conducted by amateur (non-professional) scientists from civil society usually under the direction of professional scientists.
1.1.28	**Scientific approach**: An approach comprising: - development of objective **hypothesis** concerning links - experiments to test the hypothesis statistically.
	 https://evaluationrevisited.files.wordpress.com/2010/03/cartoon-flyer.jpg
1.1.29	**Hypothesis**: A proposed explanation for an event or problem often in terms of **cause** and **effect**. The hypothesis can be tested through an **experiment** which alters, or observes, cause or effect **indicator** variables to see whether they are **dependent** or **independent**.
1.1.30	A **stressor** is a causal factor that has an **effect**/ **impact** on a **receptor**. In the case of these guidelines the stressor is **wastewater**. The receptor is **living coral reef**, coral reef associated life, and living coral reef dependent services such as fisheries and tourism.
1.1.31	An **indicator of change** comprises a set of two or more attributes at least one of which remains constant whilst one, or more, of the others may show change.
1.1.32	**Dependent variable**: A variable that is **affected** by the independent variable such as an effect on a receptor.
1.1.33	**Independent variable**: **A variable, such as a cause/stressor, that is not affected by the dependent variable such as a receptor.**
1.1.34	**Control (scientific)**: a situation that is identical in every possible way except

	for the absence of the independent variable that is being monitored.	
1.1.35	**Geographic information system** (GIS) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. GIS can show many different kinds of data on one map. This enables people to more easily see, analyze, and understand patterns and relationships.	
1.1.36	**Data table, grid or matrix**: Information placed in a framework of columns and rows according to objective criteria set for each column and row. At least one column should relate to an independent variable and one to a dependent variable.	Columns → ↑ ROWS ↓ Site* | Distance from wastewater source* | % cover of live hard coral* 1 | 1 | 0 2 | 2 | 1 3 | 3 | 20 4 | 4 | 40 5 | 5 | 70 * Numbers do not reflect real data
1.1.37	**Grievance redress**: The process by which stakeholders can complain about a problem and have their complaints addressed by the party causing the problem, initially bilaterally, and, if that fails, by independent arbitration (through a, bilaterally agreed, unbiased, third party).	

1.2	TOOLS
1.2.1	The tools for this module comprise the module, writing materials, and extra paper.

1.3	TRAINING UPTAKE INDICATORS
1.3.01	The indicators for this module comprise the training uptake test scores.

1.4	FURTHER INFORMATION
1.4.01	Corcoran, E., C. Nellemann, E. Baker, R. Bos, D. Osborn, H. Savelli

	(eds). 2010. Sick Water? The central role of wastewater management in sustainable development. A Rapid Response Assessment. United Nations Environment Programme, UN-HABITAT, GRID-Arendal. www.grida.no http://www.unep.org/pdf/SickWater_screen.pdf
1.4.02	PERSGA (in prep). Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden. Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden. PERSGA, Jeddah.
1.4.03	PERSGA (2015). Draft Regional Guidelines on Wastewater Management in Coastal Cities on the Red Sea And Gulf of Aden. August 2015. Regional Intergovernmental Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden.
1.4.04	Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph., Zurbrügg, C. (2014). Compendium of Sanitation Systems and Technologies – (2nd Revised Edition). Swiss Federal Institute of Aquatic Science and Technology (Eawag), Duebendorf, Switzerland. p. 175. ISBN 978-3-906484-57-0. http://www.sswm.info/sites/default/files/reference_attachments/TILLEY%20et%20al%202014%20Compendium%20of%20Sanitation%20Systems%20and%20Technologies%202nd%20Revised%20Edition.pdf
1.4.05	UNEP (2015). Wastewater Pollution & Coral Reefs. Science-to-Policy Brief for UNEP DRAFT September 2015. C2O. UNEP.
1.4.06	Other modules in this manual

1.5	**GROUP EXERCISE**
1.5.01	Break into groups. Discuss the opportunities and constraints to the module. Agree and present a set of review recommendations.

1.6	**TRAINING UPTAKE TEST (expand/continue on separate sheets as necessary)**	**0-10**

Pre		Post		If the test is taken before training tick (✓) the "*pre*" box and if it is taken after training tick (✓) the "*post*" box.

Tick box as appropriate.

1.6.01	Explain the purpose of this manual.		

1.6.02	Give an example of a wastewater and explain why it is wastewater.		
1.6.03	Explain when a reef is not a living coral reef.		
1.6.04	List some examples of point and non-point/diffuse sources and explain why you chose them		
1.6.05	What are the main differences between primary, secondary and tertiary treated wastewater		
1.**6.06**	What are the key elements of the Kipling method?		
1.6.07	Specify who should be involved in citizen science.		
1.**6.08**	Give an everyday example of a stressor and associated receptor.		
1.6.09	What is the difference between a dependent and an independent variable?		
1.**6.10**	Give an example of an indicator of change and why it is an indicator of change.		
1.6.11	Describe what makes a control.		

1.6.12	Describe the key elements of grievance redress.		
1.6.13	Group presentation.		
1.6.14	Examinee, name, signature and date	Examiner, name, signature and date	Total
Comments by examinee:		Comments by examiner:	

MANUAL FOR MONITORING INDICATORS OF THE IMPACT OF WASTEWATER DISCHARGE ON CORAL REEFS
MODULE 2 : MONITORNG CAUSES (sources and nature of wastewater)

Outfall of wastewater discharge in the region early 1980's

WASTEWATER CAUSAL INDICATORS						
Indicator	**Location**	**Biological**	**Chemical**	**Physical**	**Social**	**Community***
BOD			✓			
Clarity (water)				✓		✓
COD			✓			
Date	✓					✓
Discharge quantity				✓		
Distance to shore		✓				✓
Enterococci		✓				
Escherichia coli		✓				
Latitude	✓					✓
Longitude	✓					✓
Odour (water)			✓			✓
Sludge (fate)						✓
Agriculture					✓	
Landfill					✓	
Incineration					✓	
Power generation					✓	
Sea				✓		
Other						
Unknown						
TDS				✓		
TSS				✓		
Wastewater fate						✓
Potable					✓	
Home					✓	
Industry					✓	
Irrigation					✓	
Sea				✓		
Other						
Unknown						
Wastewater sector						
Commercial					✓	
Educational					✓	
Industrial					✓	
Residential					✓	
Sport					✓	
Tourism					✓	
Transport					✓	
Other						
Unknown						
Wastewater source						
Channel/drain					✓	
Cesspit					✓	
Desalination					✓	
Outfall					✓	
Septic tank					✓	
Sewer					✓	
Stormwater				✓		
Other						
Unknown						
Wastewater treatment						✓
None					✓	
Primary					✓	
Secondary					✓	
Tertiary					✓	
Other						
Unknown						
*Priority Community monitoring indicators						

The above table lists the wastewater causal indicators associated with this module to be collected using the form presented under learning point 2.1.05 Priority indicators for local communities to monitor with support from citizen science groups are highlighted in green and include: the location of the information in terms of date, latitude and longitude and distance to the shore; physical attributes of the wastewater such as water clarity and chemical characteristics such as odour. It is also suggested that communities can qualitatively assess the fate of sludge, the fate of wastewater including any wastewater treatment. Additional indicators from the list can, of course, be monitored if there is interest and resources are available for training.

TRAINEE MATERIALS

2.1	LEARNING POINTS				
2.1.01	**Module 2 – Monitoring cause (sources and nature of wastewater)**: By the end of this module students will be able to identify information on wastewater discharge and complete and prepare a questionnaire on wastewater discharge. Training in this module should take approximately four hours of presentation, an hour for the group exercises and 30 minutes for completing a questionnaire. Any fieldwork should be added to this time.				
2.1.02	**Form a citizen science group**: The group should contain people who can use/train others to use the tools specified below and people who are willing to be trained and to do the surveys.				
2.1.03	**Obtain permission**: Always get permission from the owner of information to collect information! Information can be obtained from published sources, from the agency responsible for environment, and by visiting areas and meeting owners of wastewater discharge sites.				
2.1.04	**Permanent (fixed) markers**: These are less necessary in a terrestrial versus marine environment but do allow for accurate repeat-monitoring. Make sure that the marker is located securely and has a unique identification number that will not disappear.				
2.1.05	**Complete a survey questionnaire**	**Date**		**Form**	
1	**Information collector**	**Contact details**			
2	**Information provider**	**Contact details**			
3	**Full address of the place the questionnaire applies to:**				

4	Discharge location	Latitude (deg.decdeg)		Longitude (deg.decdeg)		Distance to shore (m)			
	Permanent marker at discharge point	Code							
	Images (label image properties with form number, date, and marker ID)								
	Video URL (Uniform Resource Identifier)			Photo URL (Uniform Resource Identifier)					
	Description of discharge location								
5	Wastewater sector (circle what applies and add note)	Commercial	Education	Industrial	Residential	Sport			
		Tourism	Transport	Unknown	Other				
6	Wastewater source (circle what applies and add note)	Channel/ drain	Cesspit	Desalination	Outfall	Septic tank			
		Sewer	Stormwater	Unknown	Other				
7	Odour (0-5 where: 0 is no odour/smell; and 5 is very odorous/smelly)								
8	Clarity (0-5 where: 0 is clear; and 5 is completely opaque)								
9	Maximum quantity of discharge in m^3 per day (circle what applies and add note)								
	0	1-9	10-99	100-999	1000-9999	10000-99999	>100,000		
10	Wastewater treatment	Fate of wastewater (%). Total for all fates should be 100%.							
		Potable	Home	Industry	Irrigation	Sea	Other	Unknown	Total
	None								
	Primary								
	Secondary								
	Tertiary								
	Other								
	Unknown								
	Total								

11	**Fate of sludge (%). Total for all fates should be 100%.**					
	Agriculture		**Landfill**		**Incineration**	
	Power generation		**Sea**		**Other/ unknown**	

12	**Other water quality indicators (Tick frequency that applies. Add value for this survey, if any)**							
	Indicator	**None**	**Daily**	**Weekly**	**Monthly**	**Annual**	**Unknown**	**This survey/value**
	E. coli							
	Enterococci							
	BOD							
	COD							
	TDS							
	TSS							
	Other							

13	**Level of treatment (%) proposed by end of next 5 years. Total for all treatments should be 100%**					
	None		**Primary**		**Secondary**	
	Tertiary		**Other**		**Unknown**	

14	**Grievance redress issues (provide detail against this number on additional sheets)**	**Yes/No**	
15	**Additional question/comments**		

2.2	**TOOLS**
2.2.01	The tools for this module comprise: this module; high resolution map of the study area; Global positioning system (GPS); Flow-meter; measuring tape or stick; permanent marker and tools for installation and maintenance; digital video/still camera, water sampling bottles.

2.3	**INDICATORS OF TRAINING UPTAKE**
2.3.01	The training uptake indicators for this module comprise: the score for completing a sample questionnaire and the score for participation in

	group exercises.

2.4	FURTHER INFORMATION
2.4.01	Corcoran, E., C. Nellemann, E. Baker, R. Bos, D. Osborn, H. Savelli (eds). 2010. Sick Water? The central role of wastewater management in sustainable development. A Rapid Response Assessment. United Nations Environment Programme, UN-HABITAT, GRID-Arendal. www.grida.no http://www.unep.org/pdf/SickWater_screen.pdf
2.4.02	PERSGA (in prep). Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden. Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden. PERSGA, Jeddah.
2.4.03	PERSGA (2015). Draft Regional Guidelines on Wastewater Management in Coastal Cities on the Red Sea And Gulf of Aden. August 2015. Regional Intergovernmental Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden.
2.4.04	Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph., Zurbrügg, C. (2014). Compendium of Sanitation Systems and Technologies – (2nd Revised Edition). Swiss Federal Institute of Aquatic Science and Technology (Eawag), Duebendorf, Switzerland. p. 175. ISBN 978-3-906484-57-0. http://www.sswm.info/sites/default/files/reference_attachments/TILLEY%20et%20al%202014%20Compendium%20of%20Sanitation%20Systems%20and%20Technologies%202nd%20Revised%20Edition.pdf
2.4.05	UNEP (2015). Wastewater Pollution & Coral Reefs. Science-to-Policy Brief for UNEP DRAFT September 2015. C2O. UNEP.
2.4.06	Other modules in this manual

2.5	GROUP EXERCISE
2.5.01	Field trip: To a wastewater treatment facility and to locations of point and non-point sources of wastewater.
2.5.02	Complete a questionnaire
2.5.03	Break into groups: Discuss the opportunities and constraints to the survey questionnaire in the context of what it is supposed to achieve. Present and agree a set of review recommendations.

2.5.04	Break into groups: Prepare and present a questionnaire based on the set of review recommendations.

2.6	**TRAINING UPTAKE TEST (expand/continue on separate sheets as necessary)**	**0-10**

Pre		Post		If the test is taken before training tick (✓) the "*pre*" box and if it is taken after training tick (✓) the "*post*" box.

Tick box as appropriate.

2.6.01	Field trip		
2.6.02	Complete the above questionnaire		
2.6.03	Group presentation of module review		
2.6.04	Group reparation of a questionnaire		

2.6.05	Examinee, name, signature and date	Examiner, name, signature and date	Total

Comments by examinee:	Comments by examiner:

MANUAL FOR MONITORING INDICATORS OF THE IMPACT OF WASTEWATER DISCHARGE ON CORAL REEFS
MODULE 3 : MONITORING EFFECTS (impact of wastewater on coral reefs)

Reef monitoring, northern Saudi Red Sea, early 1980's

WASTEWATER EFFECTS INDICATORS						
Indicator	**Location**	**Biological**	**Chemical**	**Physical**	**Social**	**Community***
Calcareous algae		✓				
Chlorophyll a		✓				
Date	✓					✓
Distance to 50+m deep water				✓		
Distance to open sea				✓		
Dissolved oxygen			✓			
Enterococci		✓				
Escherichia coli		✓				
Fishing boats					✓	
Hydrocarbons			✓			
Latitude	✓					✓
Living hard coral		✓				✓
Living soft coral		✓				
Longitude	✓					✓
Non-calcareous algae		✓				
Other						
Algal bloom		✓				
Coral bleaching		✓				
Disease		✓				
Fish kills		✓				
Red Tide		✓				
Spawning (coral, grouper etc)		✓				
Whales/dolphins		✓				
Parrotfish		✓				
Particulate nitrogen (PN)			✓			
Particulate phosphorus (PP)			✓			
pH			✓			
Sedimentation				✓		
Salinity				✓		
Solid waste					✓	
Spiny sea-urchin		✓				
Time	✓					
Tourist boats					✓	
Total suspended solids (TSS)				✓		
Wastewater pollution (qualitative)			✓			✓
Water current speed				✓		
Water temperature				✓		
Water visibility				✓		
***Priority Community monitoring indicators**						

The above table lists the wastewater effects indicators associated with this module to be collected using the form presented under learning point 3.1.09 Priority indicators for local communities to monitor with support from citizen science groups are highlighted in green and include: the location of the information in terms of date, latitude and longitude; the presence of living hard coral in respect of biological organisms; and a qualitative estimation of whether there is any wastewater pollution at the location. Additional indicators from the list can, of course, be monitored if there is interest and resources are available for training.

TRAINEE MATERIALS

3.1	LEARNING POINTS	
3.1.01	**Module 3 – Monitoring effects (impacts of wastewater on coral reefs)**: By the end of this module the target group will be able to provide, locate and place permanent markers on a living coral reef and monitor the reef to detect change in key indicators of coral reef health that may be affected by wastewater. Training in this module should take approximately four hours of presentation, one to two hours for the group exercises, 30 minutes to complete the survey form and 15 minutes for the test. Any fieldwork should be added to this time.	
3.1.02	**Form a citizen science group:** The group should contain people who can use/train others to use the tools specified below and people who are willing to be trained and to do the surveys.	
3.1.03	**Site selection**: The sites selected for monitoring should be on living coral reef areas and, to the extent possible, include a possible wastewater impact site and a control site.	
3.1.04	**Obtain permission**: Always get permission from the management authority, often the Ministry responsible for Environment, for the sampling area to place permanent markers and monitor the reef around the markers.	
3.1.05	**Safety and operational considerations**: 1. Tell people where you are going and when you are due back. 2. Make sure that the boat has water, a radio and lifesaving equipment. 3. Show consideration for other users of the area you are monitoring. 4. Use the Greenfins code including neutral buoyancy to minimise damage to the environment.	http://www.greenfins.net/
3.1.06	**Permanent (fixed) markers**: Markers should comprise: stainless steel stakes for open architecture reefs and stainless steel eyed screws for solid areas of reef with replaceable tags each with a unique marker number. Details are provided in the training for trainer notes.	

3.1.07 **Survey technique**: Carefully lay a tape measure as a guide, if needed, between the markers. One form should be completed for each 20m section. Estimate the number, and/or percent area, of each indicator within 2.5m (5m wide band) of the line connecting the four markers.

3.1.08 **Other methods**: More sophisticated survey methods are available from PERSGA and can be used if there is capacity to do so but all can use the same permanent markers as fixed survey points.

3.1.09 **Survey form**

1

Information collector	Contact details

2

Date		Start time		Finish time		Form ID	

3

Name/location of site				Transect length/ width (m)		
Start marker ID		Latitude		Longitude		
End marker ID		Latitude		Longitude		

4 **Wastewater pollution (estimate from start marker and tick relevant box)**

None		low		Medium		High		Unknown	

5 **Video (start to finish marker including tags. Label video with form ID, date and marker IDs)**

URL (Uniform Resource Identifier)		Length/width (m)		

6 **Geomorphology/Oceanography (from start marker)**

Distance to 50+m deep water (m)		Distance to open sea (m)		High currents y/n or speed ms^{-1}?	

Visibility (m) (secchi disc)	Visibility (m) (markers)	Temperature (^oC)	Salinity (ppt)	Other

7 **Sediment trap near start marker (label samples with Form ID and marker ID)**

Start date	Finish date	Oven dry weight ($milligrams/cm^2$)			
		Total	Organic	$CaCO_3$	Other

8 **Other water quality indicators**

	(Tick frequency that applies. Add value for this survey, if any)							
	Indicator	None	Daily	Weekly	Monthly	Annual	Unknown	This survey/value
	E. coli							
	Enterococci							
	DO							
	pH							
	Chl *a*							
	TSS							
	PN							
	PP							
	Other							

9 Living hard coral
(Hard endo-skeleton with thin fleshy veneer. Polyps visible)

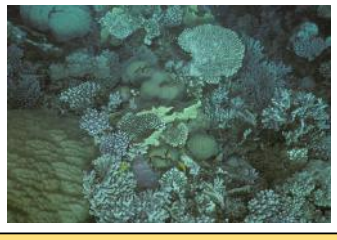


Image URL (Uniform Resource Identifier)						
Number of colonies						% cover
0	+	1+	10+	100+	1000+	

10 Living soft coral
(Fleshy. No hard skeleton. Polyps visible)

Image URL (Uniform Resource Identifier)						
Number of colonies						% cover
0	+	1+	10+	100+	1000+	

11 Non-calcareous algae
(Fleshy. No hard skeleton. Green red or brown colour. No polyps)

Image URL (Uniform Resource Identifier)						
Number of colonies						% cover
0	+	1+	10+	100+	1000+	

12 Calcareous algae
(Hard skeleton. Green red or brown colour. No polyps)

Image URL (Uniform Resource Identifier)						
Number of colonies						% cover
0	+	1+	10+	100+	1000+	

13	**Parrotfish (Parrot-like beak)**							
		**Image URL (Uniform Resource Identifier)**						
		Number of parrotfish						
		0	**+**	**1+**	**10+**	**100+**	**1000+**	
14	**Spiny sea-urchin (black-long spines)**							
		**Image URL (Uniform Resource Identifier)**						
		Number of sea-urchins						
		0	**+**	**1+**	**10+**	**100+**	**1000+**	
15	**Solid waste**							
		**Image URL (Uniform Resource Identifier)**						
		Number of items of solid waste						
		0	**+**	**1+**	**10+**	**100+**	**1000+**	
16	**Other Please note/describe and try to photograph any unusual numbers of/impact on other life.**							
		Image URL (Uniform Resource Identifier)						
		Number of incidents						**% cover**
		0	**+**	**1+**	**10+**	**100+**	**1000+**	
17	**Number of fishing boats fishing in the vicinity (1km) during the observation period**							
	Note/ image							

18	**Number of tourist boats visiting the vicinity (1km) during the observation period**	
	Note/ image	
19	**Grievance redress issues (note in a separate form with this form code)**	**Yes/No**

3.2	TOOLS
3.2.01	The tools for this module comprise: this module, high resolution map of study area; Global Positioning System (GPS); SCUBA diving equipment including adjustable buoyancy life jacket; Greenfins guides; dive support boat and safety equipment; secchi disk; permanent markers and replacement ties and tags, number engraving/stamping kit, heavy hammer; waterproof digital video/still camera; water sampling bottles; A4 waterproof questionnaire paper; A4 waterproof writing board and electrical marking tape/rubber bands for holding paper on board; pop-a-point pencils; 20m transect line; Buoyant line to see the marker.

3.3	TRAINING UPTAKE INDICATORS
3.3.01	The training uptake indicators for this module comprise: The scores from the training uptake test including the group work.

3.4	FURTHER INFORMATION
3.4.01	Corcoran, E., C. Nellemann, E. Baker, R. Bos, D. Osborn, H. Savelli (eds). 2010. Sick Water? The central role of wastewater management in sustainable development. A Rapid Response Assessment. United Nations Environment Programme, UN-HABITAT, GRID-Arendal. www.grida.no http://www.unep.org/pdf/SickWater_screen.pdf
3.4.02	PERSGA (in prep). Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden. Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden. PERSGA, Jeddah.
3.4.03	PERSGA (2015). Draft Regional Guidelines on Wastewater Management in Coastal Cities on the Red Sea And Gulf of Aden. August 2015. Regional Intergovernmental Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden.

3.4.04	Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph., Zurbrügg, C. (2014). Compendium of Sanitation Systems and Technologies – (2nd Revised Edition). Swiss Federal Institute of Aquatic Science and Technology (Eawag), Duebendorf, Switzerland. p. 175. ISBN 978-3-906484-57-0. http://www.sswm.info/sites/default/files/reference_attachments/TILLEY%20et%20al%202014%20Compendium%20of%20Sanitation%20Systems%20and%20Technologies%202nd%20Revised%20Edition.pdf
3.4.05	UNEP (2015). Wastewater Pollution & Coral Reefs. Science-to-Policy Brief for UNEP DRAFT September 2015. C2O. UNEP.
3.4.06	Other modules in this manual

3.5	GROUP EXERCISE
3.5.01	Field trip: To a living coral reef monitoring site.
3.5.02	Complete a survey form
3.5.03	Break into groups. Discuss the opportunities and constraints to the survey form in the context of what it is supposed to achieve. Present and agree a set of review recommendations.
3.5.04	Break into groups. Prepare and present a survey form based on the set of review recommendations.

3.6	TRAINING UPTAKE TEST			0-10
Pre		Post		If the test is taken before training tick (✓) the "*pre*" box and if it is taken after training tick (✓) the "*post*" box.

Tick box as appropriate.

3.6.01	Give two examples of safety/ operational considerations.		
3.6.02	What are the key requirements of a permanent marker?		
3.6.03	What are the key requirements of a transect?		

3.6.04	How can you measure visibility?		
3.6.05	How can you measure sedimentation?		
3.6.06	What should you do if you want to collect water samples?		
3.6.07	How can you tell a hard coral from a soft coral?		
3.6.08	How can you tell a coral from algae?		
3.6.09	How can you tell that a fish is a parrotfish?		
3.6.11	What sort of unusual other observations might you record?		
3.6.11	Give examples of indicators to show that the monitoring site has social and economic importance.		
3.6.12	Field trip		
3.6.13	Complete a survey form		
3.6.14	Group presentation of module review		

3.6.15	Group preparation of a survey form		
3.6.16	Examinee, name, signature and date	Examiner, name, signature and date	Total
Comments by examinee:		Comments by examiner:	

MANUAL FOR MONITORING INDICATORS OF THE IMPACT OF WASTEWATER DISCHARGE ON CORAL REEFS
MODULE 4 : INFORMATION MANAGEMENT

Columns →

ROWS ↓

Site*	Distance from wastewater source*	% cover of live hard coral*
1	1	0
2	2	1
3	3	20
4	4	40
5	5	70

* Numbers do not reflect real data

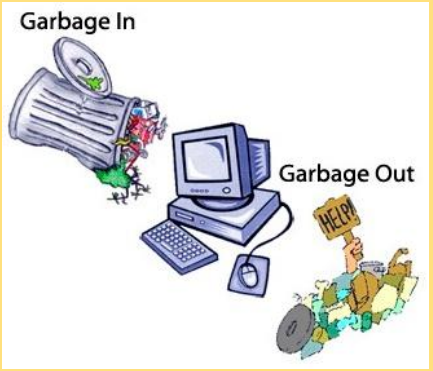
Relationship between distance from wastewater source and % living hard coral cover

(note: diagrammatic not based on real data)

= sample site = best fit = statistical confidence

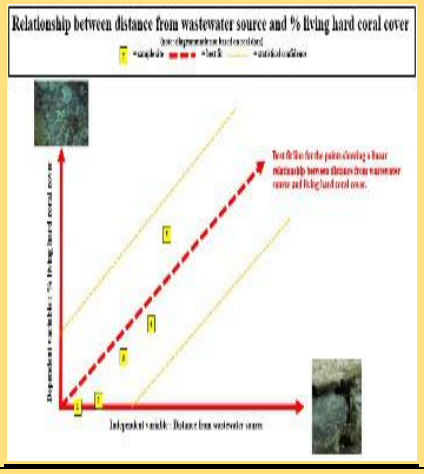
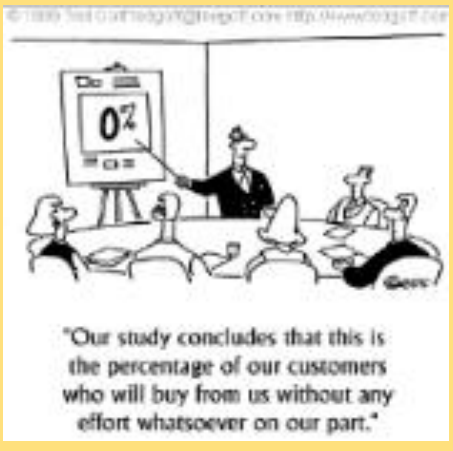
TRAINEE MATERIALS

4.1	LEARNING POINTS	
4.1.01	**Module 4 – Information management**: By the end of this module the target group will understand the key elements of the information management process and the opportunities and constraints to information management. Training in this module should take approximately three hours of presentation, an hour for the group exercise and 15 minutes for the test. There is no fieldwork proposed to be associated with this module.	
4.1.02	**Form a citizen science group:** The group should contain people who can use/train others to deliver the tools specified below and people who are willing to be trained and to apply the tools.	
4.1.03	**Information management**: Information management comprises a process containing the following 8 key elements: (1) Asking the right question(s); (2) Identification of required information (why, what); (3) Collection of information (who, when where, how); (4) Storage of information; (5) Retrieval of information; (6) Analysis of information (data); (7) Use of information; (8) Review and revision of the process.	
4.1.04	**(1) Asking the right question**	
	Information needs to be collected to help answer a question specified in terms of an **hypothesis** (a proposed explanation for an event or problem often in terms of cause and effect). The hypothesis can be tested through an **experiment** which alters cause or effect factors/variables to see whether they are **dependent** or **independent**.	

	An experiment involving dumping wastewater on a living coral reef is not appropriate because it could seriously damage the coral reef. This is avoided by using living coral reef **control sites** where wastewater is unlikely to be present and comparing their condition with living coral reef sites where wastewater is likely to be present.	
4.1.05	**(2) Identification of required information**	
	Required information characterises a **problem** and can be used to develop, deliver and monitor delivery of a **solution**. This is the "Why and what" of the Kipling approach. **Why (module 1)**: The justification for the selected indicators in terms of their relevance to the problem, delivering the solution and monitoring delivery of the solution **What (modules 2, 3)**: Clear specification of the indicators and their attributes The problem has been identified as the impact of wastewater on coral reefs. Use of information to provide a solution is given in module 5.	
4.1.06	**(3) Collection of information**	
	Collection of information: Collection of information requires the completion of the questionnaires/ forms presented in modules 2 and 3. A system for information collection also requires the remaining four elements of the Kipling approach:	

	Who: Who is going to collect the information (the people)? **When**: When will the information be collected (frequency)? **Where**: Where will the information be collected (location)? **What/How**: Primarily the tools specified in the modules.	
4.1.07	**(4) Storage of information**	
	1. **Non-indexed information**: Discrete pieces of information for which one, or more, common characteristics still have to be identified.	
	2. Indexed information: Discrete pieces of information for which one, or more, common characteristics have been identified. A simple index is one linking data using common criteria by columns and rows in a table. Such a table is a simple database. Note: The table opposite presents simulated, and not real, information.	Columns → ↓ ROWS Site* | Distance from wastewater source* | % cover of live hard coral* 1 | 1 | 0 2 | 2 | 1 3 | 3 | 20 4 | 4 | 40 5 | 5 | 70 * Numbers do not reflect real data
	3. **Hard copies**: Hard copies of the information (completed questionnaire forms)	 Courtesy:https://upload.wikimedia.org/wikipedia/commons/8/87/Old_book_bindings.jpg
	4. Digital electronic "*soft-copy*" data: Information held in binary digital "*off*" and "*on*" (010101…..) electronic form in: - a single **computer** (with back-up discs) - between computers in a **local area network** (LAN) - through the **internet** in the **digital**	

	cloud (Dropbox, One drive etc). The "**digital cloud**" is a repository of digital information stored at multiple physical locations and connected by the internet. Information can be managed from computers at different locations without the risk of loss should one, or more, of these computers malfunction.	
	5. Digital electronic database: A digital electronic database is one in which digital electronic data are indexed to allow for ease of retrieval and analyses. Microsoft Excel, Microsoft Access, and other specially designed databases, including geographic information systems (GIS), support such indexing. Many digital electronic database platforms can operate through the internet/cloud.	
4.1.08	**(5) Retrieval of information**	
	Information is more easily retrieved and used if it is: (1) well documented in respect of what/how, why, who, when, and where (2) well indexed (3) digital electronic (4) managed in the digital cloud.	
4.1.09	**(6) Analysis of information (data)**	
	Data (information) need to be analysed to test hypotheses/to answer questions. Graphic illustrations of cause and effect relationships are particularly useful. A geographic information system (GIS) can be a useful tool for analysing and presenting information spatially. The graph opposite presents information from two columns in a simple table	

	by row (site) as part of the process of analysing the possible relationship between distance from wastewater source and % cover of live hard coral*. *Note: The graph opposite presents simulated, and not real, information.	
4.1.10	**(7) Use of information**	
	Information needs to be used to support evidence based advocacy for action, action planning, management of the delivery, and monitoring of the delivery of actions to ensure accountability as described in **module 5**.	
4.1.11	**(8) Review and revision of the process**	
	The process of information management needs to be revised based on lessons learned to be applied so that mistakes are not repeated (no need to re-invent the wheel) and information management becomes more relevant and effective in helping to solve real problems.	

4.2	**TOOLS**
4.2.01	The tools for this module comprise: this module and data management

	tools such as data management software.

4.3	INDICATORS OF TRAINING UPTAKE
4.3.01	The indicators for this module comprise the score from the training uptake test.

4.4	FURTHER INFORMATION
4.4.01	Corcoran, E., C. Nellemann, E. Baker, R. Bos, D. Osborn, H. Savelli (eds). 2010. Sick Water? The central role of wastewater management in sustainable development. A Rapid Response Assessment. United Nations Environment Programme, UN-HABITAT, GRID-Arendal. www.grida.no http://www.unep.org/pdf/SickWater_screen.pdf
4.4.02	PERSGA (in prep). Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden. Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden. PERSGA, Jeddah.
4.4.03	PERSGA (2015). Draft Regional Guidelines on Wastewater Management in Coastal Cities on the Red Sea And Gulf of Aden. August 2015. Regional Intergovernmental Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden.
4.4.04	Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph., Zurbrügg, C. (2014). Compendium of Sanitation Systems and Technologies – (2nd Revised Edition). Swiss Federal Institute of Aquatic Science and Technology (Eawag), Duebendorf, Switzerland. p. 175. ISBN 978-3-906484-57-0. http://www.sswm.info/sites/default/files/reference_attachments/TILLEY%20et%20al%202014%20Compendium%20of%20Sanitation%20Systems%20and%20Technologies%202nd%20Revised%20Edition.pdf
4.4.05	UNEP (2015). Wastewater Pollution & Coral Reefs. Science-to-Policy Brief for UNEP DRAFT September 2015. C2O. UNEP.
4.4.06	Other modules in this manual

4.5	GROUP EXERCISE
4.5.01	Break into groups. Discuss the opportunities and constraints to the module in the context of what it is supposed to achieve. Present and

	agree a set of review recommendations.

4.6	TRAINING UPTAKE TEST	0-10

Pre		Post		If the test is taken before training tick (✓) the "*pre*" box and if it is taken after training tick (✓) the "*post*" box.

Tick box as appropriate.

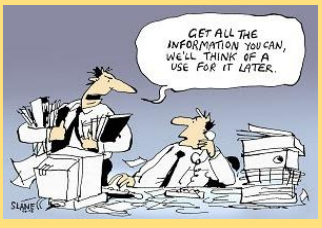
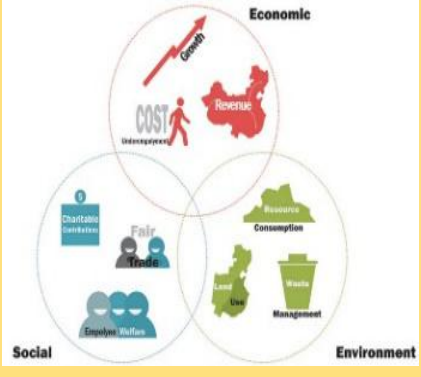
4.6.01	List the 8 key elements of the information management process.		
4.6.02	Give an example of an hypothesis		
4.6.03	Explain what allows information to be indexed.		
4.6.04	Explain the difference between a hard copy and a digital electronic copy		
4.6.05	What is the digital cloud?		
4.6.06	Give a reason for managing information in the digital cloud		
4.6.07	Name four attributes of information that allow it to be retrieved and used more easily.		
4.6.08	Give a reason for analysing information.		
4.6.09	Draw a graph specifying a dependent and independent variable and showing a relationship.		
4.6.10	Explain why it may be		

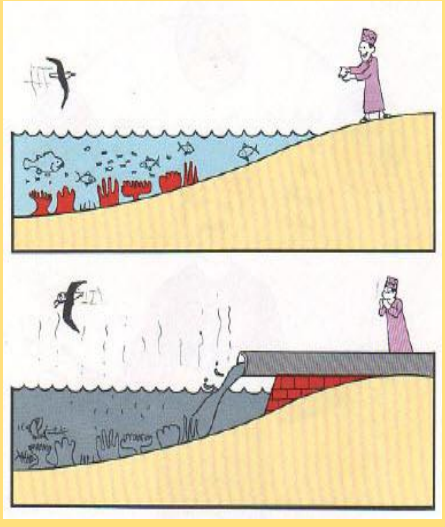
	necessary to review and revise the information management process.		
4.6.11	Group module review exercise		
4.6.12	Examinee, name, signature and date	Examiner, name, signature and date	Total
Comments by examinee:		Comments by examiner:	

MANUAL FOR MONITORING INDICATORS OF THE IMPACT OF WASTEWATER DISCHARGE ON CORAL REEFS
MODULE 5 : INFORMATION USE

PERSGA Regional Taskforce Visit to Aqaba Wastewater Treatment Plant, Aqaba, Hashemite Kingdom of Jordan
4th May 2015.

TRAINEE MATERIALS

5.1	LEARNING POINTS	
5.1.01	**Module 5 – Information use**: By the end of this module the target group will understand how to use information to identify and suggest solutions to a problem and how to advocate for delivery of these suggested solutions. Training in this module should take approximately three hours of presentation, an hour for the group exercise and 15 minutes for the test. The debate on a hypothetical wastewater development and any fieldwork should be added to this time.	
5.1.02	**Form a citizen science group:** The group should contain people who can help deliver a scientific approach to identifying and proposing solution(s) to a problem and then advocating for and supporting delivery of the proposed solution(s).	
5.1.03	**Scientific approach**: An approach comprising: - development of objective **hypotheses** concerning links; - experiments to test the hypotheses statistically.	
5.1.04	**Information use**: Information use comprises a process containing the following key elements delivered using a scientific, evidence based, approach: (1) Characterising the problem; (2) Identifying solutions (3) Advocating action; (4) Action planning; (5) Decision-making; (6) Delivery of action	
5.1.05	**(1) Characterising the problem (what is the problem?)**	
	The problem should be characterised in terms of one, or more, hypotheses. The hypotheses should propose links between objective indicators of possible cause(s) and associated stressors and social, economic and environmental effect(s) on receptors. Information should be collected and analysed to statistically prove, or	

	disprove the hypotheses, as presented in the process under modules 2, 3 and 4. The information should determine the social, economic and environmental **significance** (triple bottom line accounting) of the problem to be used to justify investment in the proposed solution. **Significance** can be determined using a risk assessment approach in which the level of risk can be calculated as the **probability** (likelihood) that an event will occur multiplied by the **severity** of the consequences if it does. Whilst probability can be identified relatively objectively the severity of the consequences is much more of a subjective value judgement.	
5.1.06	**(2) Identifying solutions (what is the solution?)**	
	The basic solutions for reducing wastewater impacts include: - removal of discharge stressor(s) - reduction of discharge stressor(s) - relocation of discharge stressor(s) - relocation of receptor(s) - adaptation of receptor(s) - compensation	✓
	↓ Removal of discharge stressor(s)	
	If the wastewater (stressor) is shown to be causing an adverse effect on the living coral reef (receptor) then the wastewater should be treated to a point where it does not adversely affect the living coral reef. Zero (wastewater) discharge to the sea is an optimal, and potentially viable, precautionary solution. Zero discharge can be achieved by treating the wastewater inland and reusing the treated water for irrigation and industry and the sludge for energy production. Some of the costs of treatment could be recovered by selling the treated wastewater and energy production from sludge.	

⬇ Reduction of discharge stressor(s)

Reduction of the discharge impact by setting discharge criteria to comply with receiving water quality criteria including those set by Blue Flag and the Great Barrier Reef Marine Park Authority:

- partial treatment of all wastewater
- full removal of selected components of the wastewater
- wastewater conservation (reduced water consumption)

The constraint to this solution is that the living coral reefs may continue to deteriorate because one, or more, stressors are not sufficiently reduced.

⬇ Relocation of discharge stressor(s)

Relocation of the discharge to an area away from coral reefs so that it does not negatively impact on living coral reefs.

The constraints to this solution are: the risks to other habitats and resources; the availability of a suitable discharge site; and the costs of relocation.

⬇ Adaptation of receptor(s)

Adaption could comprise the introduction of living corals from other areas that are more tolerant of wastewater to provide for higher resilience to wastewater stressors.

There are multiple constraints to this solution which might not be obvious to those who have experience of the management of terrestrial situations. Tropical aquatic systems have evolved in much more stable situations than most terrestrial ones and so are much less resilient and adaptive to change. Sourcing more resilient and adaptive stock and getting the transplanted stock to survive would accordingly be difficult.

⬇ Compensation

Ideally the mechanism for compensation should follow the "*polluter pays*" principle.

Compensation for the deterioration and/or loss of living coral reefs due to the negative impact of wastewater stressors can take several forms:

1. Investment in a more effective environmental management of the area negatively impacted by wastewater (in-situ) to reduce other

	stressors that might otherwise work cumulatively with wastewater so reducing the overall cumulative negative impact giving the reef more chance to survive; 2. Sacrificing any negatively impacted areas and providing compensation to enhance the protection of **other** (**ex-situ**) living coral reef areas to give these other areas more of a chance to survive; 3. Investment in alternative livelihoods and/or financial compensation for those who can no longer use the ecosystem goods and services that were provided by the living coral reef before it was negatively impacted by wastewater; 4. **Use of wastewater** for social, economic and environmental benefit rather than wasting it. The processes of Environmental Impact Assessment (EIA), Natural Resources Damage Assessment (NRDA), Risk Assessment (RA) and Grievance Redress, in compliance with the "*polluter pays*" principle, will determine the "*What and Why and When and Where and Who*" of compensation (Kipling method).
5.1.07	**(3) Advocating action** Advocacy for action is best developed using a citizen's science group or some other civil society organisation that is formed and operates according to a constitution. Make sure that all advocates are "on message" to avoid any impression of disagreement. Many of the solutions identified above require significant investment and the investment needs to be justified in legal and investment terms. If there is no legal basis for the proposed actions then legal change needs to be advocated for. Advocacy needs to be pragmatic, science based and presented in terms that can be understood and appreciated by decision-makers who may have many other calls on their time. Social, economic and environmental costs and benefits to affected communities from action need to be made clear with an emphasis on economic costs and benefits from live coral reefs such as for food, coastal protection and nature tourism. Where possible use representatives of communities affected by

	the outcome of the advocacy should advocate. Advocating action can be supported by **social media**. Social media is a way for people to communicate and interact online. Social Media tools include Facebook, Instagram, Twitter and YouTube. For more information see https://moz.com/beginners-guide-to-social-media. Advocacy for action needs to propose clear action as to what should be done. A decision maker does not want to hear about a problem unless a clear, reasonable and achievable solution is proposed. A checklist for advocating action should include the following 5 elements: 1. **Citizen science group support**: Advocate action(s) with the support of a duly constituted citizen science group; 2. **Objective message**: Make sure that the action(s) are advocated on the basis that it/they will deliver an efficient, effective, high impact and sustainable solution that can be communicated to, and by, decision makers (those who can influence and support delivery of the proposed action(s)). 3. **Consistent message**: Make sure that you have a consistent message concerning the action(s) you are advocating in respect of justification and proposed action(s); 4. **Legal basis**: Ensure that proposals for significant action include a legal basis if there is a legal basis; 5. **Legal strengthening**: If there is **no** significant legal basis for your proposed action(s) then advocate for a change in the law to support the advocated action(s).
5.1.08	**(4) Action planning** Action planning represents the process of developing an action plan and comprises the following key elements: ⬇development of terms of reference for a planning group ⬇ formation of a planning group of relevant stakeholder representatives and technical experts ⬇ develop proposed objective actions with each action following the

	"*Kipling method*" (What, Why, When, Where and Who) including costs, inputs, activities, outputs and outcomes and a "*SMART*" system for monitoring delivery of actions and holding those responsible for delivering actions accountable (the logical framework tool is a useful tool for action planning). ⬇production of an action plan according to planning regulations/requirements ⬇ review and approval of the action plan by the planning group ⬇submission to the planning authority for approval ⬇submission to the funding authority for funding For certain activities the action plan may require **Strategic Environmental Assessment** (SEA) if it relates to actions to deliver a proposed policy and **Environmental Impact Assessment** if it relates to actions to deliver a proposed physical project.
5.1.09	**(5) Decision-making**
	Decision-making needs to be representative and objective. In respect of decisions by an advocacy group the decisions should follow the constitution of the advocacy group. A decision should be taken:- ⬇ by at least a quorum (half) of the duly constituted members of the decision-making group ⬇ against a decision statement that allows a response "agree, disagree, or abstain" proposed as an agenda item ⬇ there should be an opportunity for debate ⬇ a move to a vote should be proposed and seconded ⬇ the vote should be taken and noted in meeting minutes 
5.1.10	**(6) Delivery of action**
	The main reason for using information is to deliver necessary action to solve a problem. The action plan should include a system for monitoring delivery of actions and holding those responsible for delivering actions accountable.

5.2	TOOLS
5.2.01	The tools for this module comprise: this module.

5.3	INDICATORS OF TRAINING UPTAKE
5.3.01	The training uptake indicators for this module comprise the score from the training uptake test.

5.4	FURTHER INFORMATION
5.4.01	Corcoran, E., C. Nellemann, E. Baker, R. Bos, D. Osborn, H. Savelli (eds). 2010. Sick Water? The central role of wastewater management in sustainable development. A Rapid Response Assessment. United Nations Environment Programme, UN-HABITAT, GRID-Arendal. www.grida.no http://www.unep.org/pdf/SickWater_screen.pdf
5.4.02	PERSGA (in prep). Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden. Regional Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden. PERSGA, Jeddah.
5.4.03	PERSGA (2015). Draft Regional Guidelines on Wastewater Management in Coastal Cities on the Red Sea And Gulf of Aden. August 2015. Regional Intergovernmental Organisation for the Conservation of the Environment of the Red Sea and Gulf of Aden.
5.4.04	Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph., Zurbrügg, C. (2014). Compendium of Sanitation Systems and Technologies – (2nd Revised Edition). Swiss Federal Institute of Aquatic Science and Technology (Eawag), Duebendorf, Switzerland. p. 175. ISBN 978-3-906484-57-0. http://www.sswm.info/sites/default/files/reference_attachments/TILLEY%20et%20al%202014%20Compendium%20of%20Sanitation%20Systems%20and%20Technologies%202nd%20Revised%20Edition.pdf
5.4.05	UNEP (2015). Wastewater Pollution & Coral Reefs. Science-to-Policy Brief for UNEP DRAFT September 2015. C2O. UNEP.
5.4.06	Other modules in this manual

5.5	GROUP EXERCISE
5.5.01	Break into groups: Discuss the opportunities and constraints to the module in the context of what it is supposed to achieve. Present and

	agree a set of review recommendations.
5.5.02	Break into two groups: One group should make a presentation advocating construction of a wastewater treatment facility discharging into a mersa in the context of maintaining living coral reef health and the other should review the presentation and solicit questions. At the end the two groups should vote on a decision statement to decide whether, or not, the investment is justified and set basic conditions.

5.6	**TRAINING UPTAKE TEST**	**0-10**

Pre		Post		If the test is taken before training tick (✓) the "*pre*" box and if it is taken after training tick (✓) the "*post*" box.

Tick box as appropriate.

5.6.01	List the 6 elements of information use.		
5.6.02	List the two characteristics determining the significance of an impact.		
5.6.03	What is the constraint to reducing wastewater discharge as a tool for wastewater management?		
5.6.04	What are the constraints to adaptation of receptors as a tool for wastewater management?		
5.6.05	How might compensation be used as one of the wastewater management solutions		
5.6.06	Describe the 5 elements of the checklist for advocating action		
5.6.07	Who should develop an action plan?		
5.6.08	What are the key requirements for an action within an action plan?		
5.6.09	Propose a decision statement.		

5.6.10	How should a decision be taken?		
5.6.11	What is the main reason for an action plan?		
5.6.12	Group review of module		
5.6.13	Group debate of wastewater treatment facility discharging into a mersa.		
5.6.14	Examinee, name, signature and date	Examiner, name, signature and date	Total
Comments by examinee:		Comments by examiner:	

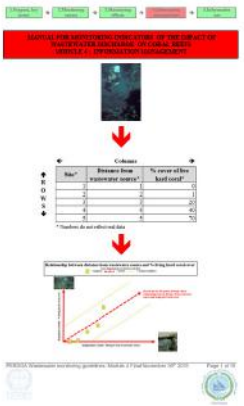
1. Purpose, key terms → **2. Monitoring causes** → **3. Monitoring effects** → **4. Information management** → **5. Information use**

Module 1
Purpose and key terms

Module 2
Monitoring causes

Module 3
Monitoring effects

Module 4
Information management



Module 5
Information Use

For more information contact PERSGA.
www.persga.org