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

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Guidelines for Compensation Following Damage to Coral Reefs by Ship or Boat Grounding

Part 1

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

GUIDELINES FOR COMPENSATION FOLLOWING DAMAGE TO CORAL REEFS BY SHIP OR BOAT GROUNDING

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

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

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Addendum:
The original published version of this document incorrectly cited Table 3.1 and failed to cite Wielgus (2004) in paragraph 3.1.3. These errors are regretted and the text has been modified accordingly.

Cover photographs: Examples of grounding accidents on Egyptian Red Sea reefs.
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FOREWORD

Since the Jeddah Convention of 1982 the participating countries have taken the lead in issuing laws and legislation that help to protect the environment of the Red Sea and Gulf of Aden. However, in many cases these laws do not cover some important concerns. Through the Regional Organization (PERSGA) several subjects have been tackled to support the convergence of legal systems handling cases involved with damage to the marine ecosystem in the region. Among these efforts is a series of workshops concerning the economic valuation of marine and coastal resources and compensation for coral reef damage that has occurred as a result of anchoring or vessel grounding incidents.

All PERSGA member states have agreed to use environmental valuation to demonstrate the benefits of the environment for human welfare, and to support decision making that encourages sustainable development in the area. These valuation studies should include all representative marine and coastal ecosystems and take place in all countries whatever their level of economic development.

Despite the fact that Egypt has the lead in compensation valuation studies, which have been followed by other countries in the region, the system developed in Egypt is now considered limited due to recent developments in the knowledge and understanding of environmental economics that have taken place over the last few years. The present guidelines are designed to be of use to stakeholders in the PERSGA region who struggle to find a reference on the practical aspects of environmental valuation specifically adapted to the context of the Red Sea and Gulf of Aden.

Within the framework of its ongoing capacity building and training programme, PERSGA held a three-day regional training workshop on "Compensation for Coral Reef Damage by Ship or Boat Grounding" at PERSGA headquarters in Jeddah. The workshop started on 3rd August 2008 and was attended by 20 participants from the PERSGA member states. The workshop centred on the concept of compensation and its relative biological, ecological, economic, and legal aspects; exchange of experience between the countries; and initiated a pilot approach to standardize regional guidelines for compensation issues in the PERSGA region.

The Red Sea and Gulf of Aden face a range of pressing challenges that environmental valuation can help to address, thereby supporting the sustainable development goals articulated in the Jeddah Convention. Although a large number of studies already exist on aspects of environmental valuation, none of these studies specifically focuses on the issues and needs of the PERSGA region. These guidelines assess the present status in the region concerning the issue of vessels grounding on coral reefs and the current measures and procedures for assessment and compensation. In addition, the report provides guidelines for national and regional initiatives that will lead towards the preparation of a regional compensation protocol.

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ABBREVIATIONS AND ACRONYMS

AMP	Aqaba Marine Park (Jordan)
ARA	Aqaba Regional Authority (Jordan)
ASEZA	Aqaba Special Economic Zone Authority (Jordan)
CARICOM	Caribbean Community
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COP	Conference of Parties (to the CBD)
COTS	crown-of-thorns starfish
CRRT	Coral Reef Rescue Team
CVM	contingent valuation method
DGPS	differential global positioning system
EEAA	Egyptian Environmental Affairs Agency
EPA	Environment Protection Authority (Yemen)
GMAD	Global Marine Aquarium Database
GONU	Council of Ministers (Sudan)
HCENR	Higher Council for Environment and Natural Resources (Sudan)
ICRI	International Coral Reef Initiative
IMO	International Maritime Organization
IUCN	International Union for the Conservation of Nature
JD	Jordanian dinar
JMA	Jordan Maritime Authority
KAU	King Abdul Aziz University (Saudi Arabia)
MA	Marine Authority (Sudan)
MAA	Maritime Affairs Authority (Yemen)
MAD	Maritime Administration Directorate (Sudan)
MARPOL	International treaty for the prevention of pollution from ships, 1973, as modified in 1978

MHUEAT	Ministry of Housing, Urbanism, Environment and Land Use Planning (Djibouti)
MOA	Ministry of Agriculture (Saudi Arabia)
MOE	Ministry of Environment (Sudan)
MPA	marine protected area
MPRSA	Marine Protection, Research, and Sanctuaries Act (USA)
MSBRA	Marine Science Biological Research Authority (Yemen)
NOAA	National Oceanic and Atmospheric Administration (USA)
NPSRPA	National Parks System Resources Protection Act (USA)
NRDC	Natural Resources Defense Council
P&I	Protection and Indemnity (Club)
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
PME	Presidency of Meteorology and Environment (Saudi Arabia)
RSGA	Red Sea and Gulf of Aden
SCENR	State Council for Environment and Natural Resources (Sudan)
SPC	Sea Ports Corporation (Sudan)
TBT	tri-butyl tin
TEV	total economic value
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNFCC	United Nations Framework Convention on Climate Change
USCRTF	United States Coral Reef Task Force
US$	United States dollar (all figures given as $ refer to US$)
VTS	Vessel Traffic Service (Egypt)
WWF	World Wide Fund for Nature

EXECUTIVE SUMMARY

Coral reefs form important ecosystems, globally and locally within the Red Sea and Gulf of Aden. These reefs contribute a variety of valuable benefits to local communities and to the gross national product of countries in whose waters they lie. These benefits include commercial, artisanal and ornamental fisheries; bio-prospecting for new pharmaceuticals; mining; revenue from tourists keen to observe their natural beauty; and shoreline protection.

That the value of these natural resources has only recently come to be appreciated is a sad reflection on our understanding of our interactions with the physical and biological environment. However, in the recent past, scientists and sociologists have begun to prepare methods of calculating a dollar value for these natural resources.

Globally, and locally, coral reefs face a variety of threats and many have suffered severe degradation. These are common resources; they form part of our natural heritage. When damage is caused to these resources, compensation should be paid by the perpetrator and efforts should be made to restore the damaged area so that it continues to provide the physical and biological benefits to society.

Ship grounding incidents are just one of many threats that coral reefs face. These accidents vary in scale from slight to catastrophic, from grounding by small pleasure craft or the careless use of anchors, to complete loss of the physical framework of the reef if struck hard by a large container ship or supertanker, with possible threats from subsequent chemical spills.

Since the opening of the Suez Canal, and with the regional increase in dive tourism, the number of large and small boats using the Red Sea and Gulf of Aden has increased significantly. With this rise in numbers has come a parallel increase in the number of grounding incidents, damage and loss to coral reefs in the area.

The legal and institutional arrangements for prosecuting offenders in the region have been varied and disparate, sometimes non existent. The presence of a clear set of regional guidelines will assist national governments to pursue offenders and obtain compensation that can be used in reef restoration or to improve navigation and management. The threat of legal proceedings also focuses the minds of ships' captains and leads to increased care and fewer accidents.

This report provides historical records of ship grounding incidents and the current legal framework in each of the PERSGA member countries and then proceeds to suggest a framework for establishing compensation payments. The historical official records show that the number of recorded incidents in each country ranges from zero in Djibouti and Jordan, 4 in Yemen and Saudi Arabia, to 22 in Sudan, and 149 in Egypt. Administrative and legal procedures for pursuing compensation claims are at different levels of development and sophistication with varied formulae for calculating compensation rates in use.

Valuation systems for coral reefs currently only consider a few of the goods and benefits described above. Values may be tempered by a weighting scale that varies with the quality of the reef (percentage coral cover, biodiversity) and include a time factor for the period when the reef can no longer supply these goods and benefits. In addition, compensation is usually

increased to include a contribution towards the costs of surveys and legal proceedings, costs of restoration, and costs of future monitoring.

Egypt has taken the lead in the development of valuation techniques and pursing legal remedies to achieve compensation payments. The basic model developed by Egypt and used to a greater or lesser extent within the region is as follows:

Compensation charge =
A x **LC** x **D** x **RP** x **V**

Where A is a measure of area in square metres, LC is the percentage of living coral, D is the percent damage in the area, RP is the number years required for recovery and V is the value of one square metre (set at US$120 but increased to US$300 for national parks).

However, coral reefs provide many goods and services within the region and this simple formula is not a true reflection of them. Secondly, a one-size-fits-all scheme of compensation in not necessarily appropriate as the uses of reefs in different countries are not the same. For example in Egypt there is a large emphasis on tourism-related revenue and less on fisheries, while in Yemen the situation is reversed. In light of these discrepancies, and aware of the range of technical capacities within the countries of the region, PERSGA has embarked on series of workshops to establish guidelines that can be used or modified to improve the procedures for calculating and pursuing compensation claims.

The guidelines describe (i) an accident assessment system based on an underwater standard survey method for assessing damage to coral reefs from grounding incidents following the FISHBONE grid mapping system that has been successfully applied by the Florida Keys National Marine Sanctuary; (ii) a set of valuation techniques that focus on three key goods and services: coral reef-related tourism and recreation, coral reef-associated fisheries, and shoreline protection services, chosen because these three goods and services are important to local economies and data are available to support estimation of the values; (iii) restoration of the damaged area.

In the final chapter, the benefits of a regional approach are discussed and areas for capacity building are highlighted. These include underwater survey techniques; documenting/ reporting incidents; assessments of coral damage; fauna and flora identification; economic valuation of natural resources; in-situ data/information collection and handling; and reef restoration and rehabilitation techniques.

A regional compensation committee is proposed to consider scientific and economic studies prepared on coral reefs and to draft laws specifically concerned with the conservation of coral reefs, as currently coral reefs are only protected indirectly by legal articles. A regional coral reef rescue team could be trained to be experts in the survey of grounding sites and the preparation and recording of grounding evidence and damage size to improve the probability of successful claims being won through the courts.

1. INTRODUCTION

1.1 THE IMPORTANCE OF CORAL REEFS

Globally, coral reefs have important ecosystem functions that provide crucial goods and services to hundreds of millions of people. The goods and services form an important source of income to the local population (fishery, mariculture, etc.), often living at subsistence levels. Also, they are a potential tourist attraction, thereby contributing to local income generation and foreign exchange. Besides, they form a unique natural ecosystem, with important biodiversity value as well as scientific and educational value. In addition, coral reefs form a natural protection against wave erosion.

Goods and services provided by coral reefs include fisheries and fish habitat functions, on which many communities depend for their livelihoods. In fact, more than 350 million people worldwide depend on coral reef communities for food and survival. Coral reefs also provide a physical structure that helps to reduce coastal erosion and protect economically important constructions and land uses. Most importantly, they offer a rich medical resource, comprising raw materials for the pharmaceutical industry. Such chemical compounds as antihistamines, antibiotics, and other medications for illnesses ranging form asthma to leukaemia and heart disease, were found, extracted, and purified from coral reefs (Terence et al., 1996).

One of the fastest growing uses of coral reefs is for tourism and recreational activities; this may constitute a substantial part of tourism-dependant economies (Dixon et al., 1993; White et al., 2000; Zakai and Chadwick-Furman, 2002). For example, in Queensland, Australia, tourism associated with the Great Barrier Reef is the state's second largest industry sector and is valued at around $1.5 billion per annum[1] (Terence et al., 1996). Globally, recreation as an ecosystem service offered by coral reefs was valued at $3,008 per hectare per year, constituting almost 50% of the total value of services offered per unit area (Costanza et al., 1997).

Most of the studies conducted in this field indicate the importance of obtaining economic values for the various reef goods and services; e.g., a fishery value and a coastal protection value. These goods and services can deal with concrete marketable products such as fish or shellfish, for which the value can be determined based on the demand, supply, price and costs. Other services depend on possible future uses of yet unknown biodiversity on reefs. The values of all these goods and services together form the Total Economic Value (TEV) (e.g., Spurgeon, 1992). This TEV can be calculated for a specific area or for alternative uses (e.g., preservation area, tourism area, multiple use area, etc.). We can also use economic valuation to calculate the economic losses due to destruction of reef functions, such as from blast fishing (Pet-Soede et al., 1999).

Ecosystems provide a great many functions, services and goods. The terms 'functions', 'goods' and 'services' have, in this context, slightly different meanings, though these terms are used interchangeably by many in the environmental economics literature (Cesar, 2000). Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem services. The following table (Table 1.1) shows the direct and indirect goods and services provided by coral reefs.

[1] All figures given as $ (dollars) refer to US dollars (US$).

Table 1.1: Ecosystem functions and corresponding goods and services of coral reefs

Ecosystem Functions	Corresponding Goods and Services	Example for Coral Reefs
Capacitance, damping and integrity of ecosystem response to environmental fluctuations	**Disturbance regulation**	Coastal protection and sediment retention
Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds	**Waste treatment**	Nitrogen fixation, waste assimilation and CO_2 and calcium budget control
Trophic-dynamic regulations of populations	**Biological control**	Feeding places both within the ecosystem and between ecosystems
Habitats for resident and transient populations	**Refuge**	Nurseries and adult habitats
That portion of gross primary production extractable as food	**Food production**	Fish and seafood products
That portion of gross primary production extractable as raw materials	**Raw materials**	Animal and plant products for medicine, curios, jewellery; coral blocks, sand
Providing opportunities for recreational activities	**Recreation**	Tourism, recreation and sport fishing
Providing opportunities for non-commercial use	**Cultural**	Aesthetic, cultural, religious and spiritual values

Source: after Costanza et al., 1997; Moberg and Folke, 1999.

In recent literature dealing with coral reef ecosystem values (e.g., Moberg and Folke, 1999 and Cesar, 2000), the goods are grouped into renewable resources (fish, seaweed, etc.) and mining of reefs (sand, coral, etc.). Table 1.2 shows an example of such a scheme. The services of coral reefs are categorized into:

(i) Physical structure services, such as coastal protection;
(ii) Biotic services, within ecosystems (e.g., habitat main-tenance) and between ecosystems (e.g., biological support through mobile links);
(iii) Biogeochemical services, such as nitrogen fixation;
(iv) Information services (e.g. climate record); and
(v) Social and cultural services, such as aesthetic values, recreation and aquatic sports.

Meanwhile, the situation is slightly different in the Red Sea and Gulf of Aden (RSGA) region where activities such as coral mining are disappearing in the more industrialized countries such as Egypt and Saudi Arabia.

1.2 CORAL REEFS IN THE PERSGA REGION

The status of coral reefs and coral communities in the Red Sea and Gulf of Aden is generally good (PERSGA, 2001, 2006), with coral cover averaging $50^{\pm}30\%$ (Figure 1.1). This includes decreases and increases in live coral cover since 2002.

Table 1.2: Goods and ecological services of coral reef ecosystems

Goods		*Ecological Services*					
Renewable resources	Mining of corals	Physical structure services	Biotic services (within ecosystem)	Biotic services (between ecosystems)	Biogeo-chemical services	Information services	Social and cultural services
Seafood products	Coral blocks, rubble and sand for building	Shoreline protection	Maintenance of habitat	Biological support through mobile links	Nitrogen fixation	Monitoring and pollution records	Support recreation
Raw materials and medicines	Raw materials for lime and cement production	Build up of land	Maintenance of bio-diversity and genetic library	Export of organic production to pelagic food webs	CO_2/calcium budget control	Climate control	Aesthetic values and artistic inspiration
Other raw materials (seaweeds)	Mineral oils and gas	Promoting growth of mangroves and seagrass	Regulation of ecosystem processes and functions		Waste assimilation		Sustaining the livelihood of communities
Curios and jewellery		Generation of coral sand	Biological maintenance of resilience				Support cultural, religious and spiritual values
Live fish and corals for aquaria							

Source: after Moberg and Folke (1999).

The 1998 bleaching event caused major damage to corals in parts of the southern Red Sea and Gulf of Aden, but caused no damage in the northern Red Sea; in some areas the recovery has been strong, and weak in others. Recent outbreaks of the crown-of-thorns starfish (COTS) have occurred in Egypt, Saudi Arabia, Djibouti and western Somalia, along with some local coral bleaching.

Threats to coral reefs differ in the region, but are growing with the increasing rate of coastal development. The major local threats include land fills, dredging, sedimentation, sewage discharge and effluents from desalination plants, mostly around towns, cities and tourist development sites. There is local reef damage around major tourist sites, caused by people and boat anchors, along with other threats. Fish populations are declining in some areas because of increased demand for and fishing pressure on food and ornamental species.

Destructive fishing practices such as trawling in fragile habitats is increasing. There has been an influx of illegal fishing vessels seeking to meet the demands of the export market and more affluent and growing populations locally. The other major threats are from pollution and shipping accidents. As climate change affects sea water temperatures, and warmer waters near the threshold limits for coral growth precipitating coral bleaching events, monitoring these reefs becomes increasingly important.

Most countries have enacted national legislation for coral reef conservation, and signed multinational agreements with assistance from the Regional Organization

for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA). However, these laws are often poorly implemented or enforced and are often ignored completely. The foremost needs are to enforce national and international laws, develop public awareness programmes and adopt sustainable management plans. This will require long-term strategies for capacity building.

PERSGA developed a Strategic Action Programme in 1998 (PERSGA, 1998), and a Regional Action Plan for the conservation of coral reefs (PERSGA, 2003). The plan aims to reduce impacts through integrated coastal management; education and awareness; marine protected areas (MPAs); ecologically sustainable reef fisheries; shipping and marine pollution control; and research, monitoring and economic valuation. Several major new MPAs are being developed in Djibouti, Saudi Arabia, Sudan and Yemen. Management of existing MPAs in a number of countries, including Egypt and Yemen, has improved with support from the Global Environment Facility and bilateral donors.

Most countries have laws for coral reef conservation, but the scope of the laws and the degree of implementation differs widely in the region. Stronger enforcement of national and international laws is needed in every country of the region, along with campaigns to raise public awareness of coral reef issues and the need to adopt sustainable management strategies. The priority actions needed to minimize the predicted damage

Figure 1.1: Map indicating the location of coral reefs in the Red Sea and Gulf of Aden

to reefs have been identified in the Regional Action Plan and the National Action Plans coordinated by PERSGA in 2003. Steps have been taken to implement action, including the recent development of standard survey and monitoring methods, and improved management of some marine protected areas. However, there is insufficient capacity for effective reef management or monitoring in most countries. This lack of capacity is an important regional issue, and major long-term programmes of capacity building are urgently required.

1.3 THREATS TO THE REEFS IN THE REGION

According to the country reports (PERSGA, 2001) and the report on the state of the marine environment in the Red Sea and Gulf of Aden region (PERSGA, 2006) issued by PERSGA as a result of the Strategic Action Programme (SAP), threats to the coral reefs in the area can be divided into human-induced threats and natural threats. The natural threats include damage caused by natural phenomena such as storms, rising seawater temperature, changes in seawater level or sudden population outbreaks, such as the crown-of-thorns starfish.

The human-induced threats, commonly known as anthropogenic threats, are those threats resulting from the unsustainable use of coastal and marine resources. Many publications have been issued on the subject of human-induced threats to coral reef ecosystems. However, an extensive review of those threats at the regional level indicated that threats can be divided into "common" threats which happen in all countries and "specific" threats which occur in certain areas due to the nature of the activities. Table 1.3 summarizes the types of threat found in the RSGA region.

1.3.1 Common Threats

a) Ship Grounding

The grounding of boats and ships is a widespread occurrence affecting the biodiversity of coral reefs. Injury to coral reefs from grounding incidents can range from relatively minor injuries to the complete

Table 1.3: Threats to coral reef areas in the RSGA region

Common Threat	Occurrence	Specific Threat	Occurrence
Ship grounding accidents	Poor navigation areas	Mining and dredging activities	Areas with no building material available
Destructive fishing practices (blast fishing, illegal fishing, etc.)	Fishing areas all over the coast	Sedimentation	Coastal construction areas
Sedimentation	Urban activities area	Pollution and industrial waste	Industrial areas
Collection of coral, fishes, and invertebrates	All over the coastal area	Oil pollution	Oil industry and transportation areas
		Sewage and household waste	Urban development areas
		Coral destruction by diving	Diving sites

breakdown of the structural complexity of the reef. The natural recovery of coral reefs from severe grounding incidents can take centuries, and artificial restoration methods are often employed. The economic value of damages caused by grounding incidents consists of the costs of injury assessments, restoration programmes, monitoring of the restoration programmes, and the lost values of the ecosystem from the onset of damage until the re-establishment of its pre-damage condition.

Coral damage resulting from ship grounding is considered a major threat to coral communities in many regions around the world. The proportional relationship between the magnitude of the damage and the amount of time needed for recovery has never been correctly established. However, the relationship between the number of ships or the traffic in the area is positively correlated with the amount of reef damage. The subject of ship grounding in the RSGA region is a complicated issue. Ship grounding accidents have been poorly documented by the authorities in the past. This paper considers the handling of such problems at a regional level.

b) Destructive Fishing Practices

All fishing methods may affect coral reefs, but destructive fishing practices are further exacerbating the pressures facing reefs around the world. Destructive fishing methods are considered to be one of the largest immediate threats to coral reef ecosystems in some countries. Unlike disturbances caused by natural events or non-point source pollution, the damage caused by destructive fishing practices can be reduced by adopting alternative methods that both lessen damage to the corals and result in more sustainable fisheries.

Destructive fishing methods are unsustainable ways to fish. These practices often result in the loss of edible reef fish, reduction of species diversity, alteration in the size structure of target species, and cascading effects on other reef fish leading to changes in species composition, biomass and density. Any type of fishing activity may cause a phase shift on a reef if the fishing activity is not well monitored and allows too many predators or herbivorous organisms to be removed from the ecosystem. It is important to protect coral reefs because healthy reefs can produce up to 35 tonnes of fish per square kilometre each year, but damaged reefs produce much less.

***Blast Fishing*:** Though forbidden in nearly all countries in the world, and despite the inherent dangers, home-made bombs are still a very popular fishing 'gear' used to catch schools of reef fish and small pelagics, thereby 'earning money the easy way'. In the past, the explosive charge came from Middle East conflicts, though fertilizers and illegally purchased dynamite, often from civil engineering projects, are currently used. The explosion shatters the stony corals and kills fish and invertebrates in a large surrounding area. Over time, blast fishing damages the whole reef and thereby destroys the resource base of many subsistence fishers. Many publications have been issued on this subject indicating the future of the blasted areas and the loss of economic revenue (McManus et al., 1997; Riegl and Luke, 1999; Fox et al., 2003; WWF, 2004, 2006).

***Fishing Gear (entanglement and bottom trawling)*:** Normal fishing gear can cause direct physical damage to the reef structure and substratum. Gill nets, fish traps and anchors break branching coral and cause coral death through entanglement. There are few studies that have documented the damage done and mortality to corals caused by monofilament fishing line. What is known is that when fishermen drop lines by coral reefs the lines catch the coral by their lead sinkers or steel hooks and then are cut off and left drifting. The discarded lines entangle corals and abrade their polyps and upper tissue layers. Corals are able to recover from small lesions, but when the area of damage is large or the damage occurs frequently, recovery may be difficult. Any bottom dragging gear, like beach seines, can damage corals by abrasion and fractures. A beach seine is a long net about 150 m with a mesh size of 3 cm and a weighted line to

hold the net down while it is dragged across the substrate. Beach seines are one of the most destructive types of fishing gear used on reefs.

Bottom trawling in deep oceans is causing the destruction of cold-water and deep-sea corals. Historically, industrial fishers avoided coral areas because their nets would get caught on the reefs. In the 1980s, rock-hopper trawls were invented; the large tires and rollers that were attached to the bottom of nets allowed the nets to roll over any rough surface. Fifty-five percent of cold-water coral in Alaska that was damaged by one pass from a bottom trawl had not recovered a year later. In the northeast Atlantic there are scars up to 4 km long on the reefs from bottom trawlers. In southern Australia, where heavy fishing occurs around coral sea mounts, 90 percent of the surfaces where coral grew are now bare rock. Even in the Great Barrier Reef World Heritage Area, seafloor trawling for prawns and scallops is causing localized extinction of some coral species. Bottom trawlers are a common fishing gear in use in the RSGA region. A report released in 2004 by WWF, IUCN, and the Natural Resources Defense Council (Gianni, 2004) cited bottom trawling to be the single greatest threat to deep sea environments.

Overfishing and/or selective fishing: Though not necessarily as destructive as the other threats described above, overfishing damages coral reefs, mainly through a reduction in fish diversity. It also decreases their value to recreational divers, who are eager to see both large predators and an abundance of small colourful fish. In general, the necessary reduction in effort to avoid overfishing and achieve optimal sustainable yields is roughly estimated to be in the order of 60 percent (McManus et al., 1992). Alternative income generation, for instance in eco-tourism, could be one way of bringing about this reduction in effort. Besides lowering the total effort, fisheries management should also focus on the creation of sanctuaries and establishment of closed seasons. Reports of fisheries landings from different countries in the region have showed a reduction in both number and size of coral reef fishes found in the total catch, which indicates damage to the fish stocks in those areas.

c) Sedimentation

The coastal area in the RSGA region is exposed to sedimentation from three main sources. The first and smallest source is natural and comes from the desert nature of the coastal plains. A huge amount of sand is blown by the prevailing winds and is deposited in the nearby reef flat areas. The second natural source results from seasonal water floods generated by rain that pours through wadis into the coastal fringing reefs. The damage to the reefs that results from these events is limited to the local area, occurs with large time intervals, and in some cases is recoverable.

The third source of sedimentation is from human activities such as land filling, shoreline alteration and urban development. These activities result in sediment that smothers corals and prevents the symbiotic algae and the coral polyps from capturing sunlight and plankton respectively, their primary sources of energy and nutrition. These problems are particularly obvious close to newly developed cities in the region such as Hurghada and Jeddah. The impact of sedimentation from these sources is relatively local; however, it lasts for a longer time than was expected and the damage can be intense. For urban induced sedimentation, economic costs are difficult to allocate as discharges often have many sources.

d) Collection and Trade of Corals, Fishes and Invertebrates

The global trade in marine aquarium animals and plants is a well established international activity with a value of $250–300 million each year. The number of people that own marine aquaria at home ranges from 1.5–2.0 million and includes about 60,000 in the USA alone. The items included in this trade include about 2,400 species of corals, fishes, invertebrates, and plants**.**

According to UNEP (2000), records of the trade in exotic species are kept on the Global Marine Aquarium Database (GMAD). However, the records always show differences between the amount exported and imported. This means that the illegal sector of this industry is finding other sources. In the last decade, with the difficulties in transport of such materials over long trips around the world, the Red Sea has become a target for obtaining such material illegally.

Despite the fact that most of the fish catching operations involve coral breakage and damage, the benefits from the trade are higher than for some other fishery operations. Accordingly, many fishers have begun to shift their activity towards fishing for exotic species. Combating such illegal activities in the region needs more effort from the concerned authorities.

1.3.2 Specific Threats

a) Mining and Dredging Activities

Coral reefs have long been used as a source for building material and for the production of lime, as well as for the ornamental coral trade. The lime is often used as plaster or mixed with cement to reduce costs for private dwellings and local administrative offices. Coral mining not only destroys reef flats, and thereby its coastal protection function, but leads indirectly to logging of secondary forests, which are used for lime burning. Notwithstanding the negative impacts of coral mining on the coastal protection service of reefs, as well as on other ecosystem services, coral mining is still extensively practiced in many parts of the world and in the RSGA region as well. A very good example of historical coral mining is the old city of Suakin on the Sudanese coast where most of the buildings are built from coral obtained from the nearby reef.

b) Pollution and Industrial Waste

Pollution from urban areas, agro-chemicals from farming and industrial discharges can kill corals. The discharges from the desalination plants and waste water treatment plants in the coastal cities are known to cause damage to the coral areas due to changes in water quality and temperature.

Many of the RSGA countries have major industrial cities along the coast. The wastes discharged from these cities are a major threat to the reefs of the Red Sea and Gulf of Aden. Besides they may affect the marine environment of adjacent countries to some degree. The control and monitoring of such wastes is the responsibility of the country in which the point of origin is located. Some of the countries in the area have regulations for discharging waste into the sea according to the MARPOL convention (1973/78) while others have not yet taken the proper procedures. In a study done by Russell (1992) on the costs and benefits of coastal waste management in urban areas he provided evidence that the environmental costs of these types of activities will severely affect other industries (tourism, fisheries, etc.) which have less impact on the environment.

c) Coral Destruction by Diving

Recreational SCUBA diving is a rapidly growing division of the international tourist industry. As coral reefs have become more accessible and facilities for visitors improved, the number of people diving on this potentially fragile ecosystem has increased exponentially (Hawkins and Roberts, 1993). According to Harriot et al. (1997), PADI, the world's largest diver training agency has seen an increase in international dive certifications from 10,000 for the year 1967 to more than 5 million by 1996. Until recently, diving tourism was thought of as an activity entirely compatible with the sustainable use of marine resources, as opposed to extractive activities such as fishing, mining, and the construction of tourist facilities. However, recent evidence has demonstrated that reefs may become degraded as a result of poorly planned or intensive tourist use (Jameson et al., 1999; Tratalos and Austin, 2001).

With the rise in popularity of recreational SCUBA diving, physical damage inflicted

by divers and boat anchoring has increased significantly. As a result, reef degradation attributed to diving pressure has become a widespread concern and risk that needs to be properly assessed, which in turn, will support effective management strategies. SCUBA divers may unintentionally damage coral and other benthic reef organisms. Several previously described studies investigated how reef walking, trampling, (Woodland and Hooper, 1997; Liddle and Kay, 1987; Hawkins and Roberts, 1993), snorkelling, and diving activities (Hawkins and Roberts, 1992) damage coral tissue by either breakage or abrasion. These studies provided a quantitative analysis of damage due to divers, thought to be the main cause of mortality in frequently visited dive sites, showing significant differences in coral cover between heavily used and the so called 'pristine' sites. Riegl and Velimirov (1991) showed that at heavily dived sites, there was more coral breakage, algal overgrowth, and tissue loss than at low frequency dive sites. Similarly, Hawkins and Roberts (1992, 1993), showed that there was a significantly high number of damaged colonies, loose fragments, and abraded coral colonies at heavily used dive sites. Furthermore, increased sediment loading on the reef due to diving activities may stress the corals and lead to mortality (Rogers, 1990).

1.4 THE NEED FOR REGIONAL GUIDELINES

Despite the fact that coral reefs are recognized as highly productive, diverse, and attractive ecosystems which provide a wide range of benefits for mankind, reefs worldwide are under siege, being damaged by over-exploitation and indirect human impacts. Part of the problem stems from the fact that the overall economic value of coral reefs is rarely considered or appreciated (Costanza et al., 1997; Daily et al., 2000).

During the last decade, it became clear that the success of any economic system depends to an extent on the number of countries acting together and applying the system in a form of union or consortium. Such systems have even more strength if the countries apply the same laws and regulations when handling common problems.

There is a need for a unified system to handle the common problem of coral damage compensation. The lack of guidance in the field of economic evaluation in the RSGA region currently opens the door to the possibility of compensation values being calculated with weak scientific evidence and based purely on previous experiences in the region which may not have occurred in similar circumstances.

In August 2008 PERSGA organized a regional workshop in Jeddah for national experts, nominated by their respective countries. They undertook a review of the current compensation systems used in the various PERSGA countries for coral reef damage caused by vessel grounding incidents. The results showed that each of the countries uses a different system based on its own experience and needs. Generally, the equation used in the Egyptian system to calculate the compensation rate is considered as the model for all other countries. However, a closer look at this equation proved that it is not suitable for all the countries in the region. The unsuitability of the equation is mainly due to the different activities performed in the coastal area of each country and the lack of consideration given to restoration. Besides, the equation is not based on a very exhaustive economic valuation scheme, but mainly considers valuation of tourism activities.

The need for regional guidelines for compensation procedures appears to be urgent. They will initiate the development, modification and standardisation of existing practices. This publication presents the current national status and a set of proposed guidelines for regional compensation procedures. The information and data are taken mainly from the discussions and suggestions during the above mentioned workshop.

2. VESSEL GROUNDING INCIDENTS IN THE RED SEA AND GULF OF ADEN

2.1 EVENTS OVER TIME AND PLACE

Ship grounding incidents are a type of marine accident that involve the impact of a ship on the seabed, often resulting in damage to the submerged part of the hull and in particular the bottom structure, potentially leading to water ingress and compromise of the ship's structural integrity and stability. Grounding incidents may give rise to a variety of consequences. Affects may be felt in: 1) the physical environmental impact, especially where large tankers are involved; 2) possible loss of human life; 3) financial consequences to local communities close to the accident; and 4) financial consequences to ship-owners, due to ship loss or penalties.

The grounding, depending on manoeuvres of the master before the impact, may result in the ship being stranded. Depending on the nature of the substrate and relief of the seabed at the location, i.e. sandy, muddy, coral or rocky, different measures have to be taken to assess the damage caused by the accident as well as damage that may take place during the release of the ship and its transfer to a safe harbour.

The physical damage of ship grounding causes a tragic loss of marine habitat and life but any subsequent loss of ship fuel or cargo potentially has even greater and longer lasting effects. Oil leakage is a common consequence of ship grounding as fuel tanks may be ruptured or pierced. The resulting oil spill is a disaster for local wildlife. Many seabirds are killed by exposure to oil, benthic communities are smothered and beaches are covered with a black sticky blanket.

Before the opening of the Suez Canal ship traffic was relatively limited in the Red Sea. With such limited maritime movements, on average only one major incident occurred each year along the coast. However, the opening of the Canal and the tremendous increase in the number and size of ships crossing to and from the Red Sea increased the potential for more accidents to occur. Figure 2.1 shows the main shipping routes

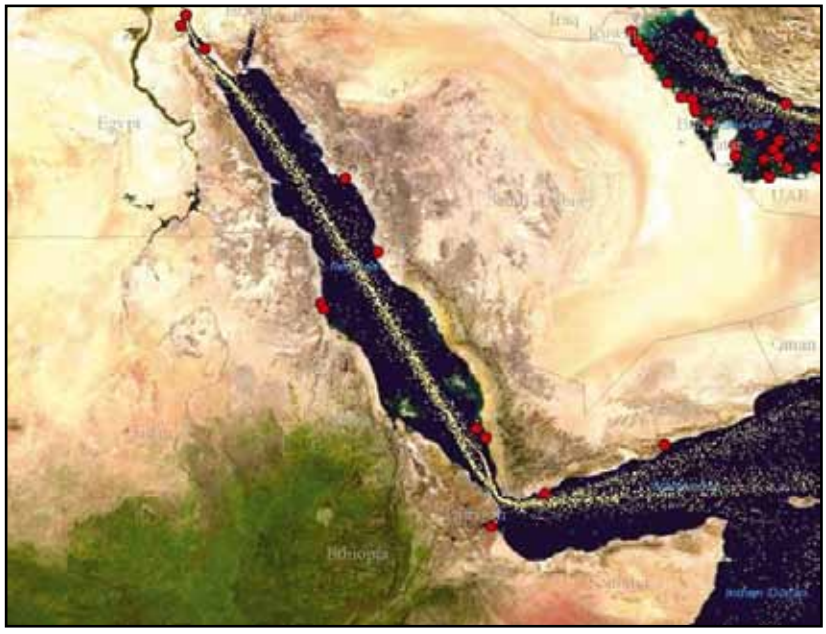

Figure 2.1: Map showing the main shipping routes (indicated with yellow spots) and the national ports (indicated with red dots) in the RSGA area

Source: IMO.

in the RSGA region and the national ports. Recent tourist development in the area, especially in the northern parts of the Red Sea (i.e. Egypt) has added an even greater traffic load due to ferries and tourist boats.

According to the available information on ship accidents, certain areas around islands and at the entrance to marinas are more likely to have ship grounding accidents. Despite the fact that the area has been fully mapped by the Royal Navy and complete sets of maps are available for navigation, certain areas are shallow due to coral growth and need a degree of navigational proficiently if they are to be avoided.

Anchor damage to coral reefs has, in the past, been considered as a minor threat; however, recent studies have shown that in the long run the damage caused by anchors in coral areas can be severe. The lack of mooring systems in many countries in the region (found only in Egypt, Jordan and partially in Saudi Arabia) increases the probability of coral damage from poor anchoring practices.

2.2 CAUSES OF EVENTS

As ports and populations along the coast expand, shipping lanes become busier and ship groundings increase in frequency. Ship grounding incidents occur for a variety of reasons ranging from human error to technical failure, and depending on the site and size of the impact the resulting damage can be minor or severe.

Before the advent of satellite navigation and modern computer charts, when captains sailed with relatively simple navigation equipment and faulty charts, ship groundings occurred in many parts of the world as result of mistakes or inexperience in navigation or from sailing in uncharted areas. However, with the revolutionary development of equipment another set of factors appears to cause ship grounding accidents. Matoba (1999) explained the effects of both the human factor and structural reliability in ship grounding and collision events. He indicated that human behaviour during accidents should be added to the accident inquiry records as well as the related structural reliability of the ship. Simonsen and Hansen (2000) presented a theoretical and statistical analysis of more than 130 ship grounding accidents. Their work discusses various aspects related to ship design with respect to grounding accidents. A relatively simple theory is reviewed for comparing the expected grounding damage to different ships, taking into account the structure, the displacement and the sailing velocity.

According to the available records, the causes of accidents in the Red Sea and Gulf of Aden seem to be related to the type of activities in the area. For example in the main channels where large ships are travelling, no accidents were expected except near the approaches to the channels. Small coral patches at the entrance to marinas are commonly neglected by small-boat captains and are a major cause of accidents.

For small boats and yachts, human error in navigation is nearly always the reason for the accident. For example, with the booming tourism industry in Egypt the number of tourist boats and private yachts has grown from a few (30) in the 1970s to about 4,000 boats in Hurghada alone in 2005. Such an increase in number without the proper training for skippers has caused a large number of grounding incidents due to the lack of experience in navigating coral reef areas.

Bad weather conditions are also one of the reasons for boat grounding accidents in the area. With the exception of the northern part of the Red Sea, which is dominated by persistent north-west winds, with speeds ranging between 7 km/hr (4.3 mph) and 12 km/hr (7.5 mph), the rest of the Red Sea and the Gulf of Aden is subject to the influence of regular and seasonally reversible winds. The wind regime is characterized by both seasonal and regional variations in speed and direction with average speed generally increasing northward.

2.3 CLAIMS AND SETTLEMENTS

The concept of environmental compensation is relatively new for many countries. Meanwhile, other nations have realized the danger of "turning a blind eye" to even small environmental damages; they have used part of their civil law to protect against environmental damage. By the end of the last century and at the beginning of the new millennium several developing countries had issued environmental laws of their own. Naturally the new laws included similar structures to those issued previously in other countries, but in addition included parts concerning the country where the law was issued.

With the development of environmental economic science as a tool for calculating the value of damage inflicted on the environment, many countries have adopted a system of environmental compensation. Coral reefs are one of the more important marine ecosystems and are responsible for a high percentage of the national income in some countries. Compensation for damage to coral reefs due to different reasons starts to appear in the courts of law around the world and the amount paid in fines has been shown to have had a positive deterrent effect on the number of accidents recorded.

In the Red Sea area, cases of coral damage compensation date back to the mid 1980s after the declaration of the first national marine park in the area of Ras Mohamed (Egypt). The management scheme of the protected area included provisions for the protection of the marine environment, especially the coral reefs. The only available law during that period was Law 102 for protected areas. According to this law, person or persons responsible for damage to a coral reef due to an accident or action could be fined. The exact amount of the fine or how to calculate it was not determined by the law. Accordingly the search for a method for evaluation of the damage and how to calculate the fine was started by a group of scientists working in the area and through visits to Ras Mohamed Park.

By the end of 1980s a formula had been generated and put to work as an internal regulation of the marine park. The formula is still in use today and its application has extended to include the whole coast of the Egyptian Red Sea. There were 39 incidents of ship groundings and breaches around Hurghada and the Sinai coast from April 1997 to April 1998. The maximum fine issued for dropping anchor over a reef was $6,000 and the maximum total fine was for the Marylin which hit Shedwan reef at Al-Ashrafi; it was fined a total of $4 million and the vessel was impounded until the fine had been paid. This aggressive action sent a clear message to shipping companies and encourages caution and care to be taken when navigating Egyptian reefs. However, the number of ship grounding accidents recorded from Egyptian waters increased to 80 for the Red Sea coast generating about $8,175,250 in fines while for the northern part, including South Sinai, the number reached 69 accidents generating $76,425,075 from 1987 to 2008.

In other areas of the Red Sea getting compensation is not as easy due to the lack of supporting laws, monitoring tools and experienced personnel. With the increase in capacity building projects carried out by regional and international organizations several other countries like Jordan, Saudi Arabia and Yemen have started to collect fines from these types of accidents when they occur in their coastal waters. The exact amount of fines and the details of the accidents themselves are still poorly documented. More anchoring restrictions, mooring buoys, navigational aids, and no-shipping areas are needed to reduce the number of ship grounding incidents that occur.

2.4 MECHANISMS AND PROCEDURES USED AT THE NATIONAL LEVEL

2.4.1 Sudan

Sudan is one of the largest countries in the region; it is divided into 25 states. The Red Sea coastline of Sudan is some 750 km long, not including all the embayments and inlets, and is located in one state called the Red Sea state.

The Sudanese coast has two prominent geographical features: coastal lagoons, locally called *marsas*, and fringing reefs, called *shia'ab* in Arabic. The marsa may be a protected embayment of the sea, or may be cut into the coastal plain, well beyond the general coastline. Within the marsa, despite the heavy fresh water influx during the short rainy seasons, corals grow and build coral knobs (tens of centimetres to metres in size) and patch reefs (metres to tens of metres in size).

The reefs are distinguished according to their shape and position. Fringing reefs line the entire Sudanese coast, with the exception of the marsas and the delta near Tokar city in the south. Fringing reefs are usually 1,000 m wide and can extend up to 3,000 m. Barrier reefs are generally separated from the coast and fringing reefs by a deep channel. The barrier reefs range from narrow discontinuous reef walls, only several tens to a few hundred metres wide, to platforms up to 14 km in width. Finally there are atolls, which are reef platforms located furthest offshore, several hundreds of metres to a few kilometres in width and surrounded by deep water. Examples of these are the Sanganeb Island and Shia'ab Rumi.

Most of the coastal activities in the Sudanese Red Sea are related to maritime transportation, port related activities and fisheries. Tourism in the area is still very limited. This is despite the fact that the Sudanese coast has a high potential for diving tourism. The coral reefs along the coast of the Red Sea form very attractive sites for divers due to the wide diversity of marine life, tremendous visibility — up to 46 m recorded — and surface water temperatures (e.g., near Port Sudan) ranging between 26°C and 30°C. The Sudanese Red Sea is considered one of the best diving locations in the world, especially by those interested in underwater photography.

a) Formal National Procedures

The legal framework in Sudan is based on the Interim National Constitution issued in 2005 which includes three main sections concerned with the protection of the environment and natural resources of the country. Those sections state that:

- The people of the Sudan shall have the right to a clean and diverse environment; the state and the citizens have the duty to preserve and promote the country's biodiversity.
- The state shall not pursue any policy, or take or permit any action, which may adversely affect the existence of any species of animal or vegetable life, their natural or adopted habitat.
- The state shall promote, through legislation, sustainable utilization of natural resources and best practices with respect to their management.

The Sudan Environment Protection Act, issued 2001, is the principal environmental law in Sudan. This law provides definitions and several clarifications regarding natural resources management, sources of pollution and pollutants, and endorses the principle of the "polluter pays". The Environment Protection Act 2001 empowers each state to establish its own independent State Council for Environment and Natural Resources (SCENR) with the responsibility to coordinate and follow-up on state efforts to ensure public participation in the decision-making process, to play an active role in coordinating the formulation and implementation of conservation policies as well as to foster environmental monitoring, protection and regulations.

A new revised draft of the Act to be issued in 2008 to suit the Interim National Constitution was submitted to the Council of Ministers (GONU) for approval. This new version includes regulations concerning protection of the marine environment. In addition a new National Maritime Law has been prepared and a final draft was submitted to GONU for approval in October 2008. This includes in Chapter 7 general regulations about the protection of the marine environment but left the executive regulations to national environmental law. According to terms of the National Interim Constitution 2005 the chain of legal powers in Sudan include: 1) national powers; 2) state powers; and 3) concurrent (joint) powers.

The formal procedures taken following each incident concerning a marine casualty that involves injury or death, damage to a vessel, cargo or to the environment include the formation of a committee of investigation by the Minister of Transport, or the General Manager of Sea Ports Corporation (SPC) depending on the seriousness of the case. The committee puts forward its findings to the party that requested it. The concerned national authorities are:

1. The Maritime Administration Directorate (MAD), responsible for marine safety, protection of the environment, as well as security matters.
2. SPC which is responsible for the operation of all government sea ports.
3. The Ministry of Environment and Physical Development through the Higher Council for Environment and Natural Resources (HCENR), responsible for all federal environmental matters.
4. Ministry of Environment and Tourism (state level).
5. Coast Guard (navy).

b) Records of Ship Groundings

A total of 22 ships have been recorded as running aground or sunk on reefs along the Sudanese Red Sea coast at Port Sudan, and on the anchorage areas around it, to 2008. They are listed below in Table 2.1.

The table shows only the name of the ship and the grounding location. This is the limit to the records found in Sudan and most of the RSGA countries. However, a very few of these ships have been subject to fines according to the Sudanese law. The records also indicated the major reasons for grounding as one or more of the following: human error (90% - IMO); engine trouble; inadequate or lack of navigation aids; rough sea; lack of updated charts; vessels arrested due to maritime claims.

Table 2.1: Ships recorded as grounded on reefs in Sudan

No.	Name of Ship	Location
1	BIJA	Inside harbour
2	Gassim	Silait anchorage
3	Shiba	Silait anchorage
4	Hassanen	Silait anchorage
5	Raad El-Bakry	Towartit anchorage
6	Manar	Abu hashish area
7	Amil	East of refinery
8	Sagr El-Gazira	Dama Dama
9	Loza and Dasman	Suakin harbour
10	Taysir	Tala Tala island
11	Fishing boat	Fija Bay
12	Towaritit tug	Abu hashish area
13	Sinkat tug	Abu hashish area
14	Fishing boats	Power station area
15	Lina	East of refinery
16	Sharifa	West Port Sudan dockyard
17	Wreck (unknown)	Flamingo area
18	Boat (unknown)	Berth No 18
19	El-Rasheed	South Bashair
20	Fishing boats	West of workshop
21	Amanda	Ragab area
22	Umbria	Silait anchorage

c) Procedures for Survey and Compensation

The procedure of the survey of the damage is to send divers for inspection and underwater photography. There are no national legal steps for compensation and no national mitigation measures for the damaged reefs.

Plate 2.1: MV Annie Sierra, run aground in November 2005 at Saliate reef near the Port Sudan anchorage area due to a navigation error

2.4.2 Yemen

Yemen has a coastline of over 2,100 kilometres, with one third on the Red Sea. The coastal and marine environments, particularly those along the Red Sea and Gulf of Aden, are very important to Yemen. Many people living adjacent to this coast depend on its renewable resources for their daily income. It is rich in coral reef communities with high biodiversity and productivity. This richness can contribute greatly to the future development of Yemen in terms of food provision, industrial and recreational needs, and ecotourism.

The intensive shipping traffic in the Red Sea and Gulf of Aden (i.e. oil and gas tankers and container ships plying the international shipping route along the Yemeni coastline; vessels visiting Yemeni ports; fishing vessels and boats working in Yemeni waters; as well as tourist yachts visiting Yemeni coasts) put coral reefs at high risk.

a) Formal National Procedures

According to the law for the protection of the marine environment in Yemen (Law 16/2004) the procedures in case of pollution also apply to general ship grounding accidents and include:

1. Response and salvage procedures to remove the ship or boat from the reef;
2. Field survey of the damaged area to:
   - Estimate the size and extent of damage.
   - Determine the activities required, and technical and financial resources needed for clean-up and restoration of the damaged area.
   - Documentation of the damaged area.

The Law 16/2004 for the protection of the marine environment states in Part 5 Article 22 that: If discharge or sinking of pollutants, or materials that may cause damage to the environment and marine life is committed in the pollution-free area by a ship, aircraft, onshore site or oil transportation vessel, a civil responsibility shall arise against the owner of that ship or aircraft, or owner/ occupant of that site or those vessels for all costs arising from remedial actions or elimination of the environmental damage, in addition to compensations entailed, or that might be entailed, from such damage and penalties prescribed in accordance with this law, regardless of any causes or justifications for the discharge, sinking or damage to the environment. Compensation for environmental damages includes the following:

a- Cost of elimination of the pollution, or environmental damage, and cleaning of the marine environment.
b- Compensation for damages caused to the marine environment or marine life, whether permanent or temporary, at present or in the future.
c- Compensation for damages caused to property or persons.

The law also named each of the concerned national authorities and prescribed their responsibility towards grounding accidents to be as follows:

1) Maritime Affairs Authority (MAA): The lead national authority responsible for salvage response to grounding accidents, damage assessment, compensation claims, and restoration of damages.
2) Environment Protection Authority (EPA): Plays an important role in assisting MAA in its assessment of damages and restoration operations.
3) Marine Science Biological Research Authority (MSBRA): Plays an importance role in the assessment of damage.

b) Records of Ship Groundings

Despite the fact that a large number of vessels pass through the coastal waters of Yemen each year, the number of recorded incidents of ships grounding is limited to a very few large ships. Table 2.2 lists the major accidents that have occurred over the last 7 years.

Table 2.2: Recorded major grounding accidents on Yemeni reefs during the last seven years

Year	Location	Vessel
2001	**West of Jabal Zugar island**	**Delos Carrier**
2004	**Southern shore of Mayun island**	**Iran Ardebil**
2005	**North of Ras Isa peninsula**	**Pontoon**
2007	**East of Saba island**	**Catrina maha (tourist yacht)**

The causes of the accidents were human or technical errors. The principal causes are summarized as follows:

1. Non-conformation of vessel position;
2. Insufficient study of waterways;
3. Insufficient attention to water or sea surface conditions;
4. Inappropriate measures taken for bad weather.

Plate 2.2: MV Iran Ardebil aground in August 2004 on the southern shore of Mayun Island, off the Yemeni Red Sea coast

c) Procedures for Survey and Compensation

There is no national rule on how to calculate the value or minimum value for compensation that is to be claimed for damages inflicted on coral reefs by ship/boat groundings. There are only general laws defining the compensation for damages to environmental resources. Law No. 16/2004 regarding protection of the marine environment from pollution sets out the components for compensation and procedures for claims for such damages. Law No. 26/2004 regarding protection of the environment defines compensation for damages to environmental resources in general.

For all past grounding incidents that have caused damage to corals, Yemen has sought the assistance of international and national experts to help in assessing and estimating compensation for damages. To estimate the required compensation for corals damaged, each grounding incident was analyzed separately in view of the extent of the damage, the required restoration activities and the estimated time required to restore the baseline level.

In all incidents damage assessment procedures included:

- An estimate of the size of the damaged area caused by the grounding accident;
- An ecological study of the area damaged (coral cover, coral diversity, etc.) by means of rapid assessment methodology and by comparing the values in the injured site with adjacent sites in case of absence of previous data for such parameters;
- Documenting injured corals (by means of photos and videos);
- Review of the literature and any available data and information on the status of corals in Yemen and at the grounding sites; and
- Analysis of data and information, review of damage assessment approaches elsewhere in the world, and assessment of the best methods to determine the compensation level for rehabilitating and interim damage.

Bearing in mind practices and standards implemented elsewhere and actual required costs for the clean-up and restoration, monitoring, and compensation of damages, many different valuation approaches were used for each event to determine the costs that were to be claimed for damages including:

1. Valuation based on coral recreational value;
2. Valuation based on the Egyptian valuation method;
3. Valuation based on previous damage claims; and
4. Valuation based on all values including non-use values (by benefits transfer method).

For all past cases, damage claims consisted of three basic components:

- Costs of clean-up and restoration;
- Costs of monitoring coral damage sites over many years after the incident; and
- Compensation for the residual (interim) damages.

Rates of compensations varied from one incident to another depending on the extent and severity of damage. Rates ranged between $800 and $1,000 per metre. The legal steps for establishing compensation for damages inflicted on coral reefs by ship/boat groundings are taken in accordance with Law No. 16/2004 regarding protection of marine environment from pollution. The procedures for the claim are set out by law as follows:

1. Costs of eliminating the damage and environmental cleansing (this includes costs of response and salvage to remove the ship grounded on the reef);
2. The compensation for the damages that affect the environment itself (as discussed above);
3. The compensation for damage that affects properties and persons;
4. The party responsible for damage is notified officially by the Maritime Affairs Authority (MAA) of the claim value for such damages; and
5. If the party above does not pay damages or deliver a financial guarantee of the same to MAA within forty-five days from the date of notification, the MAA may file a claim for compensation against that party to a competent court.

No clean-up or restoration was carried out after any of the recorded accidents, and most of the recovered compensation was used in other activities to contribute towards protection of the marine environment. In the past few years Yemen has drafted a general integrated project to assess coral reefs and one of the main components of this project aims to restore coral reefs affected by past grounding accidents.

2.4.3 Egypt

Egypt is a large country with a relatively long portion of the Red Sea coastline, about 1,800 km including the coasts of the Gulf of Suez and Gulf of Aqaba. Most of the Egyptian coast of the Red Sea is bordered with a coastal fringing reef except for parts of the Gulf of Suez. The width of the fringing reef ranges from 10 m up to

1,500 m especially on the southern part of the coast. In addition to the fringing reef a large number of submerged reefs are present especially in the area between the coast and the nearby offshore islands.

During the 1980s considerable development was directed towards the use of the tourism potential of the coastal area. Such development was particularly notable in Hurghada and Sharm El-Sheikh where the population increased up to five fold as a result of migration from the Nile valley.

a) Formal National Procedures

In the early 1980s, with the declaration of Ras Mohamed as a Marine National Park, a set of rules and regulations were applied to the area in order to protect the marine environment from damage which might be inflicted due to development. Many of these rules and regulations applied to parts of the coast under the umbrella of Law 102, issued for organizing the protected areas. Several marine protected areas were declared in the following years to cover almost all the coast of the Gulf of Aqaba and parts of the Egyptian Red Sea coast.

In 1987 the management of the protected area of Ras Mohamed issued a report about the increase in the number of ships grounding in the Gulf of Aqaba, especially in the Tiran island area (more than 10 ships). The report concluded that most of the accidents were deliberate for obtaining insurance money. As a result of this report, the Egyptian Environmental Affairs Agency started to deal with ship grounding accidents as a threat to the marine environment. The first case was that of the ship Lania carrying the flag of Holland which collided with the reef and spilled about 700 tons of fuel into the water. The damage was estimated at $100 million. However, due to the lack of scientific basis in evaluating the damage the compensation was reduced to $0.75 million. The same situation was repeated in the accident involving the ship Safir which collided with the reef leaking a vast amount of phosphate ore onto the reef. Also in this case compensation was reduced due to the lack of scientific basis for the valuation.

At the end of the 1980s, the European Union financed a project for the development of protected areas in South Sinai. The project management found the opportunity to form a special task force to solve the problem of valuation of the coral reefs using scientific methods. The team used the available information to build a case study for estimating the value of 1 m^2 of the reef and the method for determining compensation in case of reef damage. They reached the following formula in January 1992:

$$\mathbf{A} \times \mathbf{LC} \times \mathbf{D} \times \mathbf{RP} \times \mathbf{V}$$

Where: A = Impacted area (m^2)

LC = % of living coral

D = % damaged

RP = number of years needed for recovery

V = Value of 1 m^2 of the reef ($120 but recently it raised to $300)

During the preparation of the formula the team also suggested that the value of the reef be reduced to about 10% of the original value (to $12) in the reef flat area where coral coverage is always less and more exposed to natural damage. The same value was also applied to areas around the reefs even sandy, seagrass, or rocky shore. For areas above the high water mark the value of the square metre was reduced to $1.20.

Since 1992, the regulations were applied in all areas with protected status such as protected areas and environmental management areas. The method of calculation was also recognized by law courts, insurance companies, and ship owners' clubs and the Egyptian legal system was able to claim millions of dollars in compensation for reef damage. The procedure was presented at the International Coral Reef Symposium in 1996.

The concerned national authorities for grounding incidents are:

1. Search and Rescue Centre;
2. Oil Combating Centre;
3. Governorate Crisis Management Division (for coordinating tasks and disseminating updates);
4. Coast Guard (seizing the grounded vessel upon order of the prosecutor);
5. Marine and Environment Police; and
6. Egyptian Environmental Affairs Agency.

b) Records of Ship Groundings

The officially recorded numbers of ship/boat groundings, from 1987 and up till July 2008, in South Sinai and the Red Sea coast (i.e. off Hurghada and the rest of the Egyptian Red Sea) is 69 and 80 respectively (i.e. a total of 149 incidents). The incidents included 22 large accidents caused mostly by cargo ships colliding with the reefs (14 in the Gulf of Aqaba and 8 on the Red Sea coast). The total damage to the reefs was valued at $75,634,712 split between the Gulf of Aqaba ($68,899,056) and the Red Sea coast ($6,449,888). The records also show that 73 accidents were caused by live-aboard boats (55 in the Gulf of Aqaba and 18 on the Red Sea coast) causing an estimated $1,238,791 worth of damage, while 38 small day-boat accidents occurred on the Red Sea coast with damage losses estimated at $755,484.

In the northern section of the Egyptian Red Sea most of the accidents happened on the submerged reefs around the Tiran Islands at the entrance to the Gulf of Aqaba, and on the southern tip of Ras Mohamed where a large number of small patch reefs occur. On the Red Sea coast accidents were concentrated at the entrance to the Gulf of Suez especially in the area known as Ashrafy Reefs and around the northern island group. In addition, accidents also occurred on the submerged reefs around Hurghada Islands and, with less frequency, on the coastal fringing reefs to the south. The general causes of groundings are given as:

- Rough sea conditions;
- Malfunction or failure of navigational systems, steering system, or engine;
- Inadequate navigational marks;
- Inexperienced vessel captain or skipper;
- Deliberate grounding for various reasons.

c) Procedures for Survey and Compensation

The formal procedure taken is to promptly inform the relevant authorities and communicate updates as the situation changes. The follow up includes:

- In case of ship grounding, obtaining the coordinates of the grounding site from the Vessel Traffic Service (VTS);
- Following the rescue operation and providing support as requested;
- Supervising the salvage operation to make sure that secondary damage caused by this operation is kept to the minimum;
- Assigning a technical committee for making a preliminary report about the ship's condition and the range of expected damage;
- General prosecutor's order seizing the ship till legal interrogations have been completed; and
- Actual damage assessment carried out by a team of specialized marine ecologists.

For the legal procedures, legal affairs take over and proceed in accordance with the final technical report containing the compensation amount. In some cases reassessment of the damage by a neutral party would be conducted following a court order.

The assessment techniques for assessing underwater damage include:

- Documenting the event (vessel while on the reef) or the collision impacts on the vessel body using photography

and/or video;
- Measuring the dimensions of the damaged area and calculating the surface area using the nearest geometrical shape(s);
- Determining the live percentage cover of the damaged area from estimates of adjacent areas;
- Enumerating hard coral species of the area and estimating the recovery rate of each;
- Estimating percentage damage to the impacted area(s); and
- Estimating the compensation value from the above mentioned formula.

There are no continuous monitoring studies taking place on old grounding sites to assess the recovery that has occurred. For the legal steps of compensation, the court case is followed by the legal affairs of EEAA (the Egyptian Environmental Affairs Agency) as 'damage caused to public property'. Reconciliation between the sued party and EEAA is usually reached in small accidents where the owner of the ship pays a reduced amount of the original compensation value according to a deal made to avoid long court procedures (cases may take several years to be concluded through the courts).

Some measures have been applied in the Egyptian Red Sea to reduce grounding incidents such as:

- Establishing the VTS centre (Vessel Traffic Service);
- Installation of navigational marks on the edges of the reefs most likely to be hit by dive boat traffic (through a demonstration project financed by PERSGA);
- Adequate construction and operation of lighthouses and beacons; and
- Controlling the licensing of new skippers in the area to ensure that they are experienced.

Compensation rates are unified throughout the reefs of the Egyptian Red Sea, where 1 m^2 is priced at $120 (note: recently it was raised to be $300 in Ras Mohamed Park). The price is calculated from the revenues generated by the exploitation of coral reefs by the tourism industry. Other ecological, economic and social benefits and services provided by coral reefs are yet to be included in the compensation formula.

During court cases several counter arguments have been raised by the defendants (ship owners) in an effort to reduce the compensation amount. These arguments include:

- Reef ecosystems do not recover all at once to their original condition but gradually, and that is not taken into consideration when calculating the compensation amount (i.e. the first year has the maximum damage, while in subsequent years the reefs have lower damage due to their partial recovery);
- Tourism revenues fluctuate, while the per unit area rate used in the calculation of compensation is fixed; and
- Interest rates for the compensation amount are not calculated and are not relative to the estimated recovery time.

2.4.4 Saudi Arabia

The Kingdom of Saudi Arabia's coastline on the Red Sea extends over 1,840 km from the Jordanian boarder in the north to the Yemeni border in the south; a distance representing almost 79% of the total length of the Red Sea. The continental shelf extends offshore for a distance of less than 1 km in the north at the Gulf of Aqaba to over 100 km in the Farasan Banks towards the south. Most of the coast exhibits fringing reefs with large lagoons. In addition most of the offshore islands are surrounded by coral reefs which are, relatively, in a very good condition. A large number of submerged reefs are located in the middle section of the coast and especially in the Farasan area.

Despite the generally pristine condition of the corals along the coast of Saudi Arabia, the areas around the main coastal cities (i.e. Jeddah and Yanbu) have become increasingly affected by coastal development. Most of the impact comes from the increasing ship

Plate 2.3: Examples of grounding by diving boats (above) and cargo ships (below) on Egyptian Red Sea reefs

traffic in the area due to industrial and petroleum activities. The population of the Red Sea coastal cities has grown in the last decade to reach about 15% of the total population which adds more pressure on the marine environment.

a) Formal National Procedures

Regardless of the fact that Saudi Arabia is one of the leading countries in the area in the field of environmental protection, concern for the marine environment is relatively recent. The central environmental authority in Saudi Arabia is the Presidency of Meteorology and Environment (PME). The principal mandate of this authority is to set the environmental performance standards and monitor the activities of the operational agencies in addition to serving as a focal coordinator for environmental management.

There are several concerned national authorities in Saudi Arabia involved with grounding incidents on reefs. At the national level the coastal zone management plan is not yet well established, which is a source of conflict between the concerned authorities. This conflict results from the operation of different mandates in each authority on overlapping or crosscutting issues. To demonstrate this, a list of the authorities concerned with the marine environment at the national level is provided in Table 2.3.

The compensation department is in PME. It deals with compensation arising from different types of accident especially those involving oil pollution which are common on the coast of the Kingdom. The tasks of the compensation department include:

1- Coordination between the concerned organizations;
2- Carrying out ship impound procedures;
3- Ensuring that the ship owner has made a deposit in the national bank to cover the costs of property damage, clean-up operations, environmental damage, and damage assessment;
4- The follow up of the accidents in court;

Table 2.3: List of authorities concerned with the marine environment and their area of jurisdiction (Saudi Arabia)

Authority	Jurisdiction
National Committee for Marine Pollution Combat	Carry out planning and strategy to combat any pollutants
Ministry of Defence	Military activity within territorial waters
Ministry of Interior	Homeland security
Coast Guard	Between the boarder of the territorial waters and 10 km inland.
Ministry of Petroleum	Oil production and marine mineral extraction
Ministry of Municipal and Rural Affairs	Food and water management and waste disposal
Ministry of Industry and Electricity	Industrial development and electricity generation
Sea Ports Authority	All ports in the Kingdom
Royal Commission for Jubail and Yanbu	Environmental management of the industrial cities
Presidency of Meteorology and Environment	Protection of the environment and co-ordination work between different authorities and ministries

5- The collection of the claims money; and
6- Supervising the release of the ship after payment of compensation.

b) Records of Ship Groundings

Most of the recorded accidents in the KSA according to PME are those involved with oil spills in Red Sea waters. However, according to the available information, only four records were made for accidents involving coral reef damage. The available records contain only the date of the accident, the coordinates, and the amount of damaged coral in square metres. Table 2.4 shows these four records:

Table 2.4: Records of ship grounding incidents involving coral damage on the coast of Saudi Arabia

No.	Date	Coral damage area (m^2)	Locality	**Co-ordinates**
1	8/1/2008	355	Jeddah	N 21° 26’ 380” E 39° 03’ 726”
2	14/4/2008	50	Jeddah	N 21° 26’ 434” E 39° 03’ 672”
3	2006	126	Mukna	N 28° 40’ 700” E 34° 46’ 700”
4	2006	531	Mukna	Unknown

c) Procedures for Survey and Compensation

The administrative procedures for handling ship grounding accidents are coordinated between the concerned authorities by PME. PME (through its compensation department) determines the strategy to be followed in each case. A scientific survey team is organized to carry out field work in order to determine the size and magnitude of the problem. In cases which involve salvage, the proper equipment for ship salvage is determined before the survey team is called to the site. In addition, if the accident has caused any type of pollution, a separate plan is prepared for combating the pollution which involves coordination with the local authority.

2.4.5 Jordan

The coastline, of about 26.5 km, is located in the northern part of the Gulf of Aqaba. Along this short strip of land are the country's only port, industrial facilities vital to the national economy, a growing tourism industry and a delicate marine environment which is increasingly under threat. About 50% of the coast has fringing reefs while the other half is sandy with seagrass beds. The coral reefs on the Jordanian coast are ranked among the best reefs in the area. They are in a very good condition which is quite clear from the rich marine biodiversity and the large number of fishes.

Prior to 2001 the Aqaba area was governed under Law No. 7/1087 which gave the Aqaba Regional Authority (ARA) the broad powers of the government. These powers included the authority to plan and execute projects in the industrial, tourism, agricultural and service sectors. In 2001 the situation was completely changed after the establishment of the Aqaba Special Economic Zone Authority (ASEZA). ASEZA was inaugurated in 2001 as a bold economic initiative by the government of Jordan. A liberalized, low tax duty-free and multi-sector development zone, ASEZA offers multiple investment opportunities in a strategic location on the Red Sea covering an area of 375 km² and encompassing the entire Jordanian coastline, the sea-ports of Jordan, and an international airport.

ASEZA is a financially and administratively autonomous institution responsible for the management, regulation and development of the zone. Striving to turn Aqaba into a world class Red Sea business hub and leisure destination, ASEZA sustains a globally competitive investor-friendly environment and optimizes the efficient utilization of entrusted resources in harmony with the zone's Master Plan to internationally recognized standards. ASEZA also included an environmental commission within its main structure. The main objective for the Environment Commission is to evaluate the state of the environment in the zone, to develop the necessary regulations and procedures to protect the environment and to establish cooperation with the local community, national and international environmental organizations in order to protect and contribute to the sustainable development by finding the balance between investment requirements and the protection of the natural resources for the next generation.

According to information collected about ship grounding accidents on the coast of Jordan, there are no records for any accidents related to the reef. The only two records of ships sunk were those sunk deliberately by the government in order to create artificial diving sites. In addition two army tanks have been used for the same purpose.

a) Formal National Procedures:

Despite the fact that Jordan has not had any accidents, ASEZA in co-operation with the Jordan Maritime Authority (JMA) has studied cases of ship grounding among other causes of possible marine environmental damage. The results led to the establishment of the Committee for Evaluating Damages to the Environment. The committee members are:

1) ASEZA;
2) JMA;
3) Port Authority;
4) Marine Science Station; and
5) Private sector (Protection and Indemnity [P&I] Club).

Two different documents have been issued on the subject of environmental compensation:

- Instruction No. (37) for the year 2002 "Evaluation committee E-as adopted. doc".
- Instruction No. (55) for the year 2004 "Regulation of environmental damage 55".

According to the regulations the compensation rate is set at a fixed price of JD4,000 (Jordanian dinar) for damage to 1 m^2 of coral reef as a result of breaking, covering, killing or even transporting. For calculating the damage caused to the reef the following formula was adopted:

S x **C** x **D = Damaged area (m^2)**

Where: S = the surface area of damaged reef

C = % Live cover

D = % dead (can not regenerate)

Note: The formula does not consider the time of recovery for the damaged area, and replaced it with a fixed price for the coral reef unit area (m^2). So, for example, an accident damaged area of 100 m^2, with a live coral coverage of 30% and the amount of dead coral (unrecoverable) at 80% gives:

Area damaged =
100 m^2 x 30% x 80% = 24 m^2

Compensation =
24 m^2 x 4,000 JD = 96,000 JD

Plate 2.4: An army tank was sunk deliberately in 1999 off the Jordanian reefs to form a new diving site

2.4.6 Djibouti

Djibouti is a relatively small country. It lies at the junction of the Red Sea and the Gulf of Aden. It has an area of 23,000 km^2 and a coastline approximately 370 km in length. The northern coastline between the Eritrean border and Ras Bir faces the narrow strait of Bab El-Mandab. Most of Djibouti's coastline lies along the narrow Gulf of Tadjourah an east-west oriented trench that has a maximum depth of 883 m.

The coral reefs on the coast of Djibouti are mostly fringing reefs and there are several islands off the mainland also surrounded by fringing reefs. The reef edge presents variable width. Morphologically, around Musha and Maskali Islands, the actual coral formations are ended by an active cliff, completely alive, reaching 15 m. Beyond this formation, the reef slope is covered by sand and mud. What makes Djibouti unique as an ecosystem is the profuse marine life resulting from the mix of the Red Sea and the Indian Ocean, as their waters mix right here in the Gulf of Aden.

One of the highlights of Djibouti's waters are the Seven Brothers Islands (Sept Frères), a world class dive site, with drop offs, stunningly colourful soft corals, and a very interesting pelagic marine life with schools of fishes, occasional manta rays, and reef sharks. Water temperature is tropical in the summer time, with excellent visibility. Most exposed dive sites are for experienced

divers as the currents around Djibouti can be strong, but novice divers will enjoy diving in sheltered places with magnificent coral gardens, shallower water and an amazing profusion of marine life on local reefs.

a) Formal National Procedures

Interest in environmental conservation in Djibouti dates back to 1972 when the government issued Order 1363 for the establishment of Musha Island Territorial Park. Most of the laws and decrees issued since 1972 till the late 1990s were related to oil pollution except for those concerning the declaration of the protected areas in Maskali Island (1980); boat safety regulations (1984); marine protected areas (103/1985); regulations concerning the abandonment of ships (042/1986); and the more recent Decree 18/1991 for the establishment of a directorate of maritime affairs.

b) Records of Ship Groundings

No records of ship grounding accidents on the reefs of Djibouti were available and no claims for compensation have ever been made. Meanwhile, with the tourism industry booming, several tour operators have added this country to the tourism map of east Africa so it is expected that the number of pleasure boats will increase. The increase in the number of boats will create more chances for accidents to occur. So it is time to have a system to deal with boat and ship groundings in the area.

2.5 REGIONAL PERSPECTIVE

Most of the countries in the region have signed international conventions concerned with the protection of the marine environment. However, the local or national legal system in each country is primarily concerned with the prevention of marine pollution, dealing with maritime issues, and the establishment of protected areas as a method of conservation.

The Jeddah Convention (1982), formally titled "Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment", and the subsequent regional protocols – "Protocol Concerning Regional Cooperation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency", "Protocol Concerning the Conservation of Biological Diversity and the Establishment of a Network of Protected Areas in the Red Sea and Gulf of Aden", "Protocol Concerning the Protection of the Marine Environment from Land-Based Sources in the Red Sea and Gulf of Aden" provide an important basis for environmental cooperation between the states of the Red Sea and Gulf of Aden.

Despite the fact that all countries in the region are concerned with coral reef conservation, studies revealed that there are few legal articles specifically focussed on protection of the coral reef ecosystem. Some sections of national environmental laws have indirect references to protection such as Law 102 (Egypt) which prevents any practices within protected areas that cause damage to natural ecosystems and Law 4/1994 (Egypt) which prevents tampering with any wild animal or plant in its natural habitat. One direct reference, Regulation No. 55 in ASEZA (Jordan) states that any damage to corals should be compensated, but does not provide any details about the procedures that should be followed.

2.5.1 Gaps Identified for Improving the Conservation of Coral Reefs

Legal protection for coral reefs has begun relatively recently in the RSGA area. In addition, existing protection consists of piece-meal laws and policies that serve to protect only certain coral reefs, either directly or indirectly. All the scientific surveys carried out in the region report that coral reefs are threatened and their preservation requires coordinated measures at national and regional levels. Some of the gaps identified for improving the conservation of coral reefs in the area are as follows:

- There is an urgent need to provide training and awareness on concepts of conservation and sustainable use of coral reef resources;
- A network of coral reef information providers which include government institutions/NGOs/MPAs should be established;
- PERSGA should develop and strengthen synergies for policy and programmes to conserve coral reefs from grounding incidents;
- Capacity building for environmental and socio-economic assessment should be enhanced, with support and partnership of local communities and fisher folk as the basis for raising awareness and influencing changes in the behaviour of local communities who affect and are affected by coral reefs; and
- Leveraging their synergies, coordinated action should be taken by the various national government departments, research institutions and local community groups to implement coral reef management plans.

3. GROUNDING ASSESSMENTS AROUND THE WORLD

3.1 MECHANISMS AND PROCEDURES USED AT THE INTERNATIONAL LEVEL

3.1.1 Caribbean

The area around the Caribbean Islands is characterized by the presence of groups of fascinating coral reefs. For a long period of time, the reefs of this area have been subjected to different types of abuse from the local community. However, with tourism booming in the area, an industry that depends on the quality of the reefs, large fines have been imposed on those responsible for reef damage. For example, the Government in the Caribbean prepared a claim for $8 million in compensation for coastal damage caused by the Liberian-registered oil tanker, Knock Dun, when it ran aground last October, reports the Caribbean News Agency (June 21, 2001). Prior to the release of the 247 m long vessel the ship's principals lodged a $3 million deposit, binding them to conclude a settlement for the damage to the coral reef located about 9.5 nautical miles off the coast.

3.1.2 The United States

The United States legislation for the protection of natural resources is unique in that it addresses both the restoration of lost ecological services and the lost economic value of natural resources, in the assessment of charges for damages. There are two legal statutes that cover physical injuries caused to marine resources: The Marine Protection, Research, and Sanctuaries Act (MPRSA), and the National Parks System Resources Protection Act (NPSRPA). Three other bodies of law (i) the Comprehensive Environmental Response, Compensation, and Liability Act, (ii) the Oil Pollution Act, and (iii) the Clean Water Act, consider injuries to natural resources resulting from the release of oil and other hazardous substances.

The MPRSA was enacted in 1972 in response to growing concern about the increasing degradation of marine habitats in the United States. The main rules state that those responsible for injuring or destroying a sanctuary resource are liable for the costs of damage assessment, any necessary enforcement activities, restoration expenses, the value of the lost use of the resource while restoration is taking place, and the monitoring of damages and restoration activities. If the resource is not recoverable or an equivalent resource cannot be acquired, liability is for the value of the lost resource (Lee et al., 2002).

The data in Table 3.1 from Wielgus (2004) show a summary of vessel grounding cases in the Florida Keys in which legal suits for damages to coral reefs have been based on the Marine Protection, Research, and Sanctuaries Act (MPRSA). Under 'Scope of Damage' the terms *total destruction* and *partial destruction* refer to the death of all coral colonies in an area, or the occurrence of colony death and damage, respectively. 'Funds Recovered' includes compensation arising from both court decisions and out-of-court settlements.

The NPSRPA was enacted by the Congress of the United States in 1990 partly in response to a catastrophic ship grounding on a coral reef in a national park in Florida (Lee et al., 2002). Its purpose is to enable the United States government to initiate legal action against individuals who damage or destroy marine resources within the National Park System, and to allow for the recovery of funds for the prompt restoration or replacement of the affected resources. Prior to this Act, the government could recover damages to national park resources only under a legal action for damages to public property. The government had to meet a high burden of proof, and there was no assurance that any recovered funds would be used in restoring the affected resource (Lee et al., 2002).

Table 3.1: Cases of ship grounding and the following response according to Marine Protection, Research and Sanctuaries Act (1972)

Case	Year of Grounding	Ship Length (m)	Scope of Damage	Funds Recovered (US$)
Wellwood	1984	122	Extensive biological and structural injury	5,654,228
Mini Laurel	1986	65	Biological and structural injury	30,000
Alec Owen Mariland	1989	47	Partial destruction of 930 m^2; total destruction of 680.5 m^2 of reef	1,450,000
Elpis	1989	143	Partial destruction of 482 m^2; total destruction of 2604.7 m^2	2,275,000
Jacqualyn L.	1991	54	Total destruction of 123.1 m^2	251,554
Miss Baholden	1993	45	Partial destruction of 1025.6 m^2	1,873,741
Columbus	1994	52	Total destruction of 345 m^2	3,760,488
Petty Cash	1994	15	Total destruction of 17.25 m^2	25,000
Count ship Houston	1997	187	2,333 m^2 of crushed coral reef substrate; over 3,000 broken pieces of coral	5,738,000
Golden Lady	1997	22	Total destruction of 42 m^2; additional sanctuary resources injured	54,716
Fly way	1998	14.6 (Sailing)	Partial destruction of 9.3 m^2	Responsible party has undertaken restoration

Sources: Table from Wielgus, 2004; data from NOAA, 2003 and USCRTF, 2004.

3.1.3 Australia

The Great Barrier Reef around Australia is considered one of the main sources of national income; it generates billions of dollars each year without the need for constant financial input. In 1975, the Australian government issued the Great Barrier Reef Marine Park Act. Provisions contained within the act address damage to the Park caused by vessel grounding. The act states in Part VIII Enforcement, subdivision G Injunctions that if a person has done, is doing or is proposing to do an act that constitutes and offense against the act, then the Court may require the person to repair or mitigate harm to the environment (GBRMPA 1975). For example, Wielgus (2004) quotes James Aston of the Great Barrier Reef Marine Park Authority to the effect that "the costs of removing tributyl tin (TBT) or stabilizing a vessel grounding site may vary from A$1 million to A$3 million[2], fines may be charged for entering areas that are prohibited to navigation, and fines of up to A$1.1 million may be charged for long-term damage to the Reef".

[2] A$ or AUD = Australian dollar. 26 Jan. 2009, 1 AUD = 0.66 USD; 1 USD = 1.51 AUD.

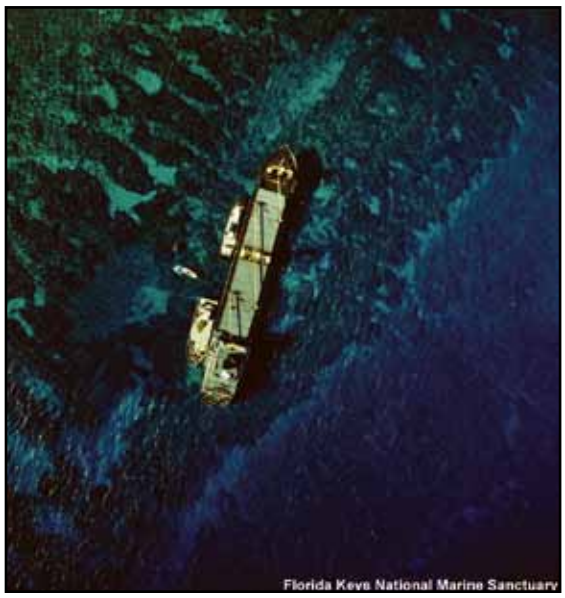

Plate 3.1: MV Willwood, grounded in 1984 on the reefs of the Florida Keys National Marine Sanctuary

3.2 INTERNATIONAL PERSPECTIVE

A variety of international legal instruments either directly or indirectly provide protection for coral reefs. Though these measures offer promise for enhanced protection of reefs, the level of protection depends on the ratification and enforcement of these instruments. The United Nations Convention on the Law of the Sea, 1982 (UNCLOS) remains the guiding document for ocean issues, but many other specialized conventions potentially afford greater protection for coral reefs. This section only addresses some of the major legal regimes which provide for the protection of coastal and marine biodiversity with a special focus on coral reefs. Such international legal regimes could be helpful in formulating a regional convention for compensation for coral reef damage from vessel grounding incidents.

3.2.1 United Nations Convention on the Law of the Sea

UNCLOS is the principal convention regarding the use of the ocean and its resources. UNCLOS grants every state 'the right to establish the breadth of its territorial sea up to a limit not exceeding twelve nautical miles, measured from baselines determined in accordance with the convention. The convention states that 'waters on the landward side of the baseline of the territorial sea' form part of the internal waters of the state. Moreover, articles 56 and 57 of the convention give coastal states sovereign rights in an 'exclusive economic zone' up to 200 nautical miles. Because most reef formations are limited to waters of less than 100 meters depth, this places the majority of coral reefs within states' internal waters and exclusive jurisdiction.

UNCLOS was a landmark treaty in the development of international environmental law because it contains many conservation-oriented provisions. Specifically, it requires states to protect and maintain their marine species, even within internal waters. The Preamble to UNCLOS states that the primary objectives of the 1982 convention include the study, protection and preservation of the marine environment. UNCLOS provides the first comprehensive statement of international law on the issue, a movement towards regulation based upon a more holistic conception of the ocean as a resource that is exhaustible and finite, and ocean usage as a resource management question. Even within the exclusive economic zones of coastal states, UNCLOS states that "the coastal state shall ensure through proper conservation and management measures that the maintenance of living resources in the exclusive economic zone is not endangered by overexploitation".

UNCLOS contains many positive obligations that affect marine resources in national waters, such as coral. Part XII of the convention sets forth many of the international legal requirements pertaining to the marine environment, including a system for enforcing those requirements. Article 192 sets forth the general obligation "to protect and preserve the marine environment". Article 193 recognizes the "sovereign right (of states) to exploit their natural resources" but this is subject to the "duty to protect and preserve the marine environment". Some of the special requirements include taking measures necessary to "prevent, reduce and control pollution of the marine environment, and to ensure that activities are so conducted as

not to cause damage by pollution to other states and their environments".

States must consider all sources of pollution to the marine environment, including the following: harmful or noxious substances from land-based sources, the atmosphere, or dumping; pollution from vessels; and contamination from other installations used to explore the seabed and subsoil.

The duties expressed in Articles 192 to 194 are binding on all states party to the convention; 157 states have signed UNCLOS and 138 have ratified it. Prior to UNCLOS there was little international regulation of the marine environment, particularly its conservation. The provisions for the protection and preservation of the marine environment reflected the growing awareness of what was happening to our oceans. Unfortunately, many nations did not ratify the convention, in part because of its controversial deep seabed provisions. Therefore, a major issue today is whether the convention reflects customary international law so that it is binding on all nations, irrespective of their membership in the convention.

3.2.2 Agenda 21

Ten years after the drafting of UNCLOS, more than 178 governments adopted Agenda 21, the final document of the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992. Agenda 21 reaffirmed many of the goals of UNCLOS but also recognized that despite national, sub-regional, regional and global efforts, current approaches to the management of marine and coastal resources had not always proved capable of achieving sustainable development, and coastal resources and the coastal environment were being rapidly degraded and eroded in many parts of the world. Chapter 17 of Agenda 21 gives the protection of coral reefs high priority and calls for an integrated, international approach for their protection and use.

To implement Chapter 17 and other international conventions, the International Coral Reef Initiative (ICRI) was created at the Small Island Developing States Conference in 1994. Through ICRI, over 80 developing countries with coral reefs sit in equal partnership with major donor countries and development banks, international environmental and development agencies, scientific associations, the private sector and NGOs to decide on the best strategies to conserve the world's coral reef resources.

Chapter 15 of Agenda 21, titled "Conservation of Biological Diversity", calls for immediate action in protecting the diversity of plant and animal resources. The chapter states: "Despite mounting efforts over the past twenty years, the loss of the world's biological diversity, mainly from habitat destruction, over harvesting, pollution and the inappropriate introduction of foreign plants and animals, has continued. Urgent and decisive action is needed to conserve and maintain genes, species and ecosystems, with a view to the sustainable management and use of biological resources". Chapter 15 is especially significant for coral reefs because of their high biodiversity.

3.2.3 Convention on Biological Diversity

The Convention on Biological Diversity (CBD), 1992, sets commitments for maintaining the world's biological diversity. The convention establishes three main goals: conservation of biological diversity, sustainable use of its components, and a fair and equitable sharing of the benefits of genetic resources. Conserving the diversity of life in the sea (especially coral reefs) calls for creative solutions that appeal to individual and national needs. The Conference of Parties (COP-II) of the CBD adopted the Jakarta Mandate in 1995 which outlined the programme of action for implementing the convention with respect to marine and coastal biodiversity. Decisions pursuant to the Jakarta Mandate recapitulate the five elements of the CBD programme on coastal and marine diversity. These are: integrated marine and coastal area management;

marine and coastal living resources including genetic resources; marine and coastal protected areas; mariculture; and alien species and genotypes.

In decision VII/5, 2004, the COP adopted an elaborate programme of work on marine and coastal biodiversity and included under programme element 2, on marine and coastal living resources, a list of suggested activities on coral bleaching, physical degradation and destruction of coral reefs. As of November 2005, there were 188 parties to the convention, and ten countries that had signed, but not yet ratified it.

The CBD is a framework treaty and has been described as containing "primarily inspirational provisions", with matters of substance left to future development by its own Conference of Parties. These objectives are connected through a principle known as "common but differentiated responsibility". This principle holds that "developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command". A balanced approach to conserve biodiversity must take account of how various levels of development affect a state's management of its natural resources.

3.2.4 Convention on International Trade in Endangered Species

Some of the PERSGA member countries were among the first states to sign and ratify the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) in 1973. CITES specifically addresses the problems associated with the international trade in endangered species. This now includes many species of coral and coral reef organisms. Live and dead marine organisms are used for multiple purposes such as aquaria, decoration, souvenirs, jewellery and precious stones. Recently, a study by TRAFFIC USA found that Indonesia supplies 95% of the world's coral trade, while the United States imports 85% of the dead coral and 98% of the live coral in the international trade.

One hundred and sixty nine nations have already signed CITES, which provides varying degrees of protection to more than 30,000 plant and animal species. Member countries agree to ban commercial international trade in an agreed list of endangered species and to regulate and monitor trade in others that might become endangered. CITES entered into force in 1975, and the CITES Secretariat announced that "not one species protected by CITES has become extinct as a result of trade since the convention entered into force". CITES protects those species listed in the three Appendices to the Convention. Any party to CITES may propose amendments to Appendices I and II, and III if the named species is within that party's jurisdiction.

In 1985, member nations of CITES listed all stony or reef-building corals in Appendix II in response to the effect of the coral trade on reef ecosystems. Now, black corals and blue corals are all listed in Appendix II of CITES and require a permit from the country of origin in order to be traded on the international market. There are approximately 230 species of coral listed by their common names on the CITES Species Database. Enforcement of the convention is not always successful. In some cases, coral collected in countries where collection is illegal (such as the Philippines) is exported and sold under the pretext of having been collected legally in a different country. Another problem is the difficulty in identifying the corals that are listed in the CITES appendices. For example, a CITES monitoring organization found that 'the trade in corals and other marine organisms is increasing and there have been many instances where CITES-listed corals have been shipped without the necessary permits, or with incorrect permits, often resulting in sizeable confiscations'.

Part of the problem has been traders claiming that corals are 'living rock' rather than 'hard

coral' and are thus exempt from the CITES permit requirements. Since only specialists could differentiate between living rock and marine organisms such as corals, the CITES governing body adopted a resolution in April 2000 to include live rock in its definition of coral rock, thereby making the live rock subject to the convention.

Another problem for reefs is that protection under CITES is not always broad enough. CITES does not list many other reef species such as puffer fish, seahorses, starfish, sea urchins, sea fans, and sponges. These reef dwellers are an integral part of the coral reef ecosystem and the collection of them for souvenirs and private aquaria can be just as detrimental to the reefs as the collection of corals themselves. CITES is useful for regulating the trade in discrete coral species, but it does not protect the entire ecosystem. Nonetheless, with effective enforcement and by raising public awareness about the need to purchase only properly documented coral species, CITES is an effective tool to fight the destruction of coral reefs.

3.2.5 World Heritage Convention

The World Heritage Convention provides another means for protecting coral reefs. The convention is under the auspices of the United Nations Educational, Scientific and Cultural Organization (UNESCO). It notes that the world's cultural and natural heritage is increasingly threatened with destruction and that the deterioration or disappearance of any item of the cultural or natural heritage constitutes a harmful impoverishment of the heritage of all the nations of the world. The convention defines "natural heritage" as physical and biological formations of "outstanding universal value from the aesthetic or scientific point of view". Under the convention, an Intergovernmental Committee for the Protection of the Cultural and Natural Heritage of Outstanding Universal Value maintains a "World Heritage List" of property forming part of the cultural and natural heritage, with the consent of the state concerned. The convention makes available a variety of technical and even financial assistance. This may include assistance in getting a site included on the World Heritage List, providing experts and others to help with the preservation of a listed site, or training staff and specialists in the identification and conservation of the cultural and natural heritage. There are 878 natural and cultural properties on the World Heritage List; 4 of those sites contain coral reefs. There is a worldwide initiative to include more marine sites on the World Heritage List.

4. REGIONAL GUIDELINES PROPOSED BY PERSGA

4.1 THE OBJECTIVES OF THE GUIDELINES

For the establishment of a common, regional set of assessment guidelines we must take into account that the types of activities that are performed on the coast differ from one country to the next in the RSGA area. The current and future uses of marine resources in the region will be affected by the degradation of its status through repeated abuse by unsustainable human activities. The countries in the region must also realize that unity in applying a common system of compensation for the whole RSGA area will improve the protected status of the region and support claims against shipping companies. However, it is predicted that such guidelines will be the first of several other tasks that should be carried out to accomplish a standardized and acceptable set of compensation procedures for the RSGA area. Among the tasks which should be followed are: adoption of the present suggested guidelines, building capacities for the concerned national experts, taking a census and detailed evaluation of the reef areas of the entire region, and modification of existing national laws, or declaration of new laws, to cope with the requirements of the compensation procedures recommended.

The current proposed guidelines have two main objectives:

To develop a standardized method for assessing the damage to coral reefs from vessel grounding and/or anchoring incidents

To ensure the applicability of such a protocol to most of the countries in the RSGA area

For the achievement of these objectives the guidelines should provide a framework for determining:

1. What resources have been injured
2. What is the loss to the public
3. How the resources can be restored

4.2 VALUATION OF CORAL REEF AREAS IN THE PERSGA REGION

4.2.1 Economic Valuation of Coral Reefs

The economic value of an ecosystem is often defined as the total value of its instruments, that is the goods and ecological services that an ecosystem provides. For coral reefs, we therefore need to know the major goods and services as well as their interactions with other ecosystems. Next, these goods and services need to be quantified and appraised (i.e. monetized). For goods sold in the market place (e.g. fish and marine organisms), this can be done in a relatively straightforward manner by looking at market prices, but for ecological services (e.g., feeding grounds, nursery sites, coastal protection), this is not the case. Therefore, complex valuation techniques are used to arrive at an economic value for these services (Spurgeon, 1992 and Dixon, 1998).

The value of all the goods and services combined gives the Total Economic Value (TEV) for an ecosystem. Each of the goods and services of coral reefs presented above in the introductory section (Chapter 1), contribute to the economic value. Fishery resources can be harvested and sold, creating value added, and likewise the coastal marine area enables sea transportation that creates profits. Similarly, preservation and eco-tourism create value which should be added as well.

However, setting a single fixed value for an area of reef in the RSGA area is an impossible task due to the variation in goods and services the reefs provide in the participating countries. For instance, reef

tourism in Egypt generates more money than fisheries while the opposite occurs in Yemen. So in the valuation process, regardless of the monetary value, we consider that all goods and services provided by the reef are the same in all countries, but with variability in usage according to national priorities and opportunities to benefit from them. All the countries of the RSGA are in various states of development, but coastal and marine activities are significantly increasing in all of them and in all cases there is need for protection of the reefs from vessel grounding damage. Developing a new regional system for compensation will help to promote the sustainability of development with due regard to protection of marine resources.

4.2.2 Valuation Techniques

Estimating the economic benefits of coral reefs to local economies is neither easy nor straightforward, due to the range of approaches available and frequent limitations of underlying data (Dixon, 1998). Many valuation methods exist, and results are rarely comparable (Leeworthy, 1991; Cesar et al. 2003; Pagiola et al., 2005; Burke et al., 2008). This is why a priority for the current guidelines is to develop a simple, broadly applicable, and regionally acceptable methodology to place a value on the coral reef goods and services, based predominantly on commonly available data.

A review of the available methods for valuation from a biological point of view revealed that all the methods have three general categories:

1) Directly to obtain information about the value of the affected goods and services or of direct expenditures;
2) Potentially applicable techniques, which use the market indirectly to obtain information about values and expenditures;
3) Survey based methods, which use hypothetical markets and situations through, for example, questionnaire surveys such as the contingent valuation method (CVM).

The use of a consistent approach should lead to more comparable estimates of value for different places and time periods. An easily replicable methodology can also be applied while varying key assumptions in order to assess the impacts of different development and management options. The current guidelines proposed are the first step towards more advanced guidelines in the future. This methodology does not assess Total Economic Value (TEV), but rather focuses on three key goods and services: coral reef-related tourism and recreation, coral reef-associated fisheries, and shoreline protection services. These three goods and services were chosen because of their importance to local economies and because data are available to support estimation of these values. The method was developed based on extensive literature review, feedback from the national representatives during the workshop, and examination of coral reef use and data availability from a few pilot locations.

a) Coral Reef-Related Tourism and Recreation

The first step toward the achievement of an appropriate valuation for the reef is to know the exact area. Several modern techniques have been developed for achieving this goal with minimum cost and effort. Among them is mapping of the reef using satellite images followed by ground-truthing which has been found to be a very reliable technique for estimating reef area in many countries around the world. However, the value of the reef not only relates to its area but also depends on its coverage of live corals.

The value of coral reef-associated tourism must be assessed using a financial analysis method. This method involves calculating the gross revenue of tourism and recreation, and subtracting operating costs to arrive at net revenue. Labour costs, service charges, and taxes are subtracted where applicable, but are later added back when estimating direct economic impact, as these expenses are likely to remain in the local economy. Hence, the direct economic impact is equivalent to gross revenue-non-labour operating costs.

A multiplier is used to estimate the wider economic impacts of visitor expenditure. Where appropriate, the value of individual tourism activities is pro-rated by the number of visitors coming to the area because of the coral reefs (reef visitation) in order to derive the reef-related tourism and recreation value. The estimation of the value for reef-related tourism and recreation should include information from the following areas and be based on a comparison between present values and those from the previous few years.

additional satisfaction derived by visitors beyond the price they paid for the experience, can be derived for reef recreation activities using estimates from field surveys or by using benefits transfer.

Marine Protected Areas: Marine Protected Areas (MPAs) are an important draw for tourists as well as an important tool for managing coastal resources and protecting coral reefs. MPAs are worth considerably more than the direct income they earn from

Plate 4.1: Both coastal developments and marine recreational activities add value as well as impacts to the reefs used

Accommodation: Identifying the "reef-related" share of accommodation expenditure requires compiling standard information on hotel room rates, occupancy rates, operating costs, taxes and service charges, as well as determining whether a guest's choice of destination is, in part, due to the area's coral reefs. Depending upon data availability, information can be compiled by individual hotel, or by accommodation type (e.g., hotel, guest house, etc.).

Reef Recreation: Reef recreation includes international and domestic visitor use of coral reefs for snorkelling, diving and sport fishing. The value of reef-related activities is estimated by totalling gross revenues and subtracting the costs. This can be estimated based on company level information, or based on the price of specific activities (i.e. dive or snorkel trips, etc.) coupled with the number or percent of visitors who engage in these activities. An additional value, "consumer surplus", a measure of the

tourist fees and visits. If well managed, MPAs should help increase fish stocks, reduce stress on reefs, and improve the country's reputation as a dive and snorkel destination. In places where MPAs have good reef visitation data, these can be used as a starting point for estimating reef use for the country. Revenue from visitor fees and other relevant fees (e.g., mooring, diving, etc.) are counted as benefits, and the non-labour costs of operating the parks are subtracted from the total. The fee revenues do not in any way represent the value of the parks, but are important to include as part of the overall income from reef-based tourism.

Additional Miscellaneous Expenditures: The values described above are considered direct economic benefits from reef-related tourism and recreation. Expenditure by tourists has additional economic benefits beyond these direct effects. For example, food purchased by visitors may be sourced from local farmers, fuel used

for transportation is purchased from local fuel distributors, visitors also spend money in restaurants, for local transportation, shopping, etc. These additional "indirect" or "secondary" economic benefits should be estimated and pro-rated by reef visitation.

Local Use: Use of coralline beaches and reef recreation activities, such as swimming or snorkelling, by the local population are important values that may not be captured in the "formal economy". This value can be estimated based on the typical number and duration of visits by locals to coralline beaches or reefs, coupled with average local wage rates (as a proxy for the value of leisure time). This value can be estimated through either formal or informal surveys and can also be neglected if the local population has its own sites (e.g. public beaches, etc.).

In calculating economic impact, the methodology deducts non-labour operating costs from the total revenues of reef-related industries. These costs can be difficult to estimate, as this data is rarely publicly available, and businesses may be reluctant to release it. Costs can be estimated using expert opinion, regional norms, or industry-wide statistical data. From the above mentioned categories, the value of tourism and recreation reef-related activities can be summarized as shown in Table 4.1.

Table 4.1: Indicators used in calculating the value of tourism and recreation as reef-related activities

Expenditure Category	Description	Approximate Value (US$)
Accommodation	Number of hotel rooms x occupancy rate x price per night included taxes and services charged	
Reef Recreation (Diving)	Number of visitors x percent of divers x price per dive including taxes and services charged	
Reef Recreation (Other, including snorkelling, glass boat, etc.)	Number of visitors x percentage performing this activities x price of trip per person including taxes and services charged	
Marine Protected Areas	Number of visitors x MPA fees including entrance and recreational activity	
Miscellaneous Expenses	Number of visitors x amount expected to spend (US$) in restaurants, local transportation, shopping (according to survey data)	
TOTAL DIRECT IMPACT		
Indirect Economic Impact	Goods and services required by tourism operators that are produced domestically, such as linen, beverages, produce, dive equipment, construction materials, etc. (according to survey)	
TOTAL DIRECT AND INDIRECT IMPACT		
Other Values		
Consumer Surplus	A percentage of increase depending on the price rise from previous years (% of total)	
Local Use	Number of locals using the beach x average spend per person x number of days of visit	
TOTAL VALUE OF TOURISM AND RECREATION REEF-RELATED ACTIVITIES		

The survey shown in Table 4.1 is to be conducted on a random sample of tourists, particularly those visiting areas where reefs are the main attraction. Also the local population survey is to be conducted on the native inhabitants of the area not the migrant population.

b) Coral Reef Associated Fisheries

The value of coral reef associated fisheries is estimated using a financial analysis approach. This method involves calculating the gross revenue of commercial fishing and processing activities, and subtracting operating costs to arrive at net revenue. Labour costs and taxes are subtracted where applicable, but are later added back when estimating economic impact, as these expenses are likely to remain in the local economy. The value of local (non-commercial) fishing for consumption or for pleasure (sport fishing) is also to be assessed.

The valuation focuses on fishes that depend directly on a coral reef for at least a portion of their life-cycle, including snappers (Lutjanidae), groupers (Serranidae), parrotfish (Scaridae), squirrelfish (Holocentridae), goatfishes (Mullidae), lobsters (e.g., *Panulirus* spp.), and sea-urchins (Echinoidea). Positive or negative changes in coral reef health will impact fisheries productivity and total fisheries revenue as a result. The activities included for calculating the total reef associated fisheries value are:

Commercial Fisheries: The revenue from commercial fisheries is based on reef associated fish catch and sale price, by species. Annual catch can be estimated from data by landing site, based on a sample of fishermen, or using estimates of fisheries productivity per unit of reef area. Local expert opinion is used to estimate both labour and non-labour costs as a percent of gross revenue.

Fish Processing Industries: The value added from formal fish processing is estimated using the sale price minus purchase price of fish and the quantity purchased by fish processors. Operating costs are then subtracted to arrive at a net value. Informal on-site cleaning is estimated based on earnings associated with cleaning at landing sites. Specific data on processing volumes and revenue are often not available, so this value may have to be estimated based on available information and expert knowledge.

Sport or Non-commercial Fishing: The values from sport fishing for consumption and pleasure are calculated separately using estimates of the percentage of the population engaging in these activities, the time spent fishing, and the market prices of reef fish. The value of leisure time, based on average local wages, is used to estimate the enjoyment value from local fishing. This is the second part of the valuation methodology where surveys may be necessary to obtain the necessary information. There is little information in the literature or that is routinely collected that reflects local informal fishing activities.

The availability and reliability of data on commercial reef fisheries will vary by country. In the absence of data on landings, commercial fisheries value will need to be estimated based on fishing effort or estimated productivity of the reef. Few countries will have data on local (non-commercial) fisheries. Formal or informal

Plate 4.2: Coral reef fisheries are very important in the calculation of reef value, not only due to their direct fishing value, but also due to the local social conditions they provide for fishers' families

Table 4.2: Indicators used in calculating the value of fisheries as reef associated activities

Indicator Category	Description	Approximate Value (US$)
Commercial fisheries	Amount (in tons) of reef fishes (from landing sites) x average price of fishes	
Fish processing industry	Total sale price of product – purchase price of fish	
Sport or non-commercial fishing	Number of non-commercial fishermen x number of days per trip x price of trip per person including taxes and services charged (according to survey data)	
TOTAL VALUE OF REEF RELATED FISHERIES ACTIVITIES		

surveys are needed to assess the value of this sector. The value of the reef-associated fisheries activities could be summarized as in Table 4.2.

c) Shoreline Protection Services

The role of coral reefs in shoreline protection has been studied intensively in the last decade. Several studies suggest that the wave attenuation (i.e. reduction in force) from coral reefs is 75% to 95% of wave energy (Hawkins and Roberts, 1992). Valuation of the shoreline protection services provided by coral reefs requires an understanding of the protection afforded by different types of coral reefs in different coastal settings.

Essential elements for understanding the damage avoided due to the presence of coral reefs include:

1. Estimating the total reef area facing the developed area of the coast (TCA);
2. Understanding the damage resulting from removing the reef that is due to wave frequency, intensity, and associated surge;
3. Identifying the existing/planned investment made in the coast in the form of hotels, resorts, or other recreational facilities (I^1);
4. Identifying the existing natural resources in the coastal and marine area in the form of diving and snorkelling sites, MPAs, mangrove areas, etc. (I^2);
5. Calculating the revenues generated from coastal activities and development (R^1); and
6. Estimating the revenues generated from land-based and marine activities performed within these areas (R^2).

Combining the previous individual elements to estimate the reduction in potential damage attributable to the coral reefs in these areas could be calculated as follows:

Value of shoreline protection by coral reef (US$/m^2) = $I^1 + I^2 + R^1 + R^2$ / TCA

d) Challenges and Limitations

The economic valuation plan described is known to be optimistic with respect to the situation in the RSGA countries. It is safe to

Plate 4.3: Reefs playing an important role in protecting the shorelines they fringe; this value should be included in reef valuation methods

say that certain limitations and challenges will be faced during any attempt to apply such a system. On the other hand it should be noted that the methodology does not attempt to provide the Total Economic Value of coral reefs. Some of the values that are not captured include poverty reduction and the nutritional benefits of subsistence fishing; social, spiritual, religious or inspirational values of coral reefs; pharmaceutical or bio-prospecting values; existence values; and the value of coral and sand as building materials. Furthermore, coastal systems are made up of highly interconnected habitats, of which coral reefs are but one important component. This methodology strives to isolate the benefits (goods and services) provided by coral reefs, but it should be noted that many of these goods and services benefit from proximity to seagrass beds and mangrove areas. Overall, the values from this valuation methodology should be considered a lower estimate of the "true" value of reefs. In summary, some of the main challenges for implementing this valuation methodology on a regional scale are:

- Distinguishing reef-related visitors from non-reef related visitors;
- Evaluating visitor responses to marginal changes in reef quality, a potentially important factor for assessing future scenarios of reef use (data are rarely available);
- Estimating the use of coralline beaches and coral reefs for informal recreation and fishing by local residents;
- Estimating the catch of coral reef associated fish species (data are often limited or unreliable);
- The methodology focuses on current economic benefits, but does not take into account whether fishing is occurring at sustainable levels. If reefs are being over-fished, the value of reef-associated fisheries is likely to decline in the future;
- The availability and reliability of data on commercial reef associated fisheries will vary by country;
- In the absence of data on landings, commercial fisheries values will need to be estimated based on fishing effort or estimated productivity of the reef. Few countries will have data on sport and non-commercial fisheries. Formal or informal surveys are needed to assess the value of this sector;
- Validating the shoreline protection model (data on wave-induced storm damage are limited); and
- Implementation of the shoreline protection valuation requires detailed data on coral reef locations and coastal elevation (these are the most important), a variety of data sets on coastal characteristics, as well as expertise in GIS.

4.3 GENERAL FRAMEWORK FOR GROUNDING COMPENSATION PROCEDURES

4.3.1 Accident Assessment System

It is extremely important that an assessment be conducted as soon after the incident as possible so that damage to biota and the substrate can be easily identified, measured and documented with still and video cameras. Bear in mind, that biofouling of a grounding site in tropical waters can quickly camouflage broken coral and abraded substrates, making it difficult to differentiate between natural and man-induced damage. Also, strong currents can alter seagrass damage-sites by displacing sediment, deepening or infilling excavation craters, and undercutting exposed rhizome mats. The assessment task team should immediately mark the end points of the damage site to facilitate return assessment visits. This can be done using tethered floats and PVC stakes fixed to the bottom. It is also helpful to obtain detailed information about the vessel and the circumstances surrounding the grounding. Once on scene the assessment vessel should be positioned as close to the grounding site as conditions permit so that diver time and energy are expended efficiently. From this vantage point it is often possible for assessment personnel to identify the major elements and the orientation of the grounding damage before entering the water.

4.3.2 Assessment of the Underwater Damaged Area

a) Damage Assessment (step-1): Establish a Master Transect Line

The FISHBONE grid mapping system is a very useful and practical technique for damage assessment that has been applied by the Florida Keys National Marine Sanctuary (Hudson and Goodwin, 2001). It is presented here as a technique to create an accurate map for the underwater damaged area in coral reef and seagrass habitats. The method demands that the beginning (inbound path) and end (final resting place) of vessel damage to natural resources is located and marked with a surface marker buoy (Figure 4.1). For coral reef and hard ground areas, a 1.25 to 1.5 cm (1/2 to 5/8 in.) diameter stainless steel or fibreglass stake is securely anchored in the substrate at either end of the grounding track. These 'master' stakes should project a minimum of 30 cm (12 in.) above the substrate so that they are easy to relocate. Placing master stake markers in seagrass or in unstable substrates such as reef rubble requires a special Manta type anchor to prevent their withdrawal.

To complete the master transect line, a metric fibreglass measuring tape is attached to the inbound path zero-metre stake and carefully laid out and securely fastened along an approximate centreline down the entire length of the grounding track (Figure 4.1). It may be necessary to affix temporary attachment points for the tape in order to hold it in place or to negotiate curves or sharp turns in the grounding track. For limestone reef rock, hardened steel masonry nails make ideal temporary fasteners. In seagrass areas underlain by soft sediment, temporary attachment stakes can be cut from lengths of plastic PVC pipe. Coarse gravel and rubble substrates will require a pointed steel rod and hammer for adequate penetration. All attachment points should be marked with high visibility plastic surveyors' flagging tape. Coordinates of the two master stakes should then be determined with a differential global positioning system (DGPS) unit capable of sub-metre (within 1 m) accuracy.

b) Damage Assessment (step-2): Quantification of Damage

Depending upon the extent and severity of damage, it may be necessary to use a combination of assessment techniques to adequately determine loss of biota and substrate. Depending upon circumstances, power and sailing vessels up to 9 m in length usually cause damage to natural resources that can range from minor to significant. As a rule they do not have sufficient weight, draft, or horsepower to cause catastrophic damage and groundings in this category can usually be assessed in one day with a minimum of equipment and personnel. On the other hand, larger vessels, due to their greatly increased weight, draft and horsepower, are capable of inflicting severe and widespread damage to biota and substrate. These catastrophic groundings may require several teams of divers, specialized equipment, and up to a week or more to assess (Hudson and Diaz, 1988). Procedures described herein can be applied as appropriate to any observable level of grounding damage to coral reef or seagrass environments.

Coral Reef Damage Assessment: Areas of grounding damage up to 10 m^2 can usually be quickly determined with a handheld 1 m^2 quadrat or by simple length-width measurements with a fibreglass metre tape. Due to their size and complexity, non-catastrophic coral reef grounding sites greater than 10 m^2 in area may require the FISHBONE grid mapping system for an accurate and efficient assessment (Figure 4.1). This technique utilizes the master transect line metre tape already installed on the grounding site, as described in step-1, as the focal point for measurements. Beginning at the '0' metre mark on the tape, a distance measurement is taken at right-angles (90°) out to the damage boundary. Repeat measurements (to the nearest cm) are repeated at 1 m intervals along both sides of the transect line and recorded in sequence on an underwater data sheet. From these data, a square metre grid of the damaged area can be plotted on graph paper or by computer to determine the total area of damage. Compass bearings should be taken at known points along the master transect line to establish the direction of the

grounding track for later use in constructing a map of the grounding site. Water depth(s) at strategic points within the grounding site and time of observation should also be recorded.

Determining percent cover and species within the grounding site is facilitated by a damage assessment data sheet printed on waterproof paper that provides a check list of coral species and other biota likely to be encountered during the survey. In coral environments, displacement and crushing of specimens within a grounding site can be so severe that percent cover cannot be determined. In these instances, percent cover is determined by sampling undamaged areas adjacent to the grounding site. A square metre quadrat constructed of plastic PVC pipe is placed on the seabed at random locations on both sides of the damage area and a full-frame vertical photograph is taken of the quadrat. Adequate quadrat coverage can usually be obtained with two photo frames (one each side) per 3 m of grounding track. This number may be adjusted up depending upon diversity and zonation of biota. If photographic equipment is unavailable, biota can be sketched in-situ on a waterproof data sheet marked with a grid. The data sheet is scaled to match a one square metre PVC quadrat frame that has been subdivided into sixteen 25 cm^2 compartments with tightly stretched nylon string or rubber bungee cord. After placing the PVC quadrat, the diver hovers directly over it and carefully sketches on the data sheet all relevant biota contained within the one square metre outlined by the frame. Although time consuming, this method is accurate because all objects are being drawn to scale. Data collected by either method are then used to obtain percent cover and species per square metre within the damaged area.

Seagrass Damage Assessment: Procedures for assessing damage to seagrass are, with minor exceptions, the same as those outlined above for coral reef areas. Assessment of grounding incidents in seagrass caused by vessels 9 m or less in length is, in most instances, considerably less complicated than those on coral reefs. Damage is typically from propellers that cut and excavate a narrow trench of uniform width through the seagrass beds, the underlying rhizome mat and sediment. These well defined scars are usually about the same width as the propeller that created them and are now devoid of living seagrass. Trench depth is a function of vessel draft and water depth. Measuring the propeller grounding track length, plus width and depth of trench, at 5 m intervals with a fibreglass metric tape will usually provide adequate quantitative assessment data. If an excavation crater (blowhole) is present, its depth should be measured and area mapped using the FISHBONE method. The volume of craters and trenches should be calculated to determine sediment loss. Any sediment eject-beams caused by the grounding that have completely buried adjacent seagrass beds should also be included. All seagrass species and associated biota impacted by the grounding should be listed and their percent cover determined by visual inspection of 25 x 25 cm PVC quadrats placed in adjacent undamaged seagrass beds. Two sampling quadrats (one each side of track) per 2 m of grounding track is usually sufficient to census bottom cover. A rigid metre-long ruler divided into centimetres makes an ideal tool for measuring narrow propeller scars, shallow trenches and excavation craters. As in reef damage assessments, aerial photography and DGPS can also be useful tools for mapping seagrass groundings.

4.3.3 Documenting the Accident

a) Damage Assessment (step-3): Camera Documentation

Beginning at the surface buoy (0-m mark on the tape), record on video tape or other appropriate digital media the significant features of the damage as they are encountered along the entire length of the master transect line. The camera should be moved very slowly and held as steadily as possible at all times. Objects or areas that exhibit major damage should be referenced by close-up video of the tape measure to pinpoint their location along the grounding track. It will sometimes be necessary to make lateral excursions away from the transect tape to capture all areas of damage. To maintain continuity, a similar procedure of tape measure registration should be done at the start and end of each lateral traverse.

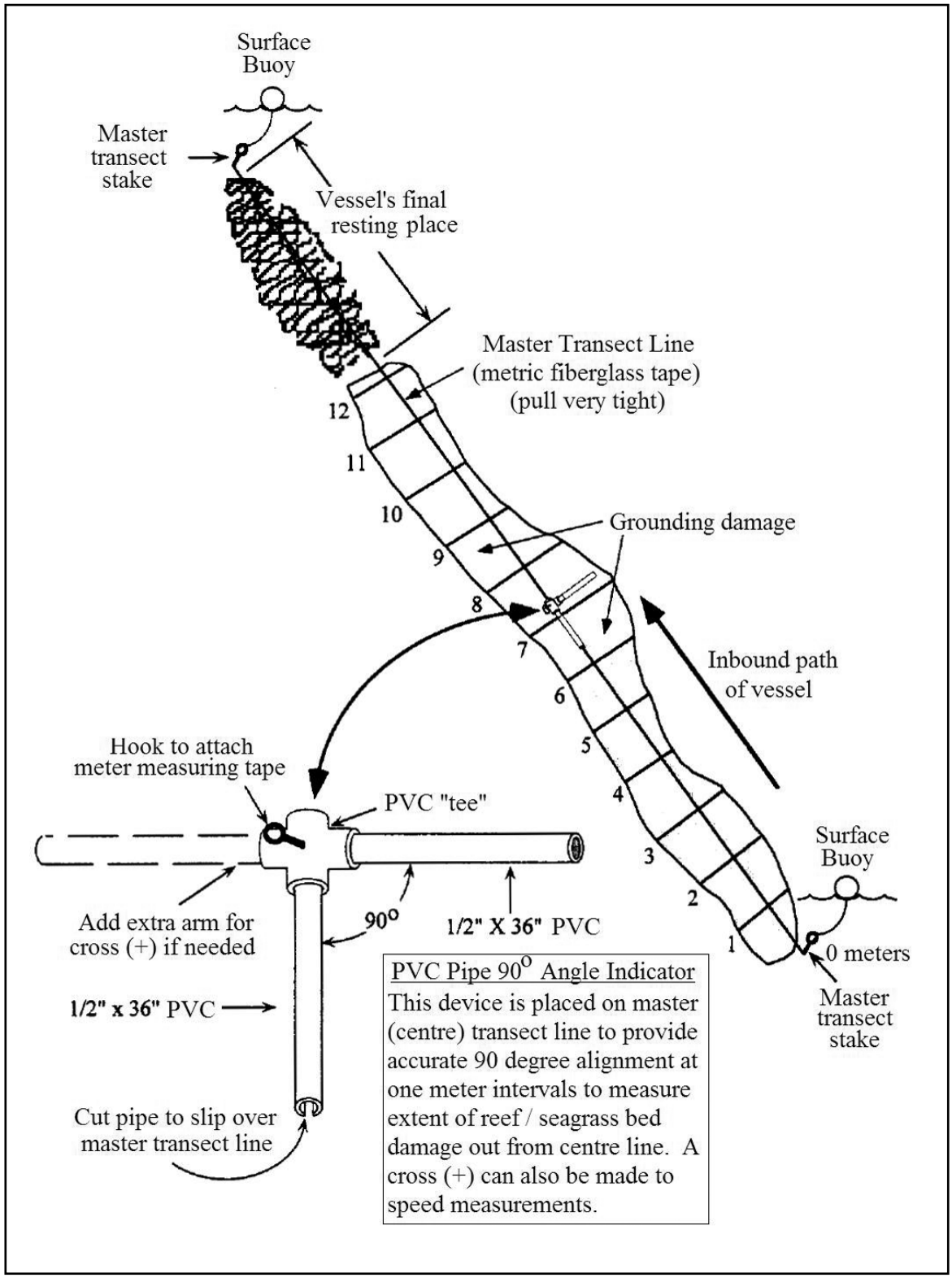

Figure 4.1: FISHBONE grid mapping system, after Hudson and Goodwin (2001)

The full extent of damage to natural resources will not always be apparent, even on video tape. Corals, reef framework, mats of seagrass and other biota will often appear only superficially damaged. Upon closer inspection, however, it is often discovered that they have been dislodged from the substrate. For this reason it is prudent to document a representative number of unstable objects as evidence of damage severity. This can be accomplished by moving the dislodged item slightly while recording it on video.

Any man-made materials found at the grounding site, such as paint flakes, propeller fragments, boat equipment, or other items that could link a vessel to a grounding site should be collected and held as evidence. Before removal, location and orientation of these items relative to the master transect line should be recorded on video, and if necessary, drawn and labelled on an underwater sketch pad. This procedure can be especially useful if a vessel has grounded, freed itself and abandoned the scene before the assessment team arrives.

In instances where a vessel remains aground for an extended period of time, it is sometimes possible to obtain underwater video footage of its hull and the adjacent seabed. This type of documentation is relatively inexpensive to obtain and can be very instructive to the Coast Guard and designated salvage agent in planning vessel removal. It is the diver/video-photographer's responsibility to ensure conditions on and around the vessel are safe before entering the water.

Underwater still-camera photographs should be taken of key areas and objects throughout the grounding site as supplementary documentation. The ability to correctly interpret size relationships in video and still-camera images is extremely important. Divers make an excellent scale for both still and video camera images and should be used whenever possible. Metre sticks, stadia rods, quadrats, and small weighted centimetre scale bars should also be used as appropriate to indicate the size of objects and natural features.

b) Aerial Photography Mapping

Although not usually employed in non-catastrophic grounding surveys, high-resolution aerial photography and the differential global positioning system (DGPS) can be used to map both coral reef and seagrass damaged sites. As a general rule, aerial photography should be considered if the area of damage is more than 100 m^2, is in clear water less than 4.5 m in depth, and contains numerous and widely dispersed isolated grounding scars. Under proper conditions, the efficiency and accuracy of mapping a grounding site by aerial photography is unequalled. For fixed-wing aircraft and helicopters, the experience of the photographer and the cameras used will determine the adequacy of the images. Regardless of the platform used, photographs should be as 'true' vertical, as possible, with camera angle perpendicular (90°) to the water surface. Photos should be taken on calm sunny days in mid-morning or early afternoon to avoid wave distortion and sun glare.

Scale in the photograph should be provided by four 1 m diameter white fibreglass targets that are arranged on the seabed to form a 25 m per side diamond or rhombus. To construct the scale, two stakes are secured in the seabed exactly 25 m apart to form points one and two of the diamond-shaped scale. A metre tape is then fastened to each stake and both tapes unreeled and brought together so that they intersect at 25 m. When the two tapes are pulled tight, the point where they cross is marked with a stake to form the third point of the diamond. This process is repeated on the opposite side to complete the fourth point of the diamond. Additional targets should also be placed over the master transect stakes and at other critical points within the grounding site as required. Targets should be securely fastened to the seafloor and displayed on a dark background for maximum contrast. For display on sandy bottoms and highly scarified areas, targets can be placed inside

a black plastic trash bag and tightly secured with duct tape. The bag should be vented and conform to target outline.

It is advisable to have the photographer take a number of oblique photographs of the site at various angles and altitudes. These can be valuable in establishing relationships to the grounding site of nearby man-made or natural features. It is important to have a vessel on-scene during the over-flight to provide a high-visibility target for the approaching aircraft. Without this visual aid it is extremely difficult for the pilot to locate the exact area to be photographed. Radio communication between on-site vessel and aircraft is strongly recommended. In some instances there may be an opportunity to take aerial photographs while a vessel is still aground. This is especially true of large vessels that may take several days to remove. Due to its high cost, aerial photography is usually prohibitive for all except catastrophic category groundings.

c) Differential Global Positioning System Mapping

Mapping of grounding sites with DGPS is relatively new and was first used in the Florida Keys National Marine Sanctuary by Richard Shaul and his associates in 1998 to map the MV Contship Houston grounding site off Maryland Shoal in the Lower Florida Keys. Criteria for cost-effective use of this equipment include: water too deep or turbid for aerial photography, more than 300 m^2 of discontinuous damaged sites, need for accurate baseline maps for restoration purposes, and availability of two suitable geo-reference points on a nearby landmass. In practice a DGPS 'slave' unit is positioned on each of the two land-based geo-reference points to communicate with orbiting geo-reference satellites and a third DGPS unit mounted on a diver-controlled pontoon floats at the grounding site. An umbilical cable extends from the DGPS unit on the float to a diver on the bottom who enters waypoints as they are encountered on the grounding site. For waypoints to be accurate the antenna mast on the pontoon float must be directly above the object or feature being mapped on the seafloor. This equipment, as described, cannot be used with a high degree of accuracy in strong currents, rough seas or other conditions that could alter vertical alignment of the DGPS antenna mast. Special software is used to convert geo-reference data collected at the site into printed maps.

4.3.4 Restoration of the Damaged Area

The team of experts should evaluate the situation of the grounding site and, after assessing the damage, prepare a suitable plan for restoring the existing damage. The restoration plan has to include the detailed logistics of the necessary steps and procedures needed, and the estimated budget should be calculated. The restoration budget is one of the more significant factors involved in calculating the compensation value for the damage caused by the grounding incident. The restoration budget will differ from one case to another according to the restoration technique and procedures needed for each case, which will depend on the damaged area, the severity of the damage, as well as the conditions at the damaged site (e.g. depth, exposure to current, remoteness, etc.). The task of restoration should be carried out as soon as the damage has been assessed and the grounded vessel has left the site. It is suggested that the agent held responsible for the grounding (i.e. the vessel owner or company) should deposit an amount of money to be used by the local authority to carry out the necessary restoration and this deposit will then be deducted from the compensation costs when approved by the court. This suggestion is very important because valuation and court approval could take several months, or even years, and restoration should begin soon after the grounding event.

Restoration of reefs damaged by grounding incidents is a new issue to discuss in the RSGA region. No restoration measures have been applied after grounding incidents in the RSGA countries so far. There are few studies in the RSGA region dealing with restoration, artificial reefs, and coral transplantation. Egypt has some undertaken some experiments with artificial reefs and coral transplantation (e.g., Kotb et al, 1999; Kotb, 2003, 2006), while PERSGA

supported a project on artificial reefs in Jordan during 2004. These studies have provided the necessary initial data and information for a regional set of restoration procedures.

Natural recovery of coral and other benthic invertebrates and fish populations can be slow in areas of degraded habitat and in the presence of other factors causing stress, such as pollutants, high water temperatures, high abundances of pest species, exotic species, or species that compete or inhibit the recruitment and growth of native fishes and corals and other benthic invertebrates. Natural recovery may never occur when the underlying habitat structure is destroyed or when the prevailing environmental conditions have been chronically degraded over time. When reefs have been damaged by human activities, removing or mitigating the anthropogenic stressors responsible for their decline may enhance natural recovery. Once these stressors are eliminated it may be possible to speed up recovery through coral reef restoration efforts.

Before going into details we must distinguish between three different expressions commonly used in this field. First is *restoration*, which is bringing a degraded ecosystem back, as nearly as possible, to its original condition. The second is *rehabilitation,* which means partially, or occasionally fully, replacing structural or functional characteristics of an ecosystem that have been diminished or lost. Despite the fact that both belong to one process known as *remediation* (remedying or repairing damage to an ecosystem) the magnitude and techniques involved are different in both cases. The main goal in cases of coral restoration is to restore ecosystem function through restoration of ecosystem structure. The concepts of restoration or rehabilitation should have separate legal definitions and be added to the existing environmental law in RSGA countries.

There are some points that should be highlighted concerning restoration processes:

1- Although restoration can enhance conservation efforts, restoration is always a poor second to the preservation of original habitats;
2- Coral reefs relatively unstressed by anthropogenic impacts can often recover naturally from disturbances without human intervention;
3- The aims of reef restoration are likely to be dictated by economic, legal, social and political constraints, as well as ecological realities. However, ignoring the latter means a high risk of failure;
4- The goals of restoration projects should be formulated at the outset as precisely as possible within a wider coastal management planning context;
5- Major physical restoration of reefs is a complex task only suitable for qualified experts. In these cases, civil engineering advice is important and some physical restoration may be a prerequisite for any chance of successful biological restoration; and
6- Restoration is not a one-off event but an ongoing process over a time-scale of several years and is likely to need adaptive management.

a) The Need for Restoration

Coral reefs are vulnerable to destruction by human activities, either gradually through degraded habitat quality, or suddenly through catastrophic damage from vessel groundings or habitat destruction. There are at least 300,000 km^2 of coral reefs in the world, so lack of hard substrate is not a critical issue, but management of degradation of natural reefs is the critical issue. The use of artificial reefs in restoration needs to be considered carefully and critically in terms of need, ecological impact, cost-effectiveness and aesthetics. Detailed planning and restoration considerations are found in the reef restoration handbook by Precht (2006).

b) Restoration Techniques

It is sometimes useful to distinguish between "physical restoration", which

centres on repairing the reef environment with an engineering focus, and "biological restoration", which focuses on restoring the biota and ecological processes. The former can be orders of magnitude more expensive than the latter. Corals, giant clams and large sponges can provide both structural and biotic components, so the distinction is sometimes blurred. For some impacts, only biological restoration may be needed; for others, a combination of physical and biological restoration may be required. However, when planning ecological restoration you should always consider both components together. Impacts such as ship groundings can cause major physical damage to the coral reef framework or create substantial areas of unstable coral rubble and sand that are unlikely to recover even over many decades unless some physical restoration is carried out to consolidate the sea bottom. Major physical restoration is generally a very expensive engineering exercise (costing about $100,000-$1,000,000 per hectare) that requires expert advice (Precht, 2006). For this reason most of the published guidelines concentrate on biological restoration. Minor reef repair and emergency triage is, however, within the scope of community-based projects.

4.3.5 Compensation Value

A compensation value for the damage done can be calculated as explained above; all the benefits of the reef area are considered and, depending on the economic valuation of the reef, an appropriate equation for assessing the compensation rate and the restoration costs is established.

The concept of environmental compensation is relatively new for many nations around the globe. Other countries have realized the danger of neglecting even small amounts of damage to their environment and have included compensation as part of their civil law to help protect the environment from damage. Several developing countries have now issued environmental laws of their own. Naturally these new laws include similar structures as those issued in other countries in addition to sections directly concerning the country where the law was issued.

With the development of environmental economic science as a tool for calculating the value of any damage inflicted on the environment, many countries around the world have adopted a system of environmental compensation. Coral reefs are recognized as important ecosystems, contributing significantly to livelihoods and income in many countries. The advent of laws demanding compensation for damage to coral reef and the amount paid in fines has been shown to have a positive effect on the number of accidents recorded; they have gone down. It is suggested that countries in the Red Sea and Gulf of Aden should adopt similar articles requiring compensation into existing national environmental laws as a further deterrent against environmental degradation.

4.3.6 Legal Arrangements

After assessing the damage and calculating the compensation value, the legal procedures of each country should be followed according to national laws. The efficiency of the procedures taken during the underwater damage assessment, the materials documenting the grounding, and the approved method for calculation of the compensation rate, will strengthen the case against the agent responsible for the grounding (i.e. vessel owner or company) and ensure that adequate compensation is paid.

4.3.7 Monitoring the Damaged Area

Short-term (e.g., 4-6 months) and long-term (e.g., longer than a year) monitoring programmes should be planned for the damaged area. The short-term programme should aim to evaluate the efficiency of the restoration procedures taken and modify these procedures if needed. The long-term programme would aim to monitor the recovery of the damaged site to determine the time when the site might be open to use again as it was previously (e.g., as a diving site or fishing area).

5. PERSGA VISION AND INITIATIVES

The importance of the issue of coral damage caused by ship and boat grounding, which has been increasing all around the RSGA region and is expected to increase further due to the rise in marine activities from tourism, has been recognized. In addition, due to the lack of experience in some countries and weaknesses in their compensation procedures, which can lead to reductions in the amount of compensation received after loss of natural resources, PERSGA has felt that some action should be taken on a regional scale to strengthen the compensation for damaged reefs caused by vessel groundings. A regional workshop was held at PERSGA headquarters in Jeddah during August 2008. The participants at this workshop were nominated by the environmental agencies in their respective countries (PERGSA member states) and each submitted a national review report covering the ship/boat grounding incidents on coral reefs and the official compensation procedures taken. Recommendations from the participants at the workshop are presented here. All suggestions and recommendations should be subject to further study and discussion before being adopted in PERSGA's future agenda.

5.1 COMPILING THE STATE OF ENVIRONMENT REPORT AT THE REGIONAL LEVEL

The first logical step needed for the development of efficient compensation procedures is an understanding of the environmental status of the RSGA region, and a map with the current condition of each reef at the national and regional level. It is a large task if only the regional scale is considered, but breaking down the reef areas to the national level, or even to the local level, will ease the overall approach.

This approach needs regional organization for coordination and standardization. Hence, PERSGA should carry out this task through a regional programme. PERSGA has a regular monitoring programme for the marine environment and another programme aiming to determine the economic value of regional marine and coastal resources. PERSGA has incorporated the valuation of resources in its future agenda. A series of workshops will be organized either at the national or regional level in order to fulfil the following:

1. Establish a regional valuation formula for the different ecosystems in the region following current international best practices. Valuation will consider all points of view: biological, social, economic, heritage, direct benefits, indirect benefits;
2. Build national capacities to carry out the necessary field work, investigate the national reef areas and collect valuation data;
3. Establish a zonation scheme for reef areas that includes all national and regional waters (categorizing the zones according to a valuation scale); and
4. Publish this zonation scheme to the public and international communities to promote awareness of any new Red Sea and Gulf of Aden compensation scheme.

5.2 REGIONAL CAPACITY BUILDING ON DIFFERENT COMPENSATION PROCEDURES

The differences between the capacities of the countries in the area of the Red Sea and Gulf of Aden notwithstanding, the role of PERSGA under the umbrella of the

Each country should produce a GIS detailed coral reef distribution map with information about the level of coral coverage, the potential for new coral settlement, and the status of the associated fauna.

Jeddah Convention, is to bring together the participating countries to discuss issues of mutual interest and provide capacity building opportunities.

Training sessions should be held to raise the capacities within the participating countries in the broad field of environmental management and valuation which would lead to an improvement in the ship grounding compensation process.

Through the preparation of the present work, and as an output from the regional workshop organized by PERSGA in Jeddah during August 2008 for national experts dealing with compensation issues, several gaps were identified in the information and data collection processes in the RSGA area. These gaps need to be filled through a capacity building training programme that contains a series of regional and national training workshops in several subjects such as:

1- Underwater survey techniques;
2- Documenting/reporting the incident;
3- Assessment of coral damage;
4- Fauna and flora identification;
5- Economic valuation of natural resources;
6- In-situ data/information collection and handling; and
7- Reef restoration and rehabilitation.

5.3 FORMATION OF REGIONAL COMPENSATION COMMITTEE AND REGIONAL ENVIRONMENTAL LAW

The current study revealed that coral reefs should have more protection in the area through the legal system. It is suggested that a high level committee should be formed at the regional level (PERSGA), its main concern to prepare legal documents suitable to be added to the environmental laws in each of the participating countries. The members of the committee will receive both scientific and economic studies prepared by each country on coral reefs and then draft a law concerned with the conservation of coral reefs and details for the compensation process. In addition the committee will seek for agreement and adoption of this law from the participating countries. This law is important to standardize the compensation procedures in the RSGA states and will overcome the lack of capacity in some member states, as well as deal with trans-boundary grounding incidents between adjacent states.

Several international agreements and conventions, where all the PERSGA member states are signatory members, deal with compensation for oil pollution, chemical hazards and garbage. For instance, MARPOL 73/78 recognised the Red Sea and Gulf of Aden as Special Areas with respect to compensation for oil pollution damage. The articles and legal provisions of such a convention could be useful in the preparation of a regional compensation protocol for coral reef damage caused by ships grounding in the RSGA area. Accordingly, the whole RSGA region could be categorized as a Special Area with respect to compensation for coral reef damage caused by vessel grounding incidents.

5.4 FORMATION OF A REGIONAL CORAL REEF RESCUE TEAM

A regional Coral Reef Rescue Team (CRRT) can be formed from a number of regional experts with sufficient background in coral reefs and high skills in diving; (possibly two from each country). The nomination of the team members and training can be organized through the national focal points and PERSGA. The members of this team should have very good experience, be able to work under difficult circumstances as ship grounding incidents happen at any time and in any place. The regional team will be useful in cases where national experts are lacking at the time of a grounding accident. The team members will gain a level of training and experience that individual countries cannot build on their own. The major tasks of this team would include:

1- Moving to the grounding site immediately (several logistical implications are involved in this, such as flying team members to the country where the incident has occurred);
2- Documenting and reporting the

incident according to the regional plan and using state-of-the-art technology (e.g. satellite position fixing, still and movie photography, advanced communications, etc.);

3- Assisting in training sessions at the national level (national teams could be formed if the budgets were made available and the need arose);
4- Assisting in the preparation of a regional restoration protocol; and
5- Carrying out restoration or rehabilitation, and monitoring of damaged reefs.

5.5. RECOMMENDATIONS TO ADOPT

Further to the above suggestions, and according to the outputs of discussions organized during the regional workshop held at PERSGA headquarters during August 2008, the following recommendations were emphasised by the national representatives. These suggestions are:

1. Develop baseline data on economic valuation of the marine and coastal habitats in the RSGA region by conducting ecological and socio-economic surveys and studies, particularly in areas with corals that are exposed to high risk of grounding events;
2. Develop a regional guide for compensation, including standards, methodology and procedures for:
   - Survey methods for damaged areas;
   - Protocols for documenting an accident or incident;
   - Calculating compensation on the basis of all direct and indirect values (e.g. restoration and social values);
   - Clean up and restoration of damaged areas.
3. Develop training programmes to enhance capabilities of the concerned national authorities in RSGA countries in: assessment of environmental impact, compensation, and rehabilitation;
4. Initiate a regional convention to cover cases of trans-boundary grounding events;
5. Fund small projects at sites for restoration of reefs damaged by ship or boat grounding.

Further recommendations could be drawn from international experience in the field of compensation for coral reefs damaged by vessel groundings. Two of the main outputs from the workshop were that coral reefs in the RSGA area are not adequately protected, and they are rapidly disappearing. Accordingly, the following are some recommendations for ensuring the long-term viability of the remaining reefs by altering human interactions with reefs.

Issuing a Special Law: Coral reefs are important ecosystems that provide a variety of essential services to mankind. We recommend, therefore, that each of the PERSGA member countries issues a special law for the protection of this particular ecosystem. The law should have several articles concerning the different threats that face coral reefs today. In addition, the law must include one article specifying the value of the coral reefs in the country, based on detailed scientific and economic studies (PERSGA could lead and standardize this initiative).

Increase World Heritage Sites in the RSGA region: Given the prediction that as much as sixty percent of the world's reefs will be gone in thirty years, the UNESCO World Heritage Committee launched in 2005 the World Heritage Marine Programme which aims to safeguard the world's marine natural heritage. PERSGA could play an important role to assist the countries of the region to add their most endangered reefs to the List of World Heritage in Danger under Article 11. Under Articles 19 and 22, a party state containing a designated reef is eligible to request international assistance in the form of technical cooperation, loans, and even grants. These funds may be used in a variety of ways, ranging from training staff to providing experts, and even supplying equipment. UNEP has already identified a number of coral reefs that it would like to see added to the World Heritage List and UNESCO's World Heritage Programme already highlights the threats to a variety of ecosystems including one in the RSGA area (Socotra Archipelago in Yemen).

6. LITERATURE

6.1 REFERENCES

Burke, L., Greenhalgh, S, Prager, D. and Cooper, E. 2008. Coastal Capital. Economic Valuation of Coral Reefs in Tobago and St. Lucia. Washington, DC: World Resources Institute. Final Report, 66 pp.

Cesar, H.J.S. (ed.) 2000. Collected essays on the economics of coral reefs. CORDIO – Sweden, 244 pp.

Cesar, H., van Beukering, P. and Romilly, G. 2003. Mainstreaming Economic Valuation in Decision Making. Coral Reef Examples in Selected CARICOM countries.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G. and Sutton, P. 1997. The value of the world's ecosystem services and natural capital. *Nature*, 387: 253–260.

Daily, G., Soderqvist, T., Aniyar, S., Arrow, K., Dasgupta, P., Ehrlich, P., Folke, C., Jannson, A., Jannson, B., Kautsky, N., Levin, S., Lubchenko, J., Maler, K., Simpson, D., Starrett, D., Tilman, D. and B. Walker. 2000. The value of nature and the nature of value. *Science* 289: 395–396.

Dixon, J.A. 1998. Economic values of coral reef: What are the issues? In: Hatziolos, M.E. et al. (eds). Coral reefs: challenges and opportunities for sustainable management. pp. 157–162. World Bank, Washington.

Dixon, J.A., Scura, L.F. and van't Hof, T. 1993. Meeting ecological and economic goals: Marine parks in the Caribbean. *AMBIO*, 22: 117–125.

Fox, H.E., Pet, J.S., Dahuri, R. and Caldwell, R.L. 2003. Recovery in rubble fields: long-term impacts of blast fishing. *Marine Pollution Bulletin*, 46(8): 1024–1031.

Gianni, M. 2004. High Seas Bottom Trawl Fisheries and their Impacts on the Biodiversity of Vulnerable Deep-Sea Ecosystems: Options for International Action. Executive Summary. IUCN, Gland, Switzerland. Available at: http://cmsdata.iucn.org/downloads/hs_bottomtrawling_execsumm.pdf

Great Barrier Reef Marine Park Authority (GBRMPA), 1975. Text for Great Barrier Reef Marine Park Act. http://www.comlaw.gov.au/Details/C2011C00149

Harriott, V.J., Davis, D. and Banks, S.A. 1997. Recreational diving and its impact in marine protected areas in Eastern Australia. *AMBIO*, 26(3): 173–179.

Hawkins J.P. and Roberts, C.M. 1992. Effects of recreational SCUBA diving on fore-reef slope communities. *Biological Conservation,* 62: 171–178.

Hawkins, J.P. and Roberts, C.M. 1993. Effects of recreational scuba diving on coral reefs: Trampling on reef-flat communities. *The Journal of Applied Ecology*, 30(1): 25–30.

Hudson, J.H. and Diaz, R. 1988. Damage survey and restoration of MV Willwood grounding site, Molasses Reef, Key Largo National Marine Sanctuary, Florida. Proc. 6th Int. Coral Reef Symp., Australia, pp. 231–236.

Hudson, J.H. and Goodwin, W.B. 2001. Assessment of vessel grounding injury to coral reef and seagrass habitats in the Florida Keys National Marine Sanctuary, Florida: protocol and methods. *Bulletin of Marine Science*, 69(2): 509–516.

Jameson, S.C., Ammar, M.S.A., Saadalla, E., Mostafa, H.M. and Riegl, B. 1999. A coral damage index and its application to diving sites in the Egyptian Red Sea. *Coral Reefs* 18: 333–339.

Kotb, M.M.A. 2003. Transplantation of corals as an approach to rehabilitate the degraded reefs in the Egyptian Red Sea. Proc. 1st Egyptian International Conference for Protected Areas and Sustainable Development, Sharm El-Sheikh, Egypt, 23–26 October 2002. *Egyptian Journal of Biology*, 5.

Kotb, M.M.A. 2006. Artificial reefs as a compromise between the tourist industry and reef conservation in the Egyptian Red Sea. International Society for Reef Studies (ISRS)–European Meeting, 19–22 September 2006, Bremen, Germany.

Kotb, M.M.A., Hanafy, M.H., Hartnoll, R. and Holt, T. 1999. Technical report of the research project "Investigation of the effectiveness of some simple methods for coral reef regeneration". A report submitted to British Gas International Ltd., August 1999, 33 pp.

Lee, V.A., Bridgen, P.J. and Environment International Ltd. 2002. The natural resource damage assessment deskbook. Environmental Law Institute, Washington D.C.

Leeworthy, V. 1991. Recreational Use Value for John Pennekamp Coral Reef State Park and Key Largo National Marine Sanctuary. Maryland, USA: National Oceanic and Atmospheric Administration.

Liddle, M. and Kay, A. 1987. Resistance, survival, and recovery of trampled corals on The Great Barrier Reef. *Biological Conservation* 42: 1–18.

McManus, J.W., Nanola, C.L., Reyes, R.B. and Kesner, K.N. 1992. Resource ecology of the Bolinao coral reef system. *ICLARM Studies and. Reviews*, 22, Manila, Philippines, 117 pp.

McManus, J.W., Reyes, R.B. and Nanola, C.L. 1997. Effects of some destructive fishing methods on coral cover and potential rates of recovery. *Environmental Management*, 21(1): 69–78.

Matoba, M. 1999. Optimization of control measures in probabilistic safety assessment of grounding and collision. *Journal of the Society of Naval Architects of Japan*, 186: 301–309.

Moberg, F. and Folke, C. 1999. Ecological goods and services of coral reef ecosystems. *Ecological Economics*, 29: 215–233.

National Oceanic and Atmospheric Administration. 2003. Reversing the tide: Restoring our nation's coastal environment. NOAA-DARP, Silver Spring, MD, USA.

Pagiola, S., K. von Ritter and J. Bishop. 2005. How much is an ecosystem worth? Assessing the economic value of conservation. Washington DC: World Bank, IUCN, and the Nature Conservancy.

PERSGA. 1998. Strategic Action Programme for the Red Sea and Gulf of Aden, 141 pp.

PERSGA. 2001. Country reports. Strategic Action Programme for the Red Sea and Gulf of Aden. 205 pp.

PERSGA. 2003. Regional Action Plan for the Conservation of Coral Reefs in the Red Sea and Gulf of Aden. PERSGA Technical Series Number 3, 55 pp.

PERSGA. 2006. The State of the Marine Environment, Report for the Red Sea and Gulf of Aden (SOMER). PERSGA, Jeddah. 241 pp.

Pet-Soede, L., Cesar, H. and Pet, J. 1999. An economic analysis of blast fishing on Indonesian coral reefs. *Environmental Conservation* 26: 83–93.

Precht, W.F. (ed.) 2006. Coral Reef Restoration Handbook. CRC Press, Boca Raton. 363 pp.

Riegl, B. and Luke, K.E. 1999. Ecological parameters of dynamited reefs in the northern Red Sea and their relevance to reef rehabilitation. *Marine Pollution Bulletin*, 37(8): 488–498.

Riegl, B. and Velimirov, B. 1991. How many damaged corals in Red Sea reef systems? A quantitative survey. *Hydrobiologia*, 216–217: 249–256.

Rogers, C.S. 1990. Responses of coral reefs and reef organisms to sedimentation. *Marine Ecology Progress Series*, 62: 185–202.

Russell, K.D. 1992. The economics of coastal waste management. In: Chua, T.-E. and Garces, L.R. (eds) Waste Management in the Coastal Areas of the ASEAN Region: Roles of Governments, Banking Institutions, Donor Agencies, Private Sector and Communities. *ICLARM Conference Proceedings* 33: 149–163.

Simonsen, B.C. and Hansen, J. 2000. Mechanics of Ship Grounding. Department of Naval Architecture and Offshore Engineering, Denmark. 120 pp.

Spurgeon, J.P.G. 1992. The economic valuation of coral reefs. *Marine Pollution Bulletin*, 24(11): 529–536.

Terence, J., Ogden, J., Weibe, W. and Rosen, B. 1996. Functional Roles of Biodiversity: A global perspective. Mooney, H., Cushman, J., Medina, E., Salsa, O. and E.-D. Schulze (eds). John Wiley & Sons Ltd., pp. 395–428.

Tratalos, J.A. and Austin, T.J. 2001. Impacts of recreational SCUBA diving on coral communities of the Caribbean island of Grand Cayman. *Biological Conservation* 102: 67–75.

UNEP. 2000. World Atlas of Coral Reefs. Published in association with WCMC by the University of California Press. M. Spalding, C. Ravilious and E. Peter Green (eds), World Conservation Monitoring Centre, 424 pp.

United States Coral Reef Task Force (USCRTF) 2004. [Online] Available at http://www.coralreef.gov/mauicoastal.cfm.

White, A.T., Vogt, H.P. and Arin, T. 2000. Philippine coral reefs under threat: the economic losses caused by reef destruction. *Marine Pollution Bulletin* 40(7): 598–605.

Wielgus, J. 2004. General Protocol for Calculating the Basis of Monetary Legal Claims for Damages to Coral Reefs by Vessel Groundings and an Application to the Northern Red Sea. Israel Nature and National Parks Protection Authority; Report. 31 pp.

Woodland, D. and N. Hooper 1977. The effect of human trampling on coral reefs. *Biological Conservation* 11: 1–4.

WWF. 2004. GCRMN "Status of Coral Reefs of the World: 2004" launch at WWF - Washington DC.

WWF. 2006. Second Annual Coral Reef Conservation and Management Conference, James L. Knight International Center - Miami, FL.

Zakai, D. and Chadwick-Furman, N.E. 2002. Impacts of intensive recreational diving on reef corals at Eilat, northern Red Sea. *Biological Conservation,* 105: 179–187.

6.2 FURTHER READING

Abdel-Azem, A.A. 2003. Impact of human activities on the reefs around Hurghada, Red Sea. M.Sc. thesis, Al-Azhar University, 210 pp.

Burke, L. and Maidens, J. 2004. Reefs at Risk in the Caribbean. Washington, DC: World Resources Institute.

Chapman, D., Iadanza, N. and Penn, T. 1998. Calculating resource compensation: An application of the service-to-service approach to the blackbird mine hazardous waste site. National Oceanic and Atmospheric Administration Damage Assessment and Restoration Program, Technical Paper 97-1.

Conservation International. 2008. Economic Values of Coral Reefs, Mangroves, and Seagrasses: A Global Compilation. Center for Applied Biodiversity Science, Conservation International, Arlington, VA, USA.

Convention on Biological Diversity (CBD). http://www.cbd.int/marine/coral.shtml. Page updated 2007/12/14.

Deis, D.R. and French, D.P. 1998. The use of methods for injury determination and quantification from natural resource damage assessment in ecological risk assessment. *Human and Ecological Risk Assessment,* 4(4): 887–903.

Dixon, J.A. 1989. Coastal resources in Kosrae: An undeveloped economic resource. Kosrae Island Management Plan, Vol. II, background paper, East-West Center.

ECLAC. 1998. Handbook for Estimating the Socio-economic and Environmental Effects of Disasters. United Nations Economic Commission for Latin America and Caribbean. 45 pp.

Edwards, A.J. and Gomez, E.D. 2007. Reef Restoration Concepts and Guidelines: Making sensible management choices in the face of uncertainty. Coral Reef Targeted Research & Capacity Building for Management Programme: St Lucia, Australia. iv + 38 pp.

Freeman, A.M. 2003. The measurement of environmental and resource values: theory and methods. Second edition. Resources for the Future, Washington, D.C.

Galor, W. 2006. An assessment of ship impact on the ground during maneuvering in a port water area. *International Journal of Materials & Structural Reliability,* 4(1): 89–97.

Hawkins, J.P. and Roberts, C.M. 1994. The growth of coastal tourism in the Red Sea: Present and future effects on coral reefs. *AMBIO*, 23(8): 503–508.

NOAA (National Oceanic and Atmospheric Administration). 1995. Habitat Equivalency Analysis: An overview. NOAA Damage Assessment and Restoration Program Policy and Technical Paper Series No. 95-1, Silver Spring, Maryland.

NOAA (National Oceanic and Atmospheric Administration). 1997. Scaling Compensatory Restoration Actions: Guidance document for natural resource damage assessment under the Oil Pollution Act of 1990. NOAA Damage Assessment and Restoration Program, Silver Spring, Maryland.

Pet-Soede, C. 2000. Options for co-management of an Indonesian coastal fishery. PhD Thesis, Wageningen Agricultural University.

Precht, W.F., Aronson, R.B. and Swanson, D.W. 2001a. Improving scientific decision-making in the restoration of ship-grounding sites on coral reefs. *Bulletin of Marine Science,* 69(2): 1001–1012.

Precht, W.F., Deis, D.R. and Gelber, A.R. 2001b. Damage assessment protocol and restoration of coral reefs injured by vessel groundings. PBS & J Ecological Sciences, Miami.

Sehgal, R. 2006. Legal regime towards protecting coral reefs: An international perspective and Indian scenario. Environment and Development Journal, pp. 183–195.

UNDP/GEF. 2008. Guidelines for Economic Analyses of Environmental Management Actions for the Yellow Sea. UNDP/GEF YSLME Project, Ansan, Republic of Korea. 35 pp.

كبير فى مصر على العائدات المتصلة بالسياحة وبدرجة أقل على صيد الأسماك، فى حين أن الوضع فى اليمن هو العكس. وفى ضوء هذه التناقضات، وإدراكاً بمدى القدرات التقنية المتباينة داخل دول الإقليم، فإن الهيئة الإقليمية للمحافظة على بيئة البحر الأحمر وخليج عدن شرعت فى عقد سلسلة من ورش العمل للوصول إلى إجراءات إسترشادية يمكن إستخدامها أو تعديلها بهدف تطوير الإجراءات المستخدمة حاليا لحساب ومتابعة إجراءات التعويض.

ويقدم هذا الدليل: (أ) نظام تقييم لأى حادث مبنى على طريقة مسح موحدة تحت الماء لتقييم الأضرار التى تلحق بالشعاب المرجانية نتيجة لحوادث الجنوح بإستخدام طريقة تسمى "هيكل السمكة" لرسم خريطة موقع الحادث تحت الماء (FISHBONE grid mapping system) والذى تم تطبيقه بنجاح بواسطة محمية فلوريدا–كيز الوطنية بالولايات المتحدة (Florida Keys National Marine Sanctuary)؛ (ب) مجموعة من تقنيات التقييم التى تركز على ثلاثة من السلع والخدمات الرئيسية التى توفرها الشعاب المرجانية: الأنشطة الترفيهية والسياحية المرتبطة بالشعاب المرجانية، مصائد الأسماك المرتبطة بالشعاب المرجانية، حماية السواحل من النحر. وقد تم إختيار هذه السلع والخدمات لأهميتها بالنسبة للإقتصاد المحلى فى كل دول الإقليم، وكذلك لوجود البيانات المتاحة لدعم وتقدير تلك القيم؛ (ج) كيفية التخطيط لإعادة تأهيل وإستعاضة الشعاب المرجانية المتضررة.

فى الفصل الأخير من هذا الدليل يتم مناقشة فوائد تطوير وتوحيد طرق التعويض من منظور إقليمى وتسليط الضوء على مجالات بناء القدرات اللازمة لذلك. ويتضمن ذلك تقنيات المسح العلمى تحت الماء؛ توثيق والإبلاغ عن الحوادث؛ تقييم حجم الشعاب المدمرة؛ تصنيف وتعريف الكائنات البحرية؛ التقييم الإقتصادى للموارد الطبيعية؛ جمع البيانات والمعلومات وتحليلها؛ وتقنيات إعادة تأهيل وإستعاضة الشعاب المرجانية.

وقد تم إقتراح تشكيل لجنة تعويضات إقليمية للنظر فى الدراسات العلمية والإقتصادية التى تم إعدادها عن الشعاب المرجانية، ولإعداد مسودة قوانين تتعلق على وجه التحديد بالمحافظة على الشعاب المرجانية، حيث أن الشعاب المرجانية فى الوقت الحاضر محمية فقط بلوائح قانونية بطريقة غير مباشرة. كذلك مقترح تكوين وتدريب فريق إقليمى لإنقاذ الشعاب المرجانية ليكونوا خبراء فى عمليات مسح مواقع جنوح السفن وتوثيق ملابسات وظروف الحادث بكفاءة وتقييم حجم الأضرار بطريقة جيدة مما سيعضد الموقف القانونى أمام المحاكم للمطالبة بالتعويض والذى سيؤدى إلى الحصول على مبالغ التعويض المقدرة كاملة.

يمكن أن تستخدم فى عمليات إنقاذ وإستعاضة للشعاب المتضررة، أو لتحسين إجراءات الملاحة والإدارة فى المنطقة. كما أن وجود وتطبيق الإجراءات القانونية الصارمة سيؤدى إلى زيادة حرص قائدى السفن والقوارب والذى سيؤدى بدوره إلى تقليل عدد حوادث الإرتطام بالشعاب.

ويقدم هذا التقرير الأعداد الرسمية المسجلة لحوادث جنوح السفن فى دول الإقليم، والإطار القانونى الحالى المعمول به فى كل دولة؛ ويقترح التقرير بعد ذلك إطاراً لدفع التعويضات. وتوضح التقديرات الرسمية أن عدد الحوادث المسجلة فى كل دولة يتراوح بين لاشىء فى جيبوتى والأردن، أربعة فى كل من اليمن والسعودية، 22 فى السودان، إلى 149 فى مصر. ويتضح أن الإجراءات الإدارية والقانونية المتبعة فى دول الإقليم لمطالبات التعويض توجد على مستويات مختلفة من التطور والتعقيد مع إختلاف صيغ حساب معدلات التعويض.

إن تقييم أهمية نظم الشعاب المرجانية فى الوقت الحاضر، وكما هو مذكور أعلاه، لا يأخذ فى الإعتبار سوى عدد قليل من السلع والمنافع التى توفرها البيئة البحرية للمجتمعات فى الإقليم. ومن الممكن التعامل مع هذا التقييم بقيم متغيرة تختلف بإختلاف نوعية الشعاب المرجانية (نسبة الغطاء المرجانى، كم التنوع البيولوجى)، كذلك تتضمن تقييم عامل الوقت للفترة التى لا تكون فيها الشعاب قادرة على تقديم السلع والمنافع المعتادة منها. بالإضافة إلى ذلك فإن قيمة التعويض تزداد عادة لتشمل تكاليف المساهمة فى عمليات تقدير مساحة الأضرار، والإجراءات القانونية، وتكاليف الإستعاضة، وتكاليف المتابعة البيئية فى المستقبل.

فى إقليم البحر الأحمر وخليج عدن كان لمصر الدور الرائد فى البدأ وتطوير تقنيات التقييم والإجراءات القانونية لتحقيق دفع التعويضات. والنموذج الأساسى الذى وضعته مصر وتم إستخدامه بقدر أكبر أو أقل فى باقى دول الإقليم هو على النحو التالى:

حساب التعويض = $A \times LC \times D \times RP \times V$

حيث يمثل (A) مساحة منطقة الحادث بالمتر المربع، (LC) النسبة المئوية للمرجان الحى، (D) النسبة المئوية للضرر فى المنطقة، (RP) عدد السنوات المطلوبة لعودة المنطقة لما كانت عليه، و(V) قيمة المتر المربع الواحد (وضعت كـ 120 دولار أمريكى لكنه إرتفع إلى 300 دولار بالنسبة للمتنزهات الوطنية).

إن الشعاب المرجانية توفر الكثير من السلع والخدمات داخل المنطقة؛ وهذه الصيغة البسيطة ليست انعكاسا حقيقيا لها. كذلك فإن فكرة مخطط واحد يناسب جميع التعويضات ليست بالضرورة مناسبة لأن إستخدامات الشعاب المرجانية فى البلدان المختلفة ليست واحدة. فعلى سبيل المثال هناك تركيز

ملخص تنفيذى

تعتبر الشعاب المرجانية من أهم النظم الإيكولوجية على الصعيد العالمى فى البحار والمحيطات وأيضا على الصعيد المحلى فى البحر الأحمر وخليج عدن. وتسهم هذه الشعاب فى مجموعة متنوعة من الفوائد القيمة للمجتمعات المحلية والإقتصاد القومى للبلدان التى تتمتع بوجود هذه الشعاب فى مياهها. وتشمل هذه الفوائد مصائد الأسماك التجارية والتقليدية وأسماك الزينة؛ إستخراج المواد الحيوية لإنتاج أدوية الجديدة؛ التعدين؛ العائدات من السياحة، بالإضافة إلى حماية الشواطئ.

إن قيمة هذه الموارد الطبيعية لم تجد التقدير اللازم إلا فى الآونة الأخيرة، مما يعكس مدى قصور إدراكنا لقيمة التفاعل بيننا وبين البيئة الطبيعية والبيولوجية. ولهذا فقد بدأ علماء البيئة والإجتماع خلال الحقبة الماضية فى إعداد طرق لحساب القيمة المالية لهذه الموارد الطبيعية.

وتواجه الشعاب المرجانية على الصعيدين العالمى والمحلى مجموعة متنوعة من التهديدات، وقد عانت مناطق كثيرة من التدهور الشديد. وتعتبر هذه الموارد مشتركة وتشكل جزءا من تراثنا الطبيعى. وعندما يحدث أى ضرر لهذه الموارد ينبغى أن يتم مجازاة المتسبب فى الضرر بدفع التعويض اللازم، كما ينبغى بذل الجهود للعمل على إستعاضة حالة المنطقة المتضررة بحيث تستطيع القيام بمواصلة تقديم المنافع المادية والبيولوجية للمجتمع.

إن حوادث جنوح السفن ليست سوى واحدة من العديد من التهديدات التى تواجه الشعاب المرجانية. وتختلف هذه الحوادث من خفيفة الأضرار إلى الكارثة البيئية، ومن جنوح قوارب الغوص أو الصيد الصغيرة، أو إستخدام القوارب للرسو بالمخاطيف، إلى إصطدام السفن العملاقة بالشعاب المرجانية وتدميرها لكل المنظومة البيئية لموقع الإصطدام، هذا بجانب التهديدات المحتملة لإنسكاب مواد كيميائية أو بترولية لاحقة نتيجة للإصطدام.

منذ إفتتاح قناة السويس ومع الزيادة المضطردة فى أنشطة سياحة الغوص على مستوى الإقليم، فقد زاد عدد السفن والزوارق الكبيرة والصغيرة التى تستخدم البحر الأحمر وخليج عدن بشكل كبير. وقد صاحب ذلك زيادة فى عدد حوادث الجنوح والضرر التى تسببت فى خسارة مساحات من الشعاب المرجانية فى المنطقة.

إن الإجراءات القانونية والمؤسسية فى إقليم البحر الأحمر وخليج عدن لمعاقبة مرتكبى تلك الأضرار متباينة ومتنوعة، وأحيانا غير موجودة. ولا شك أن وجود منظومة واضحة من الإجراءات الإرشادية سيساعد الحكومات الوطنية فى مقاضاة مرتكبى الأضرار والحصول على التعويضات المناسبة التى

"الهيئة الإقليمية للمحافظة على بيئة البحر الأحمر وخليج عدن"، هى هيئة حكومية تعنى بالمحافظة على البيئات الساحلية والبحرية فى الإقليم.

تستمد الهيئة قاعدتها القانونية من الإتفاقية الإقليمية للمحافظة على بيئة البحر الأحمر وخليج عدن (١٩٨٢م). وقد تم إعلان إنشائها فى القاهرة فى سبتمبر ١٩٩٥م، حيث تتخذ من مدينة جدة مقرا لها. تضم الهيئة فى عضويتها كل من الأردن، جيبوتى، السعودية، السودان، الصومال، مصر، واليمن.

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صورة الغلاف: مثال لحوادث جنوح السفن على شعاب البحر الأحمر المصرى.

PERSGA. 2009. Guidelines for Compensation Following Damage to Coral Reefs by Ship or Boat Grounding. Part 1. PERSGA Technical Series Number 15. PERSGA, Jeddah.

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الدليل الإسترشادى
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الجزء الأول

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