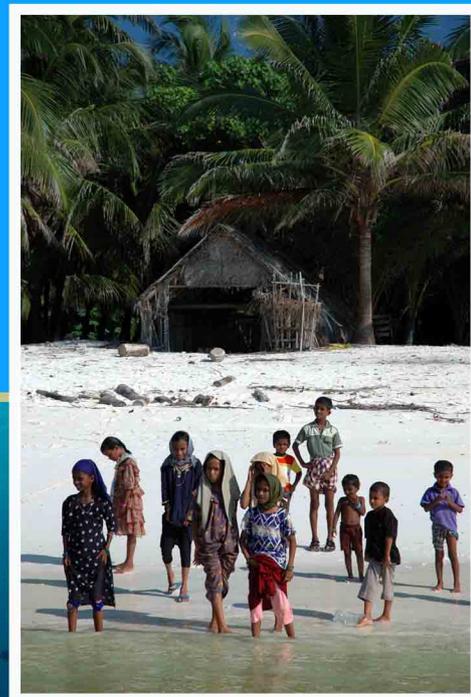


# Coastal Oceans Research and Development in the Indian Ocean

Status Report 2008

## *Summaries*

David Obura  
Jerker Tamelander  
Olof Linden



COASTAL OCEANS RESEARCH AND DEVELOPMENT IN THE INDIAN OCEAN  
Status Report 2008



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## Status Report 2008

EDITORS:

DAVID OBURA, JERKER TAMELANDER & OLOF LINDEN



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Status Report 2008**

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# Foreword

Coral reefs and tropical Small Island States are among the most vulnerable of the planet's ecosystems and societies to climate change. Since the coral bleaching event in 1998 the Indian Ocean has had repeated reminders of the specter of climate change and other planetary-scale events – cyclones and floods in Mozambique and South Asia, repeated droughts in East Africa, the tsunami of 2004 affecting Asian and island states. Further, human population growth and its impact places further stress on these fragile ecosystems. With this uncertain future facing us, it is essential to build up local and regional initiatives to understand and respond to change.

The CORDIO programme which started in 1999 as a pragmatic response to the impacts of global warming on coral reefs has over the years improved our knowledge and management of coral reefs in the region. For example data collection in the Curieuse Marine Park in Seychelles, was instrumental in guiding government policy over the management of marine protected areas, especially those that have resilient coral ecosystems. Without such important and vital information politicians, parliamentarians, local governments and MPA managers will not be able to take decisions which take into consideration coral reef recovery and conservation issues. In fact this particular report has sought to bring together research and monitoring on environmental and socio-economic

aspects and their relevance to management and policy approaches to education and community-based activities.

The Seychelles is acutely aware of the vulnerability of its coastline, marine and terrestrial habitats and population to climate change. With limited land area and high dependence on coastal resources we are indeed at the forefront of efforts to combat the complex and interacting problems of overexploitation, pollution, environmental degradation and climate change. In meeting this challenge we must continue to research and harness all the resources so that we can improve coastal management, reduce human pressures and adapt to climate change.

In September 2007, I launched the Sea Level Rise Foundation, a global platform of excellence on adaptation in small island states. With the continued bleaching of coral reefs, the role of reefs in coastal stability has been significantly weakened and I am confident that with the continuation of CORDIO in its work on coral reefs and as a partner of the Sea Level Rise Foundation we will be able to bring about further attention to the issues faced by small islands and low-lying coastal areas of east Africa and the world.

President James Alix Michel  
Republic of Seychelles



# Contents

Foreword	i		
<b>PART 1 - Regional Summaries</b>	<b>vii</b>		
Ten Years After Bleaching – Moving Into the Next Decade <i>David Obura, Jerker Tamelander, Rolph Payet, Carl Gustav Lundin &amp; Olof Linden</i>	ix	Status of Coral Reefs of the Gulf of Mannar, Southeastern India <i>J.K. Patterson Edward, G. Mathews, Jamila Patterson, R. Ramkumar, Dan Wilhelmsson, Jerker Tamelander &amp; Olof Linden</i>	45
South Asia - Summary <i>Jerker Tamelander</i>	xi		
Andaman Sea - Summary <i>Hansa Chansang &amp; Ukkrit Satapoomin</i>	xxiii	Status and Recovery of the Coral Reefs of the Chagos Archipelago, British Indian Ocean Territory <i>Alasdair Harris &amp; Charles Sheppard</i>	61
East Africa and Islands - Summary <i>David Obura &amp; Rolph Payet</i>	xxix	Status of Carbonate Reefs of the Amirantes and Alphonse Groups Southern Seychelles <i>Annelise B. Hagan, Sarah Hamylton &amp; Tom Spencer</i>	71
<b>PART 2 - Coral Reef Status Reports</b>	<b>1</b>		
Status of Coral Reefs in the Surin and Similan Archipelagos, Thailand <i>Niphon Phongsuwan, Chaimongkol Yamarunpattana, Sathika Paokanta &amp; Papangkorn Areechon</i>	3	Mohéli Marine Park, Comoros Successes and Challenges of the Co-Management Approach <i>Melissa Hauzer, Chris Poonian &amp; Cheikh Moussa Ibouira</i>	83
Status of Coral Reefs in Northern, Western and Southern Coastal Waters of Sri Lanka <i>Arjan Rajasuriya</i>	11	Coral Reef Monitoring in Marine Reserves of Northern Madagascar <i>Simon Harding &amp; Bemahafaly Randriamanantsoa</i>	93
Impacts of Reef Related Resource Exploitation on Coral Reefs: Some Cases from Southern Sri Lanka <i>P.B. Terney Pradeep Kumara, W.A.A.U. Kumara, H.A.A. Sandaruwan, R.G.A. Iroshanie, H.B.L. Upendra &amp; P.R.T. Cumarantunga</i>	23	Studies on Reef Connectivity Within the Context of the Transmap Project <i>M.H. Schleyer, A.H.H. Macdonald, D.E. Starzak, B.Q. Mann, J.P. Paula, I. Silva, A. Costa, A. Macia &amp; D. Abreu</i>	107

South African Reefs: Current Status and Research <i>Michael H. Schleyer, Louis Celliers, David Glassom, Angus H.H. Macdonald, Alke Kruger, Dorota E. Starzak &amp; Camilla Floros</i>	113	Status of Earthquake and Tsunami Affected Coral Reefs in the Andaman and Nicobar Islands, India <i>Dr. Sarang Kulkarni, Vardhan Patankar &amp; Erika D'souza</i>	173
Update on Coral Reef Activities in Mozambique (2004-2006) <i>Marcos A.M. Pereira, Eduardo J.S. Videira &amp; Alice C.D. Costa</i>	115	Assessment of Tsunami Impacts on the Marine Environment of the Seychelles <i>David Obura &amp; Ameer Abdulla</i>	185
Co-Management of the Reef at Vamizi Island, Northern Mozambique <i>Julie Garnier, Isabel Silva, Johnston Davidson, Nicholas Hill, Lara Muaves, Santos Mucaves, Almeida Guissamulo &amp; Alison Shaw</i>	121	<b>PART 4 – Biological Research</b>	<b>199</b>
Approaches to Coral Reef Monitoring in Tanzania <i>Christopher A. Muhando</i>	129	The Effects of Habitat on Coral Resistance and Resilience to Bleaching <i>G. Grimsditch, J. Kilonzo &amp; N. Amiyo</i>	201
Scleractinian Coral Fauna of the Western Indian Ocean. <i>David O. Obura</i>	139	Spawning Patterns of <i>Acropora</i> Species in the Mombasa Lagoon in Kenya <i>Sangeeta Mangubhai</i>	213
<b>PART 3 – Tsunami Impacts</b>	<b>149</b>	Spatial and Temporal Variation in Coral Recruitment and Mortality in Coastal Kenya <i>Juliet F. Karisa, Boaz Kaunda-Arara &amp; David Obura</i>	223
Post Tsunami Status of Coral Reef and Fish in Northern Aceh <i>E. Rudi, S.A. Elrahimi, S. Irawan, R.A. Valentino, Surikawati, Yulizar, Munandar, T. Kartawijaya, Y. Herdiana, F. Setiawan, S. Rizal &amp; S.T. Pardede</i>	151	High Zooxanthellae Densities and Turnover Correlate with Low Bleaching Tolerance in Kenyan Corals <i>G. Grimsditch, J. Mwaura, J. Kilonzo, N. Amiyo &amp; D. Obura</i>	235
Fishing Controls, Habitat Protection and Reef Fish Conservation in Aceh <i>Stuart J. Campbell, Tasrif Kartawijaya, Rizya L. Ardiwijaya, Ahmad Mukmunin, Yudi Herdiana, Edy Rudi, Ayie Nurvita &amp; Robby Andar V.</i>	161	Zooxanthellae Densities are Highest in Summer Months in Equatorial Corals in Kenya <i>G. Grimsditch, J. Mwaura, J. Kilonzo, N. Amiyo &amp; D. Obura</i>	237
		A Description of <i>Acropora</i> sp. 1 in the Mombasa Lagoon in Kenya – A New Species or a Potential Hybrid? <i>Sangeeta Mangubhai</i>	241

The Lallie Didham Coral and Shell Collection, at CORDIO East Africa <i>David Obura, Rose Machaku &amp; Laurence DeFrise</i>	245	Estimating Total Fishing Effort over Tidal to Annual Periods in the Diani-Chale-Gazi Reef Fishery in Kenya <i>Paul Tuda, William Nyaga, George Waweru Maina, Innocent Wanyonyi &amp; David Obura</i>	321
Resilience-Integrating Science and Management in Coral Reefs Relevant to Climate Change <i>David Obura &amp; Gabriel Grimsditch</i>	249	Assessment of Fisherfolk Organizations and Beach Management Units (BMU) in the Management of Fishery Resources in Diani-Chale, Southern Kenya <i>Stephen J. Oluoch &amp; David Obura</i>	335
<b>PART 5 – Fish Spawning Aggregations</b>	<b>261</b>		
Reef Fish Spawning Aggregations in the Western Indian Ocean: Current Knowledge and Implications for Management <i>Jan Robinson, Melita Samoily &amp; Patrick Kimani</i>	263	Development of a Web-based Geographic Information System as a Decision Tool to Support Fisheries Science and Management: A Case Study of Diani-Chale, Kenya <i>B. Munywoki, D.Obura &amp; G. W. Maina</i>	345
Reef Fish Spawning Aggregations in South Asia and the Andaman Sea: Preliminary Findings from Local Knowledge <i>J. Tamelander, S. Sattar, U. Satapoomin, S. Campbell, J.K. Patterson Edward, V. Hoon, M. Chandi, R. Arthur, S. Adam &amp; M.Samoily</i>	277		
<b>PART 6 – Artisanal Fisheries Research</b>	<b>283</b>		
The Small-scale Reef Fishery at Phuket Island, Thailand Andaman Sea Coast <i>Ukkrit Satapoomin &amp; Kanlaya Chawanon</i>	285	Additional and Alternative Occupations for the Urak Lawoi Sea Nomads of Phuket, Thailand <i>Narumon Arunothai, Paladej Na Pombejra, &amp; Jeerawan Buntowtook</i>	357
The Artisanal Reef Fishery on Agatti Island, Union Territory of Lakshadweep, India <i>J. Tamelander &amp; V. Hoon</i>	293	The Coral Reefs and Livelihoods Initiative (CORALI) - Building an Improved Approach to Livelihood Enhancement and Diversification with Coral Reef Users in South Asia and the Andaman Sea <i>B. Cattermoul, G. Sriskanthan, &amp; J. Campbell</i>	371
Increasing Catch in an Over-exploited Reef Fishery: Diani-Chale, Kenya, from 1998 to 2006 <i>G. W. Maina, D. Obura, H. Alidina &amp; B. Munywoki</i>	309	Flip - Flop: Recycling for Social and Environmental Regeneration <i>Tahreni Bwaanali &amp; Julie Church</i>	354
		<b>PART 7 – Socio-economics and Livelihoods</b>	<b>353</b>

<p>The Role of Alternate Livelihoods and Awareness Creation in Coral Reef Conservation in the Gulf of Mannar, Southeastern India <i>Jamila Patterson, J.K. Patterson Edward, V. Deepak Samuel, Dan Wilhelmsson, Jerker Tamelander &amp; Olof Linden</i></p>	<p>387</p>	<p>In the Face of Poverty Mangrove Wetlands are Lifelines: Viability Indicators in Silvofishery Initiatives along the Kenyan Coast Assessing Polyculture of Milkfish (<i>Chanos chanos</i>) and Mulletts (<i>Mugil mugil</i>) <i>H.O.D. Mirera</i></p>	<p>419</p>
<p>Human Dimensions of Madagascar's Marine Protected Areas <i>Joshua Cinner &amp; Mariana Fuentes</i></p>	<p>397</p>	<p><b>PART 8 – Education and Awareness</b></p>	<p><b>433</b></p>
<p>Socioeconomic Monitoring Initiative for Velondriake Community Managed Protected Area, Madagascar <i>Andriamalala Gildas &amp; Alasdair Harris</i></p>	<p>405</p>	<p>Teacher Training for Education on Marine Resources Conservation in Thailand <i>Somchai Sakoolthap, Wannee Wannapruk, Sirichai Issarschote, Jamlong Boonsiri, Porntip Ngansakul, Krissanon Chindamaikul, Nitiya Sangkhanan, Pahol Rongkul, Wiwaewan Tapabut, Sineenart Puangmanee, Siwat Somluk &amp; Nirut Sukkasem</i></p>	<p>435</p>
<p>Socioeconomic Monitoring Initiative at Rivière Banane, Rodrigues <i>Emily R. Hardman, Mathew Bunce, Eric F. I. Blais, Sabriné M. Desiré, Jiovanno S., J. Raffin &amp; Sydney Perrine</i></p>	<p>409</p>	<p>An Education and Awareness Program on Coral Reefs in the Andaman and Nicobar Islands <i>Dr. Sarang Kulkarni, Vardhan Patankar &amp; Elrika D'souza</i></p>	<p>439</p>
<p>Coastal Communities Adaptation and Resiliency to Vulnerability: An Analysis of Livelihood Activities in Kenya <i>Innocent N. Wanyonyi, David Obura &amp; Delphine Malleret-King</i></p>	<p>411</p>	<p>Marine Environmental Education in Kenya <i>Sarah Ater</i></p>	<p>441</p>
		<p><b>Author Addresses</b></p>	<p><b>447</b></p>

# ***CORDIO Status Report 2008***

## ***Part 1 – Regional Summaries***

*Obura, D.O., Tamelander, J., & Linden, O. (Eds) (2008). Ten years after bleaching – facing the consequences of climate change in the Indian Ocean. CORDIO Status Report 2008. CORDIO (Coastal Oceans Research and Development in the Indian Ocean)/Sida-SAREC. Mombasa. <http://www.cordioea.org>*



# Ten Years After Bleaching - Moving into the Next Decade

DAVID OBURA, JERKER TAMELANDER, ROLPH PAYET, CARL GUSTAV LUNDIN & OLOF LINDEN

This status report marks a decade of CORDIO in the Indian Ocean. Started in 1999 in response to the mass mortality of corals associated with the severe El Niño of early 1998, CORDIO now works in a broad range of disciplines exemplified by the contributions in this report, focusing on long term monitoring and research to improve environmental and resource management and policy development. Research areas extend across diverse fields in biological and social sciences, and support education programmes and capacity building. Reflecting the priorities faced by the majority of Indian Ocean coastal peoples, encompassing marine and coastal management and livelihood and economic security, in 2007 CORDIO changed its name to Coastal Oceans Research and Development in the Indian Ocean, from Coral Reef Degradation in the Indian Ocean. Under this new title, CORDIO is evolving into a broader network of collaborators, anchored in key institutions in the region, working from local to global scales, and continuing to focus on capacity building of partners and institutions in the Indian Ocean. Coral reefs remain central to CORDIO, and have provided a learning ground for translating our approaches to other marine and coastal systems.

Key features of the CORDIO programme heading into its second decade include the following:

A *sustainable livelihood approach* to resource use and conservation, focusing on

the interactions between people and marine ecosystems.

Following the distinction between basic and applied science, we focus on *bridging the gap between management needs and science*, turning basic research on issues such as coral bleaching to applied problem solving to provide answers to management questions.

From a direct focus on supporting monitoring activities, building these up to be able to enable *vulnerability analyses*. This approach emphasizes interpretation of monitoring information with respect to current and future threats, assessing vulnerability to growing human populations and climate change.

A continued focus on *capacity building and training* at all levels, from fishers through protected area rangers to undergraduate and graduate university students to Principal Investigators, building regional capacity to resolve regional issues.

*Partnerships* organized along thematic lines, such as on coral bleaching, genetic connectivity, biodiversity, resilience-based management or socio-economics, building

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the critical mass of expertise in our areas of work.

A *strategic collaboration* with the International Union for the Conservation of Nature's (IUCN) Global Marine Programme, providing complementary benefits in technical capacity and access to governance processes from national to regional levels.

In the coming decade, perhaps the major question that CORDIO and other research and management-focused organizations are asking is "how bad might it get?" Predictions of the Intergovernmental Panel on Climate Change (IPCC) are for worsening climate impacts globally. With increasing population pressure in all countries of the region, additive and synergistic effects of multiple threats are likely to worsen conditions for coral reefs. While many reef scientists are cautious, and even optimistic, about the adaptive potential of corals and zooxanthellae to climate change, all driving factors are heading in the wrong direction for corals – sea surface temperature, ocean pH, local fishing pressure, distant markets for marine products, pollution, invasive species, and the list goes on. Investments made in reef resilience and research and management capacity will be essential to minimize negative trends and to preserve any capacity for improvements, let alone attempt to reverse the trends and succeed with improving environmental health and livelihoods.

The broader context of science funding shapes the ability and potential for institutions such as CORDIO to grow and implement programmes. Globalization, including the funding for science and conservation,

tends towards larger more uniform structures at the expense of local more diversified projects. To some extent this goes against CORDIO's past practice of focusing on priorities identified locally and nationally, and tailoring our engagement at these levels. While larger sources of funding may become available through climate change and adaptation mechanisms, they may force greater uniformity of action across scales, and increase the challenge of designing projects and activities to suit local settings.

Looking back at where we started – with a meeting of 25 initial collaborators in January 1999 in Sri Lanka that resulted in the first status report of 15 papers and 108 pages – to where we are now – organization and participation in multiple workshops, conferences and partnerships each year, and this fifth status report that comprises 45 papers and 450 pages – is a grand endorsement of the vision that initiated CORDIO. We are grateful to Sida/SAREC, the World Bank and the Government of Finland for making the major investments that enabled CORDIO to grow from its first seed, and also to the many other substantial donors that have and continue to support our programmes. The core of CORDIO's work, however, has been the great number of researchers, managers and other professionals all committed to achieving our common goals, and with whom we have been lucky to work with over the years.

A summary of projects and current reef status in CORDIO regions – South Asia, the Andaman Sea, the Indian Ocean islands and the East African mainland coast – are contained in the following chapters. Further information on reef status is contained in the Global Coral Reef Monitoring Network's 2008 report, released concurrently with this report.

# South Asia - Summary

JERKER TAMELANDER

## ABSTRACT

Recovery of coral reefs in South Asia over the decade since the mass bleaching in 1998 has been patchy. In many areas coral cover has been increasing at a rather slow pace, but there are also examples of notable coral recovery, such as on the Bar Reef in Sri Lanka and some parts of the western Atoll chain in the Maldives. The Indian Ocean tsunami in 2004, although devastating in coastal areas in parts of the region, had little significant long-term impact on coral reefs, with the exception of areas where tectonic activity has left reefs exposed or where sediment deposition was very severe. However, direct anthropogenic stress continues to degrade reef areas and in combination with climate change poses an unprecedented threat both to coral reefs and the people that depend on them. To mitigate ecological, social and economic impacts on a large scale much more effort is required to improve management effectiveness, reduce direct stress and promote adaptation on reefs. This should include the application of resilience principles in addressing coral reefs and associated ecosystems as well as natural resource dependent and coastal communities, e.g. by promoting sustainable livelihoods enhancement and diversification.

## INTRODUCTION

The South Asia region includes five coastal countries: Bangladesh, India, Maldives, Pakistan and Sri Lanka.

Of these only India and Maldives, and to a lesser extent Sri Lanka, have major coral reef areas. These three countries have been the focus of CORDIO activities since 1999, and for the purposes of this paper the term South Asia is used mostly referring to them.

Loss of coastal biodiversity, habitat degradation and the modification of coral reefs, mangroves and other key ecosystems, with subsequent degradation of marine and coastal services and products, is a major concern to South Asian nations. The primary driver of this change is poverty and economic development pressures. All South Asian countries are grappling with significant national development challenges. India's population is 1.13 billion people, and still growing at a rate of 1.4% (UNDP 2007). In the Maldives limited land area and large distances between islands and atolls cause transport and communication problems as well as congestion - close to a third of the population of the Maldives now lives in the capital, Male. The internal conflict in Sri Lanka has been going on for a quarter of a century. Over 50,000 people have been killed, and the mobility and development opportunities for coastal dwellers in the north and east have been reduced. The direct costs of military activity and losses as a result of reduced business opportunities and tourism have been significant.

Sri Lanka, India and the Maldives all are medium human development countries, with a human development index (HDI) above the overall regional index of 0.611 (both Pakistan and Bangladesh have lower HDIs, but only sub-saharan Africa has a lower

overall regional HDI). Poverty is widespread. In India over a third of the population lives on less than USD 1 per day, and over a quarter of the population lives under the national poverty line in both India and Sri Lanka (UNDP 2007). The coastal population is also predominantly poor and natural resource dependent (see also e.g. Whittingham et al 2003, Wilhelmsson et al 2005).

The need to promote national development has many times led to unsustainable practices, where short-term economic gains are made at the expense of the integrity of coastal and marine ecosystems and resources, and while this has led to economic growth it has not always successfully addressed local poverty. Globalization and external market forces in some cases further exacerbate the problem. This undermines both the future of human societies dependent on natural resources and services as well as the economic growth of the countries.

An equally severe threat is posed by climate change. The global temperature increase from the end of the 19th century to the beginning of the 21st century is 0.76°C, and the rate of warming has doubled over the past 100 years. Eleven of the last twelve years (1995-2006) rank among the twelve warmest years since the mid 1800s. The sea surface temperature is also increasing, and the average temperature of the global ocean has increased to depths of at least 3000 m. Sea level rise, caused by thermal expansion and melting ice, is progressing at increasing rates, and the total sea level rise during the 20th century was estimated to have been 0.17m. Increasing carbon dioxide concentrations lead to acidification of the ocean, and IPCC projects reductions in average global surface ocean pH of between 0.14 and 0.35 units over the 21st century, adding to the present decrease of 0.1 units since pre-industrial times (IPCC 2007c). While the exact effects of ocean acidification are not detailed in IPCC's fourth assessment, it has been estimated that calcification has decreased by 10% from pre-industrial times (Lindeboom 2002), and that biogenic aragonite precipitation in the tropics could drop by 14-30% by

the middle of the 21st century (Kleypas et al 1999). Further, future tropical cyclones are likely to become more intense, with larger peak wind speeds and more heavy precipitation (IPCC 2007d).

## **Coral Reef Status, Trends and Threats**

### ***Coral bleaching***

Coral reefs in South Asia suffered significant large-scale bleaching in 1998, with a significant reduction in coral cover. The impact was very variable, ranging from almost 100% mortality in some areas, such as in the Laskahdweep islands, India, and many parts of the Maldives and the Bar Reef area in Sri Lanka. Other areas exhibited much lower bleaching related mortality, such as e.g. on the Indian coast of the Gulf of Mannar, and the Andaman and Nicobar Islands. In many areas the exact impact of the 1998 bleaching event is unknown due to the lack of baseline data on both benthic and reef fish communities (e.g. Linden and Sporrang 1999, Souter and Linden 2000, Linden et al 2002, Souter et al 2005, Rajasuriya et al 2004).

Now, ten years after the 1998 bleaching event, some of the intermediate and longer term implications are becoming evident. It is clear that the recovery process is highly variable in the region. In the Chagos archipelago, where human interference and anthropogenic stress is very low, reef recovery has been remarkably fast, with a return to pre-bleaching coral cover on many reefs, and healthy recruitment rates and normalizing population structure (Harris and Sheppard 2008). Near-shore patch reefs on the severely bleached Bar Reef in Sri Lanka have also regained coral cover through abundant growth of *Acropora* spp. (Rajasuriya 2004, 2008). In the extensive Maldives archipelago several atolls show very limited recovery, as has been found through the national monitoring programme, while there are many reports of areas where recovery is higher, notably reefs in the western atoll chain (Zahir 2005, Zahir pers. comm.) Similarly, in the Lakshadweep archipelago, coral cover is increasing at most reef sites and algal turf and macroalgae have considerably reduced from earlier studies. However, the rate of coral growth

remains patchy (Arthur 2008).

Although bleaching has been observed almost on an annual basis in the region since 1998 this has been mostly on a local scale and during the warm and calm period in April-May. Bleaching in the Lakshadweep in April 2007 was higher than normal summer bleaching, and some reports confirm that this pattern of bleaching is on the increase, with the possibility of some amount of bleaching-related mortality (Arthur 2008). Reports from the Indian coast of the Gulf of Mannar, which suffered little impact of the event in 1998, annually exhibits bleaching around May but usually with full recovery within weeks-months (Patterson et al 2008, Patterson pers. comm.).

### *Indian Ocean earthquake and tsunami 2004*

The devastation from the Indian Ocean tsunami in 2004 has been documented in some detail in a number of reports (e.g. UNEP 2005, Wilkinson et al. 2006, and see reports this volume). Damage to human life, society and infrastructure was very high in many parts of South Asia, and tens of thousands of human lives lost. The reefs of the Andaman and Nicobar Islands were, due to their proximity to the epicentre of the earthquake, among the hardest-hit. In the northern group of the Andaman Islands large areas were uplifted, causing permanent damage to shallow reefs. Up to 15 meter-high waves were observed in parts of the Nicobar Islands, causing significant reef damage, and silt deposition was high. In total over 300km<sup>2</sup> of reefs were destroyed (Kulkarni 2008).

On a regional level, though, with the exception of areas affected by tectonic activity, the damage to coral reefs was mostly moderate or not significant, and recovery predictions are good. (Rajasuriya et al 2005, Patterson et al 2005, Zahir et al 2005, Wilkinson et al. 2005). Impacts on the reef fish community appear similarly limited, although more detailed conclusions with respect to reef associated biota can not be made for most parts of the region due to low data availability and resolution (spatial, temporal and taxonomic).

It is clear that the tsunami had a much lower

impact on coral reefs than the bleaching in 1998, and indeed much lower than the chronic stress from a range of human activities. However, a significant threat lies in the synergistic effects of these stresses. Some indications of higher destruction on already degraded reefs has been reported, e.g. where mass mortality in 1998 was high, coral growth remains low and the reef structure has been weakened by bioeroderes (e.g. Rajasuriya et al 2005), and it may prevent successful recovery.

### *Anthropogenic stress*

While large-scale disturbances such as bleaching, tsunamis and cyclonic storms may damage coral reefs over large areas, it is clear that, on a local level, much of the reef damage observed in South Asia is caused by direct anthropogenic stress. For example, over 32 km<sup>2</sup> of coral reef has already been degraded around the 21 islands of the Gulf of Mannar largely as a result of human activities, including the loss of an entire island to coral mining (Rajasuriya et al 2005, Patterson et al 2005). Many of the livelihood options available to a large number of poor coastal dwellers have a direct negative impact on coral reefs (Kumara 2008), and overfishing and fishing using destructive methods is a perennial problem in many parts of the region.

Surveys of reef areas where human impact and use of reef resources has been limited often find reefs in better health, such as in Chagos. In northern Sri Lanka around the Jaffna Peninsula, where reef use has been limited due to internal conflict, reefs are relatively undamaged, whereas elsewhere in the country they are heavily impacted by human activities due to poor management (Rajasuriya 2008).

Direct anthropogenic threat and poor management of coral reef areas is considerable cause for concern. The IPCC predicts that the resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change associated disturbances, including ocean warming and acidification, in combination with other stresses, such as pollution and overexploitation of resources. Direct anthropogenic stress increases vulnerability to climate

change by reducing resilience and adaptive capacity because of resource deployment to competing needs (IPCC 2007a). Thus coral reefs affected by over fishing, destructive fishing, land runoff, nutrient and other pollution will be more vulnerable to increases in water temperature and ocean acidification.

### *Climate change*

The impacts of higher temperatures, more variable precipitation, more extreme weather events, and sea level rise are already felt in South Asia and will continue to intensify. Particularly vulnerable are coral reefs, mangroves and salt marshes. Increases in sea surface temperature of one to three degrees Celsius are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatization by corals. However, corals are considered to have a low adaptive capacity, and species extinction and reef damage is projected with higher confidence than has been done previously (e.g. in the IPCC third assessment report) as warming proceeds. Bleaching and coastal erosion will affect fisheries resources negatively, and reduce tourism value of coastal areas (IPCC 2007 d). Some change has already been observed (e.g. Rajasuriya et al 2005), and reduced distribution of coral reefs is inevitable should present trends continue.

On small islands, such as along the Maldivian ridge and the Andaman and Nicobar Islands, sea-level rise is expected to exacerbate inundation, storm surges, erosion and other coastal hazards, threatening human populations, infrastructure and livelihoods. The occurrence of unusually strong tidal waves in the Maldives in May 2007, with an unprecedented degree of flooding and significant implications for populations both in the immediate and long-term, may be a warning of things to come (Government of the Maldives, UN and IFRC 2007).

### *Socioeconomics and livelihoods*

Socioeconomic status and trends among reef dependent communities in South Asia have been synthesized e.g. by Wilhelmsson et al (2005) and

Whittingham et al (2003) including through case studies on the Gulf of Mannar (Rengasamy et al 2003), the Lakshadweep Archipelago (Hoon 2003) and South Andaman (Singh and Andrews 2003).

There are large differences in the socioeconomic status of people in the three countries, with the greatest poverty in India and the dependence of people on the marine environment strongest in Maldives - 100% of the population in the Maldives lives in the coastal zone, compared with 81% in Sri Lanka, and 26% in India (expressed as population within 100 km of the coast) (WRI 2000). However, throughout South Asia coastal and marine ecosystems and resources provide large benefits to the countries through key industries such as fisheries and tourism. In 2000 the number of people directly employed in fishing and aquaculture in India was c. 6 million, in Sri Lanka close to 150,000 and in the Maldives c. 20,000. Further, millions of people rely heavily on coastal and marine resources for economic sustenance and protein. For example, in the Maldives fish protein constitutes 60% of total protein supply on a national level, compared with 10% in Asia overall and 6% in the world (WRI 2000). On Agatti island in the Indian Union Territory Lakshadweep, 20% of the households report reef fishery and gleaning as their main occupation, but as much as 90% of the protein intake in poor households comes from reef fishing and gleaning (Hoon 2003).

A report by Kumara et al (2008) clearly shows that direct anthropogenic stress is causing significant reef damage in South Asia, with many local livelihoods threatening to undermine the ecosystems that support them. However, it is also clear that viable livelihood options are not always available to coastal dwellers, or they are not in a position to diversify income generation due to both external factors as well as intrinsic factors within the community (Cattermoul et al 2008).

The threat of climate change will further compound the already difficult social and economic situation faced by South Asian countries and their coastal communities. According to the IPCC (2007a),

regions facing multiple stresses that affect their exposure and sensitivity as well as their capacity to adapt, such as South Asia, are particularly vulnerable to climate change, due to poverty and unequal access to resources, food insecurity, trends in economic globalisation, conflict, and incidence of disease. Climate change effects are already impacting the economic performance of the countries in the region, including, for example, increased damages and deaths caused by extreme weather events, and adverse impacts on natural resource dependent livelihoods, such as fisheries. Particularly the poorest people are most at risk, and climate change will impinge on the sustainable development of most developing countries of Asia as it compounds the existing pressures on natural resources and the environment (IPCC 2007a). Further predicted effects include e.g. coastal water temperature increases exacerbating the abundance and/or toxicity of cholera, crop yields decreasing by up to 30% by the mid-21st century, coastal areas increasingly at risk from flooding from the sea and, in heavily-populated mega-delta regions, from flooding from rivers (IPCC 2007a).

## RESPONSES

South Asia stands to suffer significant consequences from climate change, but it is responsible for only 13.1% of global greenhouse gas emissions and, with almost half of the world's population, has the lowest regional per capita greenhouse gas (GHG) emission. However, its carbon efficiency (in terms of output generated measured in GDP at purchasing power parity per unit GHG emission) is still lower than the industrialised west, although higher than in other developing regions (IPCC 2007b). It is clear that the answer to slowing and turning the global climate change trends lie in drastic mitigation actions mainly outside, but also within South Asia, especially in India. However, in view of present trends it is absolutely essential that environmental management on a local, national and regional level sufficiently address climate change threats by increasing the

resilience and adaptation capacity of ecosystems and human societies, and reducing vulnerability.

To this end, CORDIO and IUCN, in association with other partners, have initiated a regional programme on resilience research and capacity building. To date this has included a range of training courses, ecological and socioeconomic studies and pilot projects.

A South Asia Reef Resilience Workshop was held in Bentota, Sri Lanka, 15-18 January 2007, bringing together coral reef scientists, managers and policy makers from five countries in South Asia and around the Bay of Bengal: Indonesia, India, Maldives, Sri Lanka and Thailand. The workshop provided insight into the state of coral reef resilience research and management adaptations internationally (see e.g. Grimsditch and Salm 2006), identified and discussed regional needs and priorities, and promoted learning and exchange of information. Resources recently developed through major international collaborations were highlighted and distributed to participants, including R2 Resilience Toolkit (R2 2004) developed by the Resilience Partnership<sup>1</sup> and the Manual for the Study and Conservation of Reef Fish Spawning Aggregations published by the Society for Conservation of Reef Fish Aggregations (Colin et al 2003). The workshop was followed by a regional Coral Reef Experts Group Meeting, with the objectives to facilitate peer-to-peer exchange on applying resilience principles in management among key coral reef experts in the region; as well as to develop, define and prioritize regional and national/local resilience projects for implementation. The sessions produced a number of recommendations on research and management direction and policy, and defined pilot projects (IUCN 2007a,b).

Building on these activities a regional Coral Reef Resilience Field Training for South Asia and the Andaman Sea will be organized in the Maldives in January 2008. The Field Training will build capacity

<sup>1</sup>Resilience Partnership: The Nature Conservancy, IUCN – The World Conservation Union, Great Barrier Reef Marine Park Authority, NOAA, World Wildlife Fund, and Wildlife Conservation Society

among marine scientists in the region in assessing and monitoring resilience and adaptation of coral reefs, and will serve as a field trial for a regional methodology on resilience monitoring under development by IUCN, CORDIO and other partners. It will also set up a South Asia regional network as part of the global Resilience Assessment project of IUCN's Working Group on Climate Change and Coral Reefs (IUCN 2006). Targeted research will attempt to identify areas naturally resilient or resistant to bleaching, and whether bleaching patterns observed are an indication of adaptation to climate change. It should, however, be noted that in terms of degree heating weeks most parts of the region have not been subjected to the same temperature stress as in 1998, and patterns observed may be normal seasonal fluctuations.

A regional research project on reef fish spawning aggregations (FSA) has also been initiated. Interview surveys were conducted among fishing communities in selected areas of India, Indonesia, Maldives, Sri Lanka and Thailand in order to determine the level of awareness of FSAs among fishers; which reef fish species form FSAs; sites of aggregation formation; seasonal patterns; and to assess fishing pressure on and status of FSAs. Results show that only a minority of fishers possess reliable knowledge of spawning aggregation sites, species and times, but possible FSAs were reported from all areas studied. As has been found in many other parts of the world, FSAs in the region are targeted by fishers. The results from this study will be used to increase awareness among communities as well as managers and policy makers of the ecological significance and vulnerability of reef fish spawning aggregations in order to design and implement suitable management responses (Tamelander et al 2008).

In order to address the plight of the many coastal natural resource dependent poor and address their resilience and vulnerability in the face of environmental change, CORDIO has entered into a partnership with a number of regional and local partners, the Coral Reef and Livelihoods Initiative

(CORALI<sup>2</sup>). Building on knowledge on the complex relationships between people and reefs, the relationships between coastal policies and poor people's livelihoods and e.g. the impacts of change in the post-harvest fisheries sector on poor people, the initiative seeks to understand the factors that help or inhibit livelihood change, and conducts research and development focused on constructing a basic approach for supporting Sustainable Livelihood Enhancement and Diversification (Whittingham et al 2003, Cattermoul et al 2008, and the references therein). Approaches are tested through pilot initiatives at six field sites around the region. This is complemented by a range of education and awareness initiatives implemented by CORDIO and other CORALI partners.

Research is also carried out to study resource use and responses to environmental, social or political change. For example, a fish catch monitoring programme in the Lakshadweep (Tamelander and Hoon 2008) has generated information much more detailed than was previously available, and through this also identified a number of features of the fishery that are vital when developing management responses. Similar fish catch monitoring has also been initiated in the Gulf of Mannar, along with bycatch assessment in the mechanized local fishery (Patterson et al unpubl).

The data, information and knowledge generated through CORDIO activities can support and underpin management and policy responses, and over the past years CORDIO South Asia has increasingly sought to strengthen the way it communicates management and policy implications of its findings. A review commissioned in 2006 to identify past successes and shortcomings in this respect and to provide further guidance, found the scientific base to CORDIO's South Asia Programme very strong, with coral reef monitoring of high quality. The status

<sup>2</sup>CORALI is a collaborative initiative between IUCN – The World Conservation Union, Coastal Ocean Research and Development in the Indian Ocean (CORDIO), United Nations Environment Programme (UNEP) South Asia Cooperative Environment Programme (SACEP), International Coral Reef Action Network (ICRAN) and IMM Ltd., as well as national and local organizations in South Asia and the Andaman Sea.

reports were identified as a crucial and great achievement, and it was noted that the awareness and education, and alternative livelihoods components have made great progress on a local level, particularly in India. The review suggested that to fully realize the objective of supporting policy formulation and uptake, new partnership arrangements with relevant agencies is needed, as well as increased focus on informing policy makers in-country through project implementation partners (Samoilys 2006). A number of tools and products targeted at managers and policy makers are being developed, in part through CORALI, including a regional MPA Managers Toolkit, GCRMN reports, as well as policy influencing materials and policy fora. This will be complemented by education and awareness materials targeting a broad range of stakeholders, in particular school children and teachers.

## **CONCLUSIONS AND RECOMMENDATIONS**

The compounded threats from direct anthropogenic stress and climate change, together with unequally distributed wealth and, for the majority of the regions people, low socioeconomic status, demands concerted and comprehensive effort from all stakeholders and at all levels. The activities presented herein, along with numerous other government, IGO, NGO, CBO and private sector initiatives, have taken significant steps to addressing this. However, it is clear that, in view of the scale of the problems the region faces, and the rate at which environmental change is occurring, the current response will not be sufficient for sustainable development and meeting Millennium Development Goals, and a large section of the region may face increasing hardship.

Marine and coastal governance needs to be strengthened on both national and regional level, including underpinning decision making with best available science findings and concerted action that is integrated across sectors. Improved flow of information and knowledge between research

institutes, line agencies and ministries is needed. The recently established South Asia Coral Reef Task Force has an important mandate in this regard (SACEP 2007), as does regional bodies such as South Asia Cooperative Environment Programme (SACEP), the Land Ocean Interaction in the Coastal Zone (LOICZ) Regional Node for South Asia, and the South Asian Association for Regional Cooperation (SAARC). The evaluation analysing the efficacy of CORDIO's approach to dispensing policy advice in South Asia provides useful recommendations, and identifies opportunities for increased support to policy formulation (Samoilys 2006).

Resilience principles should be applied in the creation, zoning and management of Marine Protected Areas (MPAs), as well as in the establishment of networks of MPAs. Many of the regions MPAs remain de facto paper parks and there is a need to assess and strengthen management effectiveness across the board. The World Commission on Protected Areas and its Marine Plan of Action (Laffoley (ed) 2006) may provide useful guidance. MPAs should also increasingly go beyond biodiversity conservation, and can be applied e.g. as tools for resource and integrated coastal management. However, fair and equitable sharing of benefits must be ensured in the development of MPAs and MPA networks, to a much larger extent than has been done in the past.

South Asia's fishery resources are under strain and in many cases overexploited, and initiatives focusing on the small-scale artisanal fishery are particularly urgent, as is addressing frequent and blatant breaches of existing legislation with respect to destructive resource use. Importantly, a proactive approach should be taken with respect to management of those parts of the region where reef fish populations still are comparatively healthy, such as many parts of the Maldives and the Lakshadweep islands, to ensure resource use does not become unsustainable and to ensure benefits arising from the fishery accrue to local populations. This includes e.g. a very cautious approach to developing export fisheries for grouper and other high value reef fish. Where present,

overcapacity in the mechanized and industrial fishing fleets needs to be decommissioned.

Addressing the issues outlined above and strengthening economic development in coastal and marine areas must go hand in hand with livelihoods enhancement and reducing the vulnerability and natural resource reliance among coastal dwellers. This must include efforts to engage, involve and empower local communities to address their plight. It should also be recognized that low awareness and educational levels remains an obstacle to sustainable development (e.g. Patterson et al 2008), and must be addressed through the national educational systems as well as dedicated and specific activities, such as is required e.g. to support other activities as outlined here.

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# Andaman Sea - Summary

HANSA CHANSANG & UKKRIT SATAPOOMIN

## INTRODUCTION

The Andaman Sea coast is one of the two main coral reef areas of Thailand (the Gulf of Thailand being the other), with a total area of 78 km<sup>2</sup> of primarily fringing reefs ranging from near shore to offshore areas (Chansang, et al 1999). These reefs are an important resource for tourism in Thailand. However, rapid coastal development on the Thai Andaman Sea coast over the past three decades has led to degradation of coastal resources. Although development has increased economic growth of the country as well as income of the population, it has also affected both the physical environment and socio-economic condition of coastal communities. Changes in resource uses patterns have led to increasing natural resource exploitation and degradation.

Coral reefs clearly exemplify this trend, with a change from a traditional and sustainable fishery for domestic and local consumption to increasing exploitation of reef areas for tourism and recreational uses. Concern regarding the degradation of reef habitats and depletion of reef resources this has caused has led to a number of management measures by government. However, in spite of this there are still knowledge gaps and room for improving effective management.

The devastation caused by the Indian Ocean tsunami in 2004 emphasized many of these gaps, in response to which CORDIO expanded activities to the Andaman Sea, with a view to supporting sustainable

coastal development and wise utilization of living coastal resources.

## Activities

Coordinated by Phuket Marine Biological Center (PMBC), CORDIO activities in the Andaman Sea were implemented in collaboration with academic institutions, government agencies and NGOs in Thailand as well as Aceh, Indonesia, covering 6 focal areas:

- Strengthening capacity for coral reef monitoring and assessment
- Monitoring of coral reefs
- Research on coral reef fishery and the fishermen
- Alternative or supplemental livelihoods
- Strengthening community participation in reef management
- Public education and awareness building.

## Strengthening Capacity for Coral Reef Monitoring and Assessment in the Andaman Sea

While there is considerable coral reef monitoring capacity within the Andaman Sea region – for example, in Thailand reef monitoring has been carried out for the past three decades – monitoring capacity and effort have not been evenly distributed. In order to address this and to promote use of standard and compatible methodologies as well as strengthen networking of researchers and managers and to

*Obura, D.O., Tamelander, J., & Linden, O. (Eds) (2008). Ten years after bleaching - facing the consequences of climate change in the Indian Ocean. CORDIO Status Report 2008. Coastal Oceans Research and Development in the Indian Ocean/Sida-SAREC. Mombasa. <http://www.cordioea.org>*

promote sharing of data, knowledge and experience, a training workshop was held in Phuket, Thailand in April 2006. Eighteen participants from Thailand and Indonesia, representing government agencies, universities and NGOs participated in the workshop.

Besides standard techniques, including benthic line intercept transect, manta tow as well as fish visual census, the course also covered training in measuring other key environmental parameters such as turbidity, salinity and temperature, as well as exercises in using data sheets, data entry and basic analysis (Dartnell and Jones, 1986; English *et al*, 1994).

The activities under this programme have successfully expanded the ongoing coral reef monitoring by increasing the numbers of monitoring teams in Thai waters - the training led to the establishment of monitoring sites on Adang Rawi Islands, Thailand, by Prince Songkhla University, and local NGOs have used the reef assessments to manage reefs for ecotourism activities in the area. Further, the training increased capacity for reef monitoring in Indonesia, and participants from Syiah Kuala University carried out reef surveys on Weh and Aceh Islands in Sumatra in collaboration with Wildlife Conservation Society (Campbell *et al*. 2008., Rudi *et al* 2008.).

It is recommended that additional parameters should be considered as indicators of reef health in monitoring reef health, besides coral cover.

### **Monitoring of Coral Reefs in the Andaman Sea**

The reefs in Thai waters have been monitored under the long term monitoring programme (Phongsuwan and Chansang, 1993; Phongsuwan *et al*, 2008). As part of CORDIO support, reef monitoring in 2006 was carried out at Surin Islands National Park and Similan Islands by PMBC (Phongsuwan *et al*. 2008); and Adang Rawi Islands of Tarutao National Park by Prince Songkhla University (unpubl.). Results indicate that reefs in the Andaman Sea are resilient to natural stress and damage (CORDIO Andaman Sea 2007; Phongsuwan *et al*. 2008). The reefs did not suffer

extensive damage from the bleaching event in 1998 in comparison to reefs in e.g. Maldives (Zahir *et al*, 2005) and Sri Lanka (Rajasuriya, 2002). Based on permanent transects, only 18.3% of reefs were affected by the tsunami and are predicted to show recovery within the next 3-10 years if conditions remain favorable to reef growth. However reefs close to tourist development areas show signs of degradation (Phongsuwan *et al*, 2008).

Baseline quantitative data of reefs in northern Sumatra, Indonesia is comparatively limited, both before and after the Indian Ocean tsunami. In the aftermath of the tsunami long term reef monitoring was recognized as a priority, and monitoring was carried out on Weh and Aceh Islands by a team from Syiah Kuala University and Wildlife Conservation Society, Aceh. The main objectives of this monitoring were to provide reliable data and information on benthic hard coral and reef fish abundance of the area. Surveys conducted at 21 sites on Weh Island and Aceh Islands in February 2007 shows that coral reef condition and reef fish abundance varies significantly between the islands, that fish population abundance is related to coral cover, and importantly that management status of the area impacts on fish communities. Natural coral recruitment was observed to take place two years after the tsunami, especially on rocky substrates in shallow waters. However, rubble substrates in deeper waters prevent recruitment due to post settlement mortality of the recruits (Campbell *et al*. 2008, Rudi *et al*. 2008).

### **Research on Coral Reef Fisheries**

While coral reef fishing is a common occupation among local fishing communities in Thailand, in particular among indigenous people, very little is actually known about the fishery, its impact on reefs and its role for the well being of fishing communities. Increasing development and expansion of reef exploitation by a mechanized coastal fishery as well as the tourism industry, has greatly affected the lives of reef fishers by reducing access to fishing grounds and diminishing resources. A CORDIO supported study

(Narumon 2008.) has compiled socioeconomic information on reef fishing communities; the magnitude of indigenous fishing in reef areas both outside and inside marine parks; and conflicts in relation to other resource uses, in particular tourism, focusing on ethnic Thai and sea gypsy fishing communities in the southern part of Phuket (Satapoomin and Chawanon, 2008); and in Tarutao National Park and Mu Ko Phetra National Park in southern part of the Andaman Sea (Plathong et al, unpubl).

A study by Plathong et al. (unpubl) has shown that fishing in marine parks has grown from a seemingly sustainable fishery for local consumption to a commercial, illegal but profitable fishery. The combination of increasing demand of seafood for park visitors and for regular markets on the mainland makes law enforcement a challenging task. Sea gypsies have also had to adapt their lifestyles to support the growing tourism industry. This urgently requires further study to create appropriate planning and management strategies and action dealing with issues of fishing rights of traditional fishermen in and around marine parks.

The study by Satapoomin and Chawanon (2008) is the first study of its kind focusing on the reef fishery in Thai waters. Results indicate a trend of changing from traditional fishing to accommodate more modern fishing methods as well as new occupations in particular in the marine tourism sector (see also Narumon 2008). However, while the study provides a lot of information previously not available, the comparatively short time span places limitations on conclusions pertaining to the crucial questions of whether present reef fishery is sustainable or not. Continuation and geographic expansion is recommended.

### **Alternative or Supplemental Livelihoods**

The indigenous fishing communities, locally known as sea gypsies, are traditional stakeholders of reef resources in the Andaman Sea. With changing patterns of reef uses and increasing number of other stakeholders, their livelihoods have been threatened

through competition and declining resources. As yet there is only a scattering knowledge about their livelihood and socioeconomic condition. Options for providing alternative or supplemental livelihoods have been considered by government as well as NGOs. This study has reviewed previous studies and focused on extracting “lessons learned” from past livelihood projects in three indigenous communities in Phuket Province, Thailand. Research methods included literature review, interviews and consultations with organizations, local government and other stakeholders, case studies, and stakeholder meeting.

The finding shows that there were numerous projects and activities to provide alternative or supplemental livelihood but most of them did not respond to the real need of the communities. This is due to several factors: short-term activities; project not feasible economically; lacking knowledge of project personnel on strengths and weaknesses of the communities; and a deeply-root bias against the communities. Lack of coordination and collaboration among different agencies or organizations working is a major problem.

The recommendations for future action emphasize improvement on government and other agencies in working with the communities on various aspects: increasing effort in understanding and appreciating special characteristics of the communities; better coordinating and integrating work among different agencies and organizations; providing small-scale long-term alternative occupational activities while promoting market for communities’ products; and creating innovative methods in working with the communities. It is hoped that information obtained will be useful to initiate some solution assisting the communities in adapting to present development.

### **Strengthening Community Participation in Reef Management**

In Thailand, the government has recognized the importance of community involvement in resource management after decades of absolute government control. To strengthen community involvement, it is necessary to increase awareness and sense of ownership

of resources by coastal communities as well as continuing planning and action by the government. The activity in this project was on strengthening the community network of long tail boat operators throughout west coast of Phuket Island. They are part of marine and coastal resources conservation volunteer network established under government support. Their main income derives from day tours to reefs. The activities by the network are assisting in reef surveillance, installation and maintenance of mooring buoys, and, reef and beach clean up. Under CORDIO support a meeting to strengthening network on coral reef conservation was held. The stakeholder workshop served the purpose of reviewing status of community involvement, introducing new groups of stakeholders into the network as well as serving as a forum for discussing about conflict among groups. The workshop has succeeded in agreement on reef uses zoning and self-regulation in order to avoid conflict of reef fishery and tourism along the west coast of Phuket Island. It is the first attempt by reef users in resolving the conflict among themselves and imposing their own regulations of reef uses. It is a starting point toward community action in reef management.

### **Public Education and Awareness Building**

This project was initiated with the reasoning that the lack of awareness and knowledge of sustainable use by coastal communities was an underlying cause of degradation of marine resources. Therefore the strategy was to provide knowledge on resource conservation to coastal communities of the Andaman Sea by using existing facilities and expertise. The project was separated into 2 subprojects based on target groups i.e. youth and teachers.

*-Training for school and college students in Phuket and Phangnga Provinces on marine resources conservation (Sukswan et al 2007)*

Phuket Aquarium was responsible for educating students in Phuket and Phangnga Provinces on marine resources and the need for wise utilization of the resources. The objectives were providing knowledge

and creating awareness on living coastal resources, the importance of living coastal resources, and need for sustainable uses.

One-day training activities were carried out for 1520 high school students and college students during June to December 2006. Each session contained 30-40 students and included lectures and outdoor activities. The project was well received by education institutions in Phuket and Phangnga Provinces. It is recommended that this type of activity should be continued annually so that more students from various locations and levels can participate. In addition possible local funding should also be sought to continue the project.

*-Teacher training for education on marine resources conservation (Sakoolthap et al, 2008)*

This project targeted enhancing capacity of local school teachers in educating younger generations and possibly communities on sustainable use of marine resources. The Phuket Rajabhat University had developed teaching manuals and conducted two training workshops on coastal resources and management for primary school teachers (Grade 4-6) and secondary school teachers (Grade 7-9) of local school of Phuket and Phangnga Provinces to provide knowledge on resources as well as teaching local teachers to use the manuals.

The project has been well received and participants were satisfied with the manuals and trainings. It is recommended that with more input and feedback from teachers, improvement and expansion of teaching manuals should be carried out to cover all subjects on coastal and marine areas including the problems related to global warming effect and natural hazards such as tsunami. It is also aimed to acquire local government support for the activity whenever possible. The outcome of continuous activities will strengthen community awareness and involvement in managing resources in the future. The training workshops should also be continued with local funding and extend to include teachers in other provinces along the coast of the Andaman Sea.

## CONCLUSION AND RECOMMENDATIONS

The CORDIO Andaman Sea project was a small project both in term of activities and duration. The project included activities to assist present management scheme as well as for long term results. For present management, the activities were: reef monitoring and capacity building in reef monitoring within Thailand and Indonesia; and activities to fill in missing gaps in reef research and management. The project has successfully initiated some actions which will lead to sustainable resource management in the long term. It requires continuous effort so that the activities will be taken up by communities. The future plan should aim at empowering stakeholders to actively participating in management by education and stimulating private sectors support. This will take time especially projects on sociological aspects such as community participation in resource management, education to create environmental awareness and adaptation of traditional users in accessing their own resources or to receive fair treatment such as for the sea gypsies.

The project has had limited success in creating reef monitoring network in the Andaman Sea. The monitoring network has been set up by research institutions volunteers, and NGOs in Thailand. The project has succeeded in establishing linkage between Thailand and Indonesia within this short duration. Some countries in the region need outside financial support to continue reef monitoring activities. Thus assistance from international organizations is needed both for organizing activities as well as for financial support in establishing the Andaman Sea network. The network should include other activities besides reef monitoring and it should be a part of the Indian Ocean network.

In conclusion it is felt that there are enough expertise and readiness of certain groups of stakeholders to carry on activities in the Andaman Sea especially in Thailand. The main obstacles are lack of coordination among various activities directed toward

a common goal and lack of financial support for some activities. Besides providing extra financial support, the outside assistance can stimulate further progress by providing information exchange and lessons learned within the network. Lessons learned from Thailand can also be shared to other countries within the region which are facing similar threats regarding resource use. It is hoped that the effort in conducting work such as CORDIO can continue in the future.

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# East Africa and Islands - Summary

DAVID OBURA & ROLPH PAYET

## INTRODUCTION

The Eastern Africa region comprises both the islands in the western Indian Ocean and the East African mainland coast, comprising nine countries – Comoros, Kenya, Madagascar, Mauritius, Mozambique, Reunion (France), Seychelles, South Africa and Tanzania – crossing a broad range of development levels, from among the highest in Africa (Mauritius, South Africa) to among the poorest (Comoros, Madagascar). With mainland countries and islands from large to small, and a wide mix of people and cultures, the countries of the region face a diverse range of environmental and resource pressures related to the sea, and to coral reefs in particular.

As in the South Asia region (see previous summary), eastern Africa faces a wide range of linked socio-economic and environmental problems, including over-exploitation of fisheries and other living resources, destructive activities such as dynamite fishing, unplanned growth and development of villages, towns and cities and their attendant impacts on the coast and nearby coastal waters, increased tourism development, and on top of this all, climate change.

While pressures in the region tend to be lower than in Asia as population densities are lower and historical pressure has been much less, eastern African countries

tend to have weaker governance structures and lower technical capability to manage impacts to the environment. And apart from the small island states, marine and coastal issues tend to have a low priority for central governments and for society as a whole, so problems tend to persist and worsen before attempts at resolution are made.

## Coral Reef Status, Trends and Threats

### *Coral bleaching*

Since the major bleaching event in 1998 marine researchers and managers have been on the alert for repeat bleaching events. 2005 saw the most extensive hotspot develop in the western Indian Ocean since 1998, and though 2007 was initially predicted to be as warm or warmer than 1998, it turned out not to be a bleaching year, with both the El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole in negative phases. During this season an early warning system was put in place that incorporated monitoring of internet-based datasets on global temperature, the ENSO and IOD indices, NOAA temperature anomaly charts and observations from the field. Monthly updates were sent out by email, and this is repeated annually during the bleaching season of January-May.

As in South Asia, sites show very variable levels of recovery from the 1998 bleaching event, with most sites still at intermediate levels of recovery. A small

*Obura, D.O., Tamelander, J., & Linden, O. (Eds) (2008). Ten years after bleaching - facing the consequences of climate change in the Indian Ocean. CORDIO Status Report 2008. Coastal Oceans Research and Development in the Indian Ocean/Sida-SAREC. Mombasa. <http://www.cordioea.org>*

number of reef areas that were either lightly impacted in 1998 or have showed rapid recovery since then have been noted, including sites such as the Chagos archipelago (Harris and Sheppard, this volume), Vamizi island in Mozambique (Garnier, this volume) and the Songo Songo reef system in Tanzania. These sites are the focus of increasing research to understand what characteristics enhance their resistance or tolerance to bleaching, and/or high capacity for recovery and resilience.

While CORDIO has supported monitoring programmes that initially focused on bleaching impacts and recovery, many of these are increasingly being targeted at local management needs and priorities, which from the majority of reports in this volume can be seen to be focused on community fisheries and MPA management. This entails customization of methods to suit local personnel and language (e.g. Muhando et al., this volume) and embedding monitoring programmes, both biological and socio-economic in local conservation partnerships. Complementary to this development is a focus on raising standards and improving techniques in monitoring programmes by adding indicators that relate to coral population structure, recruitment and indicators of ecosystem resilience (Obura and Grimsditch, this volume)

Basic research is increasingly being applied in the region and integrating with monitoring programmes supported by CORDIO. Recruitment studies are now widespread, in the Seychelles, Tanzania and Kenya (e.g. Furaha, this volume), and through a new global collaboration, CORDIO is building up research on coral-zooxanthellae dynamics and bleaching dynamics (Grimsdith et al., this volume). The first study on hard coral reproduction at equatorial latitudes is reported here (Mangubhai, this volume), confirming that unlike at higher latitudes where spawning is more synchronized, coral spawning in Kenya is spread over a broad season during the warmest months of the year.

### *Fish and fisheries*

Fishing continues to be a key sector for poor communities in the region, as an activity of last resort

and for economic development, but unmanaged fisheries are a key factor driving reef degradation. A number of key factors contribute to this. First is the importance of local governance in managing small-scale fisheries, touched on by many reports in this volume. Most countries in the region are attempting to build the capacity for co-management of local fisheries, whereby the past approach to centralized fisheries management is giving way to sharing responsibilities with local fisher associations. At the other end of the scale, regional processes are maturing with increased collaboration on fishery policy and instruments, with the South West Indian Ocean Fisheries Commission (SWIOFC), South West Indian Ocean Fisheries Programme (SWIOFP), and fisheries partnership agreements all increasingly active in addressing inshore and offshore fishery issues.

Increased work on artisanal fisheries is highlighted by a series of papers on the Diani-Chale fishery in Kenya (Maina et al., this volume, Tuda et al., this volume, Munywoki et al., this volume and Oluoch et al., this volume), showing how co-management of fisheries can be supported and built up in stages by progressively building up fishers' capacity to undertake management functions, such as monitoring. Extensive datasets that focus on local dynamics can result, providing estimates of daily catch rates at the local scale, and scalable up to national levels (Tuda et al., this volume). To make monitoring accessible to fishers the units and methods were adapted to the local context, and this can also be essential in resolving key conflict issues, such as on the impacts and use of illegal gears. Finally, while co-management of resources by users should be encouraged throughout the region, along with the development of local area management plans to maximise ownership and stewardship of resources, communities and their leaders need significant assistance in capacity building, to enhance their skills to exercise these responsibilities (Oluoch et al., this volume).

The roles of governance and capacity are highlighted in Tanzania. Dynamite fishing has been on the resurgence from 2005-2007, with multiple blasts daily reported in the Tanga and Dar es Salaam

regions. Initially stopped in 1996 through involvement of the Tanzania Navy, political will has eroded in recent years, allowing its resurgence. Conflicting approaches to resolution of the issue between stakeholder groups and local government structures, particularly in Tanga, have led to increasing polarization of different camps with a role in ending the practise. Nevertheless, high-level meetings in late 2007 between all the ministries responsible and supported by stakeholder groups have taken place, indicating growing political will to resolve the issue. The issue is particularly poignant in Tanga, where over 12 years of investment in district level co-management, in the Tanga Coastal Zone Conservation and Development Programme, involving the Tanzania government, IUCN and Irish Aid have probably left the most highly capacized set of district officials and village communities, yet even so dynamite fishing was able to resume.

Fish spawning aggregations (FSA) were previously unknown to science and management in East Africa. New research initiated in the Seychelles and now spreading to Kenya and Tanzania (Robinson et al. this volume) show that FSAs have indeed been common in the region, though now somewhat depleted by fishing. Indeed, fishers were well aware of their presence, targeting them for a high catch. Knowledge on FSAs will provide an additional tool for fisheries management that is highly valuable, and can complement other management options.

### ***Poverty, livelihoods and education***

The Socio-economic Monitoring programme of the Western Indian Ocean (SocMon WIO) has been increasingly active in 2005-2007, growing to include 12 sites spread across all countries in the region (e.g. Wanyonyi et al., this volume, Hardman et al., this volume and Andriamalala and Harris, this volume). Partners include scientists, national MPA agencies, community-based projects and conservation NGOs, all needing information on livelihoods and attitudes to improve the targeting of their interventions to improve the welfare of local peoples and at the same time conserve reef resources. Parallel socio-economic

studies are also being conducted within countries of the region (e.g. Cinner and Fuentes, this volume), linking the social condition of communities to environmental and resource condition.

With great sensitivity among fishers to the restrictions on fishing imposed by protected areas, attitudes surveys of MPA-affected communities are increasingly being done (Hauzer et al., this volume). These also serve as valuable education tools, raising awareness of the broader issues addressed by MPAs and longer term benefits of their presence. Education programmes are increasingly being implemented, with a focus on bringing marine environmental education into the classroom through training of teachers (Ater, this volume) linked with activity programmes getting children onto the reef, participating in art competitions and annual events such as the Marine Environment Day.

## **RESPONSES**

With increasing challenges to conserving and sustaining marine ecosystems, CORDIO has identified the following responses to increase the impacts and outcomes of its activities:

Improving and extending standard *monitoring programmes* to include higher and broader levels of data collection and sampling effort, for example:

Through IUCN's Climate Change and Coral Reefs working group, expand the scope of reef monitoring to include key indicators for coral resistance to bleaching and reef resilience to change, to better understand long term prospects for reefs under increasing local pressures and climate change.

Through the SocMon WIO programme, expand the commitment to using social science in marine ecosystem management and of monitoring key indicators for dependence on marine resources, and adaptive capacity for change.

Linking local and national coral reef monitoring with other components of coastal and ocean observation systems (e.g. seagrasses, mangroves,

fisheries) of importance to governments and international institutions.

Building up *regional research* and collaboration programmes.

Genetic connectivity is a critical issue to understand where environmental quality is declining on regional scales, and a new network, the WIO Marine Genetics Network (WIOMagnet) was initiated in 2007 with funding from the WIOMSA MASMA programme. Building up capacity in Mauritius, Tanzania and Kenya, we are hoping that it will grow and join with other genetics initiatives in other countries of the region to address regional connectivity issues.

The biogeography and diversity levels of the region have never been dealt with comprehensively, and following the lead of the 'Coral Triangle' region in the Asia-Pacific, a new research agenda is being established in this volume to determine if there is a core biodiversity region in the WIO, and if so, what its relevance to the whole region may be under climate change. This work will build on work started in the East Africa and Western Indian Ocean Islands Marine Ecoregion programmes initiated by WWF (EAME and WIOMER).

Improving the *livelihood sustainability* of marine-dependent communities:

Trialing innovative individual livelihood options through the development of local opportunities

and transfer from other regions in the Indian Ocean or beyond, such as with mariculture, worm composting and others.

Investing more in education, to enhance peoples' desire and ability to broaden and improve their choices. This will involve moving from our focus to date on marine and environmental education, to also including adult education and more classical education, to assist poor communities in accessing more opportunities in society.

With increased globalization and the information society, access to Information Communication Technologies (ICT) can greatly influence opportunities available to poor communities. A partnership with the Swedish institution SPIDER in providing access to mobile telephony and the internet will help identify opportunities for improving livelihood options for coastal communities.

Finally, within the context of national and international commitments and agreements in the WIO, CORDIO will increasingly focus on *policy* responses needed to achieve project and overall goals. This will require focusing attention on specific opportunities for engaging with policy makers in individual projects and countries, focusing on developing necessary and enabling conditions to support the implementation of recommendations made by projects.