9. Post-Tsunami Status of the Coral Reefs of the Islands and Atolls of the Maldives

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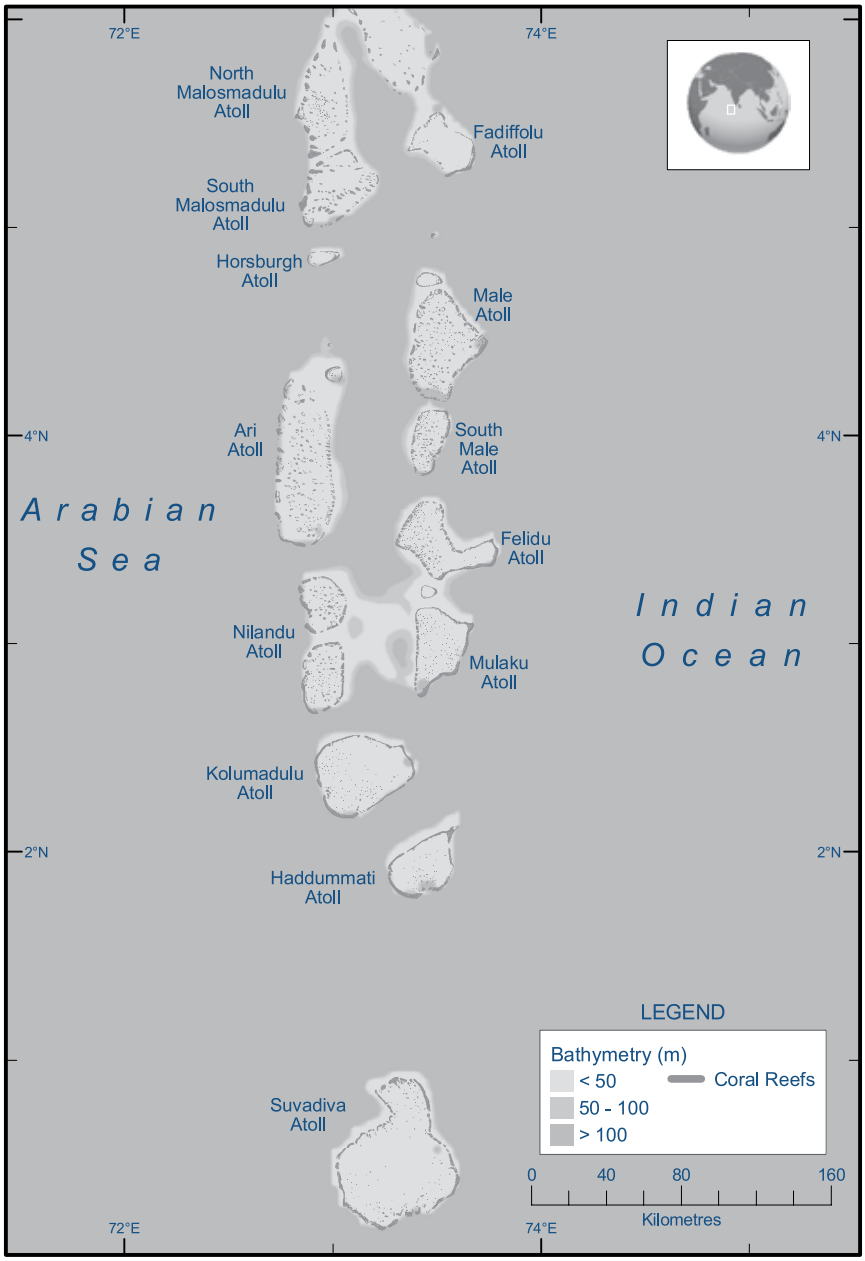
Summary

- The tsunami caused significant damage to communities on the Maldives (which are all coastal); 82 people died and another 26 are missing;
- All islands are less than 3 m above sea level, thus 69 of the 199 inhabited islands were damaged; about one-third of the 300,000 residents lost their homes, livelihoods or other local infrastructure; flooding caused widespread electricity failures, disruptions to water supplies, damage to several harbours and jetties, erosion of coastal zones and seawater penetration into the atoll soils; many sewerage systems were damaged, leading to contamination of groundwater supplies;
- The tsunami caused severe damage to the tourism industry (the largest economic sector); occupancy rates dropped immediately to 40%, but returned to 75% within 1 year;
- The tsunami damaged or destroyed: 170 fishing vessels; 374 small fish processors; jetties; wharf walls; harbour sea walls; causeways; and replaced 375,000 cubic metres of sand in dredged basins. However, fishing has recovered, mainly due to increased landings of tuna;
- Economic losses are estimated at US$480 - 1,000 million and include damage to infrastructure, fishing vessels, households and lost income from tourism, fishing, and agriculture;
- There was minor direct damage to coral reefs, however the 1998 coral bleaching event caused more damage; the reefs were damaged by debris from buildings and other sources, and sediment being washed into the ocean, smashing and smothering new coral recruits; and
- Coral reefs are critical to the Maldives as erosion barriers, sources of sand and rock, and a major attraction for the tourist industry; the tsunami slowed recovery from earlier damage caused by bleaching, coral mining and dredging and exacerbated by inappropriate coastal development;
- The most serious threat to reef recovery is illegal harvesting of coral sand and rock from reef flats and lagoons to build houses and repair roads.


72°E
74°E
4°N
2°N
North Malosmadulu Atoll
Fadiffolu Atoll
South Malosmadulu Atoll
Horsburgh Atoll
Male Atoll
Ari Atoll
South Male Atoll
Felidu Atoll
Nilandu Atoll
Mulaku Atoll
Kolumadulu Atoll
Haddummati Atoll
Suvadiva Atoll
Arabian Sea
Indian Ocean
LEGEND
Bathymetry (m)
< 50
50 - 100
> 100
Coral Reefs
0
40
80
160
Kilometres

Malé, the capital of the Maldives, is one of the most densely populated islands in the world with more than 80,000 people living within 2 square kilometres. The tsunamis flooded some of the island and damaged parts of the seawall, buildings and vehicles parked on the roads (photo from Hussein Zahir).

Introduction

Approximately 3 hours after the 26 December 2004 earthquake, waves of 1- 3 metres high were reported throughout the Maldives. The tsunami caused rapid water surges across the reefs and islands, rather than the large waves experienced in Thailand and Sumatra. The first surge was the largest, lasting approximately 20 minutes before being followed by a large retreat of water. The force of these waves and consequent flooding caused widespread damage to the populated islands; 80% of the 25 atolls in the Maldives are only 1 m above sea level. Approximately 69 of the 199 inhabited islands were damaged in some way, while nearly one-third of the country's 300,000 residents lost their homes, livelihood or other local infrastructure. The total financial cost is estimated at US$480 – 1,000 million; an estimate based on the recorded damage to infrastructure, fishing vessels, personal belongings, tourism and the loss of the small but locally significant agricultural production. More than 50% of the Maldivian GDP is derived directly from coral reef and island tourism and a further 12% is derived from reef fisheries. There was immediate concern that the tsunami had adversely affected the coral reefs, further exacerbating the damage experienced during the massive coral bleaching of 1998.

The tsunami caused significant damage to Maldivian communities, which are all 'coastal'. Flooding caused widespread power failures, disruptions to water supplies, damage to harbours and jetties, erosion of coastal zones and seawater penetration into the soil, resulting in damaged or destroyed agriculture. The waves also damaged many sewerage systems, leading to contamination of groundwater supplies, the sands and the sea around the islands. The coral reefs were damaged by debris from the smashed infrastructure being washed into the ocean. Many of these problems existed prior to the tsunamis. However, the tsunamis reinforced the need to rectify the problems associated with the unsustainable use of coral reefs and poor

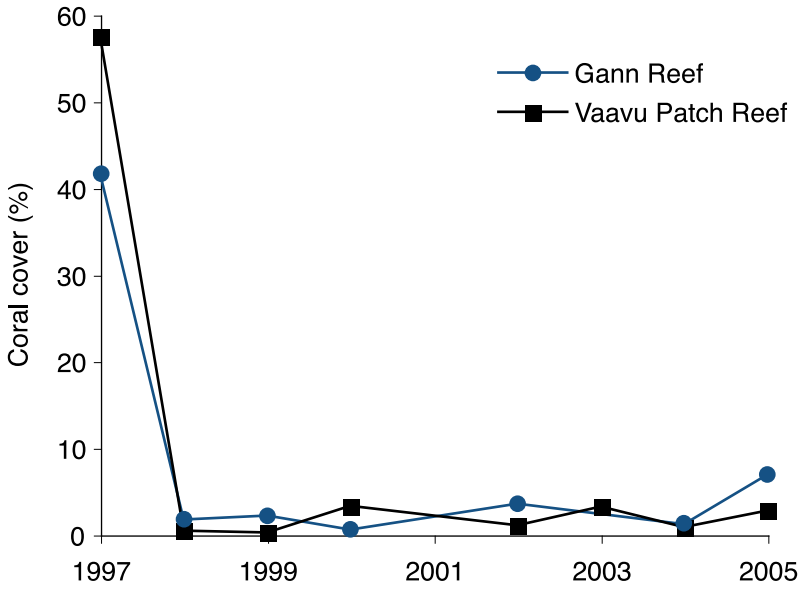
coastal management. The tsunamis also highlighted the urgent need for an effective early warning system and proactive disaster management plans.

Tourism is heavily dependent on healthy coral reefs, thus some of the island hotels have assisted the government with the development and management of marine protected areas (MPAs) for coral reef conservation. Several different fisheries operate on the coral reefs: live bait fish are caught in coral reef lagoons for tuna fishing and reef fish are harvested for tourist resorts and export, particularly grouper for the live food fish trade. Similarly, sea-cucumbers, sharks (for fins) and aquarium fishes are taken for export. These activities are having clear effects as grouper and sharks are becoming rare, with the potential to cause long-term damage to reef health. Although the biodiversity has not been studied in detail, more than 250 hard coral species and more than 1,200 total species have been recorded, making the Maldives one of the richest marine areas in the region.

Status of Coral Reefs Pre-Tsunami

The Republic of the Maldives consists of 1,190 islands in 25 atolls spread over 900 kilometres in the central Indian Ocean. Most of the islands are surrounded by coral reefs that were in good to excellent condition prior to 1998, when the massive El Niño climate change switch resulted in coral bleaching and approximately 90% mortality of all corals on most Maldivian reefs, reducing many sites to 2% live coral cover. The northern and central parts of the archipelago were most severely damaged and recovery was slow and variable. Bleaching was less damaging along the southern atolls, with some reefs retaining 40-55% live coral cover.

There are very few estimates of coral cover prior to 1998. One study measured 37% cover at 3 locations and 47% at 7 locations, suggesting that coral cover in the southern, central and northern atolls averaged 25 to 50% (with a range between 5 and 100%) before the major disturbances.



Coral reef recovery since the 1998 bleaching event has been slow and variable (from Hussein Zahir 2004).

The 1998 bleaching event shifted the balance on the reefs, with slow growing and massive corals becoming proportionately more abundant than the faster growing and more structurally complex branching and plate forming corals (preferred by the tourism industry). By 2002, there were encouraging numbers of new branching *Acropora* and *Pocillopora* recruits suggesting possible recovery to the former coral community structure. These corals were prominent on North Malé and Ari Atolls prior to the tsunamis.

Many of the apparently dead, large *Acropora* table corals were regenerating live tissue; recovery was assisted by relatively low levels of fishing. Algal grazing fish were abundant and were clearing fleshy algae and facilitating the settlement of new coral larvae. In contrast, North Malé and Ari atoll lost many slower growing massive corals, which may reduce the capacity of the reef to grow and add new rock in the future. In addition, a minor coral bleaching event in 2003 and a severe storm in May 2004 slowed recovery from the 1998 bleaching event. There are predictions that the reefs will be different in the future with the slow growing coral

SAVE THE CHILDREN – AN EYEWITNESS ACCOUNT

"A gentle earthquake shook my room early on 26 December, but the word 'tsunami' never crossed my mind. It was a perfect Maldives day, sunny and warm. The resort was quiet after Christmas, until there were the sounds of roaring water and screams at 11:00 am: "Save the children! Save the children". Seawater poured under the door, the electrical sockets exploded in sparks, and I smashed the door to escape. Unbelievably, the turquoise sea was dirty brown, and staff and guests were frozen in fear, not knowing what to do, as waves crashed onto the island. The water rose from ankle deep to waist high in seconds. The first large wave crushed me against the wall and stripped me of my phone and other possessions. I stopped breathing, realizing there was no high ground or tall buildings for an escape. This was a remote island, 1 m above sea level, with deep water all around. I struggled to the reception area, climbing over desks, computers and other debris and joined the staff who were screaming "Allah! Allah!" as they clung desperately to pillars. Seconds later, the full force of the tsunamis hit, shattering windows and collapsing walls. I blacked out as the water rose, and when I came to, the water had gone. Then I saw another larger and faster wave coming, and screamed for people to hang on. This wave raced furiously across the island full of debris, chairs, television sets, and was followed immediately by 2 more waves. Then silence. I screamed to the guests, "Stay away from the beach, the waves will return, don't move". The water receded leaving large coral blocks on the island, and reef fishes flopping in the sand. Wounded guests appeared with horrific cuts and injuries. We spent a long afternoon assisting them; however at 12:45 pm there was a rumour of a 50 m wave coming in 15 minutes. I had the difficult decision of telling guests to prepare for more waves. Luckily, the wave was not 50 m high, but we clung to trees as it roared over the island. The next 3 days were spent: attending the injured; waiting for rescue; patrolling the trashed island; scaring away looters; watching for more waves; and calming the panicked and emotionally disturbed staff. There was also a lot of thinking about the loss of my possessions, while being dehydrated and hungry. When I returned to the USA, I had lost 12 kg in weight but was much wiser about the power of the ocean and awed to be still alive" (from Dave Lowe, theloweroad@gmail.com).

species (such as agariciids and faviids) continuing to dominate over the branching acroporids and pocilloporids. However, there are encouraging signs of strong recruitment by the faster growing corals, thus the structure of the reefs of the future is uncertain.

Status of Coral Reefs Post-Tsunami

An Australian inter-disciplinary team, in cooperation with the Maldives Marine Research Centre, surveyed 124 reef sites on 7 atolls along 177 km in early 2005. The primary objectives were to document:

- the nature and extent of any tsunamis related impact on coral reefs;
- any changes to island geomorphology; and
- the impact of the tsunamis on associated baitfish resources.

There was only minor damage from the tsunamis to the coral reef resources of the Maldives. The observed damage, however, was additional to the massive damage suffered during the 1998 bleaching event. Unfortunately, there are few baseline data to compare the pre-1998 coral reef status and with the damage caused by the tsunamis. The lack of regular assessment and monitoring is unfortunate considering that the major economic activities in the Maldives depend on coral reefs.

BAA ATOLL – AN EYEWITNESS ACCOUNT

"The earthquake woke me in Baa Atoll, but it wasn't much more than a tremor. Later I learned there had been one in Malé or Colombo - vague rumours. I was worried at first that a part of Malé might have slumped away but confirmed that had not happened so organised to do some work. I was just approaching the water to do a survey when the wave came in. Extraordinarily high tide I thought at first, until I glanced up and around and realized sea level up and down the beach was higher than the land - not a lot, but it didn't take a lot of imagination to conjure up something worse. I rushed back into my room and hauled my gear up a story; then moved out to survey the scene with the camera (and mask, fins, snorkel and water just in case). The largest waves coming across the reef flat were 2 m at the highest, putting them about a meter higher than the beach top, and they broke about knee deep 15 m inshore. In places where the flow was obstructed and contained, such as a room with the entrance facing the water and the back door closed, the water reached a meter or more in height - until the windows broke. The water took the path of least resistance so was channeled along paths and roads, which were generally lower than the surrounding thick vegetation. On Goidhoo Island, an east-west road had recently been cut from one end of the island to the other and in the process a several meters high cobble berm at the east end had been removed. The water flowed like a river down that road. Perhaps the road acted like a safety valve but had the berm, a natural levee, been intact, I suspect that much less water would have entered the island. On many islands the freshwater lens was contaminated with seawater. The consequences were variable depending on how salt-resistant the vegetation was, how much seawater gained entrance, and how much the lens had been overpumped" (from William Allison, beliamall@dhivehinet.net.mv).

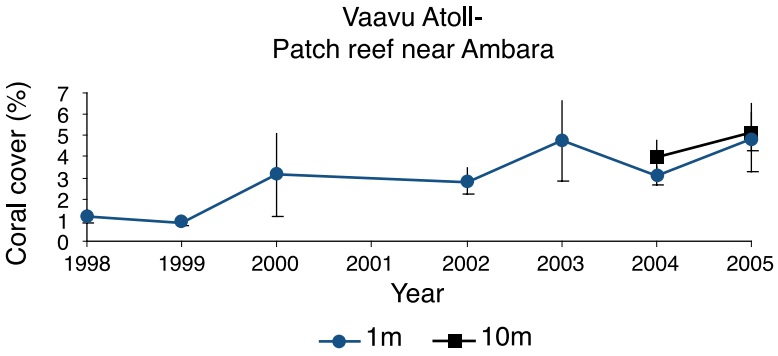
Raa and Baa Atolls: The effect of the tsunamis was generally minor on these atolls, although 45% of the surveyed sites had some damaged corals. Toppled corals were found along 22% of the transects, and 17% had broken branches. Smothering of corals by fine sediments was the most common stress, with 52% of transects showing a light 'dusting' of sediment which will inhibit future recruitment. No damage was observed at Vaffushi and Badaveri reefs.

South Malé Atoll: Detached and partially dead *Porites* boulders were observed at Finolhu Fahlu reef on the eastern side of the atoll. There were variable amounts of coral rubble and sand on the slopes of Guradihoo, Gulhee and Embudhoo reefs. On the eastern side of the atoll, there was damage at Guraidhoo and Kandooma thilla (bommie), including losses of gorgonians (from Marine Conservation Society survey).

Vaavu and Vattaru Atolls: Extensive sand and rubble deposits were observed along the east-facing channels near Foththeyo, Keyodhoo, and Devana Kandu reefs. There was no evidence of tsunami damage on the west-facing site of Mas Araa Falhu; however, there were large amounts of sediment and rubble on the slopes of the channel to the south. The tsunamis had only a minor impact on the recovery of the corals after the 1998 bleaching event. However, the deposition of sediment caused significant coral mortality at one site on Vattaru Atoll. The eastern dive site at Fotteyo channel was badly damaged, with a whole thilla being converted into a rubble mound (from Marine Conservation Society survey).

Meemu Atoll: Palm fronds and tree branches were seen on most of these coral reefs, although most of the tsunami damage resulted from rubble and sand deposition. No tsunami damage was observed at Kurali Kandu, Kolhuvaariyaafushi, or Thuvaru reefs.

Thaa and Laamu Atolls: The villagers on these atolls reported the greatest tsunami damage on land, yet the minor damage on the surrounding coral reefs was patchy and similar to storm damage. The high energy reefs on the outer edge of the atolls suffered limited damage (<1% of corals were broken); the greatest damage was in the channels with about 8% breakage of corals, some sand deposition and overturned rubble. The channels and lagoons generally contain less robust corals that are more vulnerable to environmental disturbance.



There has been slow coral recovery on Vaavu Atoll after coral cover dropped from an estimate of 55- 60% cover in 1997 (from Hussein Zahir).

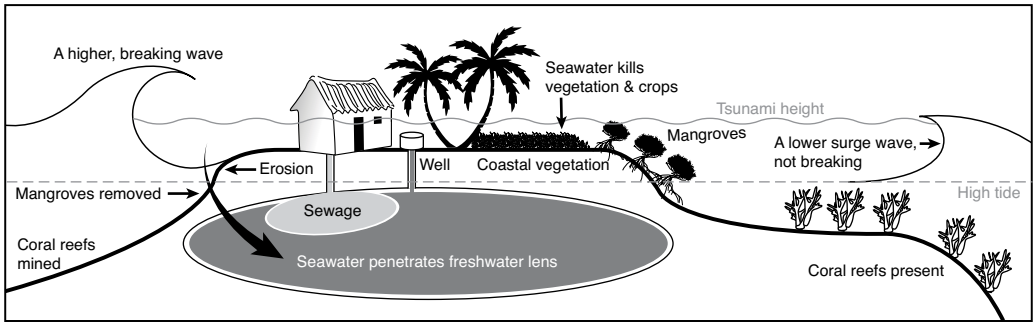
SCUBA DIVING DURING A TSUNAMI

"The morning of the 26th December was sunny and warm as usual on Faru Island in the Maldives. At breakfast, a companion asked if we felt the earthquake in the early hours of the morning. We had slept though it. Around 9:00 am on the way out for a dive, we observed that the water was rushing out of the lagoon at a very fast rate. The water was very turbulent at the first dive site, so the skipper aborted that attempt and chose a more sheltered and safer site. There was a slight current of about one knot when we entered the water; but within minutes we were swept from one direction to the next with a current that had increased to 5 knots. We kept the reef wall on our left side, but suddenly we were traveling in the opposite direction at a greater speed. Then the current would stop and reverse direction at an even greater speed for 3 or so minutes. No fish were seen swimming during this dive, and all had taken refuge in holes in the reef. There was one reef shark circling in the same spot with the pectorals fins down; it remained in the same spot as we passed back and forth each time. At 18 m depth, we experienced a dangerous down current, which forced us down to 28 m in seconds. We would have gone deeper, except that we were able to hold onto the reef and force our way back to 18 m. This used up valuable energy and it was necessary to regain normal breathing and to surface with regular decompression stops at 4 m and 3 m (the dive computers were unreliable under such unusual conditions). Entering the boat was extremely difficult, because the ocean swell had gone wild and the boat was corkscrewing around. On the way back to Faru, we noticed a lot of debris in the water, clothing, shoes, ice boxes, parts of boats etc. But there was total chaos back at the resort; the jetty was completely wrecked and people were crying. It was like a scene out of a Hollywood movie. It was then that we then realized that we had and unforgettable experience of being underwater during a tsunami. Our room was partly destroyed, and included a unicorn fish in the bedroom along with parts of a tree; all of our possessions were destroyed. There was no electricity, drinking water was rationed, food was running out, and the Malé International Airport was under water – but we were safe!" (from Greg and Deirdre Stegman).

Ari, North Malé and Felidhe Atolls: Surveys in June and July 2005 showed that coral cover was low (averaging 10% or less) and dominated by pocilloporids and acroporids. There was very little structural damage from the tsunamis, either inside or outside these 2 atolls. Some dive guides reported damage on the western channel reefs of Ari atoll (Thundufushi thilla), and some of the inner thilla reefs where flow was amplified through channels. However, there appears to have been little impact from the tsunamis at this atoll (from the Marine Conservation Society and Maldives Scuba Tours).

Socio-Economic Damage

Tourism: Tourism is the most important contributor to the Maldivian economy and has helped drive the recent economic expansion. From 1978 to 2004, the number of resorts increased from 17 to 87 and the annual number of tourist arrivals increased from 30,000 to more than 615,000. The 2004 tsunamis caused severe damage to the industry: 19 resorts were initially closed; 1,200 hotel beds were lost; tourist arrivals declined; and resorts reduced staff as occupancy rates dropped to 40%. Almost 1 year later, occupancy has increased to



This figure illustrates the potential impacts of a tsunami (or storm surge) on a coral island. The removal of reef flat corals and mangrove trees exposes the shore to greater erosion and more penetration of seawater from surging waves. The seawater will damage island agriculture and enter drinking water in the freshwater lens under the islands.

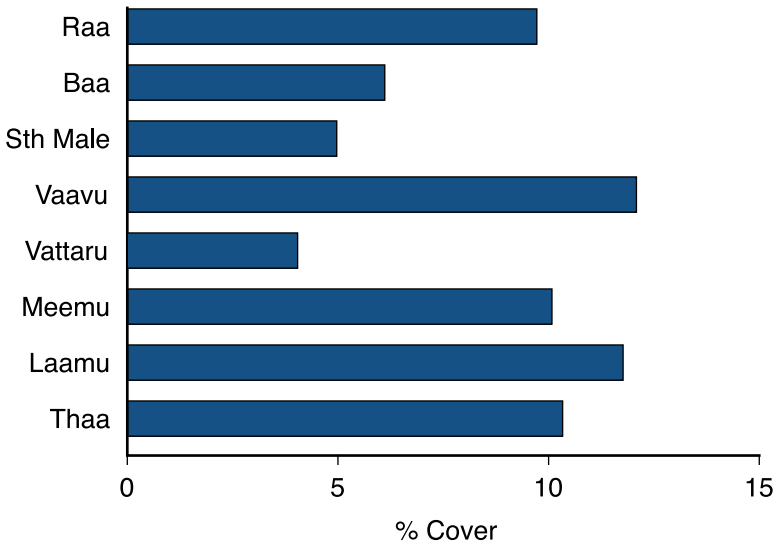
75%. The estimate to rebuild the resorts exceeds US$100 million and business losses for the sector may be in excess of US$250 million.

Fisheries: The Maldivian tuna fishing fleet is undergoing modernisation and expansion, with larger commercial vessels replacing the smaller, traditional boats (dhonis), and modern floating, freezing and canning operations are being built. A fresh tuna packing industry is being developed, putting more pressure on Maldivian fishery resources. The main target species, skipjack (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*), are highly migratory, oceanic and abundant; however there is debate whether the fisheries expansions will result in similar declines in fish stocks elsewhere.

The tsunamis destroyed 120 fishing vessels, damaged a further 50 vessels and resulted in the loss of equipment from 374 small fish processors, including ocean cages for the live grouper trade. Despite these losses, fishing activity appears to have recovered since the tsunamis, as catches in the first quarter of 2005 exceeded 2004 levels, mainly due to large tuna landings in the south of the country.

Construction and coral extraction: More than 6,000 homes were destroyed by the tsunamis, and many buildings made from traditional materials (especially coral rock) collapsed. Rebuilding is underway; however, there is a shortage of construction materials e.g. timber, washed aggregate and steel for concrete structures. Thus, there has been a resurgence of illegal extraction of sand and rock from reef flats and coral lagoons to build houses and to repair roads and paths.

Maritime infrastructure: The tsunamis damaged or destroyed approximately 36 jetties, 4,200 m of wharf wall, 15,000 m of harbour sea walls, 25 light beacons, 65 reef markers, 120 entrance markers and 300 m of causeway; the tsunamis 'replaced' 375,000 cubic metres of sand in dredged boat basins. There was relatively limited damage to maritime facilities along the inner, non-exposed, sides of the atolls, although many harbours were damaged, either from increased siltation or damage to coral block breakwaters.



The amount of live coral (as % cover) at 8 sites in the Maldives remains low after the tsunamis, reflecting the major coral loss in 1998 (from AusAID report 2005).

Rehabilitation and Recovery Efforts

There has been increased need for building materials following the tsunamis and imports from India cannot keep up with the demand. Hence attempts have been made to consolidate building foundations by using a foundation of coral rock and cement. Coral harvesting is illegal and highly variable, and there is a risk that if some coral reefs are damaged or lowered, the islands may lose their erosion barriers and the sources of sand to replenish the islands.

Many aid agencies offered to assist following the disaster. AusAID, the Australian agency sent a 12 person mission to assess the damage and advise on future remediation. The aid agency for the United States (USAID) focused on emergency relief and humanitarian assistance, with US$1.3 million used to airlift relief supplies, plastic sheeting, water containers and safe drinking water and hygiene kits.

Recommendations, Conclusions and Predictions

The tsunamis did not cause significant damage to Maldivian coral reefs; the damage was far less than human damage to the reefs caused by coral rock and sand collection from reef flats and coral death during the 1998 coral bleaching event. Thus, the tsunamis have slowed the recovery from earlier damage, and focussed attention on the need for better management of direct human pressures and inappropriate coastal development. Because of the importance of coral reefs to the Maldivian economy, the following recommendations are advanced to promote sustainable development:

- **Marine protected areas:** The conservation of the biodiversity and resilience of coral reefs will be enhanced by an expanded and better enforced network of MPAs. Local and national governments are advised to increase resources for training and reef management. Active participation and support of local communities in resource management is the key to success. Local communities can be motivated to assist in

TSUNAMI DAMAGE THREATENS PROGRESS TOWARDS MILLENNIUM DEVELOPMENT GOALS (MDGs)

The tsunamis sharply magnified problems associated with polluted groundwater and rising sea level in the low-lying Maldives, according to a report issued by UNDP. "Besides destroying thousands of homes in the Maldives, the tsunamis left many islanders with long-term pollution to their water supply," said Kari Blindheim, acting UNDP Resident Coordinator in the Maldives. The review of progress towards the MDGs indicated that the tsunamis destroyed more than 90% of toilets on some islands and contaminated groundwater supplies with salt and faecal matter washed out of septic tanks. The problem remains a year after the tsunamis and has been further exacerbated by nearly 340,000 cubic metres of waste from damaged homes, which rotted on many islands and seeped into the groundwater. "The tsunamis highlighted how vulnerable the Maldives are to climate change, and how environmental sustainability needs to be a major focus for this country, at the foundation of national and local development policies and programmes. If environmental issues are not addressed, the consequences will be serious. Fisheries and tourism, the biggest earners for the economy, both rely on biodiversity and a pristine environment." The report suggests that the tsunamis slashed estimated economic growth in the Maldives from 7.5% per annum to 1% for 2005. Tourist arrivals during the first quarter of 2005 were 44% lower than during the same period in 2004, with severe impacts on the national budget. The report states that the Maldives suffered relatively more economic damage than the other tsunami-hit countries (from www.undp.org/tsunami).

conservation projects through resource ownership, cultural preservation, provision of alternative livelihoods and by providing information e.g. showing them that most reef fish families are more abundant inside MPAs than outside;

- **Coral reef monitoring and management:** The Maldivian coral reef monitoring program should be expanded to include more reefs to provide information to reef managers and follow recovery after the 1998 bleaching and the 2004 tsunamis. There is a need for increased cooperation between government and international agencies, tourism operators, communities and NGOs by the development of working partnerships. Regulations banning coral and sand mining should be enforced to protect the barrier function of coral reefs;
- **Fisheries management:** Data from the economically important live bait and reef fish fisheries should be incorporated into a national data system to detect the effects of overfishing and other environmental disturbances. The Ministry of Fisheries, Agriculture and Marine Resources is encouraged to expand and strengthen capacity to monitor, analyse and protect Maldivian marine resources;
- **Capacity building:** There is an urgent need to increase national capacity in coral reef science and conservation (including fisheries management and socio-economic monitoring). Environmental, developmental and/or poverty reduction initiatives in coastal areas should be integrated to reflect the inter-linked nature of the problems and solutions;

- **Vulnerability assessments:** Atoll and community-based vulnerability assessments using island-level task forces would strengthen preparedness, planning and responses for damaging events. A wider national assessment would identify natural resources that serve as protection from environmental hazards and equipment and organisations required. Coral reef assessments should include specific studies on the implications of coral bleaching and disease on local communities and the economy;
- **Island geomorphology:** A basic monitoring program of island shorelines at different sites would improve understanding of seasonal and long-term trends in sediment transport and erosion, as well as the effects of major natural events, such as tsunamis and storm surges;
- **Reef dredging operations:** Ongoing monitoring is required to assess the effects of widespread dredging for land reclamation, building materials, harbour maintenance and construction materials. The development of sustainable sand mining policies is required to minimise adverse impacts to the economically and socially important coral reefs.

LACK OF BUILDING MATERIALS PROMPTS ILLEGAL CORAL EXTRACTION

A mission from the United Nations Environment Programme (UNEP) found that artisanal extraction of coral sand from lagoons (manually using sacks) was evident at most islands. They witnessed active and uncontrolled coral sand exploitation, which has apparently increased since the tsunamis. The Government of Maldives has recognised that coral reefs represent important defences against natural disasters and provide crucial marine habitat. In 1992, the Government banned mining of shallow coral 'house reefs' around an island, on atoll rim reefs, and from bait fishing reefs. The Ministry of Fisheries, Agriculture and Marine Resources administers applications to extract coral, sand and coral aggregates from the beaches and reefs around uninhabited islands, with advice from the Ministry of Environment and Construction. Nevertheless, Maldivian reefs have been extensively exploited for construction, although official statistics show there have been large reductions in the total volumes of sand and coral extracted. This, however, appears to be due to the under-reporting of illegal activities rather than a substantial reduction in demand. A review of sand mining regulations from other countries indicates that sand mining should be restricted to depths greater than 10 m and at a minimum distance of 600 m from shore (www.seafriends.org.nz/oceano/seasand.htm). The restrictions on beach sand mining in the Maldives have not been assessed to determine their effectiveness at protecting islands from increased storm surge vulnerability (from UNEP, www.unep.org/tsunami).

Reviewers

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UNEP (2005), (www.unep.org/tsunami/reports/maldives.pdf).

Other sources of information are listed on Page 143, including the H. Zahir *et al.* contributions in the CORDIO reports and the A. Rajasuriya *et al.* contributions in the GCRMN reports.