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11. Status of the Coral Reefs in Australia and Papua New Guinea

Andrew Chin, Hugh Sweatman, Susan Forbes, Helen Perks, Ryan Walker, Geoff Jones, David Williamson, Richard Evans, Fraser Hartley,Shannon Armstrong, Hamish Malcolm, Graham Edgar

With Contributions From: Kevin Bancroft, Joe Valentine and Bob Halstead

Abstract

- The corals reefs of Australia and Papua New Guinea cover 19% of the world's total reef area and contain levels of biological diversity approaching the 'hot spots' of the Philippines and Indonesia;
- Human pressures on these reefs are lower than in other parts of the world (particularly SE Asia). The reefs of eastern Australia, particularly the Great Barrier Reef (GBR), have a long history of research and monitoring and world leading management;
- Most coral reef management is implemented through Marine Protected Areas (MPAs) while fisheries resources are managed through specific fisheries management arrangements. Australian reefs are usually managed through cooperative arrangements between state and national governments, while management arrangements in PNG are predominantly driven by efforts of NGOs, local communities and local governments.

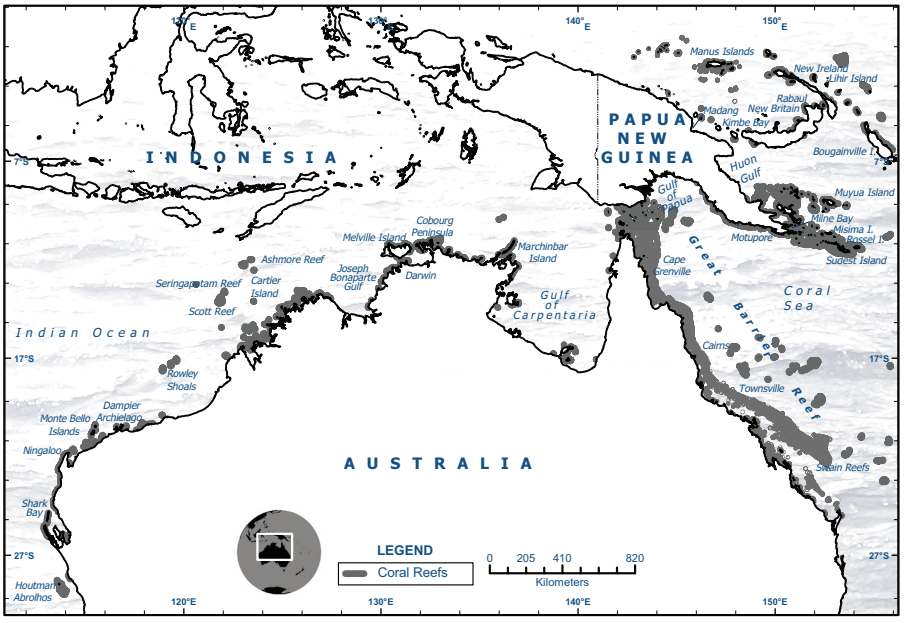
Eastern Australia

- The oceanic and island reefs of the GBR and the Coral Sea are amongst the best understood and managed in the world with considerable capacity and expertise in research and management, particularly along the GBR;
- Rezoning of the GBR in 2004 was a major undertaking that is showing significant ecosystem benefits; new management plans are being developed for many Coral Sea islands and reefs;
- There is good information about many GBR reefs, and information is improving about Coral Sea reefs;

- The reefs remain in relatively good condition and the GBR may be in a recovery phase from previous disturbances indicating good resilience; many pressures remain and some Coral Sea reefs have not recovered from storms and bleaching in 2002;
- On-going pressures include coastal development, declining water quality, fishing, recreational use, outbreaks of crown-of-thorns starfish (COTS) and other species. Recent pressures include coral disease, declining resilience of some reefs (particularly inshore reefs), declines in high level predators, and climate change effects;
- The outlook for these reefs is generally good if pressures can be reduced and resilience to climate change maintained.

Western Australia

- Western Australian reefs include extensive coastal reef systems and isolated and remote offshore oceanic reefs and islands;
- Most reefs are far from urban centres and are in relatively good condition. New management plans have been introduced and more are being developed;
- The rezoning of Ningaloo Marine Park in 2005 has increased no-take areas to 34%, helping to increase the resilience of this coral reef to pressures from climate change;
- Other pressures include fishing (recreational, commercial and illegal foreign fishing), major resource development (including ports), pollution, localised recreational use, coral bleaching, and outbreaks of the coral eating snail, *Drupella*;
- Research and monitoring has increased significantly, paralleled by increases in research capacity;
- The prognosis for these reefs is good provided reef resilience can be maintained against climate change damage.



Papua New Guinea

- Papua New Guinea (PNG) has many coastal reefs and offshore patch reefs with high biodiversity;
- Information on PNG reefs is limited, with little research, monitoring and management capacity. Some monitoring data are available from independent sources;
- Many areas are remote, isolated and difficult to access and manage. However, this isolation has reduced the impact of human activities on reefs;
- Pressures include terrestrial sedimentation from poor land management, over-fishing (particularly of invertebrates such as sea cucumbers), loss of top level predators in some areas, destructive fishing, COTS outbreaks and coral bleaching;
- PNG reefs are likely to be affected by global climate change, thus local stresses should be addressed to maintain reef resilience against climate change threats.

Status of Coral Reefs, Mangroves and Seagrasses in 2008

The reefs of eastern Australia include the Great Barrier Reef (GBR), oceanic reefs in the Coral Sea, Lord Howe Island, and transient coastal coral reefs in the Solitary Islands.

Great Barrier Reef: The GBR covers approximately 350 000 km^2 including 2000 individual reefs along the east coast of Queensland. It was officially protected in 1975 with the establishment of the Great Barrier Reef Marine Park (GBRMP) and declared a World Heritage Area in 1981. The GBRMP was rezoned in 2004 to include 33% of the area as no-take 'green' zones to protect ecosystem resilience and provide ecological 'insurance' against increasing pressures. The GBR has considerable research and management infrastructure such as the Great Barrier Reef Marine Park Authority, the Australian Institute of Marine Science (AIMS), universities (particularly James Cook University and the University of Queensland), the Marine and Tropical Science Research Facility and the Queensland Environmental Protection Agency. The GBRMP is primarily managed through marine park zoning that allows different uses to occur in different areas. Fishing is regulated through fisheries management arrangements overseen by the Queensland Department of Primary Industries and Fisheries.

There is a long history of research and monitoring on the GBR, ranging from major, inter-agency research programs to many small independent research projects. The AIMS Long-term Monitoring Program has conducted annual manta-tow monitoring since 1986, with more intensive scuba surveys of coral reef benthos and fish at fixed sites since 1993. The program was altered in 2006 to monitor the effects of GBRMP rezoning with reef monitoring now conducted every two years.

Coral cover on the GBR is greatly affected by disturbances such as cyclones and outbreaks of COTS (*Acanthaster planci*) and, to a lesser extent, by coral bleaching and disease. The GBR appears to be in a period of recovery and growth; COTS activity has declined following the third recorded 'wave' of COTS outbreaks. In 2006–2007 only 4–6% of reefs surveyed showed significant COTS activity and no COTS activity was recorded on the Swains reefs in the southern GBR; the first time the Swains reefs have not had COTS activity since the mid 1980s.

Hard coral cover has increased in the Cairns, Whitsundays and Swains regions of the GBR with the highest cover being in the Capricorn-Bunker (55%) and the Whitsunday (46%) sectors.

Coral cover was lowest on mid-shelf reefs in the Townsville sector which is recovering from COTS outbreaks. Coral cover on outer-shelf reefs in the northern GBR has declined by 50% in the last two years from very high levels recorded in 2000. This decline is attributed to storm damage and coral disease.

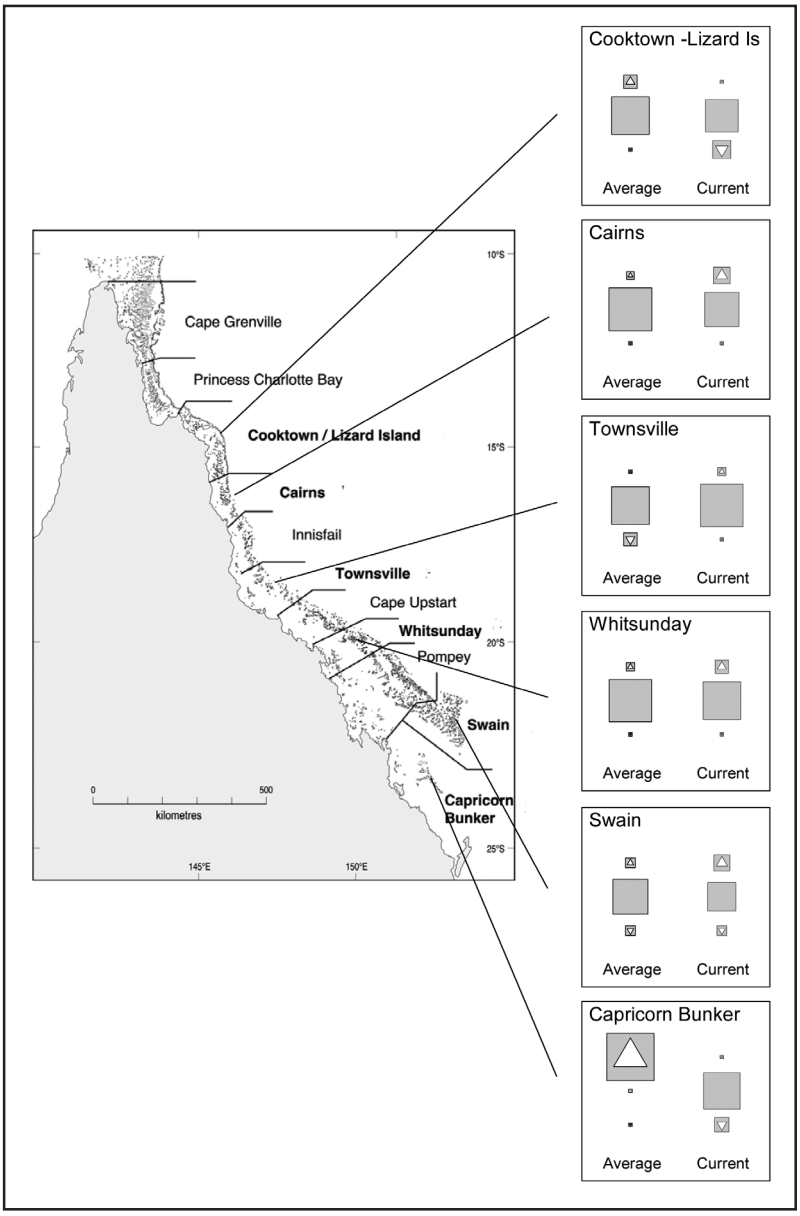
The increase in no-take reserves in the GBRMP has resulted in positive ecological flow-on effects. The biomass and density of target fish species has significantly increased in the 4 years since the new zoning was introduced (Box p. 164), and COTS outbreaks appear to be significantly reduced within no-take reserves (Box p. 162), suggesting that there are ecological processes operating within no-take reserves that are not fully functional elsewhere.

Although the GBR is in relatively good condition and has world best practice management, it faces on-going challenges. Many components of the GBR ecosystem may be highly vulnerable to climate change including increasing evidence of the emerging threats of ocean acidification. The resilience of the GBR may be reduced by human pressures: declining water quality is already affecting some inshore coral reefs with observed changes in community composition and density and diversity of juvenile corals on some reefs. There is also emerging evidence that community composition on inshore reefs has significantly changed since European settlement started 200 years ago. Extractive activities such as fishing may alter ecological processes and trophic pathways (Box p.162); and the density of top predators such as reef sharks appears to have been significantly reduced on some reefs. While the GBR coastal population is small compared to other areas, it is rapidly increasing and bringing greater pressures for development and use of the GBRMP.

NO-TAKE MARINE RESERVES REDUCE COTS OUTBREAKS

It has been suggested that human activities such as nutrient enrichment of coastal waters through terrestrial runoff, and the removal of predators through fishing, may influence outbreaks of COTS. Extensive surveys of the GBRMP over a 10 year period of active COTS outbreaks occurring after no-take reserves were fully implemented (1994–2004) showed that the relative frequency of COTS outbreaks was 3.75 time higher on 'open' reefs compared to reefs zoned as 'no-take' marine reserves. While these data are clear, there is no obvious explanation for these differences. The main target species (groupers and snappers) extracted from the 'open' reefs surveyed are not considered to feed on COTS. This suggests that no-take marine reserves preserve some ecological links or a trophic pathway that indirectly control COTS numbers.

There are approximately 3800 km^2 of mangrove and saltmarsh habitat along the GBR coast, with this area remaining relatively stable. However these mangrove forests are only remnants of more extensive forests that have been progressively cleared since European settlement started 200 years ago. Some localised losses of mangroves have occurred and the main pressures are from continued coastal development.



Summaries of trends in hard coral cover along the length of the GBR, 1993–2007. Each section of the GBR is represented by two sets of squares. The dimensions of each square represent the proportion of reefs showing an increase (top square), no change (middle square) or decrease (bottom square) in coral cover. Arrow heads show whether a change is an increase or decrease. The left hand box plots show average trends over the last 15 years, right hand box plots show current trends (from 2006–2007), for example, the majority of reefs in the Capricorn Bunker section have had increasing coral cover over the last 15 years. In 2006–2007, coral cover stayed the same on most reefs, declined on some reefs and increased on a few reefs.

GBR seagrasses are highly variable and are particularly affected by storms and floods. There are approximately 46 000 km^2 of deep and shallow seagrass beds with no apparent widespread declines, although there have been localised losses. Seagrasses are affected by declining water quality, coastal development and localised impacts.

Further information: The AIMS Long-term monitoring program:

- http://www.aims.gov.au/docs/research/monitoring/reef/reef-monitoring.html

Science and research on the GBR:

- http://www.gbrmpa.gov.au/corp_site/info_services/science_management
- http://www.rrrc.org.au/

ECOLOGICAL EFFECTS OF THE REZONING OF THE GBR MARINE PARK

The inshore coral reefs of the GBR Marine Park predominantly fringe continental islands. Due to their proximity to population centres, these inshore reefs are frequently visited and subject to significant levels of recreational fishing pressure. High levels of compliance and relatively effective surveillance and enforcement also mean that these inshore reefs are some of the best protected within the GBRMP. Monitoring of fish populations using underwater visual census (UVC) was initiated in 1999–2000 to assess the effectiveness of zoning protection since late 1980s on reefs of the Palm, Whitsunday and Keppel islands. Published results focused on the major target of GBR hook and line fisheries, the coral trout (a grouper, *Plectropomus* spp.): after 12–14 years of protection, coral trout biomass had increased 3–6 fold within no-take marine reserves while there were no increases in surrounding fished areas. The GBRMP zoning plan was updated in July 2004 and the area of no-take marine reserve was increased from 4.5% to 33.4%. New studies revealed that after only 1.5 to 2 years of no-take protection, the coral trout density had increased significantly in newly protected areas (by about 65% in 2 island groups), but there were no significant changes in areas open to fishing. These early results provide an encouraging message that bold political steps to protect marine biodiversity can produce rapid positive results for exploited species.

Coral Sea Reefs and Islands: These reefs grow around oceanic islands and seamounts scattered across 780 000km^2 of ocean east of the GBR. Some remote reefs are visited by tourism operators (for example, Osprey Reef, Flinders Reef) but most are rarely visited. There are several MPAs on Coral Sea islands and reefs, including the Coringa-Herald, Lihou Reef, Elizabeth and Middleton Reef reserves, and Lord Howe Island. The Elizabeth and Middleton reefs and Lord Howe Island are the most southerly coral reefs in the world and are strongly influenced by the south flowing East Australian Current. There has been limited research and monitoring apart from occasional surveys by AIMS and JCU for the Department of the Environment, Water, Heritage and the Arts (DEWHA). Climate change is probably the main pressure on these reefs.

Osprey Reef is an oceanic seamount 340 km NNE from Cairns and 180 km off the coast. This reef is frequently visited by divers from Cairns and Port Douglas and has been monitored by Reef Check Australia volunteers since 2002. Hard coral was damaged by coral bleaching in 2002 but appears to have recovered. Coral cover remains at about 40% at two sites with one site showing a slight decrease since 2004. An unofficial agreement has been reached between fishers and the tourism industry to protect high value tourism sites from fishing impacts. Further information on Osprey Reef from Reef Check Australia:

- http://www.reefcheckaustralia.org/publications/2008%20Site%20Report%20finalsm.pdf

The **Coringa-Herald Nature Reserve** is 400 km directly east of Cairns and covers 8856 km^2 including 6 islets and cays with a total area of 124 ha. AIMS surveys showed low coral cover compared to the GBR, with 4.5% cover recorded in 2003 and 7.3% in 2006–2007. There is evidence of significant coral mortality following coral bleaching in 2002 and physical damage from storms. Recovery appears to be slow and is probably dependent on self-seeding, making these reefs vulnerable to localised extinctions. The fish assemblages are very different to the GBR and indicate that these reefs may be 'stepping stones' between the GBR and the South Pacific. Some holothurians (sea cucumbers) of high commercial value were found to be more abundant within the reserve compared with other sites, suggesting some benefit of the reserve for these species. In 2005 beneficial insects were released at Coringa-Herald to minimise damage to the Pisonia forest from pest insects.

The **Lihou Reef Nature Reserve** is 700 km due east of Cairns and includes 18 coral cays covering 91 ha dotted around Lihou Reef, a U-shaped line of reefs facing west-south-west and enclosing a lagoon. No new surveys have been conducted at Lihou Reef since the previous *Status of Coral Reefs of the World: 2004*, when coral cover in 1984 and 2004 was low (<10%) with many corals bleaching due to elevated sea surface temperatures at the time of the 2004 survey. There was also evidence of bleaching from the 2002 bleaching event.

The **Elizabeth and Middleton Reefs Reserve** covers 1880 km^2 and the reefs are part of the Lord Howe volcanic chain. Surveys in February 2006 found that coral cover was similar to 2003 levels: 25% at Elizabeth Reef; and 11% at Middleton Reef. There was no evidence of recent bleaching or *Drupella* activity and only limited evidence of COTS. Surveys of fishes have recorded 324 species with two additional goby species identified in 2007. Genetic studies on the Galapagos sharks suggest that the Elizabeth and Middleton Reef population forms a single stock that is distinct from the Lord Howe Island population. In 2006 the Australian Government introduced a 7 year management plan for the reserve and has since increased compliance and enforcement patrols.

Lord Howe Island is 700 km north-east of Sydney and was listed as a World Heritage Area in 1982. The reefs around Lord Howe Island have a unique mix of tropical and temperate species with 83 coral species, 500 fish species and more than 300 species of macro-algae. Surveys in 2006 and 2008 found that coral communities were generally in good condition with 22% coral cover in 2006 and 19.3% in 2008. The most striking change between 2006 and 2008 was the increasing prominence of the 'lamington' urchin, *Tripneustes gratilla*. Abundance of *Tripneustes* increased dramatically from 2.4% of total invertebrate abundance in 2006 to 27% in 2008. The greatest increase was at sites in the Admiralty Islands where a massive outbreak

occurred, averaging > 270 individuals per site (200 m^2 survey area) in 2008. The *Tripneustes* population outbreak has significantly altered the bottom community with reductions of iconic macro-algae species, such that commercial dive operators have reported reduced aesthetic value at these sites. While flow-on effects to the broader community are not yet evident, the *Tripneustes* outbreak represents a potential threat to Lord Howe Island reefs. Lord Howe Island and its surrounding waters are designated MPAs, managed by the New South Wales and Australian Governments. The MPAs include significant 'no-take' zones to protect representative habitats from human influences. Further information about Lord Howe Island at:

- http://www.mpa.nsw.gov.au/lhimp.html
- http://www.environment.gov.au/coasts/mpa/lordhowe/index.html

More information on Coringa-Herald, Lihou, Elizabeth, Middelton and Lord Howe Island at:

- http://www.environment.gov.au/coasts/mpa/publications/index.html

The **Solitary Islands** are 600 km north of Sydney on the northern coast of New South Wales (NSW). The corals grow on a rock basement and are transient, such that they do not form carbonate reef structures. More than 90 hard coral and 530 fish species have been recorded and include a mix of tropical and sub-tropical species. Coral communities are dominated by *Turbinaria* spp., tabulate and corymbose *Acropora* spp., *Pocillopora* spp. and *Goniastrea* spp. The NSW Marine Parks Authority has surveyed the Solitary Island reefs every 2 years since 2000. Coral cover between sites varies between 15% and 50%. From 2002–2006 average coral cover combined for all sites has remained stable at about 30%. Low levels of coral bleaching were observed between 2000 and 2007, but the Solitary Islands did not experience the mass coral bleaching observed elsewhere in Australia in 2002. Some corals have been affected by a 'white syndrome' disease with 10% mortality of tagged corals; research is on-going. The Solitary Islands and surrounding waters are zoned as MPAs, managed by the NSW and Australian Governments. The Solitary Islands Marine Park was rezoned in 2002 and initial results show that some fishes are showing positive trends within sanctuary zones. More information about the Solitary Islands at:

- http://www.mpa.nsw.gov.au/simp.html
- http://www.environment.gov.au/coasts/mpa/solitary/index.html

Western Australia

Western Australia (WA) has rich marine biodiversity that is ranked second in the world in terms of its endemism. WA's coral reefs are diverse and include the Houtman Abrolhos Islands as the most southerly reefs in the Indian Ocean, Ningaloo Reef as the longest fringing reef in the world (280 km), and emergent oceanic reefs and islands such as Ashmore and Scott reefs. WA contains 44% of Australia's coastline and the coastal areas between Carnarvon and the Northern Territory contain large areas of coral reef. Most reefs are far from population centres and are often close to the coast. There is minimal terrestrial runoff as much of the adjacent coast is dry and arid. Marine Parks in WA are managed and monitored by the Western Australian Department of Conservation (DEC, formerly the Department of Conservation and Land Management) and the Federal Government DEWHA, apart from the Houtman-Abrolhos Islands which are managed by the WA Department of Fisheries.

Research and management effort in WA is rapidly increasing, including new management plans for Ningaloo Reef (2005), Ashmore Reef (2002), Cartier Reef (2002), the Rowley Shoals

(2007) and the Montebello/Barrow Islands (2007). Three new marine parks are likely to be declared in the near future and regional marine planning is underway. The launch of the new Western Australian Marine Science Institution (WAMSI) in May 2007, a collaborative research initiative between Commonwealth research organisations, State government departments, WA universities and the private sector, has significantly increased WA's marine research and monitoring capacity and will help to underpin management of its marine resources. An increase in knowledge of the extensive fringing coral reefs of the Kimberley suggests these reefs are of international significance and a major research program for the region is being developed.

The vast distances and the isolation of many reefs pose significant challenges for research, monitoring and management. More information about WA reefs can be found at:

- http://www.dec.wa.gov.au/park-finder/property/marine-parks-and-reserves/ningaloo-marine-park.html
- http://www.environment.gov.au/coasts/mpa/index.html
- http://www.wamsi.org.au

The **Ashmore and Cartier Island** reefs lie in the Timor Sea between WA and Indonesia. Ashmore is 840 km west of Darwin, in more than 100 m depth, forming a shelf-edge coral atoll. The Ashmore Reef National Nature Reserve includes 3 islands, a large reef shelf and the surrounding waters. Cartier Island lies 46 km southeast of Ashmore and together the 2 reserves cover 750 km^2. Scott, Ashmore and Cartier reefs were severely bleached in 1998 with more than 80% declines in coral cover to 30 m depth. Subsequent bleaching in 2003 caused a further 15% decline in coral cover at some sites. By 2005 live coral cover had declined to 10% at Ashmore and 16% at Cartier with very few coral recruits. Coral diversity may have decreased following the bleaching but fish communities remain diverse and abundant. Some high-value sea cucumbers are absent and may have become locally extinct due to over-exploitation. Indonesian fishers have historically fished Ashmore and Cartier heavily, especially harvesting sea cucumbers, trochus and shark fin. The 2002 management plan banned fishing in the reserve and has seen effective enforcement. In 2008 an Australian customs vessel was deployed to Ashmore Reef as a near permanent police presence.

The **Rowley Shoals** lie 300 km north-west of Broome and include Mermaid, Clerke and Imperieuse reefs. All three reefs are MPAs and are cooperatively managed by the Australian and WA Governments. There are more than 233 species of hard coral growing in clear waters down to great depths and 528 fish species have been recorded. Mermaid Reef is managed by the Australian Government and a new management plan will include installing moorings to reduce anchoring damage. Surveys in 2006 and 2007 added 23 new coral species as well as 43 echinoderms and 373 molluscs. The WA Government released a new management plan for Clerke and Imperieuse reefs in 2007 that extended the park to 87 632 ha, of which 24% are no-take 'sanctuary zones'. Imperieuse Reef suffered significant cyclone damage in 1995 that reduced coral cover from 60% to 10% but the reef has made a rapid recovery. Due to their isolation and protection from most human impacts, the Rowley Shoals are amongst the most pristine coral reef environments remaining in the world and, apart from some targeted reef fish species, the coral reefs of the Rowley Shoals appear to be in good condition.

The **Dampier Archipelago** contains coral communities that are subject to many human stresses. The mining towns of Dampier and Karratha have the highest per capita boat ownership in WA

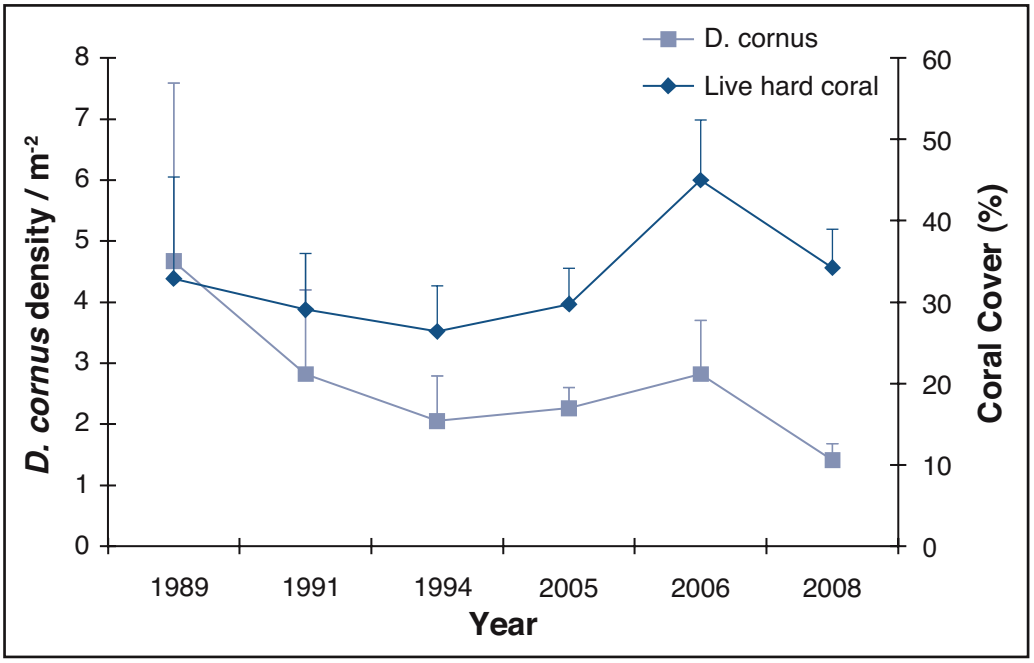
along with rapid industrialisation, including a major dredging project in Dampier Harbour. The corals are also subject to extremely variable environmental conditions including macro-tides, cyclones and storm events, high and/or extremely variable turbidity, and warming seawater temperatures. There are a broad range of coral habitats in the Dampier Archipelago that support the second most diverse coral fauna in WA. A marine park is proposed for the Dampier Archipelago and the planning process is nearing completion. DEC surveyed 12 sites across the Archipelago in September 2008 as a precursor to a long term monitoring program for the proposed marine park. The dominant coral forms are corymbose and plate *Acropora* spp., with significant numbers of poritid, favid and mussid corals. *Drupella* and COTS were rarely encountered during the survey.

The **Monte-bello and Barrow Islands** lie off the Pilbara coast in north-west WA, 1600 km north of Perth. The islands form a complex archipelago of 265 low lying islands and islets in an area of 2100 km^2 containing mainly tropical flora and fauna. The Montebello/Barrow Islands MPAs were established in 2005 with a new management plan introduced in 2007. These coral reefs may be a source of larval recruits for coral reefs further south such as the Pilbara inshore islands, Muiron Islands and Ningaloo reef. DEC is establishing a long-term monitoring program and initial surveys in August 2006 established 26 potential sites. Live hard coral cover ranged from 2–58% at 19 sites, and from 37–62% at 7 patch reefs. Mean cover of macro-algae was low (<6%) while turf algae were more abundant (27–67%). The abundance of COTS and *Drupella* was low.

Ningaloo Reef is the longest fringing reef in the world (280 km) and is 1000 km north of Perth where temperate and tropical currents converge in the Ningaloo region. This has resulted in high coral reef diversity with more than 500 fish, 250 coral and 600 mollusc species. Ningaloo Marine Park (which includes State and Commonwealth waters) was established in 1987 and the State waters of the marine park were extended in 2004 along with the inclusion of the Muiron Islands Marine Management Area. Combined, the marine reserves cover 5355 km^2 and are managed by the WA and Australian Governments. The WA Government released a new management plan for the State section in 2005 with increases in the area of 'sanctuary zones' to 34% of the park area. DEC are implementing a long-term monitoring program that will help improve the science underpinning the management of Ningaloo Marine Park.

The first major coral bleaching event recorded at Ningaloo Reef occurred during winter in 2006. An unusual combination of low spring tides, a high pressure system and cold air temperatures resulted in the bleaching of shallow water corals. However, almost full recovery has occurred.

Between the mid-1980s and 1990s Ningaloo Reef was severely damaged by outbreaks of the coral eating snail, *Drupella cornus*, with coral mortality approaching 100% in some locations. DEC surveyed *Drupella* density and benthic reef communities (including coral cover) in 1987, 1989, 1991, 1994, 2005, 2006 and 2008, with future surveys to be conducted every 3 years. Currently, coral cover varies between 30% and 60% and *Drupella* and COTS densities are low to moderate. Coral communities are healthy and dominated by *Acropora* spp. at most sites. Overall, coral communities appear to have recovered from the *Drupella* damage in the 1980s with coral cover increasing consistently at most locations. Ningaloo Reef faces pressures from storms and cyclones, pollution, local fishing and recreational use (such as anchor damage), coastal development and introduced species (such as foxes that take newly hatched turtles).



The overall trends in* Drupella cornus *density at Ningaloo Marine Park 1989-2008 show similar trends to live hard coral cover (data show means of all locations with standard error).

Macro-algae, seagrasses and mangroves: The Ningaloo Marine Park includes 2200 ha of macro-algal meadows. The dominant genera are *Sargassum*, *Padina*, *Dictyota* and *Hydroclathrus*. Seagrasses are patchily distributed within the reserves and are not a major component or major primary producer. While no comprehensive surveys of macro-algae or seagrasses have been completed, the region is currently the focus of marine flora studies. Mangroves comprise about 0.1% (33 ha) of the area of the Marine Park, and the mangroves, seagrasses and macro-algae appear to be relatively healthy.

Research and monitoring in the Ningaloo Marine Park is rapidly increasing with the initiation of the Ningaloo Research Program (NRP) associated with the release of the 2005 Ningaloo Marine Park Management Plan. The program has grown to approximately $30 million dollars of research over 4 years with co-investment and collaboration of research organisations and universities through WAMSI and through the CSIRO Wealth from Oceans National Research Flagship and the Ningaloo Collaboration Cluster. More information about the Ningaloo Research Program and its key elements:

- www.ningaloo.org.au
- www.wamsi.org.au
- www.csiro.au/science/Ningaloo

The **Houtman Abrolhos Islands** consist of 122 islands 60 km off Geraldton on the mid-west coast of WA. These islands are the most southerly coral reefs in the Indian Ocean and support a mix of tropical and temperate fauna including 389 species of fish and more than 50 coral

genera. The islands are important habitats for seabirds and sea lions, and are crucial to the WA rock lobster (crayfish) fishery with up to 50% of the western lobster spawning output coming from the area. The islands are managed by the WA Department of Fisheries and management arrangements are currently being reviewed. The islands are zoned as a Fish Habitat Protection Area (253 100 ha) that currently includes 4 'Reef Observation Areas' (6859 ha) that exclude extractive activities except for licensed lobster trap fishing. Between 1995 and 2002, coral trout numbers increased between 3 and 7 times within the closed areas but there was no clear pattern for wrasses. There are no existing coral reef monitoring programs, however, the Abrolhos Island Research Institute was established in 2006 and is likely to increase research activity. Baldchin grouper (a wrasse) are under pressure in the Houtman Abrolhos Islands and an interim ban on the take of baldchin grouper was introduced in 2008. More information on the Houtman Abrolhos Islands can be found at:

- http://www.fish.wa.gov.au/sec/env/west/index.php?0502

Papua New Guinea

The coral reefs of the north and east coast of Papua New Guinea (PNG) lie within the 'coral triangle' that includes eastern Indonesia, the Philippines, Timor Leste and the Solomon Islands. The coral triangle is a global centre of marine biodiversity and has very high conservation value. Many reefs in PNG are close to shore and sensitive to terrestrial influences. Research and monitoring capacity in PNG is relatively low with most programs run by NGOs; such that there are few long term datasets for PNG reefs. There are also few MPAs in PNG and awareness and support for marine resource management is mostly limited to areas where NGOs have active programs such as in Kimbe Bay, Kavieng, Manus and Madang. A system of customary tenure ('tambu') for fringing reefs and inshore fishing resources exists in many coastal communities. Temporary closing of a reef is a historical practice that is now declining. Most reefs in PNG are in relatively good condition, although some reefs are under pressure from: sedimentation arising from poor management of mining, land clearing, oil-palm plantations and logging; over-fishing, including top predators such as sharks and invertebrates such as sea cucumbers (bêche-de-mer); the live fish trade; COTS outbreaks; and coral bleaching.

The **New Britain Province (East and West)** is a large area that includes the well studied Kimbe Bay region being monitored by The Nature Conservancy (TNC). At least 860 fish and 400 hard coral species have been recorded from Kimbe Bay. Annual reef monitoring by James Cook University (JCU) and TNC began in 1996. Coral cover on the coastal fringing reefs declined from ~70% to ~7% between 1996 and 2003, but has recovered considerably in the last 5 years. Cover of all major coral families has increased, including acroporids, pocilloporids and poritids, with total branching coral cover peaking at 26% in 2007. Likewise, declines in coral reef fish biodiversity between 1997 and 2002 have been followed by almost full recovery of most affected reef fish species between 2002 and 2007. However, severe localised bleaching was recorded at surveyed reefs in early 2008, and macro-algal cover and the amount of unconsolidated sediments have increased gradually over the last 10 years.

Four marine reserves were established in 1999 and changes in coral and fish assemblages in Kimbe Bay are almost identical across all 4 areas. The marine reserves have resulted in increases in the abundance of a few reef fishes, most notably the surgeonfish (Acanthuridae). Since 2006 TNC have been developing an MPA network for Kimbe Bay that incorporates the principles of reef resilience and connectivity as well as social and economic factors. They are

working with local communities and governments, with the support of local NGOs (Mahonia Na Dari), to establish 'community protection areas' or Locally Managed Marine Areas (LMMAs), and to address land use and management issues. The Kimbe Bay wide system of MPAs is likely to deliver major benefits to the region. Researchers from JCU have shown that fish larvae in Kimbe Bay are retained within a single MPA and also transported to adjacent MPAs, demonstrating wide-spread larval connectivity within the MPA network.

There has been little other coral reef research in the rest of East New Britain province since the *Status of coral reefs of the World: 2004* report. Information about research and management in Kimbe Bay can be found at:

- http://www.nature.org/wherewework/asiapacific/papuanewguinea/work/art6726.html;
- http://www.lmmanetwork.org/Site_Page.cfm?PageID=42

The **New Ireland Province** includes diverse fringing coral reef, lagoonal and mangrove systems. The Wildlife Conservation Society (WCS) PNG Marine Program monitors 3 'tambu' sites established in 2006 and are establishing new tambu areas with partner communities, which also participate in monitoring 6 areas through the PNG LMMA Network. From 2006–2008 data were collected at 6 sites: Ungakum (no-take) and Kavulik (open to fishing) in the Tsoi Islands of the archipelago; and Lasigi (no-take), Malom (open), Silom (notake) and Dabanot (open) on the north-eastern central coast of the main island. In 2008 mean coral cover in the Tsoi islands was 19%, a significant drop from 41% in 2007. Coral cover at the main island sites in 2007 ranged between 24% ands 30%, and 2008 results for Malom are 23%. Macro-algal cover increased at all sites from 52% in 2006 to 59% in 2007, and further increased to 72% at 3 of the 6 sites in 2008. Average coral cover at all sites dropped from 40% in 2006 to 30% in 2007, and declined again to 20% at 3 of 6 sites in 2008. The greatest change between 2006 and 2007 was at the central main island sites, Lasigi and Malom, where coral cover decreased by as much as 23% and macro-algal cover increased by 17%; possibly due to impacts from extensive oil palm plantations and COTS outbreaks. There has been minimal coral disease and some coral bleaching, but some 'tambu' areas have been affected by COTS. Damaged areas represent a mean of 0.1% of total area, which is significant considering that hard coral cover is as low as 8% at some sites. COTS damage variation between sites is high.

New Ireland Province Monitoring Sites	Bleaching (m^2/ha.)	*A. planci* predation (m^2/ha.)	*Drupella* sp. predation (m^2/ha.)	Black band disease (m^2/ha.)	White band disease (m^2/ha.)
Managed areas (Tambu)	175.4 (SD 192.3)	5398 (SD 9595)	111.1 (SD 235.9)	Not seen	333 (SD 748)
Areas open to fishing	209.5 (SD 238.5)	727 (SD 983)	50.6 (SD 61.4)	Not seen	260 (SD 171.5)

This table summarises coral damage recorded by WCS in September and October 2007 at protected and nearby unprotected sites in New Ireland. No clear pattern has emerged in these indicators of damage on the 12 transects each 50 m by 2 m at 4 m and 7 m depth. Values are means with standard deviation (SD).

Reefs in New Ireland support relatively healthy populations of rarer fish such as bumphead parrotfish (*Bolbometopon muricatum*), humphead wrasse (*Cheilinus undulates*) and reef sharks; however commercial fishing pressures are increasing to supply a fish processing plant in Kavieng. Pressure on sea cucumbers is also increasing with PNG National Fisheries Authority surveys in 2006 showing stock collapses at several sites. The implementation of LMMA 'no-take' areas by the communities has shown rapid and positive results: after one year, mean fish biomass increased from 239 kg/ha to 303 kg/ha at the managed no-take sites while there was no significant change at the fished 'open' sites. The greatest change in biomass was recorded in piscivores at shallow sites, with a significant increase of 3.83 kg/ha at managed sites compared to a decrease of 2.43 kg/ha recorded at 'open' sites. These trends were strongest in both density and biomass of the trout and groupers (Serranidae) and snappers (Lutjanidae). Support for the reintroduction of customary management techniques has grown since 2006 within the Province, with more communities planning on re-introducing tambu areas. However, there is low capacity to support such community initiatives, at village, government and NGO levels. Some New Ireland Local Level Governments are developing laws to recognise community based fisheries management areas. More information about New Ireland:

- http://www.wcs.org/globalconservation/marine/46886020;
- http://www.lmmanetwork.org/Site_Page.cfm?PageID=42

Manus Province: The WCS is monitoring sites at Andra and Ahus islands 5 km off the north coast of Manus Island. Total coral cover is about 25% at Andra Island and 24% at Ahus Island, slight decreases from the 30% reported in the *Status of the Coral Reefs of the World: 2004*. Algal cover is approximately 43–44% at Andra and Ahus islands respectively. Fish biomass is relatively high at both islands (Andra 332 kg/ha, Ahus 346 kg/ha) compared to other sites in PNG.

Manus Site	Total fish Biomass (kg/ha)		Hard Coral Cover (%)		Algal Cover (%)	
Andra	331.6	SD 124.9	24.5	SD 9.8	43.8	SD 6.7
Ahus	345.6	SD 178.0	23.9	SD 8.7	44.6	SD 12.6
	COTS Abundance		***Tridacna* spp. Abundance**		**Sea Cucumber Abundance**	
Andra	0.17	SD 0.39	1.08	SD 1.16	8.00	SD 8.6
Ahus	0.08	SD 0.29	0.42	SD 0.51	0.42	SD 0.7

These ecological data from Andra and Ahus Island, Manus Province from Sept–Oct 2007 show relatively healthy coral and fish populations but low abundance of target species such as giant clams (Tridacna) and sea cucumbers, COTS populations are also low. Fish biomass by underwater visual census on belt transects; percent cover by point intercept transects; data <4m depth. Values are means with standard deviation (SD).

Manus has the smallest land area and population of any PNG province with about 500 people on Andra Island and 900 on Ahus Island. The Andra community has a customary monopoly to supply local and provincial capital markets with lime from scleractinian corals to chew with betelnut. Whilst this has reduced their reliance on other marine products, most noticeably

Tridacna spp., clams and sea cucumber, the *Acropora* cover on Andra is low compared to Ahus (5.4% compared to 10.6%). The locals on Andra Island perceive that the condition of marine resources has declined over the past 5 years and will continue to decline for the next 5 years.

IMPRESSIONS OF PNG REEFS AFTER 33 YEARS OF DIVING

Coral reefs are not monuments, but are very dynamic. I witnessed a COTS invasion of the reefs around Milne Bay in the early 1980s that wiped out almost all of the hard corals but within 5 years the reef had regenerated. These are now 'old' reefs with very large plate and other corals that are breaking, simply because of their large size. In 2008 there is a moderate outbreak of COTS on some reefs again. I also witnessed massive coral bleaching with large scale mortality (1996 and 1998); there have been no serious bleaching events since. The bleaching in both instances followed a change in current direction, from the north bringing warmer water. My principal observation is that recovery of coral reefs is swift if water quality is good. I have also observed and photographed a vibrant, healthy (almost exuberant!) coral reef where volcanic CO_2 bubbles to the surface. It is interesting that those corals tolerate the presumably acidic conditions, although water pH was not measured. There is also a healthy seagrass bed, and barren areas where the vents and sea floor are hot. In Port Moresby where a sewage outfall was built into the lagoon, rapid and chronic deterioration of the reefs occurred. Reefs that have suffered trauma through dynamite or ship grounding appear to take much longer to recover. In my view, the biggest degradation of reefs is due to kilometres of long lines strung over them and over-fishing of sharks, whose populations have very obviously fallen dramatically! Another area of concern to me is near Sanaroa Island in D'Entrecasteaux group where sea fans appear to have a disease; notably a gold mine recently opened in the area. There are plenty of reefs that are as good as they were 35 years ago, some better and some worse. Chronic pollution is not a problem for most of the country. In the Bismarck Sea, corals are in excellent condition in water temperatures that hover around 30°C most of the year. Although some reefs are affected by problems, most reefs in PNG remain relatively pristine and are in good condition (from Bob Halstead, a diving industry pioneer in PNG; http://www.halsteaddiving.com)

Madang: Madang is on the north coast of PNG and the Madang Lagoon is the largest and most ecologically diverse lagoon along this coast. In 2002, 652 species of reef fishes had been recorded on the fringing reefs to about 30 m depth; representing about 61% of PNG's known fauna and 24 % of the Indo-West/Central Pacific. Madang has 4 Wildlife Management Areas (WMAs) established with local communities at Tab, Sinub, Tabad and Laugum islands. These WMAs cover 1085 ha of coral reef, mangrove, seagrass and open sea habitat (approximately 27.1% of Madang Lagoon): approximately 5.9% is protected from all extractive use; 17.8% is 'high level' managed fishery with only line fishing permitted; and 3.4% is 'low level' managed fishery with subsistence fishing allowed using non-destructive methods. The Tab Island WMA is important for dive tourism and as a year round fish spawning site. Monitoring around Madang has been conducted since the mid 1990s: by the Christensen Research Institute (CRI) until 1996 and then by Wetlands International-Oceania. Previous surveys (reported in *Status: 2004* report)

suggest that Madang Lagoon has relatively high coral cover (35–40%) but suggested declines in top predators and an increase in macro-algae. WWF are currently working in Madang. More information on LMMAs in PNG:

- http://www.lmmanetwork.org/Site_Page.cfm?PageID=42

Future Health of the Coral Reefs

The coral reefs of Australia and PNG are in relatively good condition and, combined with the remote location of many reefs and relatively small populations, the overall prognosis for these reefs is good. This is especially the case for Australian reefs such as the GBR which have comprehensive and effective management. However, many pressures remain. Climate change remains the major significant threat to coral reefs in the region, along with emerging climate related threats such as ocean acidification. The threat of climate change requires that reef resilience is maximised wherever possible. This will require effective management of fisheries and other extractive activities as well as effective, on-ground management of coastal development, water quality and pollution. Successfully managing these pressures will maintain ecosystem function and subsequently maximise resilience to the potential impacts of climate change. Effective MPA networks are seen to be a critical part of maintaining resilient reef ecosystems and well designed and managed MPAs are showing a variety of positive effects at sites across Australia and PNG.

Australia is in the enviable position of having strong community and political commitment to manage coral reefs resources and the capacity to do so. Unfortunately this capacity is weaker in PNG where marine resource management is largely reliant on NGOs working with local communities and governments at specific sites. However, there are promising signs of increasing awareness and successes in these areas which may represent a cause for cautious optimism.

Nevertheless, climate change presents a serious medium to long-term threat to coral reefs in Australia and PNG and it is certainly conceivable that some reefs may be degraded to the point where they cease to have viable coral communities while others may undergo phase shifts to persistent alternative states. Hence, efforts to maintain reef resilience should be complemented by efforts to address global climate change.

Recommendations

- Addressing the root causes of climate change as well as taking action to maintain reef resilience is essential;
- Continue to establish and maintain effective management plans that include networks of MPAs and 'no-take' areas that provide ecologically connected refuges for coral reef species and manage the use of marine resources;
- Implement effective integrated coastal management to address pressures from declining water quality and coastal development, industrial use, land clearing, logging, agriculture and mining;
- Ensure that extractive uses such as fishing are sustainable and are adequately managed;
- Maintain capacity in research, monitoring and management in Australia and encourage major increases in capacity in WA;

- Improve coordination and management of information about coral reefs so that information is stored appropriately, traceable and retrievable; and
- Increase capacity and support for research, monitoring and management in PNG and build support for a coordinated program to implement MPAs and land and marine resource management programs with local communities, as well as programs to monitor any social and environmental changes resulting from such programs.

Author Contacts

Andrew Chin, James Cook University, Townsville, Andrew.chin@jcu.edu.au; Hugh Sweatman, Australian Institute of Marine Science, Townsville, h.sweatman@aims.gov.au; Susan Forbes, Department of the Environment, Water, Heritage & the Arts, Canberra, susan.forbes@environment.gov.au; Helen Perks and Fraser Hartley, Wildlife Conservation Society, PNG Marine Program, helenaperks@yahoo.com; Geoff Jones, David Williamson and Richard Evans, James Cook University , Shannon Armstrong and Kevin Bancroft, Department of Conservation, Western Australia; Hamish Malcolm, NSW Marine Parks ; Graham Edgar, University of Tasmania; Joe Valentine, Aquenal Pty Ltd , Bob Halstead, Bob Halstead Diving.

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TIMOR-LESTE: THE FIRST CORAL REEF STATUS REPORTS

Timor-Leste became independent in 2002 as a country with widespread poverty and malnourishment. Coastal villages rely heavily on seafood from the nearby coral reefs; thus, there is a strong risk that reef degradation or over-harvesting could result in ecological collapse, with on-going problems for the local people. Coral reefs around Ataúro Island (30 km north of the capital Díli) and at Behau (41 km east of Díli) were assessed in 2004, 2005 and 2008. At Ataúro, there were relatively large areas of recently dead corals, probably due to destructive fishing. The larger commercial reef fish (groupers, *Serranidae*, and snappers, *Lutjanidae*; larger than 40 cm) were rarely observed, and it appeared that smaller species, such as butterflyfish *(Chaetodontidae)*, were being targeted by fishers. The situation of the corals at Behau is quite different. The reef is widely used by recreational SCUBA divers and although live coral cover and total live cover were lower than at Ataúro Island, no coral bleaching or recently killed corals were recorded. Commercial fishes were also seldom observed at Behau (K41 station), although the condition was slightly better than Ataúro.

Reef degradation and over-harvesting of reef species occurs throughout the country. Probably, the first large-scale damage to the East-Timorese reefs occurred during Indonesian occupation (1975–1999), when thousands of people were forcibly displaced from the mountains to the coast in an attempt to control the independence movement. This resulted in increased fishing pressure over the reefs. Other human impacts include: blast fishing introduced by Indonesian fishermen (although this is illegal under new legislation, it occurs along the northern coast using military explosives from army/guerrilla contacts); spear fishers destroying corals in attempts to increase fish catches; damage during the construction of fish traps; mining of coral for lime for chewing betel nut (mama-malus) which reduces hunger pains; marine and terrestrial debris, mainly domestic, that entangles the reef framework; cyanide fishing; and fishing with *Acanthua* tree branches which contain a toxin to stun fish. The East-Timorese National Directorate of Fisheries and Aquaculture is establishing coral reef monitoring to evaluate reef areas and measure the extent of human impacts in order to improve coastal management (from Leo Dutra, Shane Penny, Narciso Carvalho, Carlos de Jesus, Constâncio S Silva, Anselmo Amaral, José Nunes, Lucas Fernandes, Celestino da Cunha, Benedito Trindade, Wayne Lovell, leo.dutra@csiro.au).