Biodiversity and Conservation Priorities of Reef-building Corals in Bali, Indonesia

Authors: Turak, Emre, and Devantier, Lyndon

Source: Bali Marine Rapid Assessment Program 2011: 78

Published By: Conservation International

URL: https://doi.org/10.1896/054.064.0106

Chapter 5

Biodiversity and Conservation Priorities of Reef-building Corals in Bali, Indonesia

Emre Turak and Lyndon DeVantier

EXECUTIVE SUMMARY

This report describes the results of surveys of biodiversity and status of coral communities of Bali, surveyed in November 2008 (Nusa Penida area) and April–May 2011 (main island). This area forms part of the Nusa Tenggara region of the Lesser Sunda Islands, at the southern edge of the Coral Triangle (CT), earth's most diverse tropical marine province. The surveys were designed to assess biodiversity and ecological condition and identify sites of conservation priority, towards expanding and improving functionality of the Marine Protected Areas network. The surveys formed part of a collaborative project between Conservation International and partners, including the Indonesian Department of Nature Conservation (PHKA), the Indonesian Ministry of Marine Affairs and Fisheries (MMAF), the Indonesian Institute of Sciences (LIPI).

A total of 85 stations (adjacent deep and shallow areas) at 48 sites (individual GPS locations) were surveyed. Coral communities were assessed in a broad range of wave exposure, current and sea temperature regimes, and included all main habitat types: cool water rocky shores, cool water reefs with broad flats, warm water reefs with broad to narrow flats, and coral communities developed on predominantly soft substrate.

The survey area is characterized by highly localized, consistent variation in several key parameters for coral growth and reef development: current flow (ranging from ca < 1 knot to > 4 knots), temperature regime (ranging during this study from ca 23–30 C, but declining to 16 C at times) and wave energy regime (ranging from ca < 1 m – 5 m), associated respectively with exposure to the Indonesian Throughflow in Lombok Strait, localized upwellings and long-period ocean swells from the Indian Ocean.

Species richness and undescribed species

Bali host a diverse reef coral fauna, with a confirmed total of 406 reef-building (hermatypic) coral species. An additional 13 species were unconfirmed, requiring further taxonomic study. At least one species, *Euphyllia* spec. nov. is new to science, and a second, *Isopora* sp., shows significant morphological difference from described species, such that there are likely to be more than 420 hermatypic Scleractinia present, in total. Notably, several widespread species exhibit consistent local morpho-types around Bali.

Within-station (point) richness around Bali averaged 112 species (s.d. 42 spp.), ranging from a low of just two species (at site B22, a muddy non-reefal location) to a high of 181 species at B16 (Jemeluk, Amed). Other species-rich sites included Menjangan N (168 spp., site B26) and Penutukang (164 spp., site B21). These results for site and overall richness are similar to those from Bunaken National Park and Wakatobi (392 and 396 spp. respectively), higher than for Komodo and Banda Islands (342 and 301 spp.), and lower than Derewan, Raja Ampat, Teluk Cenderwasih, Fak-Fak/Kaimana and Halmahera (all with more ca 450 spp. or more).

Community structure

At site level, 5 major coral community types were identified, related to levels of exposure to waves, currents — upwelling, substrate type and geographic location. These five communities were further sub-divided into 10 main coral assemblages. Each of the five communities was characterized by a more-or-less distinctive suite of species and benthic attributes.

Coral cover

Cover of living hard corals averaged 28 %. Dead coral cover was typically low, averaging < 4 % overall, such that the overall ratio of live : dead cover of hard corals was highly positive (7 : 1), indicative of a reef tract in moderate to good condition in terms of coral cover. Areas of high soft coral cover occurred on rubble beds, likely created by earlier destructive fishing, coral predation and the localized dumping of coral down-slope during creation of algal farms. Minor evidence of recent and not-so-recent blast fishing and coral diseases were also present, the latter typically on tabular species of *Acropora*. Some localized damage from recreational diver impacts, was also apparent. A very strong stress response, in the form of cyanobacterial growth was likely linked with eutrophication and sewage seepage from coastal tourism development.

Coral injury

The above impacts notwithstanding, corals of Bali exhibited relatively low levels of recent coral injury overall, in terms of the proportion of species present that were injured and the average levels of injury to those species. This was well represented by the large monospecific stands and intact massive corals present, with little evidence of major past disturbances such as coral bleaching-related mortality triggered by elevated or depressed sea temperatures, past outbreaks of coral predators, major destructive fishing activities, diseases or other impacts. This is consistent with the high positive ratio of live:dead coral cover.

Interregional comparisons

Bali's coral faunal composition is typical of the larger region, with most species recorded being found elsewhere in the CT. The overall high similarity in species composition with other parts of Indonesia notwithstanding, several important differences were apparent among these regions in the structure of their coral communities. Bali showed closest similarity to Komodo, also in the Lesser Sunda Islands and subject to a somewhat similar environmental regime in respect of current flow and cool water upwelling. These regions showed moderate to high levels of dissimilarity from most other regions to the north, notably from the more species- and habitat-rich regions of Derewan, Sangihe-Talaud, Halmahera and the Bird's Head Seascape of West Papua.

Conservation priorities

Discovery of an undescribed species of *Euphyllia* on the E coast of Bali, and the presence of other apparently local endemic corals, notably *Acropora suharsonoi*, suggests that the region does have a degree of faunal uniqueness, possibly related to the strong current flow through Lombok Strait. In this respect, the strong ITF currents may, paradoxically, both limit and foster dispersal and recruitment in different areas respectively. Local recruitment around Nusa Penida may be restricted by the currents, which may nevertheless transport larvae further afield. Genetic, reproductive and larval settlement studies would be required to test this hypothesis. If this is the case, then the islands may require careful management of local impacts, as replenishment from outside sources may be a prolonged process.

Coral communities of Nusa Penida differ from those of the main island of Bali, and are subject to different environmental conditions and human uses, and hence may require separate management focus. Reefs of high local conservation status around Nusa Penida include those at Crystal Bay, Toya Pakeh, Sekolah Dasar and N Lembongan (Stations N3, N4, N7, N8, N14 and N17. Reefs of high conservation value around Bali were widespread along the E and N coasts, and include Jemeluk, Menjangan, Gili Tepekong, Penutukang, Bunutan, Gili Selang and Gili Mimpang (Stations B16, B26, B10, B14, B21, B15, B25, B8, B18 and B7).

All the above reefs have strong potential for development of MPAs providing sufficient logistic resources and long-term support are provided. Notably, site 26 at Menjangan already forms part of the marine protected area of Bali Barat. Reefs at Jemeluk (Amed) and around Gili Tepekong, Gili Selang and Gili Mimpang are also of very high conservation value for a number of different criteria. The Batu Tiga area in particular has strong potential for development of an MPA, given that the islands are not inhabited and the reefs are already used regularly for recreational SCUBA diving.

Additionally, the wave exposed S coast community was not thoroughly surveyed because of large ocean swell. Many of these S coast reefs are highly prized for surfing, and as such draw large numbers of tourists to Bali each year. In the latter respect, their future conservation should be considered a priority for maintaining surf tourism on the island. Further offshore, some of these areas are crucial migration corridors for cetaceans and other species.

The presence of cool water upwelling and/or strong consistent current flow in some areas (eg. Nusa Penida, E Bali, as indeed also in Komodo and other areas of Indonesia) may be particularly important in buffering the incident reefs against rising sea temperatures associated with global climate change.

There is significant potential for development of MPAs providing sufficient logistic resources and long-term support are provided. Continuing impacts, particularly from litter and other forms of pollution and from poorly regulated / managed tourism development, are of concern. In respect of establishing the MPA network, the following recommendations are made:

1. A multiple use MPA model, with different areas zoned for different levels of protection and use, is likely to be the most appropriate, given the broad range of activities that already occur on Bali's reefs. However, this model should include adequate core areas excluding extractive activities, to ensure conservation of key habitat and community types and foster replenishment.

2. As far as practicable, the MPA network should include representative and complementary areas encompassing the main coral community types (Figs. 7 and 12), and reefs of high conservation value (diversity, replenishment, rarity, Table 5.10).

3. As far as practicable, the network should include reefs subject to cool water upwelling and/or strong and consistent current flow, as a potential safeguard against increasing sea temperatures associated with global climate change over coming decades. Reefs of Nusa Penida and E Bali, particularly those under the influence of Lombok Strait, should be included in the network.

4. There are many competing uses for Bali's coastal and marine resources, and it will be challenging to achieve the right balance among different levels of protection and use. Given the overwhelming importance of ocean-based toursim (surfing, diving and swimming), particular focus should be paid to maintaining healthy and attractive reef-scapes for these activities, and hence a focus on non-destructive, non-extractive activities in core zones.

5. Once an MPA network is established, enforcement of regulations will be crucial.

6. Consideration should be given to a 'User-pays' system (eg. Bunaken National Park) whereby visitors pay a nominal fee for access. This can provide significant funds for MPA management and benefits to local communities.

In respect of litter and water quality:

7. There is a widespread issue of litter and other forms of water pollution. A number of strategies may be employed / expanded to reduce the amount / impact of plastic and other pollution by: a) encouraging traditional packaging as much as practicable; b) continuing education campaigns in local mass media and schools; c) voluntary and funded litter clean-up activities on beaches and reefs.

8. Aim to improve stream and river water quality to reduce transport of litter / pollutants to reefs by restoring riparian vegetation; and with public education campaigns re inappropriate waste disposal.

5.1 INTRODUCTION

The island of Bali, Indonesia, is situated to the west of and bordering the deep-water Lombok Strait. The larger region, collectively known as the Lesser Sunda Islands, extends from Bali in the west to Timor in the east, and has been characterized as the Lesser Sunda Ecoregion (LSE) (Green and Mous 2007). The region is located on the southern edge of the Coral Triangle (CT), renowned for its globally outstanding marine biodiversity (Figure 5.1).

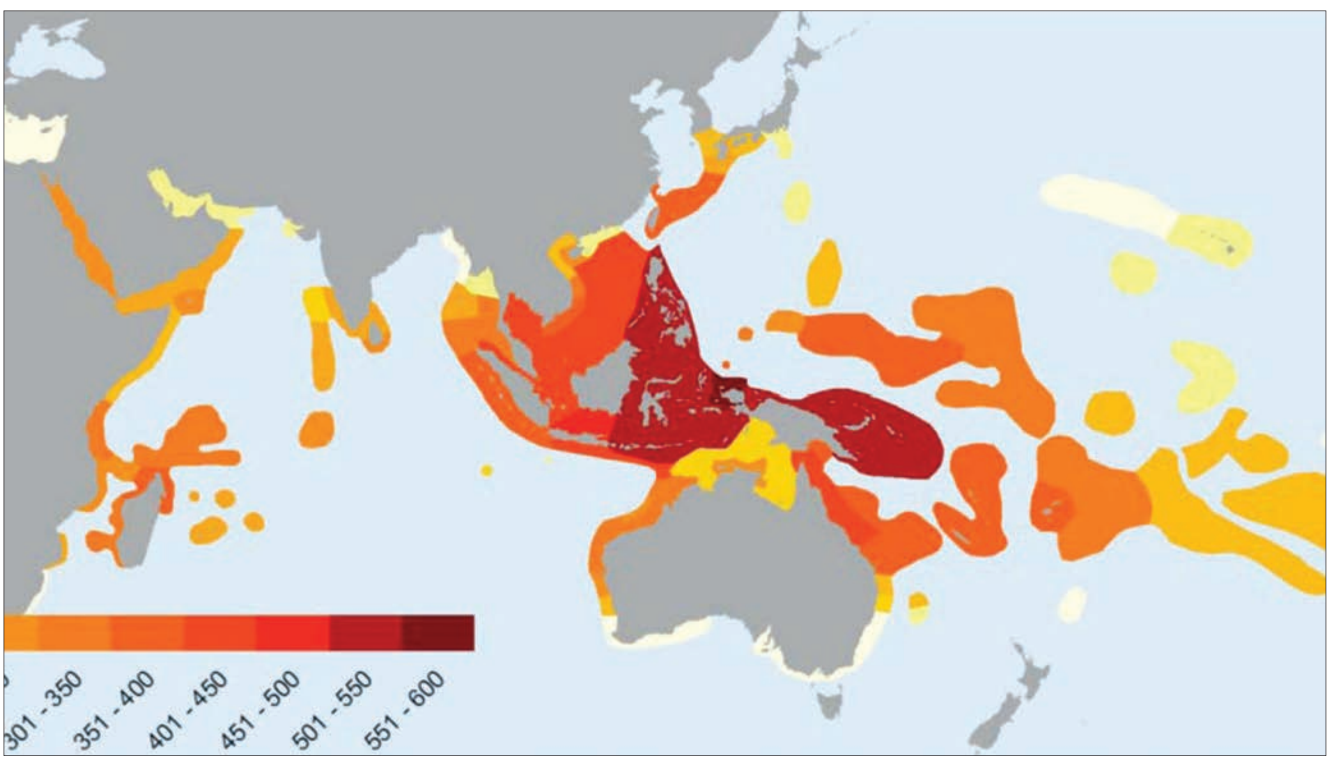

Figure 5.1. The Coral Triangle (dark red, after Veron et al. 2009). Bali is located on the SW corner.

5.1.1 Environmental Conditions and Oceanography

Bali has characteristic oceanography, tectonic–eustatic history and ecological / biological patterns. With the main Lesser Sunda island chain, Bali forms part of the north-western boundary to the Indian Ocean, and provides a major point of differentiation in several key climatological and oceanographic features.

Unlike the adjacent region to the west, which sits atop the Sunda Shelf, and regions much further east (eg. Papua) located atop the Sahul Shelf, the Lesser Sunda islands, with islands to their north, have, during the past several million years, always had deep water adjacent to their coasts. These islands have presumably played a major role as biological refugia during the Pleistocene glaciations, with significant biogeographic implications (eg. Barber et al. 2000):

> *"… there is a strong regional genetic differentiation that mirrors the separation of ocean basins during the Pleistocene low-sea-level stands, indicating that ecological connections are rare across distances as short as 300–400 km and that biogeographic history also influences contemporary connectivity between reef ecosystems."*

The Lesser Sunda Islands, including Bali, appear to be an important transition zone, with distinct faunal elements, including endemic stomatopods, fishes (M. Erdmann, G. Allen pers. comm.) and corals, and distinct coral assemblages (with relatively low coral diversity in some areas due to high wave exposure and currents).

Situated within the doldrums, Bali is sufficiently close to the equator to be unaffected directly by major tropical storms – cyclones and typhoons. There are two monsoon seasons annually, the South-east and North-west monsoons, with episodic torrential rain during the latter, from November to April. The remainder of the year is predominantly dry and hot.

The region is under the influence of the Indian Ocean Dipole (IOD). This caused anomalous upwelling, low sea surface temperatures, and low sea surface heights along the north-eastern Indian Ocean in 1997 (Abram et al. 2004, van Woesik 2004).

"Along with regional upwelling, which led to nutrient enrichment and phytoplankton blooms off the coast of Bali, there was also evidence of macroalgal blooms on the Balinese reefs. … Coral mortality was a consequence of direct physical smothering by these macroalgae. *Acropora* and pocilloporid corals were particularly vulnerable. These corals are among the most ubiquitous, but are also the most susceptible corals in the Indian and Pacific Oceans, and are usually first to respond to any form of perturbation … the anomalously low sea levels associated with the IOD caused direct and prolonged aerial exposure, which lead to considerable coral mortality. … the IOD-related upwelling, independent of the wildfires, caused significant coral mortality that may have extended for at least 4000 km..." *(van Woesik 2004).*

The precise eastern extent of the influence of the 1997 IOD is not known, although the exceptionally high Chlorophyll A concentrations of September 1997 did not appear to extend eastwards beyond Bali. Strong ocean mixing typically influences both the nutrient concentrations and sea surface temperature. Sea surface productivity, as exemplified by Chlorophyll A concentration, is patchy both spatially and temporally. Waters to the south of the main island chain have higher concentrations than those to the north. Sea surface temperatures are typically cooler along the southern (Indian Ocean) coasts, particularly in the eastern and central areas (eg. Figure 5.4, May 2004). The northern coasts are usually warmer, other than in highly localized areas of upwelling.

South- and south-west facing coasts are exposed to long period ocean swell episodically exceeding 5 m height from the Indian Ocean, generated by tropical–temperate storms, many of which are thousands of km away. Bali and Lombok each host active volcanoes and the area is subject to episodic earthquakes. Tsunamis can be generated by the tectonic activity.

On its eastern shore, Bali borders Lombok Strait, with water depths greater than 1,000m in places. Lombok Strait is a major corridor of the Indonesian Throughflow (ITF), transporting Pacific Ocean water through Indonesia to the Indian Ocean. Although the main direction of water transport is from north – south, there is limited water exchange in the opposite direction. The ITF exports warm, lower salinity water from the North and central-west Pacific, providing a major water source for the north-east Indian Ocean.

> *"A net transport of nearly 20 million m3/s (Godfrey 1996) … from the Pacific into the Indian Ocean through the Indonesian Archipelago. Originating from the Pacific, Indonesian Throughflow waters enter the Celebes Sea, move southward at velocities up to 1 m/sec (Wyrtki 1961) through the Makassar Strait, spread south and east into the Flores and Banda Seas, and ultimately exit between the Lesser Sunda Islands (Gordon & Fine 1996). Seasonally reversing east–west currents up to 75 cm/s in the Java and Flores Seas (Wyrtki 1961) further mix the surface waters."* (Barber et al. 2002).

Localized upwellings are generated by the ITF, where sea temperatures can differ by as much as 14 C within several km (ranging from 16–30 C). In addition to the effects of the ITF, local sea surface current patterns around Bali and adjacent islands are influenced by seasonal, tidal, wind and wave forcing. The long period ocean swells of the Indian Ocean impacting on the southern coastlines are likely to provide a major differentiating factor in species composition and community structure. These attenuate more or less gradually as the swell dissipates as it propagates northward between the islands.

5.1.2 Biological and biogeographical patterns and endemism

Perhaps paradoxically, the main areas of through-flow (eg. Lombok Strait) may be considered as both contributing to and restricting dispersal (see later). The local currents may prove as important as the influence of the ITF in connecting and isolating local populations.

> "[While] *broad-scale oceanographic data may provide reasonable dispersal predictions…, other data may over-simplify the currents experienced by larvae that originate in near-shore environments. Eddies, stagnation zones, and local reversals of long shore currents are common in coral-reef systems, as are seasonal, tidal and weather-driven changes in current flow … These mesoscale coastal current patterns may greatly influence larval movements … and local retention … and are implicated in the formation of discrete population units … as well as in genetic structuring"* (Barber et al. 2002).

The larger Lesser Sunda Islands region hosts more than 500 species of scleractinian reef-building corals (523 species; Veron et al. 2009). Prior to the present study, a total of 12 taxonomic sites, centred on Bali and the N coast of Flores, and 104 ecological survey sites, centred on Komodo, W Lombok and W Timor – Roti, had been assessed (the former by Charlie Veron, the latter by the present authors). These locations are each dissimilar from the others, however the degree to which these locations are unique or representative of larger areas is presently unquantified.

Within the Lesser Sunda Islands, there are several sources of differentiation in respect of coral species composition and patterns in community structure, primarily caused by local – regional differences in oceanography, especially upwelling and ocean swell. Another key factor is suitability of habitat and substratum. Coastlines of Bali and adjacent islands have been formed predominantly by limestone, indicating earlier periods of reef growth and deposition.

The larger region ('southern island arc') was identified as an important area of endemism within the Coral Triangle (Erdmann and Manning 1998, Wallace 1994, 1997, Allen 2007, Veron et al. 2009), hosting species that are, on present data, considered endemic or sub-endemic (occurring more or less sparsely in other areas within the CT). These discovered in the vicinity of the present study are listed below with their author and place of discovery.

Acroporidae

- *Acropora suharsonoi* Wallace, 1994 (Lombok)
- *Acropora sukarnoi* Wallace, 1997 (Bali)
- *Acropora parahemprichii* Veron, 2002 (Bali)
- *Acropora minuta* Veron, 2002 (Bali)
- *Acropora pectinatus* Veron, 2002 (Bali)

Poritidae

- *Alveopora minuta* Veron, 2002 (Bali)

Fungiidae

- *Halomitra meierae* Veron, 2002 (Bali)

Several of these species (eg. *Acropora pectinatus, Acropora sukarnoi, Alveopora minuta*) have subsequently been found elsewhere. Nevertheless, the Bali – Lombok area appears particularly interesting in respect of coral endemism.

5.1.3 Socio-economy

Bali's traditional lifestyle relied primarily on various forms of subsistence agriculture and fishing, the former flourishing on the rich volcanic soils from Bali's active volcanoes, the latter on the rich marine coastal life. This began to change rapidly in the early 1970s, with the arrival of the first wave of international travellers; and over the subsequent 40 years, surf, beach, dive and cultural tourism have all burgeoned, collectively accounting for some 80 % of the economy in the early 21st century. The following quotes are excerpted from the project background document for the present survey (M. Erdmann, CI Indonesia Marine Program):

> *"Bali's rich marine resources have long been an important economic asset to the island—both as a source of food security for local communities (many of whom derive a significant proportion of their animal protein needs from seafood) and also as a focus for marine tourism. Diving and snorkeling attractions such as Nusa Penida, Candi Dasa, Menjangan Island (Bali Barat National Park), and the Tulamben USS Liberty wreck have been drawing tourists into Bali's water for decades, while more recently the private marine tourism sector has expanded the menu of options to include sites like Puri Jati, Karang Anyar, and Amed. Other important economic activities in Bali's coastal zone include seaweed farming and ornamental fish collecting."*

5.1.4 Development

A census of Bali's population in 2010 recorded 3,891,428 people, increasing steadily from the 2,469,930 people present in 1980, the 2,777,811 people present in 1990 and the 3,150,057 people present in 2000 (http://www.citypopulation.de/Indonesia-MU.html). The rapid increase in population and support infrastructure over the past several decades has, however, come at significant environmental cost:

> *"Unfortunately, rapid and largely uncoordinated development in Bali's watersheds and coastal areas, along with a lack of clear marine spatial planning for the island, has led to significant deterioration of many marine environments around Bali due to a combination of overfishing and destructive fishing, sedimentation and eutrophication from coastal development, sewage and garbage disposal at sea, and dredging/reef channel development. At this point in time, the long-term sustainability of the many important economic activities occurring in Bali's coastal zone are in question."*

5.1.5 Planning for future sustainability

Given these increasing levels of threat and impact to Bali's marine and terrestrial resources, the Bali Government is presently working towards a comprehensive long-term development strategy for the island, including greatly improving spatial planning in both the terrestrial and marine areas of Bali (M. Erdmann, CI Indonesia Marine Program):

> *"One important part of this initiative has been the decision by the Bali Government to design and implement a comprehensive and representative network of Marine Protected Areas around the island that prioritizes sustainable and compatible economic activities (including marine tourism, aquaculture and sustainable small-scale fisheries).*
>
> *To initiate the planning for this network of MPAs, … (a) multistakeholder workshop … was organized by the Marine Affairs and Fisheries Agency of Bali Province, in collaboration with the Bali Natural Resources Conservation Agency (KSDA), Warmadewa University, Udayana University, USAID, Conservation International (CI) Indonesia and local NGOs within the framework of a "Bali sea partnership". The Bali MPA Network workshop was attended by 70 participants from the provincial government, regency governments, universities, NGOs, private sectors, community groups, traditional villages forum and fishermen groups.*
>
> *Importantly, the workshop participants identified 25 priority sites around Bali as the top candidates for inclusion in a network of MPAs for the island* (Figure 5.2). *This list of sites included existing national/local protected areas such as Bali Barat National Park/Menjangan Island, Nusa Penida, and Tulamben, while also including a number of additional sites that currently have no formal protection."*

5.1.6 Rationale and assessment objectives

Following the 2010 workshop, CI was asked by the Bali government, via the provincial Marine Affairs and Fisheries Agency, to lead a team of local and international experts in surveying candidate MPA sites, the results to be used to provide clear recommendations on priority development sites and next steps for the design of the MPA network.

> *"The team has been requested to build upon the survey data compiled during the November 2008 CI-led "Marine Rapid Assessment" of the Nusa Penida reef system to provide a more comprehensive report on the biodiversity, community/assemblage structure, and current condition of coral reefs and related ecosystems around Bali. Based upon this information, the team is to provide recommendations on how to best prioritize the 25 candidate sites for inclusion in an ecologically-representative network of MPAs. This information will be used to finalize the MPA network development plan and to justify/socialize these plans to government and local community stakeholders, so must be*

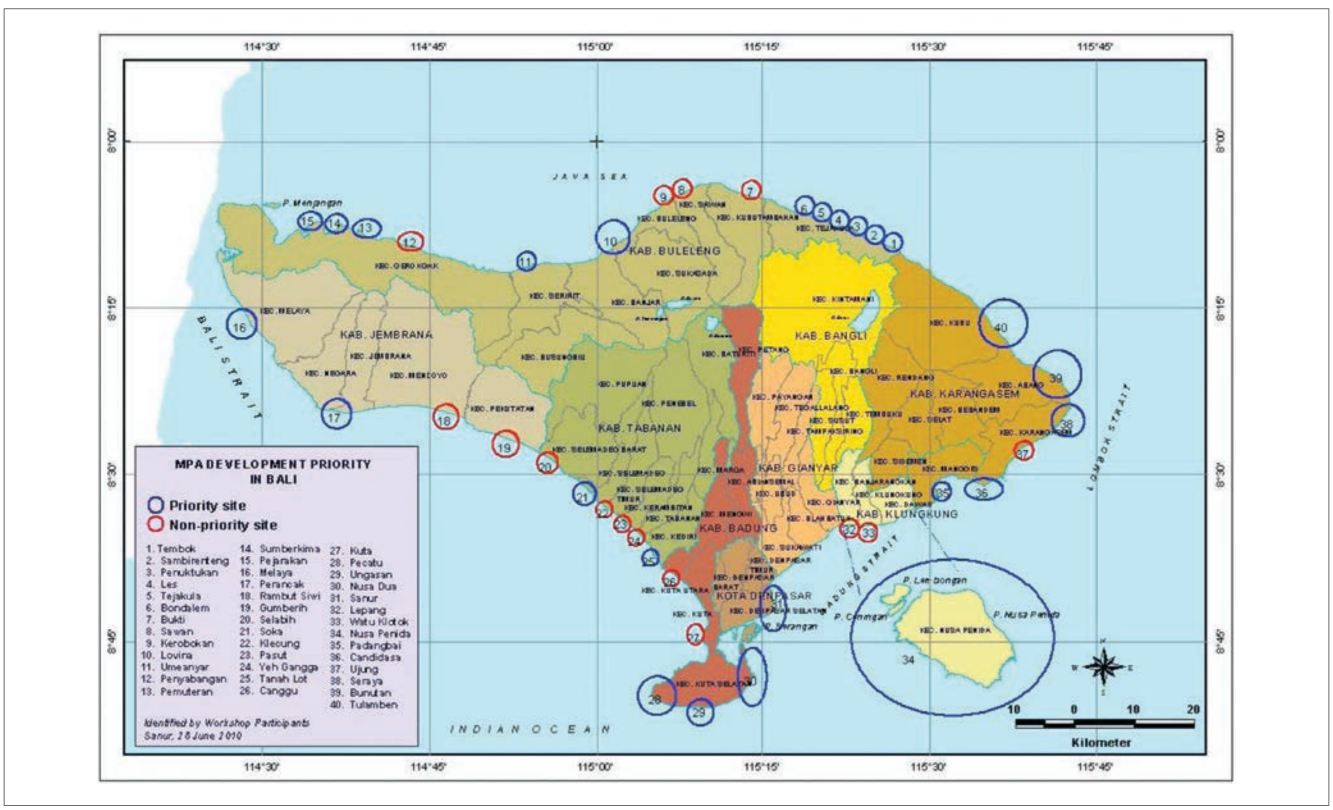

Figure 5.2. Candidate priority and non-priority sites identified during the Bali MPA workshop, June 2010.

compiled in a manner that is easily understood by a lay people audience." (M. Erdmann, CI Indonesia Marine Program 2011).

The assessment, conducted during the period of April–May 2011, has the following three primary objectives:

- Assess the current status including biodiversity, coral reef condition and conservation status/resilience of hard corals of the 25 candidate MPA sites around the island of Bali identified by the June 2010 Bali MPA Network workshop. Thorough species-level inventories of each of these groups will be compiled.

- Compile spatially-detailed data on biological features which must be taken into consideration in finalizing the Bali MPA Network design. This includes not only an analysis of any differences in reef community structure of the 25 priority sites, but also specifically identifying areas of outstanding conservation importance due to rare or endemic hard coral assemblages, reef communities exposed to frequent cold-water upwelling that may be resilient to global climate change, or other outstanding biological features.

- Taking the above into account, provide concrete recommendations to the Bali government on the next steps to be taken to finalize the design of the Bali MPA Network.

In addressing these objectives, this study documents coral species composition, community structure and ecological status of the reef-building corals of Bali. These results were compared with those of previous surveys in the "Coral Triangle" region, specifically with Nusa Penida and adjacent islands, Derewan (Berau, East Kalimantan, 2004 TNC REA), Sangihe-Talaud region (N Sulawesi, 2001 TNC REA), Bunaken National Park (N Sulawesi, 2003, IOI), Raja Ampat (including 2001 CI Marine RAP and 2002 TNC REA), Cenderawasih Bay (2006 CI Marine RAP), the FakFak/Kaimana Coastline (2006 CI Marine RAP). The goal was to quantitatively assess ecological and taxonomic similarities in coral assemblages across this section of the Coral Triangle.

5.2 METHODS

Rapid Ecological Assessment (REA) surveys were conducted using SCUBA at 31 reef locations (each with a specific GPS position) around Bali in April–May 2011, complementing the 17 locations already surveyed around Nusa Penida in 2008 (Figure 5.3, Appendix 5.1). At most locations (stations), deep and shallow reef sites (designated as station #.1 and #.2 respectively) were surveyed concurrently, representing the deeper reef slope (typically > 10m depth) and the shallow slope, reef crest and flat (typically < 10m depth), for a total of 85 stations. Deep stations were surveyed first, in accordance with safe diving practice, with the surveyor swimming initially to the maximum survey depth (usually 30–40 m), then working steadily into shallower waters. In this report, the term 'station' refers to the combined results of the two stations (depths), unless otherwise specified with the specific depth designator (station #.1 and #.2 respectively).

The method was identical to that employed during biodiversity assessments in ca. 35 other regions of Indonesia and the Indo-Pacific, providing the opportunity for detailed comparisons of species diversity, composition and community structure, and of the representativeness and complementarity of different areas in terms of their coral communities. The field and analytical methods are explained in detail elsewhere (eg. DeVantier et al. 1998).

At each station, the survey swim covered an area of approx. one ha in total. Although 'semi-quantitative', this method has proven superior to more traditional quantitative methods (transects, quadrats) in terms of biodiversity assessment, allowing for the active searching for new species records at each station, rather than being restricted to a defined quadrat area or transect line. For example, the present method has regularly returned a two- to three-fold increase in coral species records in comparison with line transects conducted concurrently at the same stations (DeVantier et al. 2004).

Two types of information were recorded on water-proof data-sheets during the ca. one and a half hour SCUBA survey swims at each station:

1. An inventory of species, genera and families of sessile benthic taxa; and

2. an assessment of the percent cover of the substrate by the major benthic groups and status of various environmental parameters (after Done 1982, Sheppard and Sheppard 1991).

5.2.1 Taxonomic inventories

A detailed inventory of sessile benthic taxa was compiled during each swim. Taxa were identified in situ to the following levels:

- stony (hard) corals – species wherever possible (Veron and Pichon 1976, 1980, 1982, Veron, Pichon and Wijsman-Best 1977, Veron and Wallace 1984, Veron 1986, 1993, 1995, 2000, Best et al. 1989, Hoeksema 1989, Wallace and Wolstenholme 1998, Wallace 1999, Veron and Stafford-Smith 2002, Turak and DeVantier 2011), otherwise genus and growth form (e.g. *Porites* sp. of massive growth-form).

- soft corals, zoanthids, corallimorpharians, anemones and some macro-algae – genus, family or broader taxonomic group (Allen and Steen 1995, Colin and Arneson 1995, Gosliner et al. 1996, Fabricius and Alderslade 2000);

- other sessile macro-benthos, such as sponges, ascidians and most algae – usually phylum plus growth-form (Allen and Steen 1995, Colin and Arneson 1995, Gosliner et al. 1996).

At the end of each survey swim, the inventory was reviewed, and each taxon was categorized in terms of its relative abundance in the community (Table 5.1). These ordinal ranks are similar to those long employed in vegetation analysis (Barkman et al. 1964, van der Maarel 1979, Jongman et al. 1997).

For each coral taxon present, a visual estimate of the total amount of injury (dead surface area) present on colonies at each station was made, in increments of 0.1, where 0 = no injury and 1 = all colonies dead. The approximate proportion of colonies of each taxon in each of three size classes was also estimated. The size classes were 1–10 cm diameter, 11–50 cm diameter and > 50 cm diameter (Table 5.1).

Taxonomic certainty: Despite recent advances in field identification and stabilizing of coral taxonomy (e.g. Hoeksema 1989, Veron 1986, Wallace 1999, Veron 2000, Veron and Stafford-Smith 2002), substantial taxonomic uncertainty and disagreement among different workers remains (Fukami et al. 2008). This is particularly so in the families Acroporidae and Fungiidae, with different workers each providing different taxonomic classifications and synonymies for various corals (see e.g. Hoeksema 1989, Sheppard and Sheppard 1991, Wallace 1999, Veron 2000). The analyses herein rely on our synthesis and interpretation of these revisions and with particular reliance on the species distribution maps of Veron (2000), currently being updated in the biogeographic database Coral Geographic (www.coralreefresearch.org).

Extensive use of digital underwater photography and a limited collection of specimens of taxonomically difficult reef-building coral species were made, in collaboration with Indonesian colleagues, notably Mr. Erdi Lazuardes of CI Indonesia, and the Indonesian Institute of Sciences, to aid in confirmation of field identifications.

Small samples, usually < 30 cm on longest axis, were removed from taxonomically-difficult corals in situ, leaving the majority of the sampled colonies intact. Living tissue was removed from the specimens by bleaching with household bleach. Many of these specimens were identified, using the above reference materials, during and following the survey, and have been deposited for short-term storage at the CI Office, Bali.

5.2.2 Benthic cover and reef development

At completion of each survey swim, six ecological and six substratum attributes were assigned to 1 of 6 standard categories (Table 5.2), based on an assessment integrated over the length and depth range of the swim (after Done 1982, Miller & De'ath 1995). Because the cover estimates apply for the area and depth range over which each survey swim was conducted (eg. ca 40 – 9m depth; 8 – 1m depth respectively), these may not correspond precisely with line transect estimates made at a single depth or set of depths (ed: see Chapter 3).

The stations were classified into one of four categories based on the amount of biogenic reef development (after Hopley 1982, Hopley et al. 1989, Sheppard & Sheppard 1991):

1. Coral communities developed directly on non-biogenic rock, sand or rubble;
2. Incipient reefs, with some calcium carbonate accretion but no reef flat;
3. Reefs with moderate flats (< 50m wide); and
4. Reefs with extensive flats (> 50m wide).

Table 5.1. Categories of relative abundance, injury and sizes (maximum diameter) of each benthic taxon in the biological inventories.

Rank	Relative abundance	Injury	Size frequency distribution
0	absent	0–1 in increments of 0.1	proportion of corals in each of 3 size classes: 1) 1–10 cm 2) 11–50 cm 3) > 50 cm
1	rare		
2	uncommon		
3	common		
4	abundant		
5	dominant		

Table 5.2. Categories of benthic attributes

Attribute		Ranks used in calculating Replenishment index CI	
Ecological	**Physical**	**% cover**	**Rank**
Hard coral	Hard substrate	0	0
Dead standing coral	Continuous pavement	1–10 %	1
Soft coral	Large blocks (diam. > 1 m)	11–30 %	2
Coralline algae	Small blocks (diam. < 1 m)	31–50 %	3
Turf algae	Rubble	51– 75 %	4
Macro-alga	Sand	76–100 %	5

The stations were also classified arbitrarily on the degree of exposure to wave energy, where:

1. sheltered
2. semi-sheltered
3. semi-exposed
4. exposed

The depths of the stations (maximum and minimum in m), average angle of reef slope to the horizontal (estimated visually to the nearest 10 degrees), and underwater visibility (to the nearest m) were also recorded. The presence of any unique or outstanding biological features, such as particularly large corals or unusual community composition, and evidence of impacts, were also recorded, such as:

- sedimentation
- blast fishing
- poison fishing
- anchoring
- bleaching impact
- crown-of-thorns seastars predation
- *Drupella* snails predation
- coral diseases

All data were input to EXCEL spreadsheets for storage and analysis of summary statistics.

Rarity index

The presence of species that are rare in the study area may afford some stations greater importance than others in terms of the conservation of biodiversity of corals. An index, *RI*, to indicate the relative importance of stations based on their compliment of rare coral species was calculated for each station (after DeVantier et al. 1998):

$$RI = (\sum A_i / P_i)/100$$

where A_i=abundance rank for the *i*th coral taxon at a given station (1-5, as in Table 5.2), and P_i=the proportion of all stations in which the taxon was present. This index weights species on a continuum according to their frequency in the data set, and gives highest values to stations which are least representative or most unusual faunistically (ie. with high abundance of taxa which are rare in the data set).

Coral Injury

Each coral species in the stations was assigned a score for its level of injury, from 0–1 in increments of 0.1 (from 0: no injury to any colony of that species in the station to 1: all colonies of the species were dead, see Methods above). Stations were compared for the amounts of injury to their coral communities, for the proportion of the total number of species present in each station that were injured, and the average injury to those coral species in each station.

Coral community types

Site groups defined by community type were generated by hierarchical cluster analysis using abundance ranks of all corals in the individual station inventories. The analysis used Squared Euclidean Distance as the clustering algorithm and Ward's Method as the fusion strategy to generate station groups of similar community composition and abundance. Analyses were conducted on the raw (untransformed) data. The clustering results were plotted as dendrograms to illustrate the relationships among stations in terms of levels of similarity among the different community groups. Two sets of analysis were undertaken:

i. Bali
ii. Various regional analyses of adjacent regions of the CT, including Komodo, Wakatobi, Derewan, Sangihe-Talaud, Banda Islands, Bunaken National Park, Raja Ampat, Cenderwasih Bay and Fak-Fak/Kaimana (Figure 5.4).

To facilitate accurate comparison, all datasets used in the regional analysis had been recorded during various surveys undertaken by the present authors (listed in References).

5.3 RESULTS

5.3.1 Environmental Setting

The full range of reef development occurs throughout the survey area, ranging from coral communities developed directly on non-reefal substrata, to incipient reefs with some accretion, to large sub-tidal and inter-tidal reefs with flats wider than 50 m (Table 5.3, Appendix 5.1). The coral communities were developed from low-tide level to >60 m depth, although most coral growth occurred above 30 m depth, on slopes ranging from <5° (reef flats) to 90° to the horizontal (vertical reef walls), the latter being uncommon (Appendix 5.1). The communities were distributed over exposure regimes from sheltered to highly exposed, related to the degree of protection provided by coastal features from oceanic swells from the Indian Ocean. Large ocean swells during the survey period precluded survey of many highly-exposed S coast locations, although Bali site 4 on the SE coast to the south of Nusa Dua is a relatively exposed site, as are Nusa Penida sites 5 and 6.

Most coral communities were developed in areas of hard reefal or non-reefal substrate (mean of 76% cover) with only small areas of sand (mean 14%), and were subject to variable levels of current flow, ranging from calm to >2 knots, related chiefly to the influence of the ITF through Lombok Strait and tidal movements. There were usually negligible levels of sedimentation, other than at silty sites on the N coast of Bali. The typically low silt levels contributed to the relatively high water clarity, which averaged 15 m, ranging from 3 m to 30 m during the survey period (Table 5.3).

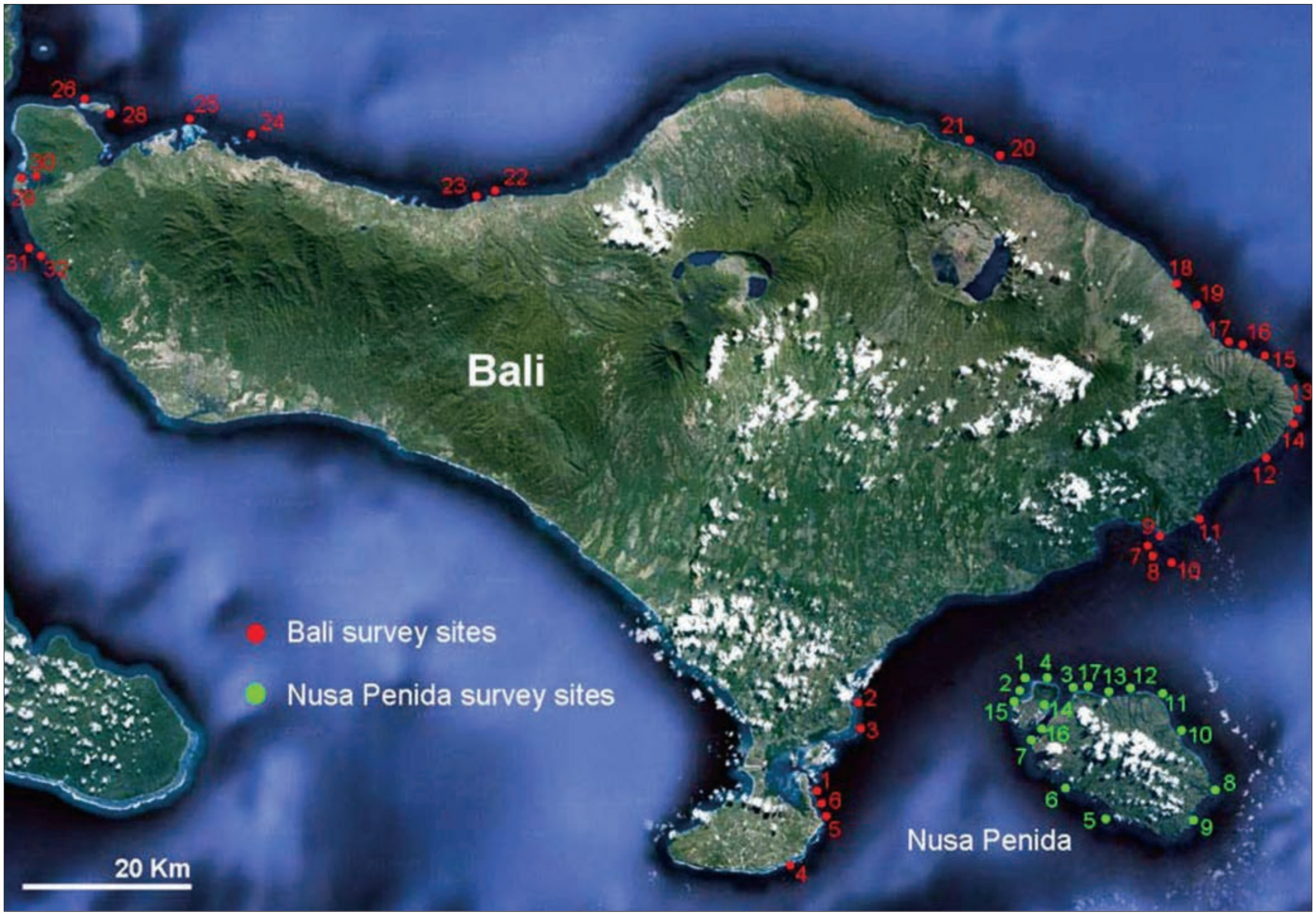

Figure 5.3. Approximate location of survey sites, Nusa Penida (17 sites, October 2008) and Bali (31 sites, April–May 2011).

Figure 5.4. General areas of surveys conducted in regions of the Indonesian section of the Coral Triangle, including Bali and Nusa Penisa, Komodo, Banda Islands, Wakatobi, Derewan, Bunaken, Sangihe-Talaud, Halmahera, Raja Ampat, Teluk Cenderawasih and Fak-Fak/Kaimana. These survey regions are each large and support diverse reef habitats. These were each surveyed as comprehensively as practicable in the limited time available (see References for details).

Around Nusa Penida, many of the large intertidal reef flats are covered with seaweed farms. In the process of establishing and maintaining these farms virtually all live coral has been cleared from the area. While some of the excess material may have been used on land, much of it, in the form of coral rubble, including fairly large blocks, was dumped down the adjacent reef slopes. This activity has resulted into two negative impacts to the fringing reefs. First, virtually no intertidal coral community is now present, resulting in the absence, or extremely rare occurrence, of coral species limited to intertidal areas. Secondly, the loose rubble on the upper slopes is frequently moved around by the action of waves and strong currents, further damaging corals in these areas.

5.3.2 Cover of corals and other sessile benthos

Cover of living hard corals was typically moderate to high (eg. Plates 5.1–5.3), averaging 28 % (Figure 5.5), and ranging from 1–70 %. sites with high live coral cover were widespread (Appendix 5.2). Highest cover (60 % or more) occurred most commonly (but not exclusively) in shallow stations (< 10m depth), notably at Nusa Penida Stations 1.2, 3.1, 7.2 and 17.2 and Bali Stations 15.2, 26.2 and 30.2. Cover was dominated in many stations by large monospecific stands, indicative of the likely importance of asexual reproduction via fragmentation in maintaining high cover locally. Elsewhere, the presence of large intact massive corals, with little or no sign of scarring, was consistent with relatively minor long-term impact from disturbances over the past several decades.

Overall, rubble and dead corals contributed ca. 10 % cover, most of which was in the form of rubble (8 %). sites with high cover of rubble (20 % or more) included Nusa Penida Stations 7.1, 13.2, 14.1 and 15.2 and Bali Stations 7.1, 8.1, 9.1, 9.2, 11.1, 11.2, 15.1 and 16.1. The only stations with relatively high cover of standing dead corals (20 % or more) were Bali Stations 7.1, 9.1 and 9.2. Previous mortality of live corals was mostly attributable to crown-of-thorns seastar and/or *Drupella* snail predation, diseases, or algal growth from localized eutrophication. Low levels of coral diseases, particularly 'White-band' disease, were also apparent, developed primarily on tabular species of *Acropora*. There was, however, only low cover of recently killed corals (< 1 %), and the continuing minor disturbances notwithstanding, the overall ratio of live : dead cover of hard corals remained strongly positive at ca 7 : 1, indicative of a reef tract in good condition in terms of coral cover. The ratio of live hard coral cover to dead corals plus rubble was also positive at ca 5 : 2, and is consistent with these reefs supporting ca. 40 % mean live hard coral cover during periods of low disturbance.

Soft coral cover was moderate, averaging 10 % overall, and high in patches, notably on coral rubble beds. sites with high

Table 5.3. Summary statistics for environmental variables, Bali (including Nusa Penida), October 2008 and April–May 2011

Environmental variable	Mean (s.d.)	Range	Median	Mode
Reef development (rank 1–4)	2.8 (1,1)	1–4	3	4
Slope angle (degrees)	16 (15)	2–90	10	5
Exposure (rank 1–4)	2.4 (0,7)	1–4	2	2
Water Clarity (Visibility m)	15 (8)	3–30	16	20
Hard substrate (%)	76 (25)	0–100	85	90
Sand (%)	14 (18)	0–95	5	5
Water temperature (C)	28.6 (1,2)	23–30	29	29

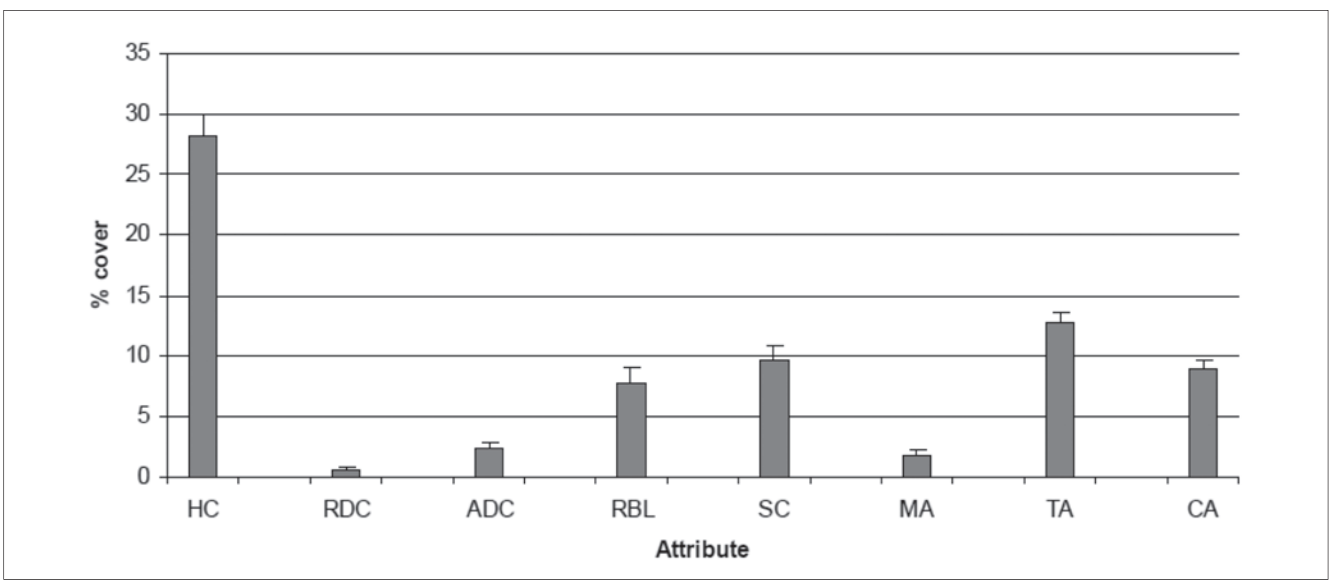

Figure 5.5. Mean % cover (+ s.e.) of sessile benthos, Bali, April–May 2011 and Nusa Penida (October 2008). HC – Hard Coral; RDC – Recently Dead Coral; ADC – All Dead standing Coral; RBL – coral Rubble; SC – Soft Coral; MA – Macro-Algae; TA – Turf Algae; CA – Coralline Algae.

cover (30 % or more) included Nusa Penida Stations 7.2, 12.1, 12.2 and 13.2, and Bali Stations 4.1, 12.1, 12.2, 13.2 and 28.2 (Appendix 5.2).

Diversity of soft corals and related taxa was moderate to high at some of these sites (Plate 5.5 and see later), although typically dominated by stoloniferous taxa, especially xeniids. There was only low cover of macro-algae at most station, averaging < 2 % overall. Only two sites had moderate MA cover (20 %, Nusa Penida Stations 1.2 and 2.2). Cover of turf and coralline algae was low to moderate overall, averaging 13 % and 9 % cover respectively (Figure 5.5).

5.3.3 Species richness

Bali hosts a rich coral fauna of 406 confirmed hermatypic scleractinian species, of which 367 species were recorded from the main island of Bali and 296 species from Nusa Penida. A further 13 species were recorded during the field surveys but remain unconfirmed at present (Appendix 5.3), such that there are likely to be some 420 hermatypic Scleractinia present, in total. One species, *Euphyllia* spec. nov. is new to science (Plate 5.5), and a second species, *Isopora* sp., may also be undescribed (Plate 5.6), showing significant morphological variation from known species in its genus. Additionally, several widespread species exhibit consistent local morpho-types around Bali.

A further ca. 100 species have distribution ranges that include the general area of the Lesser Sunda Islands (Wallace 1999, Veron 2000, Veron et al. 2009), but were not recorded around Bali or Nusa Penida during the present surveys, possible localized disjunctions related to failures of dispersal and / or recruitment (see later).

Of the 406 confirmed species recorded, almost all are shared with other areas of Indonesia (Appendix 5.3 and see later). The overall high degree of biogeographic similarity notwithstanding, differences exist among these areas in terms of the *relative abundances* of the species present. This in turn has had a differentiating effect on coral community structure (see later).

Plate 5.1. High cover of reef-building corals, Nusa Penida Station N1.2, composed predominantly of *Acropora* spp.

Plate 5.2. High cover of reef-building corals, Bali Station B30.2, composed predominantly by *Porites nigrescens* and *Seriatopora* spp.

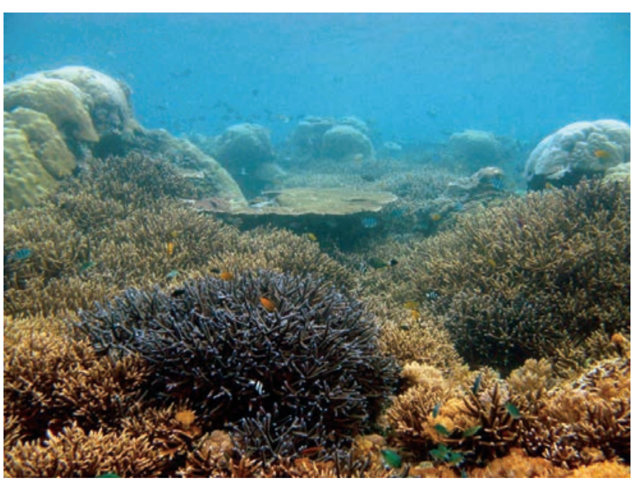

Plate 5.3. High cover of reef-building corals, Nusa Penida Station N4.2, composed predominantly by *Acropora* spp. and *Porites* spp.

Plate 5.4. High patchy cover of soft corals, mostly *Sarcophyton* spp., Nusa Penida Station N16.2.

Within-station (point) richness around Bali averaged 112 species (s.d. 42 spp.), ranging from a low of just two species (at site B22, a muddy non-reefal location) to a high of 181 species at B16 (Jemeluk, Amed). Other species-rich sites included Menjangan N (168 spp., site B26) and Penutukang (164 spp., site B21). These results for site and overall richness are similar to those from Bunaken National Park and Wakatobi, higher than for Komodo and Banda Islands, and lower than Raja Ampat, Teluk Cenderwasih, Fak-Fak/ Kaimana and Halmahera (Table 5.4).

Other hard corals, soft corals and other biota

In addition to the hermatypic Scleractinia, numerous other hard and soft corals were recorded, with greater or lesser taxonomic certainty (see Methods and Table 5.5). These included 3 species of the ahermatypic dendrophyllid *Tubastrea*, the 'blue coral' *Heliopora coerulea*, 5 species of hydroid 'fire corals' *Millepora*, the 'organ-pipe coral' *Tubibora musica* and lace corals *Stylaster* and *Distichopora* spp., including the recently described *Distichopora vervoorti* Cairns and Hoeksema, 1998 (Table 5.5). An additional 57 genera of alcyonacean soft corals, plus zoanthids, corallimorpharians, hydroids and related sessile benthos were also recorded. In particular, xeniid and neptheid soft coral genera were well represented with high abundance. Diversity and abundance of sponges was also exceptionally high.

Rarity

The Rarity Index, which rated sites in respect of the occurrence of species otherwise rare in the Bali data set, revealed a broad range of RI scores, with site B7 (W Gili Mimpang, Batu Tiga) being most unusual faunistically, followed closely by site B16 (Jemeluk, Amed) (Table 5.6).

Reefs of Menjangan, Penutukang, Sumba Kima and Cenigan channel also scored highly, indicating locally unusual coral composition and abundance (Table 5.6). More than one-quarter of coral species in the total species pool were locally uncommon or rare, occurring in four or less of the 48 sites. Thirty-three reef coral species were recorded from only one site, 41 species from two sites, 22 species from three sites and 26 species from four sites.

5.3.4. Coral Replenishment

Stations with high coral diversity, abundance and live cover were considered important for the maintenance and replenishment of populations. These were ranked using a simple

Table 5.4. Comparison of diversity and other ecological characteristics of Bali with other Indo-West Pacific coral reef areas. KO – Komodo National Park; DE – Derewan, East Kalimantan; W – Wakatobi area, S. Sulawesi; BN – Bunaken National Park; S-T – Sangihe-Talaud Isl.; BRU – Brunei Darussalam; RA – Rajah Ampat area, Papua; BI – Banda Isl., Banda Sea, Maluku. Data from Turak 2002, Turak 2004, Turak 2005, Turak 2006, Turak and DeVantier 2003, Turak and DeVantier 2009 Turak and DeVantier in press,, Turak and Shouhoko 2003, Turak et al. 2003.

Attribute	Bali	KO	DE	W	BN	ST	BI	RA	TC	FFK
Total number of species	406	342	449	396	392	445	301	487	469	469
Average no. of species per site	112	100	164	124	155	100	106	131	178	171
% of sites with over ⅓rd species	38	43	78	41	85	8	61	18	79	65
Average % hard coral cover	28	32	36	32	41	21	40,3	33	27	26
Number of sites surveyed	48	21	36	27	20	52	18	51	33	34
Area covered (× 1000 km^2) approx.	3,7	2	20	10	0,9	23	0,4	30	27	12

Plate 5.5. Euphyllia spec. nov., discovered by M. Erdmann, E coast of Bali. Close-up of polyp details.

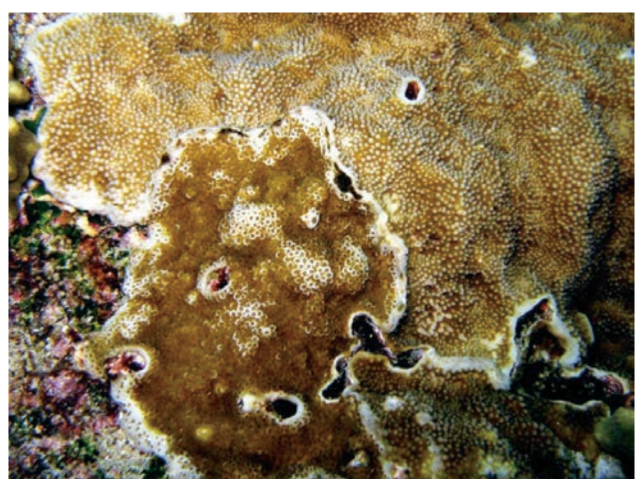

Plate 5.6. Unidentified *Isopora* sp. (center) next to *Isopora palifera* (top and right), Nusa Penida Station N9.2.

Table 5.5. Azooxanthellate scleractinian hard corals, non-scleractinian hard corals, soft corals and other biota recorded in Bali. Results are the number of stations from which each taxon was recorded.

Hard coral taxa	Sites
Scleractinia	
Dendrophylliidae	
Tubastrea micrantha	18
Tubastrea coccinae	14
Tubastrea folkneri	6
Milleporina	
Milleporidae	
Millepora dichotoma	16
Millepora exesa	43
Millepora intricata	10
Millepora platyphylla	18
Millepora tenera	8
Hydroida	
Stylastridae	
Distichopora	4
Stylaster	2
Helioporacea	
Helioporidae	
Heliopora coerolea	18
Alcyonacea	
Tubiporidae	
Tubipora musica	38

Soft coral taxa	Sites
Alcyonacea	
Clavulariidae	
Carijoa	1
Cervera	1
Clavularia	11
Alcyoniidae	
Cladiella	15
Dampia	5
Klyxum	2
Lobophytum	30
Rhytisma	4
Sarcophyton	63
Sinularia spp.	67
Sinularia brascica	
Sinularia flexibilis	10
Nephtheidae	
Capnella	28
Dendronephthya	28
Lemnalia	16
Litophyton	1
Nephthea	40
Paralemnalia	29
Scleronephthya	25
Stereonepthya	2
Umbellulifera	3

Soft coral (*continued*)	Sites
Nidaliidae	
Chironephthya	7
Nephthyigorgia	3
Siphonogorgia	4
Xeniidae	
Anthelia	20
Cespitularia	11
Efflatounaria	13
Heteroxenia	6
Sympodium	3
Xenia	43
Briareidae	
Briareum	28
Anthothelidae	
Alertigorgia	1
Annella	7
Melithaeidae	
Acabaria	1
Melithaea	18
Acanthogorgiidae	
Acanthogorgia	3
Muricella	4
Plexauridae	
Echinogorgia	1
Menella	3
Paraplexaura	1
Villogorgia	1
Gorgoniidae	
Hicksonella	
Pinnigorgia	9
Rumphella	8
Ellisellidae	
Dichotella	5
Elisella	13
Junceella	12
Ifalukellidae	
Ifalukella	1
Isididae	
Isis	3
Pennatulacea	
Veretillidae	
Veretillum	1
Virgulariidae	
Virgularia	2
Pteroeididae	
Pteroeides	1

Other	Sites
Antipatharia	
Antipathidae	
Antipathes	15
Cirrhipathes	19
Zoanthidae	
Palythoa	69
Zoanthus	9
Coralimorpharian	31
Anemon	26
Cerianthus	1
Plumulariidae	2
Aglophenia	30
Lytocarpus philippinus	9

OTHERS	Sites
Spons	31
Cliona	6
Carterospongia	8
Xestospongia	33
Sponge encrusting	25
Sponge massive	17
Sponge blue thin rope	1
Sponge blue tubes	8
Sponge rope	4
Ascidian	
Botryllus	1
Lissoclinum	2
Diademnum	18
Polycarpa	8
Tridacna	
Tridacna crocea	4
Tridacna squamosa	12
Tridacna maxima	17
Echinodermata	
Linckia	18
Culcita	13
Alga	
Halimeda	9
Caulerpa serrulata	7
Dictyosphaeria	15
Turbinaria ornata	12
CRA	33
Peyssonnelia	18
Lamun	
Thalassodendron	3
Halophila ovalis	2
Enhalus	1
Syringodium	1

Table 5.6. Site ranking (scores) for RI from highest to lowest for top 20 sites, Bali. B indicates site on main island of Bali, N indicates site on Nusa Penida and adjacent smaller islands.

Site name	Site No.	RI
West Gili Mimpang (Batu Tiga)	B7	16,22419
Jemeluk, Amed	B16	14,30168
Menjangan North	B26	11,07563
Penutukang	B21	10,40893
Menjangan East	B28	10,13587
Sumber Kima	B25	10,03883
Ceningen channel	N14	9,164788
Taka Pemutaran	B24	8,910188
Batu Kelibit, Tulamben	B18	8,842868
Kepa, Amed	B17	8,476171
Gili Biaha/Tanjung Pasir Putih	B11	8,115602
Tukad Abu, Tulamben	B19	7,867889
East Gili Mimpang (Batu Tiga)	B9	7,466243
Secret Bay, Reef north shore	B30	7,202368
Gretek	B20	6,80481
Malibu Point	N10	6,659188
Crystal Bay South	N17	6,472372
Gili Selang North	B13	6,375295
Batu Abah	N8	6,288729
South of Batu Abah	N9	6,284583

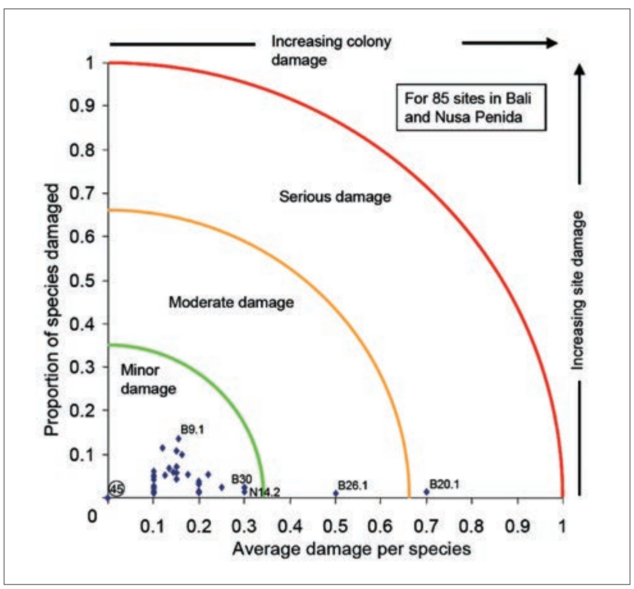

Figure 5.6. Scatterplot of levels of recent injury to reef-building corals in 85 stations, Bali.

coral replenishment index CI (Table 5.7 and see Methods). These were widespread across Bali and Nusa Penida, with highest scoring sites at Jemeluk, Amed (B16), Crystal Bay South (N7), Menjangan North (B26) and Toya Pakeh (N3).

Around Nusa Penida in particular, asexual reproduction by fragmentation, budding and/or stoloniferous growth (the latter in soft corals) was particularly prevalent, and may be compensating to some degree for possible low rates of recruitment by planulae, potentially the result of strong current flow limiting local settlement.

5.3.5. Coral injury

Corals of Bali exhibited relatively low levels of recent injury overall, in terms of the proportion of species present that were injured and the average levels of injury to those species (Figure 5.6). This is consistent with the high positive ratio of live : dead coral cover. The overall healthy condition of corals was well represented by the large monospecific stands and intact massive corals present, with little evidence remaining of major past disturbances such as coral bleaching-related mortality triggered by elevated or depressed sea temperatures in 1998, past outbreaks of coral predators, major destructive fishing activities, diseases or other impacts. Earlier impacts had, however, occurred from clearing of corals from reef

Table 5.7. The top 20 sites for the Coral Replenishment index *CI* in Bali. B indicates site on main island of Bali, N indicates site on Nusa Penida and adjacent smaller islands.

Nama Stasiun	No. Stasiun	CI
Jemeluk, Amed	B16	8,46
Crystal Bay South	N7	8,2
Menjangan North	B26	7,95
Toya Pakeh	N3	7,64
Gili Tepekong, Candi Dasa	B10	6,84
Sekolah Dasar	N17	6,63
Mangrove N Lembongan	N4	6,36
Gili Selang South	B14	6,27
Batunggul	N11	6,12
Batu Abah	N8	5,88
Penutukang	B21	5,72
Teluk Lembongan Pantoon	N1	5,72
Bunutan, Amed	B15	5,67
East Gili Mimpang (Batu Tiga)	B8	5,55
Sumber Kima	B25	4,98
Batu Kelibit, Tulamben	B18	4,92
West Gili Mimpang (Batu Tiga)	B7	4,82
Gretek	B20	4,82
Menjangan East	B28	4,7
Gili Biaha/Tanjung Pasir Putih	B11	4,62

Plate 5.7. Seaweed farm, Station N14.2, Nusa Penida

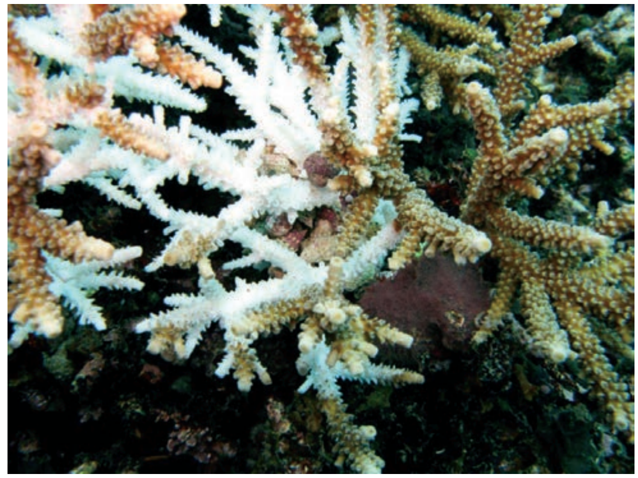

Plate 5.8. Predation by Drupella snails on Acropora yongei, Station N14.1, Nusa Penida.

Plate 5.9. Recent predation by Crown-of-thorns seastars on *Acropora sukarnoi*, Station N8.2, Nusa Penida.

Plate 5.10. Diseased colony of *Goniopora tenuidens*, Station N13.2, Nusa Penida.

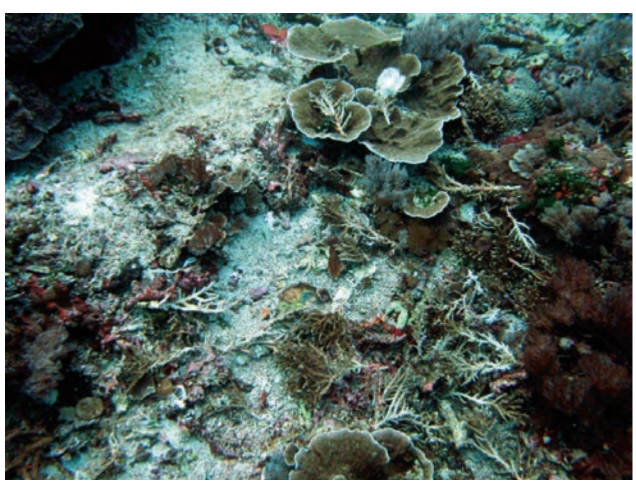

Plate 5.11. Blast fishing damage, Station N8.1, Nusa Penida.

flats for development of seaweed farms. The main sources of the relatively minor recent coral injury were predation by *Drupella* snails, and to a lesser extent Crown-of-thorns seastars, and coral diseases (Plates 7–11).

5.3.6 Litter and pollution

Continuing impacts, particularly from litter and other forms of pollution and from poorly regulated / managed tourism development, are of concern. As noted by van Woesik some 15 years ago:

> *"… between September 1992 and September 1997, there has been a major change to the coral reefs at Sanur and Nusa Dua, south-eastern Bali, Indonesia. The reef has changed from being dominated by coral to one being dominated by macroalgae, sponges and filter feeders. This is a sure sign of eutrophication and reef degradation. The source(s) of the eutrophication is presently unknown, but are in urgent need of investigation. Eutrophication is likely to stem from local sewage discharges from Benoa Harbour and local hotels. … It appears that a priority for south-eastern Bali is to improve the water quality, by investing in sewage treatment"*

The situation in respect of coral – algal cover in 2011 in the Sanur – Nusa Dua area does not appear to have deteriorated further since 1997, although various forms of pollution, most notably plastic and other kinds of litter, were apparent at all sites around the main island of Bali (Plates 5.12–5.13). Sources of the pollution include dumping on the coast and in streams, from ships and boats, and from more distant sources, transported in ocean currents.

One of us (LD) has spent considerable time in Bali since 1975, and personal observations and other anecdotal evidence suggests that the amount of litter, and indeed pollution more generally, has increased significantly over the past several decades, in proportion with Bali's growing human population and the increasingly ubiquitous use of plastics in packaging; and consistent with van Woesik's observations in 1997.

During this study, we had no opportunity to specifically investigate waste treatment and disposal as they relate to water quality on coastal reefs. However, personal observations indicated that in 1975, the only stream that showed obvious signs of pollution was one in the centre of Denpasar. Today, unfortunately, most streams that were crossed during travel to the survey locations around Bali appear polluted to greater or lesser degree by plastics and other forms of waste, much of which is subsequently transported into the coastal marine environment by stream flow. Opportunities exist to reduce these impacts through education programs that encourage continued and expanded use of traditional biodegradable packaging (eg. banana and palm leaf bags), better waste management and disposal, and restoration of riparian zones along streams.

5.3.7 Coral community Structure around Bali

The cluster analysis revealed four main coral community groups (Figure 5.7) at site level, one of which was subdivided into two communities (B and C) based on major differences in exposure, substrate type and other environmental variables (Figures 5.7, 5.8). Each community was characterized by a distinctive suite of species and benthic attributes (Tables 5.8, 5.9, Figure 5.9), although some species were more or less ubiquitous across several community types, notably *Acropora* and *Porites* spp. and various faviids. Because of their commonness, these taxa were not useful in differentiating among the different communities, although they do contribute significantly to coral cover in the region (Plates 5.14–5.23).

Community A: Agariciid – faviid community

This community occurred predominantly in warm waters (mean temperature of 29.6 C) of good clarity (mean visibility of 15 m) along the sheltered N coast of Bali (mean exposure of 2.1), on moderately to well-developed reefs (mean

Plate 5.12. Plastic litter and silt fouling the reef, Bali Station 31.

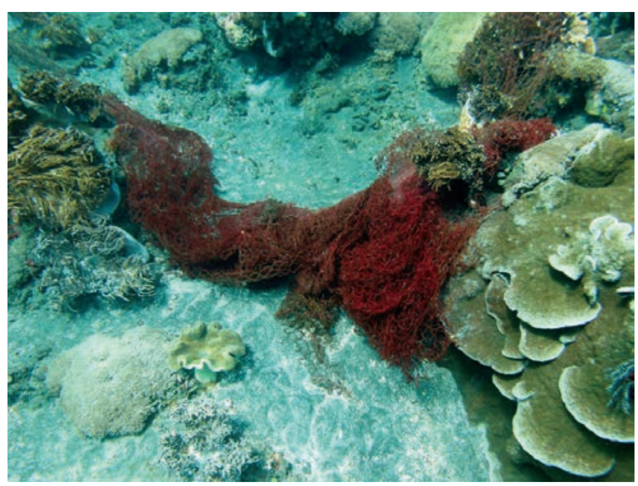

Plate 5.13. Abandoned 'ghost' net tangling corals, Bali Station B13.2.

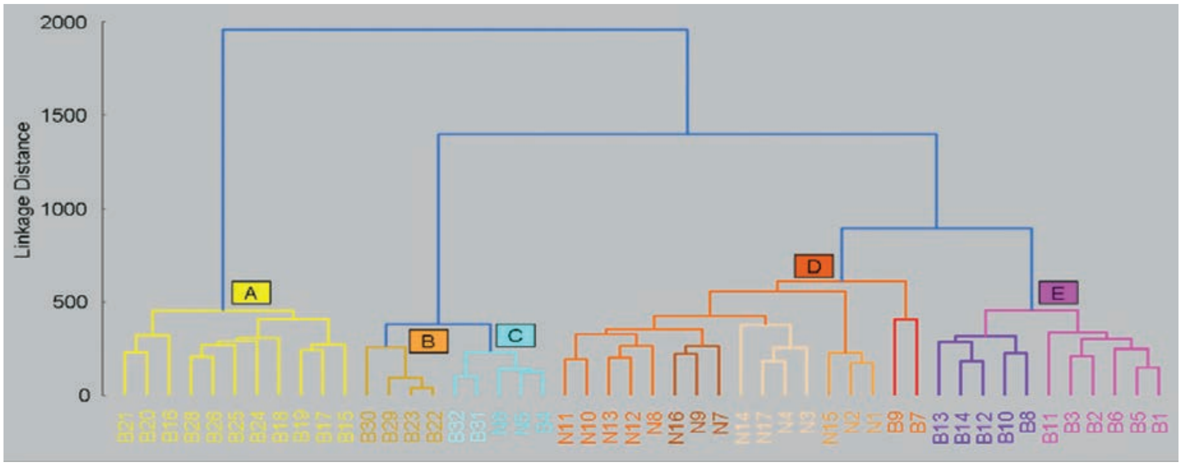

Figure 5.7. Dendrogram illustrating results of cluster analysis of coral communities of 48 sites from Bali (B#) and Nusa Penida (N#.).

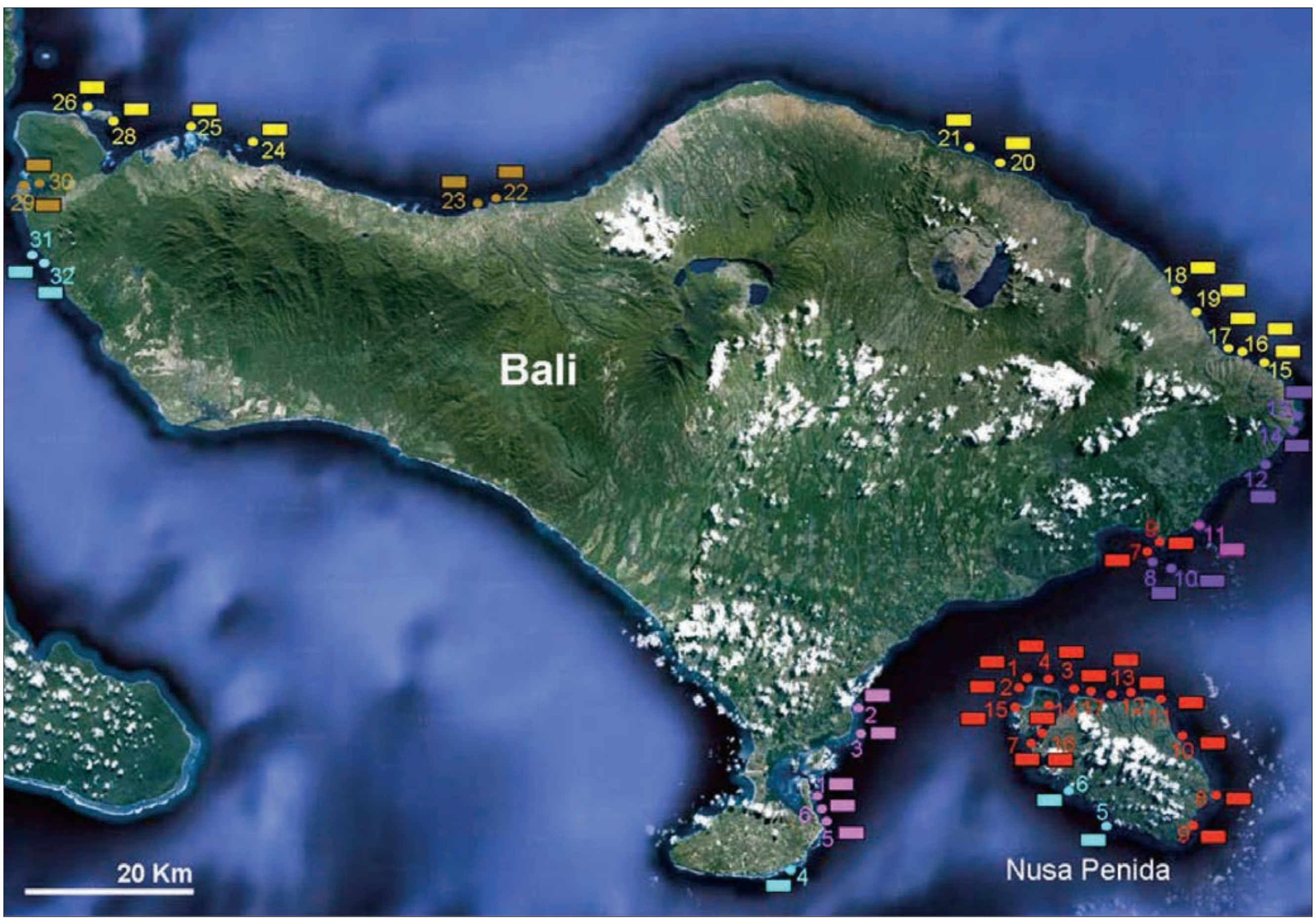

Figure 5.8. Distribution of coral community types at 48 sites, Bali. The 5 communities show a moderately high degree of geographic separation across the survey area. Each site has one shaded 'community rectangle' indicating the identity of the community present, where Community A is represented by yellow, B by brown, C by blue, D by red, and E by pink and purple coloured rectangles.

of 2.5) with relatively steep slopes (mean of 24 degrees) (Figure 5.8, Table 5.8). Characteristic indicator species included the agariciids *Leptoseris explanulata* and *L. mycetoseroides* and *Pavona varians*, faviids *Favites abdita*, *Favia pallida*, *Goniastrea retiformis* and *G. aspera* (Table 9). Tabular and branching *Acropora* and foliose *Montipora* were also common. Community A had moderately high cover of living hard corals (mean 28%) and was the most species rich (mean of 154 reef coral spp. per site) (Plates 5.14, 5.15).

Community B: Pocilloporid – poritid community

This community of Bali's N coast clustered with the following community C in the dendrogram (Figure 5.7) because both communities share low species richness and the presence of stress-tolerant coral species. It was, nevertheless, separated from it based on markedly different environmental characteristics, notably its relatively sheltered exposure regime (mean of 1.8), low degree of reef development (mean of 1.8), low water clarity (mean of 5 m) and very low level of hard substrate (mean of 19%) and high levels of sand and silt (means of 54 and 25% repsectively) (Figure 5.6, Table 5.8). This community had moderate cover of live hard corals (22%) and was characterized by the pocilloporids *Seriatopora*, *Pocillopora* and *Stylophora* spp., branching and massive poritids *Porites* spp. and the staghorn acroporid *Acropora pulchra* (Table 5.9). The pocilloporids are typically common colonizing species, often with rapid turnover of populations, while massive *Porites* are among the more stress-tolerant. The small free-living corals *Heterocyathus* and *Heteropsammia*, and seagrass *Halophila ovalis*, all typically associated with soft sediments, were also present. Community B had lowest species richness (mean of 19 reef coral spp. per site) (Plates 5.16, 5.17). These various environmental and biotic characteristics are consistent with a community of marginal and/or stressed reef habitats.

Community C: Faviid – pectiniid community

This community occurred in the more exposed locations of the S coasts of Bali and Nusa Penida, extending along the W coast towards the NW corner of Bali (mean exposure of 2.8), in cooler waters (mean temperature of 27.8 C) of low clarity (mean of 7 m), and with low levels of reef development (mean of 1.8) (Table 5.8, Figure 5.8). It was characterized by a mix of massive and encrusting faviids *Favia*, *Favites*, *Platygyra*, *Plesiastrea*, *Cyphastrea* and *Echinopora* and the encrusting-plating pectiniids *Mycedium elephantotus* and *Oxypora lacera* (Table 5.9). Community C had low reef coral species richness (mean of 56 spp. per site), lowest mean cover of living hard corals (mean 12%) and highest cover of soft corals (mean of 18%) (Plates 5.18, 5.19). It is likely that this community is widespread along the more wave-exposed coastlines of Bali and Nusa Penida.

Community D: Mussid – merulinid community

This community occurred predominantly along the more wave-sheltered coastlines of Nusa Penida and adjacent islands, and to a lesser extent on the E coast of Bali (Figure 5.8), on well developed reefs (mean of 3.2) in areas of high water clarity (mean of 19 m) and often in areas of moderate to strong current flow. It had highest cover of living hard corals (mean of 36%) and moderately high cover of soft corals (mean of 11%), and was moderately species rich (mean of 117 reef coral species per site, Table 5.8), being characterized by the mussids *Lobophyllia* and *Symphyllia* spp. and merulinids *Hydnophora* and *Merulina* spp. (Table 5.9, Plates 5.20, 5.21). Tabular and branching *Acropora* and foliose *Montipora* were also common. This community had highest cover of rubble and dead coral (means of 11% and 3% respectively). As illustrated in the dendrogram (Figure 5.7), this community encompasses four of the five coral communities previously identified for the Nusa Penida area in the earlier, smaller stand-alone analysis focused on that

Table 5.8. Summary statistics (mean values) for environmental and benthic cover variables for 5 coral communities of Bali. Differentiating characteristics are in bold type.

Coral community attributes					
	A	B	C	D	E
No. of sites	11	4	4	17	11
Maximum depth (m)	20	16	20	19	14
Minimum depth (m)	6	1	7	5	5
Slope (degrees angle)	24	8	9	13	17
Hard substrate (%)	73	**19**	**87**	80	82
% cover benthos					
Hard coral	28	22	**12**	**35**	26
Soft coral	5	0	**18**	11	12
Macro algae	1	1	4	2	2
Turf algae	17	**3**	17	10	13
Coralline algae	10	0	2	8	**13**
Recently dead coral	1	0	0	1	1
All dead coral	2	0	2	3	2
% cover substrate					
Continuous pavement	50	15	**75**	62	54
Large blocks	12	0	8	11	16
Small blocks	11	4	6	7	11
Rubble	9	3	2	11	5
Sand	15	**54**	10	9	14
Silt	3	**25**	0	0	0
Environmental variables					
Exposure	2.1	**1.8**	**2.8**	2.4	2.6
Reef development	2.5	1.8	1.8	**3.2**	2.8
Visibility (m)	15	5	7	**19**	13
Water temp (C)	29.6	28.5	27.8	28.1	28.6
Mean no. of reef-building coral species	**154**	**19**	59	117	119

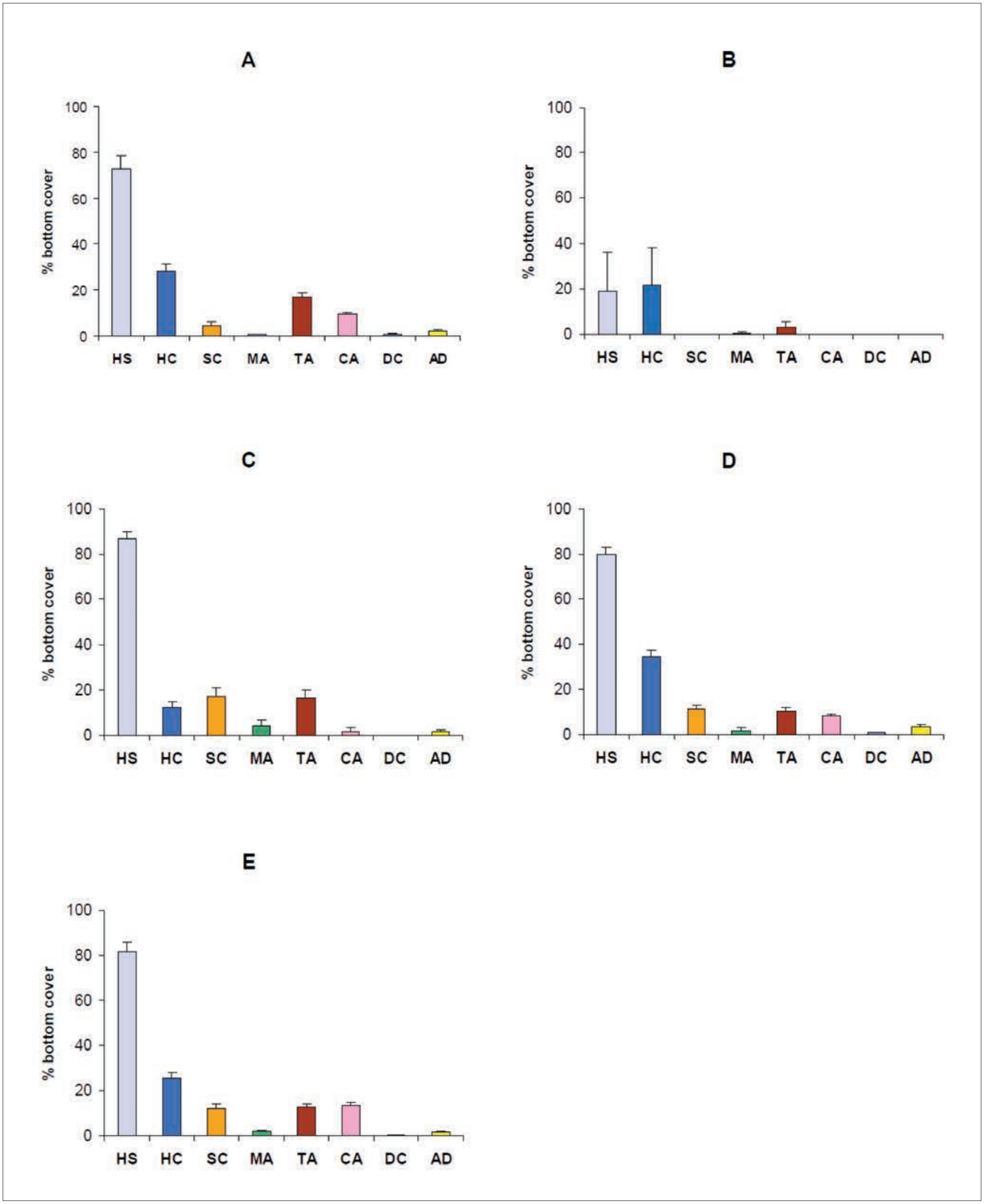

Figure 5.9. Mean cover of benthic attributes in 5 coral community types, Bali. HS: Hard Substrate, HC: Hard Corals, SC: Soft Coral, MA: Macro Algae, TA: Turf Algae, CA: Coralline Algae, DC: Recently Dead Coral: AD: Old Dead Coral. Error bars are Standart Error (SE).

Table 5.9. Characteristic coral species in 5 coral community types, Bali. Taxa used as indicators for the relevant community types are in bold.

Community A		
Scleractinia	abn	stn
Leptoseris explanata	27	11
Porites massive	26	11
Pocillopora verrucosa	24	11
Favites abdita	24	11
Porites cylindrica	24	11
Montipora grisea	23	11
Pavona varians	23	11
Galaxea fascicularis	22	11
Favia pallida	22	11
Goniastrea retiformis	22	11
Platygyra daedalea	22	11
Favites pentagona	21	11
Goniastrea pectinata	21	11
Leptoseris mycetoseroides	20	11
Goniastrea aspera	20	11
Montastrea colemani	20	11
Porites rus	20	11
Acropora tenuis	19	11
Hydnophora microconos	19	11
Symphyllia recta	19	11
Other taxa		
Palythoa	23	11
Sinularia spp.	19	11
Sarcophyton	14	10
Sponge massive	21	9
Dendronephthya	18	9
Xestospongia	16	8
Millepora exesa	15	8
Linckia	14	8
Sponge encrusting	14	7
CRA	14	7
Carterospongia	13	7
Melithaea	12	7
Lobophytum	11	7
Tridacna maxima	10	7
Sponge	15	6
Diademnum	14	6
Polycarpa	11	6
Tridacna squamosa	7	6
Culcita	7	6
Aglophenia	12	5

Community B		
Scleractinia	abn	stn
Porites massive	5	3
Seriatopora hystrix	6	2
Porites nigrescens	6	2
Seriatopora caliendrum	4	2
Stylophora pistillata	4	2
Acropora pulchra	4	2
Hydnophora rigida	4	2
Pavona decussata	3	2
Cyphastrea serailia	3	2
Heterocyathus aequicostatus	4	1
Pocillopora damicornis	3	1
Euphyllia paraancora	3	1
Heteropsammia cochlea	3	1
Porites flavus	3	1
Goniopora stokesi	3	1
Stylophora subseriata	2	1
Montipora aequituberculata	2	1
Montipora altasepta	2	1
Montipora delicatula	2	1
Acropora tenuis	2	1
Other taxa		
Pennatulacea	4	2
Caulerpa taxifolia	4	2
Halophila ovalis	4	2
Culcita	3	2
Sponge	3	1
Millepora exesa	2	1
Millepora intricata	2	1
Clavularia	2	1
Dendronephthya	2	1
Xenia	2	1
Antipathes	2	1
Sponge rope	2	1
Padina	2	1
Caulerpa serrulata	2	1
Caulerpa racemosa	2	1
Syringodium	2	1
Lobophytum	1	1
Heteroxenia	1	1
Zoanthus	1	1
Anemon	1	1

table continued on next page

Table 5.9. *continued*

Community C				**Community D**		
Scleractinia	abn	stn		**Scleractinia**	**abn**	**stn**
Favites pentagona	12	5		***Galaxea fascicularis***	40	17
Galaxea fascicularis	11	5		*Favites pentagona*	33	17
Platygyra daedalea	10	5		*Platygyra daedalea*	33	17
Plesiastrea versipora	10	5		***Pavona explanulata***	28	17
Symphyllia recta	8	5		***Lobophyllia hemprichii***	27	17
Favia speciosa	8	5		*Symphyllia recta*	26	17
Pachyseris speciosa	7	5		***Goniopora tenuidens***	43	16
Mycedium elephantotus	7	5		*Echinopora lamellosa*	37	16
Cyphastrea serailia	6	5		*Porites* massive	32	16
Acropora sukarnoi	8	4		*Pavona varians*	31	16
Oxypora lacera	8	4		*Hydnophora exesa*	30	16
Hydnophora exesa	8	4		*Acropora microclados*	25	16
Favites russelli	8	4		*Symphyllia agaricia*	21	16
Leptoseris explanata	7	4		*Lobophyllia robusta*	20	16
Pocillopora eydouxi	6	4		*Pocillopora verrucosa*	31	15
Echinopora lamellosa	6	4		*Pectinia lactuca*	27	15
Symphyllia agaricia	5	4		*Merulina scabricula*	25	15
Symphyllia valenciennesii	5	4		*Favia favus*	23	15
Favia favus	5	4		*Favia matthaii*	22	15
Porites massive	5	4		*Symphyllia radians*	19	15
Other taxa				**Other taxa**		
Sinularia spp.	13	5		*Sarcophyton*	34	17
Sarcophyton	9	4		***Xenia***	45	16
Xestospongia	8	4		*Sinularia* spp.	31	16
Capnella	6	4		*Palythoa*	31	16
Junceella	6	4		***Millepora exesa***	30	16
Palythoa	6	4		*Tubipora musica*	32	15
Lobophytum	7	3		*Coralimorpharian*	30	15
Sponge	7	3		*Capnella*	26	13
Tubipora musica	6	3		*Nephthea*	26	13
Dampia	6	3		CRA	27	12
Xenia	6	3		*Paralemnalia*	25	12
Anemon	4	3		*Anthelia*	25	12
Tubastrea micrantha	6	2		Anemon	19	12
Amphiroa	6	2		Sponge	27	11
Aglophenia	5	2		*Briareum*	19	11
Coralimorpharian	4	2		*Cirrhipathes*	15	11
Dictyosphaeria	4	2		*Scleronephthya*	23	10
Nephthea	3	2		*Lemnalia*	19	10
Melithaea	3	2		*Xestospongia*	18	10
Elisella	3	2		*Dictyosphaeria*	17	9

table continued on next page

Table 5.9. *continued*

Community E		
Scleractinia	abn	stn
Favites pentagona	29	11
Seriatopora hystrix	27	11
Porites cylindrica	27	11
Pocillopora verrucosa	23	11
Acropora sukarnoi	23	11
Favia matthaii	22	11
Echinophyllia aspera	21	11
Favia favus	21	11
Lobophyllia hemprichii	20	11
Favia speciosa	20	11
Platygyra daedalea	20	11
Pocillopora eydouxi	19	11
Acropora microclados	19	11
Symphyllia agaricia	19	11
Plesiastrea versipora	19	11
Symphyllia radians	17	11
Symphyllia recta	17	11
Porites massive	17	11
Favites russelli	15	11
Montipora vietnamensis	13	11
Other taxa		
Sarcophyton	25	11
Sinularia spp.	25	11
Aglophenia	22	10
Palythoa	21	10
Xenia	23	9
Lobophytum	16	9
CRA	20	8
Xestospongia	15	8
Tubipora musica	15	7
Nephthea	14	7
Peyssonnelia	14	6
Capnella	13	6
Briareum	10	6
Millepora exesa	9	6
Paralemnalia	11	5
Sponge encrusting	11	5
Cespitularia	9	5
Millepora platyphylla	7	5
Sponge massive	7	4
Millepora dichotoma	6	4

area (Turak and DeVantier 2008), prior to addition of the Bali dataset in this larger analysis.

Community E: Acropora sukarnoi community

This community occurred exclusively along the E coast of Bali (Figure 5.8). It can be separated into two sub-communities (illustrated in Figure 5.8 with pink and purple rectangles respectively), the former mainly occurring on the SE coast in the Nusa Dua – Sanur area, the latter further to the NE, around Candi Dasi – Padang Bai – Talumben. This community had moderately high cover of living hard and soft corals (means of 26 % and 12 % respectively) and was moderately species rich (mean of 119 reef coral species per site, Table 5.8), being characterized by the acroporids *Acropora sukarnoi* and *A. microclados* and *Montipora vietnamensis*, poritid *Porites cylindrica* and pocilloporid *Pocillopora eydouxi* (Table 5.9, Plates 5.22, 5.23).

5.3.8 Comparisons between Bali and adjacent regions

Bali shares almost all coral species with other areas of Indonesia (Appendix 5.3), with the possible exception of *Acropora suharsonoi* (Plate 5.24) and the undescribed species of *Euphyllia* found during the present study (Plate 5.6). Comparisons of levels of similarity in coral composition and community structure were conducted with those of other regions of Indonesia, including Komodo, Wakatobi, Derewan, Banda Islands, Bunaken, N Halmahera and three areas of the Bird's Head Seascape (Raja Ampat, Teluk Cenderwasih and Fak-Fak/Kaimana)

For these regional comparisons, two sets of analyses were undertaken:

1. Using the presence of species in each region
2. Using the species-abundance at the individual site level:
    a. For Bali with Komodo, Banda Islands, Bunaken and Wakatobi (134 sites)
    b. For Bali with Derewan, Sangihe-Talaud, Raja Ampat, Fak-Fak/Kaimana and Teluk Cenderwasih (254 sites).

1. Species presence

Corals of Bali and Nusa Penida were most similar to those of Komodo, the closest location geographically, also forming part of the Lesser Sunda Island chain, and also subject to localized cool water upwelling. These two locations formed a second cluster with Wakatobi and Bunaken, and then with Banda Islands (Figure 5.10).

A second major group of locations included Derewan, Sangihe-Talaud, Halmahera, Raja Ampat, Fak-Fak/Kaimana and Teluk Cenderwasih, reflecting their higher overall species richness (and habitat diversity).

2. Species – abundance

Most sites from Bali and Nusa Penida formed one or more coherent sub-clusters (Figs. 11 and 12, illustrated in purple and pink). Coral communities of Bali and Nusa Penida were

Plate 5.14. Example of coral community A, Station B16.2, Bali, here showing very high cover of reef corals in shallow waters, mainly acroporids *Montipora* (foreground) and *Acropora*.

Plate 5.15. Example of coral community A, Station B17.1, Bali, showing impact of silt.

Plate 5.16. Example of coral community B, Station B30.2, Bali, composed predominantly of *Acropora pulchra* with smaller *Seriatopora hystrix*.

Plate 5.17. Example of coral community B, Station B22.2, Bali, with many small, unattached *Heterocyathus* and *Heteropsammia* corals scattered among seagrass *Halophila* on a soft substrate.

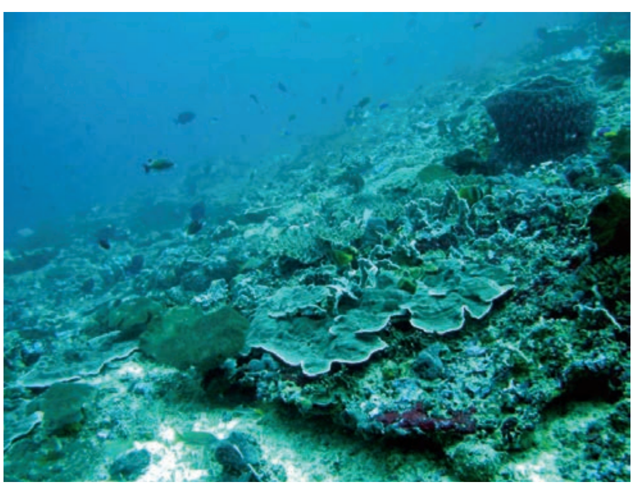

Plate 5.18. Example of coral community C, Station B5.1, Nusa Penida, with encrusting and plating pectiniids and faviids predominant.

Plate 5.19. Example of coral community C, Station B4.1, Bali, with rhodophyte algae and soft corals predominant.

most similar to each other and then with those of Komodo (and a few Banda Island sites). These collectively formed one of the two main clusters of sites (left of Figure 5.11). The second main community group cluster was composed predominantly by sites from Wakatobi, Banda Islands and Bunaken, with some sites from N Bali sharing similarity with some Bunaken sites.

In the second site-level analysis (Figure 5.12), there is a clear clustering of coral communities of Bali with those of Nusa Penida, forming coherent sub-clusters in the large community grouping (left of Figure 5.12). Other more-or-less coherent sub-clusters were formed by sites of Fak-Fak/Kaimana; Derewan and Raja Ampat (in part) and Sangihe-Talaud (with some RA sites). Various sites from Teluk Cenderawasih were spread widely across the dendrogram, some clustering with Fak-Fak/Kaimana, others with Derawan and Raja Ampat (Figure 5.12).

These various results indicate that in terms of both coral species composition (presence, Figure 5.10) and abundance (community structure, Figures 5.11 and 5.12), Bali and Nusa Penida have a degree of self-similarity with each other and dissimilarity from most other regions of Indonesia, being closest in these attributes to Komodo, also in the Lesser Sunda Island chain.

Plate 5.20. Example of coral community D, Nusa Penida Station N1.2, composed predominantly of tabular and foliose acroporids.

Plate 5.21. Example of coral community D, Nusa Penida Station N8.2, showing a diverse coral assemblage developed on an irregular reef spur.

Plate 5.22. Example of coral community E, Station B6.2, Bali, with large stand of *Acropora sukarnoi* (centre).

Plate 5.23. Example of coral community E, Station B8.2, Bali, with large tabular *Acorpora cytherea* (centre).

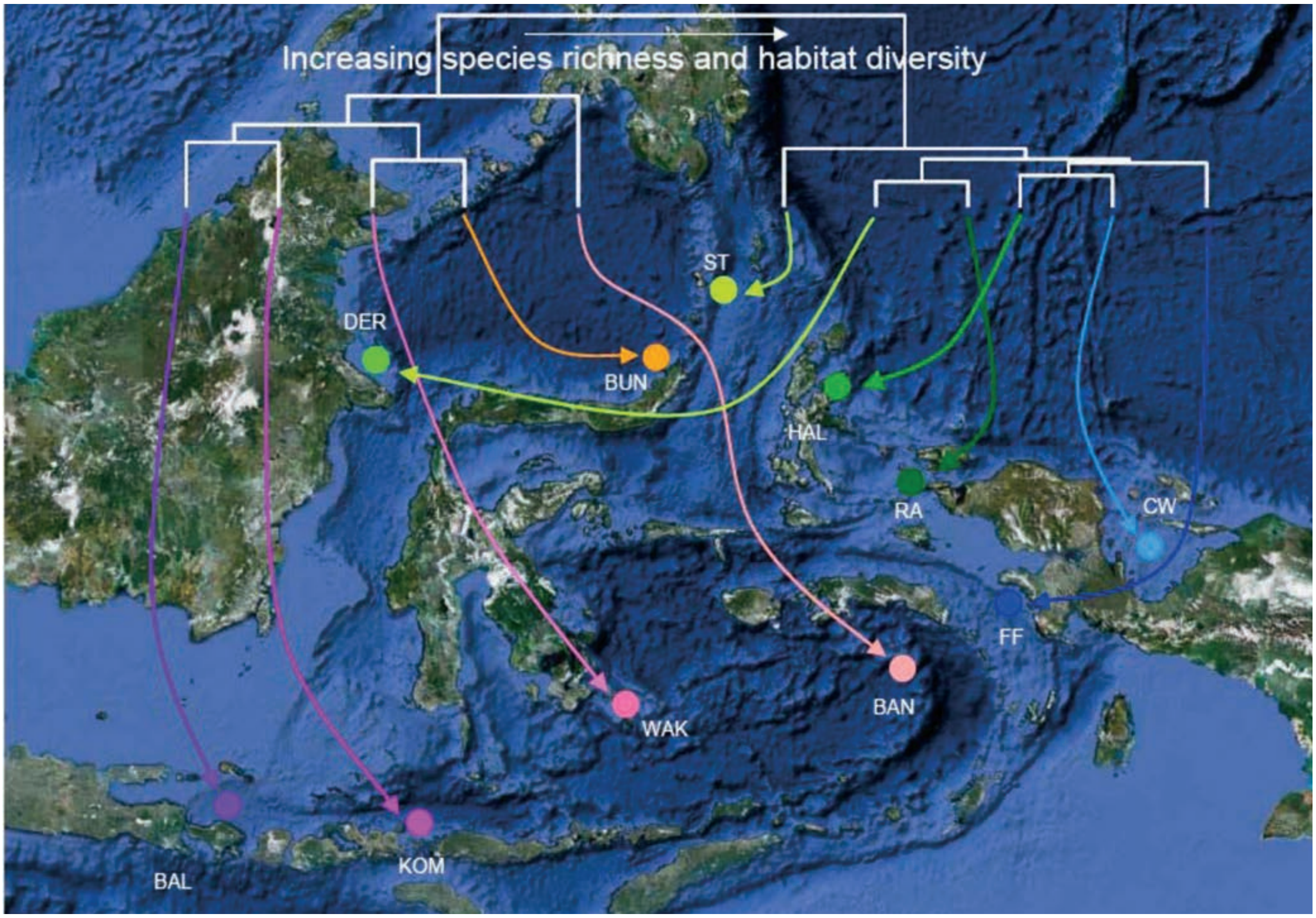

Figure 5.10. Dendrogram illustrating degree of similarity of different locations in terms of reef coral species presence, where BAL – Bali and Nusa Penida, KOM – Komodo, WAK – Wakatobi, BUN – Bunaken, BAN – Banda Islands, DER – Derewan, ST – Sangihe-Talaud, HAL – Halmahera, RA – Raja Ampat, FF – Fak-Fak/Kaimana and CW –Teluk Cenderawasih.

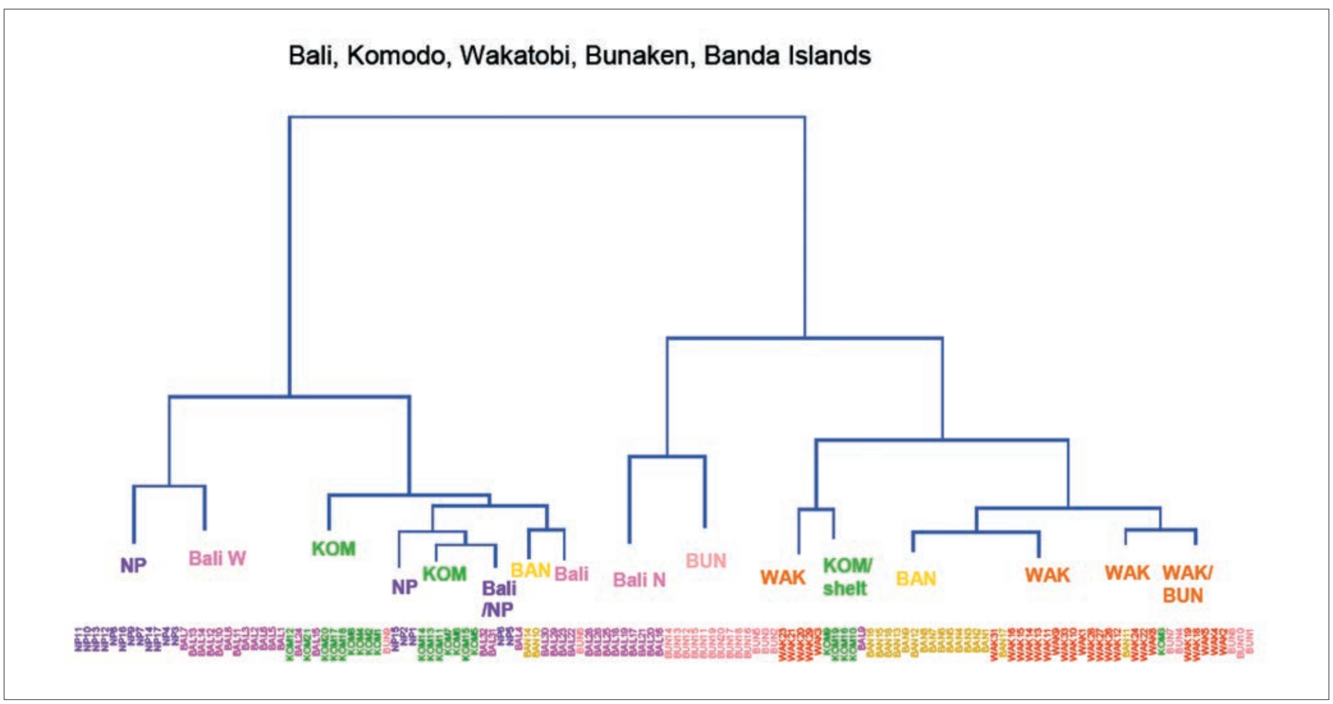

Figure 5.11. Dendrogram illustrating results of cluster analysis of coral communities of 254 sites across six widespread regions of Indonesia: Bali (with geog. location of sites), Nusa Penida (NP), Komodo (KOM), Bunaken (BUN), Wakatobi (WAK) and Banda Islands (BAN).

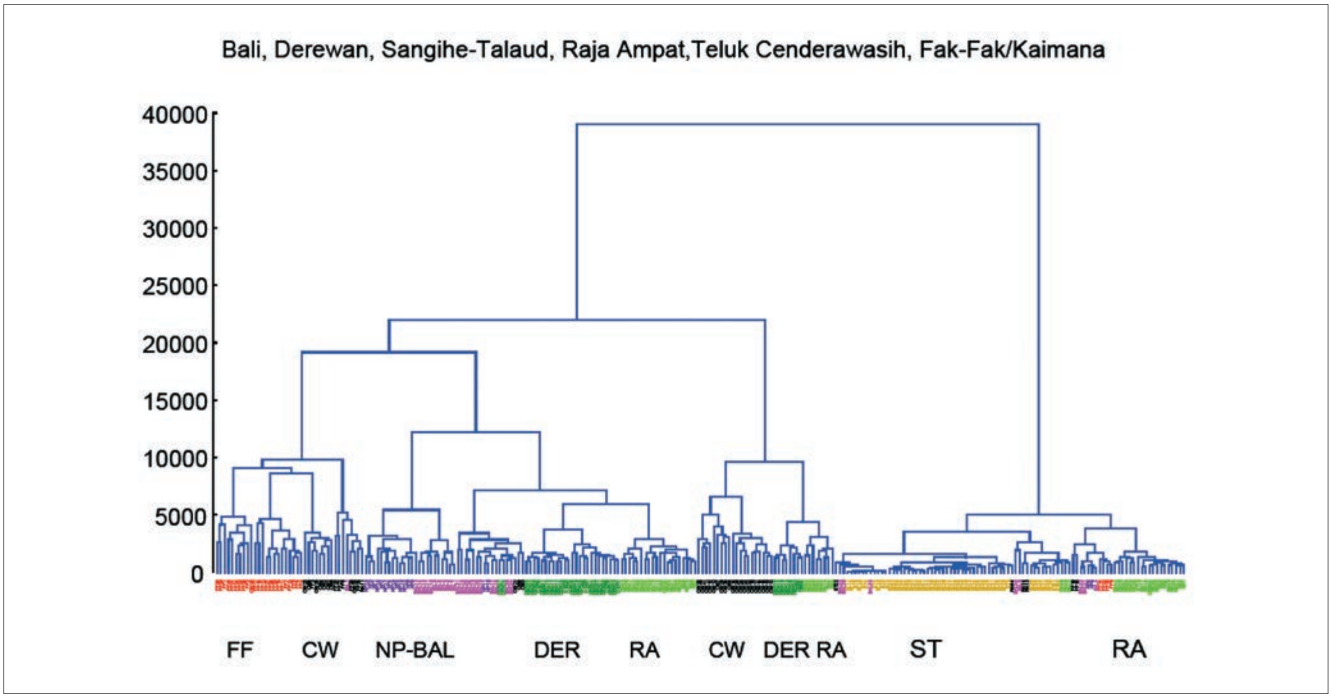

Figure 5.12. Dendrogram illustrating results of cluster analysis of coral communities of 254 sites across six widespread regions of Indonesia: Bali and Nusa Penida (NP-BAL), Derewan (DER), Fak-Fak/Kaimana (FF), Teluk Cenderawasih (CW), Raja Ampat (RA) and Sangihe Talaud (ST).

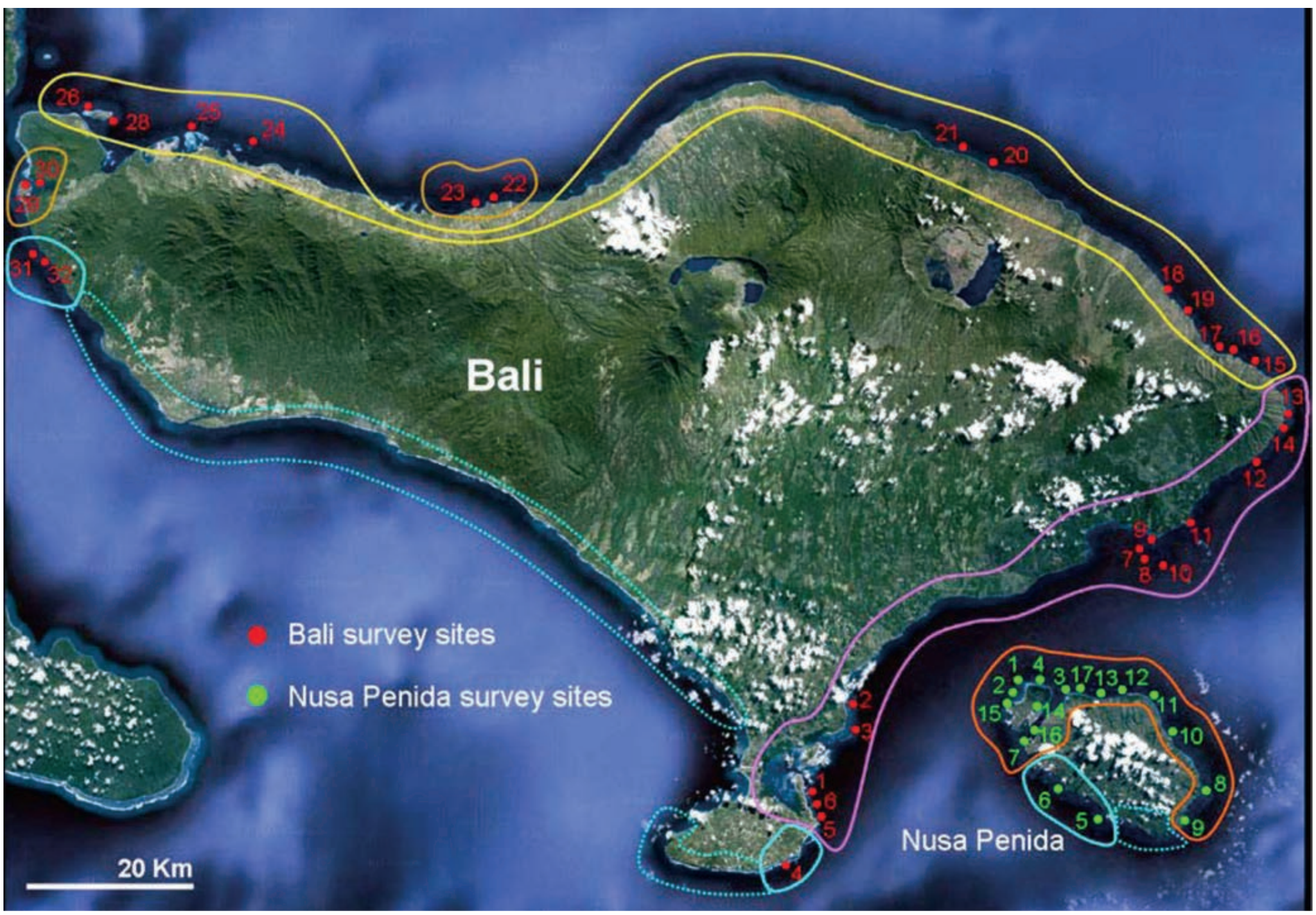

Figure 5.13. Areas hosting main coral habitats and community types of Bali. Image courtesy of Google Earth. Coloured areas correspond to main coral community types in Figure 5.7.

5.4 DISCUSSION

Bali's coral habitats, although not as diverse as some other regions of Indonesia, do encompass a broad range of environmental conditions, and can be differentiated based on the following characteristics (after DeVantier et al. 2008):

1. S coasts – upwelling and / or wave exposed
2. Lombok Strait – variable temperature regime and strong current flow, with some areas likely to be biologically isolated via the strong ITF currents
3. NE and N coasts – warmer waters and more sheltered, mix of soft and hard substrates
4. NW coast – best reef development, but also with significant areas of soft substrate (eg. sites 22, 23, 29, 30).

These habitat types have a major structuring influence on coral communities, as simplified in Figure 5.13. Planning for a network of Marine Protected Areas (MPAs) should aim to represent these main habitat / community types in the network, with particularly important reef stations in each habitat highlighted later herein (Table 5.10, Figure 5.14).

Bali's regional richness of 406 reef coral species is higher than Komodo (342 spp., also in the Lesser Sunda Islands), and Banda Islands (301 spp.) and very similar to Bunaken NP and Wakatobi (Table 5.4). Bali's species composition and community structure show closest similarity with Komodo (Figures 5.10, 5.11), reflecting the fact that both regions experience a similar range of physico-chemical environmental conditions in respect of the sea temperature regime (localized cool water upwelling), current flow and attenuation in wave energy around the islands. Further afield, species composition of Bali differs substantially from the more species rich (and habitat rich) regions of Derewan, Sangihe-Talaud and the Bird's Head Seascape of West Papua (Figures 5.10, 5.12).

Discovery of an undescribed species of *Euphyllia* on the E coast of Bali (Plate 5.5), and the presence of other apparently local endemic corals, notably *Acropora suharsonoi* (Plate 5.24), suggests that the region does have a degree of faunal uniqueness, possibly related to the strong current flow through Lombok Strait. In this respect, the strong ITF currents may, paradoxically, both limit and foster dispersal and recruitment in different areas respectively. Local recruitment around Nusa Penida may be restricted by the currents, which may nevertheless transport larvae further afield. Genetic, reproductive and larval settlement studies would be required to test this hypothesis.

Plate 5.24. *Acropora suharsonoi*, a reef coral with an apparently highly restricted distribution range of N Bali and W Lombok, here at Bali site B26.

5.4.1 Conservation priority

Nusa Penida

The high coral cover of many sites around Nusa Penida in particular may be maintained more by asexual reproduction and growth of fragments, evidence for which was apparent in the large monospecific coral stands and spread of stoloniferous soft corals. Based on known rates of growth, the largest monospecific stands (eg. *Acropora horrida*) are likely to be 100s of years old, and play important roles in maintenance of community structure, providing a high degree of ecological stability to their stations. The presence of local morpho-types in several widespread coral species around Nusa Penida, and apparent absence of species known from adjacent areas (eg. *Acropora surharsonoi* (Plate 5.24) from the Gilis, Lombok and NE Bali mainland) lends further support to the likely role of the ITF in isolating the Nusa Penida islands from other sources of replenishment, both local and further afield. If this is the case, then the islands may require careful management of local impacts, as replenishment from outside sources may be a prolonged process.

Locally, most coral communities of Nusa Penida differ from those of the main island of Bali (Figures 5.7–5.13), and are subject to different environmental conditions and human uses, and hence may require separate management focus. Reefs of high local conservation status around Nusa Penida include those at Crystal Bay, Toya Pakeh, Sekolah Dasar and N Lembongan (Stations N3, N4, N7, N8, N14 and N17, Table 5.10, Figure 5.14). Although all these sites were lumped in major community type D in the broader analysis that included all the Bali sites (Figure 5.7), they do support several different coral assemblage types, designated as different coloured sub-clusters in Figure 5.7 (and as presented in Turak and DeVantier 2009).

Bali

Reefs of high conservation value around Bali were widespread along the E and N coasts, and include Jemeluk, Menjangan, Gili Tepekong, Penutukang, Bunutan, Gili Selang and Gili Mimpang (Stations B16, B26, B10, B14, B21, B15, B25, B8, B18 and B7), representing mainly community types A and E.

Along with the Nusa Penida reefs already identified (Community type D), all the above reefs have strong potential for development of MPAs providing sufficient logistic resources and long-term support are provided. Notably, site 26 at Menjangan already forms part of the marine protected area

Table 5.10. Conservation values of survey sites in Bali. Replenishment Index (CI) scores from highest to lowest; Rarity Index (RI) ranked from highest (1, most unusual faunistically) to lowest. Species richness – reef-building Scleractinia; site numbers and community types correspond with those in Figures.

Site name	Site No.	CI	RI	HC cover	Species richness	Community type
Jemeluk, Amed	B16	8,46	2	32,5	181	A
Crystal Bay South	N7	8,2	25	55	123	D
Menjangan North	B26	7,95	3	50	168	A
Toya Pakeh	N3	7,64	33	55	114	D
Gili Tepekong, Candi Dasa	B10	6,84	23	40	137	E
Sekolah Dasar	N17	6,63	17	45	138	D
Mangrove N Lembongan	N4	6,36	22	45	134	D
Gili Selang South	B14	6,27	29	32,5	125	E
Batunggul	N11	6,12	21	35	140	D
Batu Abah	N8	5,88	19	50	121	D
Penutukang	B21	5,72	4	27,5	164	A
Teluk Lembongan Pantoon	N1	5,72	39	60	81	D
Bunutan, Amed	B15	5,67	28	32,5	120	A
East Gili Mimpang	B8	5,55	35	32,5	122	E
Sumber Kima	B25	4,98	6	30	154	A
Batu Kelibit, Tulamben	B18	4,92	9	30	157	A
West Gili Mimpang	B7	4,82	1	27,5	142	D
Gretek	B20	4,82	15	20	150	A
Menjangan East	B28	4,7	5	20	150	A
Gili Biaha/Tanjung Pasir Putih	B11	4,62	11	17,5	142	E
Tukad Abu, Tulamben	B19	4,56	12	21	156	A
Kepah, Amed	B17	4,54	10	22,5	158	A
Malibu Point	N10	4,38	16	30	141	D
Glady Willis, Nusa Dua	B2	4,32	27	22,5	133	E
Jepun, Amuk Bay, Candi Dasa	B9	4,04	13	12,5	126	D
Ceningen channel	N14	4,04	7	20	119	D
Taka Pemutaran	B24	3,96	8	25	138	A
Gili Selang North	B13	3,88	18	27,5	117	E
Sental	N13	3,86	24	20	126	D
Seraya	B12	3,84	31	30	110	E
Terora, Sanur	B1	3,82	26	22,5	126	E
Mushroom Bay North	N2	3,75	40	50	74	D
Melia Bali hotel	B6	3,74	32	27,5	121	E
South of Batu Abah	N9	3,62	20	17,5	116	D
Buyuk	N12	3,62	34	30	115	D
Secret Bay, Reef north shore	B30	3,36	14	60	44	B
Crystal Bay Rock	N16	3,34	30	25	103	D
Mushroom Bay South	N15	2,64	36	30	81	D
Sanur Channel N side	B3	2,46	37	20	79	E
Pearl farm, NW Bali	B31	2,18	41	20	75	C
Nusa Dua – Public beach	B5	1,51	38	10	102	E
Manta Point	N5	1,04	42	10	70	C
Pura Kutuh	B4	0,8	46	10	62	C
Peternakan mutiara, Barat laut Bali	B32	0,72	47	10	45	C
Old Manta Bay	N6	0,71	44	3	42	C
Secret Bay, Muck dive	B29	0,36	45	3	21	B
Kalang Anyar	B23	0,1	48	1	8	B
Puri Jati	B22	0,07	43	2	2	B

of Bali Barat. Reefs at Jemeluk (Amed) and around Gili Tepekong, Gili Selang and Gili Mimpang are also of very high conservation value for a number of different criteria (Table 5.10). The Batu Tiga area in particular has strong potential for development of an MPA, given that the islands are not inhabited and the reefs are already used regularly for recreational SCUBA diving.

The lower coral diversity communities B and C did not score highly on the various criteria assessed in Table 5.10, but nevertheless should not be excluded from conservation planning. In particular, the wave exposed S coast community C was not thoroughly surveyed because of large ocean swell (Figure 5.13). Many of these S coast reefs are highly prized for surfing, and as such draw large numbers of tourists to Bali each year. In the latter respect, their future conservation should be considered a priority for maintaining surf tourism on the island. Further offshore, some of these areas are crucial migration corridors for cetaceans and other species.

The presence of cool water upwelling and/or strong consistent current flow in some areas (eg. Nusa Penida, E Bali, as indeed also in Komodo and other areas of Indonesia) may be particularly important in buffering the incident reefs against rising sea temperatures associated with global climate change.

5.4.2 MPA network recommendations

In respect of establishing the MPA network, the following recommendations are made:

1. A multiple use MPA model, with different areas zoned for different levels of protection and use, is likely to be the most appropriate, given the broad range of activities that already occur on Bali's reefs. However, this model should include adequate core areas excluding extractive activities, to ensure conservation of key habitat and community types and foster replenishment.

2. As far as practicable, the MPA network should include representative and complementary areas encompassing the main coral community types (Figs. 7 and 12), and reefs of high conservation value (diversity, replenishment, rarity, Table 5.10).

3. As far as practicable, the network should include reefs subject to cool water upwelling and/or strong and consistent current flow, as a potential safeguard against increasing sea temperatures associated with global climate change over coming decades. Reefs of Nusa Penida and E Bali, particularly those under the influence of Lombok Strait, should be included in the network.

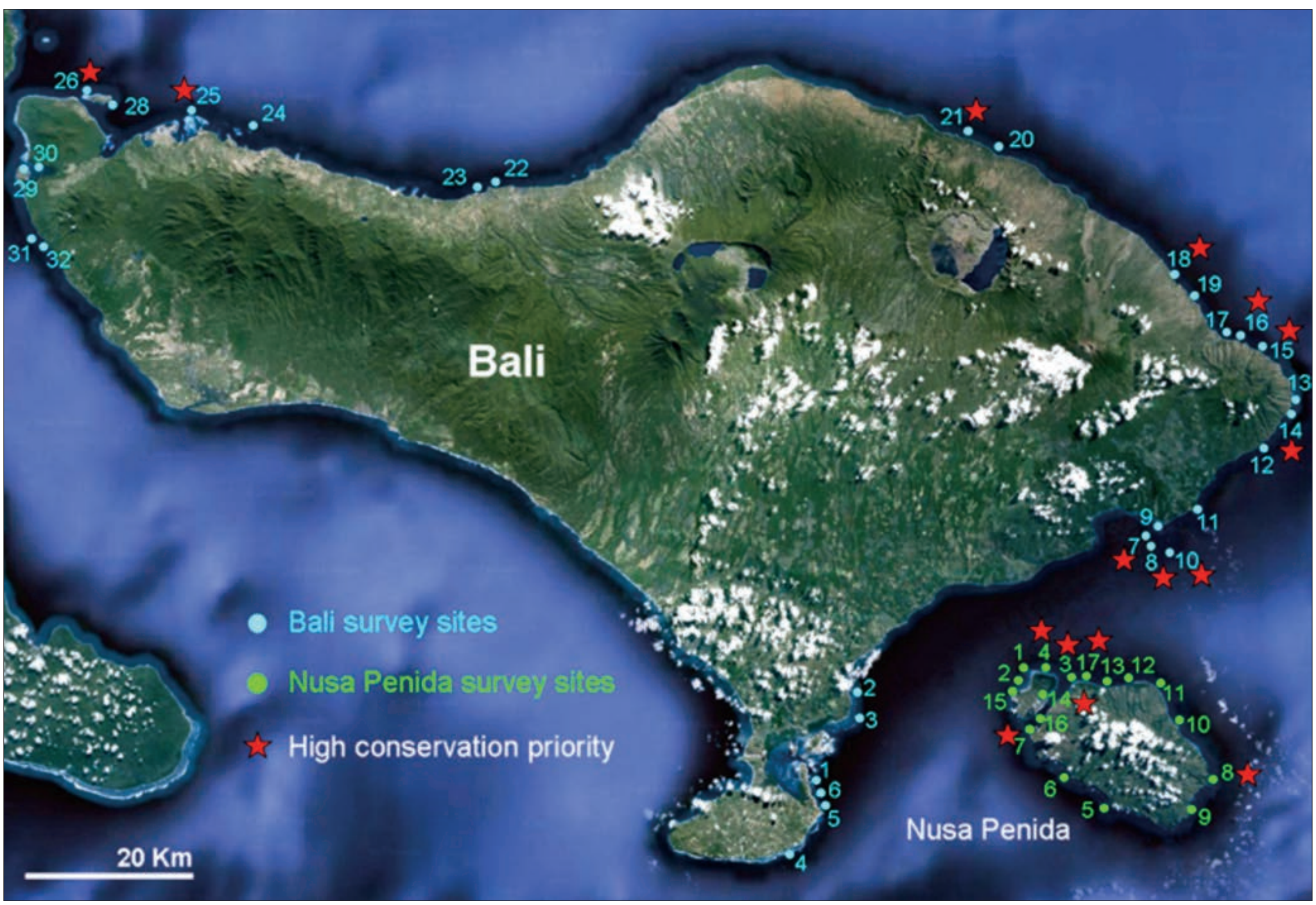

Figure 5.14. Reefs of high conservation priority, Bali, indicated by red stars.

4. There are many competing uses for Bali's coastal and marine resources, and it will be challenging to achieve the right balance among different levels of protection and use. Given the overwhelming importance of ocean-based tourism (surfing, diving and swimming), particular focus should be paid to maintaining healthy and attractive reef-scapes for these activities, and hence a focus on non-destructive, non-extractive activities in core zones.

5. Once an MPA network is established, enforcement of regulations will be crucial.

6. Consideration should be given to a 'User-pays' system (eg. Bunaken National Park) whereby visitors pay a nominal fee for access. This can provide significant funds for MPA management and benefits to local communities.

In respect of litter and water quality:

7. There is a widespread issue of litter and other forms of water pollution. A number of strategies may be employed / expanded to reduce the amount / impact of plastic and other pollution by: a) encouraging traditional packaging as much as practicable; b) continuing education campaigns in local mass media and schools; c) voluntary and funded litter clean-up activities on beaches and reefs.

8. Aim to improve stream and river water quality to reduce transport of litter / pollutants to reefs by restoring riparian vegetation; and with public education campaigns re inappropriate waste disposal.

ACKNOWLEDGEMENTS

We thank Dr. Mark Erdmann and staff of Conservation International Indonesia and CI International for organizing the survey. We also thank Dr. Joanne Wilson of The Nature Conservancy and Laure Katz of CI for help in the field, our colleagues from the Indonesian Institute of Sciences, the Indonesian Department of Nature Conservation, the Indonesian Ministry of Marine Affairs and Fisheries, and our other Indonesian and international colleagues for facilitating and supporting the field surveys. We also gratefully acknowledge Dr. Suharsono of the Indonesian Institute of Sciences, Dr. Mark Erdmann (CI), Mr. Erdi Lazuardi (CI Sorong Office), and Dr. Carden Wallace and staff of the Museum of Tropical Queensland (MTQ) for facilitating the continuing coral taxonomic studies. Dr. Charlie Veron (Coral Reef Research) and Dr. Carden Wallace (MTQ) provided much valued taxonomic advice.

REFERENCES

Abram N.J., M.K. Gagan, M.T. McCulloch, J. Chappell dan W.S. Hantoro, 2003. Coral reef death during the 1997 Indian Ocean Dipole linked to Indonesian wildfires. *Science* 301: 952.

Allen, G.R., 2007. Conservation hotspots of biodiversity and endemism for Indo-Pacific coral reef fishes. *Aquatic Conservation: Marine and Freshwater Ecosystems* 18: 541–556.

Allen, G. dan Steen, R. 1994. *Indo-Pacific Coral Reef Field Guide.* Singapore, Tropical Reef Research.

Barber, P.H., S.R. Palumbi, M.V. Erdmann dan M.K. Moosa, 2000. A marine Wallace's line? *Nature* 406: 392–693.

Barber, P.H., S.R. Palumbi, M.V. Erdmann dan M.K. Moosa, 2002. Sharp genetic breaks among populations of *Haptosquilla pulchella* (Stomatopoda) indicate limits to larval transport: patterns, causes, and consequences. *Molecular Ecology* 11: 659–674.

Barkman, J.J., H. Doing, dan Segal, S. 1964. Kritische bemerkungen und vorschlage zur quantitativen vegetationsanalyse. *Acta Botanica Neerlandica* 13: 394–419.

Colin, P.L. and Arneson, C. 1995. *Tropical Pacific Invertebrates*. Coral Reef Press, California, USA.

DeVantier, L.M., De'ath, G., Done, T.J. dan Turak, E. 1998. Ecological assessment of a complex natural system: a case-study from the Great Barrier Reef. *Ecological Applications* 8: 480–496.

DeVantier, L.M., De'ath, G., Klaus, R., Al-Moghrabi, S., Abdal-Aziz, M., Reinicke, G.B., dan Cheung, C.P.S. 2004. Reef-building corals and coral communities of the Socotra Islands, Yemen: A zoogeographic 'cross-roads' in the Arabian Sea. *Fauna of Arabia* 20: 117–168.

DeVantier, L.M., Turak, E., dan Skelton, P. 2006. Ecological Assessment of the coral communities of Bunaken National Park: Indicators of management effectiveness. *Proceedings of the 10th International Coral Reef Symposium*, Okinawa.

DeVantier, L.M., Turak, E., dan Allen, G. 2008. Lesser Sunda Ecoregional Planning Coral Reef Stratification Reef- and Seascapes of the Lesser Sunda Ecoregion. Report to The Nature Conservancy, Jl. Pengembak No. 2, Sanur – Bali 80228, Indonesia, 30 hal. ditambah Lampiran.

Done, T.J. 1982. Patterns in the distribution of coral communities across the central Great Barrier Reef. *Coral Reefs* 1: 95–107.

Erdmann, M.V. dan R.B. Manning, 1998. Nine new stomatopod crustaceans from coral reef habitats in Indonesia and Australia. *Raffles Bulletin of Zoology* 46(2): 615–626.

Fukami, H., Chen, C.A., Budd, A.F., Collins, A., Wallace, C., Chuang, Y.-Y., Chen, C., Dai, C.-F., Iwao, K., Sheppard, C., dan Knowlton, N. 2008. Mitochondrial and nuclear genes suggest that stony coral sare monophyletic but most families of stony corals are not (Order Scleractinia, Class Anthozoa, Phylum Cnidaria). *PLOS One* http://dx.plos.org/10.1371/journal.pone.0003222.

Gosliner, T.M., Behrens, D.W. dan Williams, G.C. 1996. *Coral Reef Animals of the Indo-Pacific.* Monterey, USA. Sea Challengers.

Green A.L. dan P.J. Mous, 2007. Delineating the Coral Triangle, its ecoregions and functional seascapes. Report based on an expert workshop held at the TNC Coral Triangle Center, Bali Indonesia (April - May 2003), and subsequent consultations with experts held from 2005 to 2007. Version 4.0 (August 2007). Report from The Nature Conservancy, Coral Triangle Center (Bali, Indonesia) and the Global Marine Initiative, Indo-Pacific Resource Centre (Brisbane, Australia). 78 hal.

Hoeksema, B.W. 1989. Taxonomy, phylogeny and biogeography of mushroom corals (Scleractinia: Fungiidae). *Zoologische Verhandelingen* 254: 1–295.

Hoeksema, B.W. dan Putra, K.S. 2000. The reef coral fauna of Bali in the centre of marine biodiversity. *Proceedings of the 9th International Coral Reef Symposium*, Bali, Vol 1.

Hopley, D. 1982. *The Geomorphology of the Great Barrier Reef: Quaternary Development of Coral Reefs.* New York. John Wiley-Interscience, 453 hal.

Hopley, D., Parnell, K.E. dan Isdale, P.J. 1989. The Great Barrier Reef Marine Park: Dimensions and regional patterns. *Australian Geographic Studies* 27: 47–66.

Jongman, R.H.G., ter Braak, C.J.F. dan van Tongeren, O.F.R. 1995. Data analysis in community and landscape ecology. Cambridge University Press, 299 hal.

Miller, I.R. dan De'ath, G. 1995. Effects of training on observer performance in assessing benthic cover by means of the manta tow technique. *Marine and Freshwater Research* 47: 19–26.

Sheppard, C.R.C. dan Sheppard, A.L.S. 1991. Corals and coral communities of Arabia. *Fauna of Saudi Arabia* 12: 13–170.

Turak, E. 2002. *Assessment of coral biodiversity and coral reef health of the Snagihe-Talaud Islands, North Sulawesi, Indonesia, 2002*. Final Report to The Nature Conservancy.

Turak, E. 2004. *Coral Reef Surveys During TNC SEACMPA RAP of Wakatobi National Park, Southeast Sulawesi, Indonesia, May 2003*. Final Report to The Nature Conservancy.

Turak, E. 2005. *Coral Biodiversity and Reef Health*. Dalam: Mous, PJ, B. Wiryawan dan L.M. DeVantier (eds.) 2006. *Report on a rapid ecological assessment of Derawan Islands, Berau district, East Kalimantan, Indonesia, October 2003*. TNC Coastal Marin Program Report.

Turak, E. 2006a. *Corals and Coral Communities of the Komodo National Park*. Dalam: Beger, M dan Turak, E (2006) A Rapid Ecological Assessment of the reef fishes and scleractinian corals of Komodo National Park, Indonesia in 2005. The Nature Conservancy.

Turak, E. dan DeVantier, L.M. 2003. *Corals and coral communities of Bunaken National Park and nearby reefs, North Sulawesi*, Indonesia: Rapid ecological assessment of biodiversity and status. Final Report to the International Ocean Institute Regional centre for Australia and western Pacific.

Turak, E. dan DeVantier, L.M. 2009. Biodiversity and Conservation Priorities of Reef-building Corals in Nusa Penida. Final report to Conservation International, Indonesia.

Turak, E. dan DeVantier, L.M. 2011. *Field Guide to Reef-building Corals of Brunei Darussalam.* Department of Fisheries, Brunei Darussalam, 256 hal.

Turak, E. dan DeVantier, L. Dalam pencetakan. *Biodiversity and conservation priorities of reef-building corals in the Papuan Bird's Head Seascape*. Conservation International, Indonesia.

Turak, E. dan Shouhoka, J. 2003. *Coral diversity and status of the coral reefs in the Raja Ampat islands, Papua province, Indonesia, November 2002.* Final Report to The Nature Conservancy

Turak, E., Wakeford, M. dan Done, T.J. 2003. *Kepulauan Banda rapid ecological assessment, May 2002: Assessment of coral biodiversity and coral reef health*. Dalam, Mous, P.J (ed), Report on a rapid ecological assessment of the Kepulauan Banda, Maluku, Eastern Indonesia, held April 28 – May *5 2002,* TNC and UNESCO publication, 150 hal.

van der Maarel, E. 1979. Transformation of cover-abundance values in phytosociology and its effects on community similarity. *Vegetatio* 39: 97–114.

van Woesik, R. 1997. A comparative survey of coral reefs in south-eastern Bali, Indonesia, 1992 and 1997. Laporan tidak dipublikasi.

van Woesik, R. 2004. Comment on "Coral Reef Death During the 1997 Indian Ocean Dipole Linked to Indonesian Wildfires". Science 303: 1297.

Veron, J.E.N., DeVantier, L.M., Turak, E., Green, A.L., Kininmonth, S., Allen, G.R., Stafford-Smith, M.G., Mous, P.A. dan Petersen, N.A. (tidak dipublikasi) Global coral biodiversity: a blueprint for reef conservation.

Veron, J.E.N. 1986. *Corals of Australia and the Indo-Pacific.* Angus and Robertson, Australia, 644 hal.

Veron, J.E.N. 1990. New Scleractinia from Japan and other Indo-west Pacific countries. *Galaxea* 9: 95–173.

Veron, J.E.N. 1993. *A Biogeographic Database of Hermatypic Corals Species of the Central Indo-Pacific Genera of the World.* Australian Institute of Marine Science Monograph Series Vol. 10, 433 hal.

Veron, J.E.N. 1995. *Corals in Space and Time The Biogeography and Evolution of the Scleractinia.* University of New South Wales Press, 321 hal.

Veron, J.E.N. 1998. *Corals of the Milne Bay Region of Papua New Guinea*. Dalam: Werner, TA dan Allen GR (eds). A *rapid biodiversity assessment of the coral reefs of Milne Bay*

Province, Papua New Guinea. Conservation International, RAP Working Papers, 11.

Veron, J.E.N. 2000. *Corals of the World.* Australian Institute of Marine Science publ.

Veron, J.E.N. 2002. *New Species Described in Corals of the World*. Australian Institute of Marine Science Monograph Series, Vol. 11. Australian Institute of Marine Science publ.

Veron, J.E.N. dan Pichon, M. 1976. Scleractinia of Eastern Australia. Part I Families Thamnasteriidae, Astrocoeniidae, Pocilloporidae. Australian National University Press, Canberra, Australian Institute of Marine Science Monograph Series 1, 86 hal.

Veron, J.E.N. dan Pichon, M. 1980. Scleractinia of Eastern Australia. Part III Families Agariciidae, Siderastreidae, Fungiidae, Oculinidae, Merulinidae, Mussidae, Pectiniidae, Caryophylliidae, Dendrophylliidae. Australian National University Press, Canberra, Australian Institute of Marine Science Monograph Series 4, 422 hal.

Veron, J.E.N. dan Pichon, M. 1982. Scleractinia of Eastern Australia. Part IV. Family Poritidae Australian National University Press, Canberra, Australian Institute of Marine Science Monograph Series 5, 159 hal.

Veron, J.E.N., Pichon, M. dan Wijsman-Best, M. 1977. Scleractinia of Eastern Australia. Part II Families Faviidae, Trachyphylliidae. Australian National University Press, Canberra, Australian Institute of Marine Science Monograph Series 1, 233 hal.

Veron, J.E.N. dan Wallace, C.C. 1984. Scleractinia of Eastern Australia. Part V Family Acroporidae. Australian National University Press, Canberra, Australian Institute of Marine Science Monograph Series 1, 485 hal.

Veron, J.E.N., DeVantier, L.M., Turak, E., Green, A.L., Kininmonth, S., dan Petersen, N.A. 2009. Delineating the Coral Triangle. *Galaxea* 11: 91–100.

Wallace, C.C. 1999. *Staghorn corals of the World.* CSIRO publ., Australia.

Wallace, C.C. dan Wolstenholme, J. 1998. Revision of the coral genus *Acropora* (Scleractinia: Astrocoeniina: Acroporidae) in Indonesia*. Zoological Journal of the* Linnean Society 123: 199–384.

Wallace, C.C., Turak, E. dan DeVantier, L.M. Submitted. Novelty, parallelism and record site diversity in a conservative coral genus: three new species of *Astreopora* (Scleractinia; Acroporidae) from the Papuan Bird's Head Seascape. *Proc. Royal Society B*.

World Fish Center (diakses pada 19 Mei 2007). An Institutional Analysis of Sasi Laut in Maluku, Indonesia. http://www.worldfishcenter.org/Pubs/Sasi/.pdf

Appendix 5.1. Characteristics of survey stations. Nusa Penida, November 2008 and Bali, April–May 2011. EXP – Exposure rank; RD – Reef Development rank; VIS – Underwater Visibility (water clarity, in meters); WT – Water Temperature (degrees centigrade, see Methods).

Location	Station name	Station	Date	Latitude, S	Longitude, E	EXP	RD	VIS	SP
Lembongan	Lembongan Bay Pantoon	**1.2**	20-Nov-08	8°40.455	115°26.328	3	4	20	23
Lembongan	Mushroom Bay North	**2.2**	20-Nov-08	8°40.781	115°25.977	3	4	20	23
Nusa Penida	Toya Pakeh	**3.1**	21-Nov-08	8°40.997	115°28.957	2	4	25	29
Nusa Penida	Toya Pakeh	**3.2**	21-Nov-08	8°39.84	115°28.017	3	4	20	29
Lembongan	Mangrove N Lembongan	**4.1**	21-Nov-08	8°39.84	115°28.017	2	4	20	28
Lembongan	Mangrove N Lembongan	**4.2**	21-Nov-08	8°47.943	115°31.584	3	4	20	29
Nusa Penida	Manta Point	**5.1**	22-Nov-08	8°47.943	115°31.584	3	1	15	26
Nusa Penida	Old Manta Bay	**6.1**	22-Nov-08	8°45.242	115°28.194	3	1	12	28
Nusa Penida	Crystal Bay South	**7.1**	26-Nov-08	8°42.977	115°27.431	2	3	25	27
Nusa Penida	Crystal Bay South	**7.2**	22-Nov-08	8°42.977	115°27.431	3	3	25	29
Nusa Penida	Batu Abah	**8.1**	23-Nov-08	8°46.461	115°37.616	2	2	30	28
Nusa Penida	Batu Abah	**8.2**	23-Nov-08	8°46.461	115°37.616	3	2	25	29
Nusa Penida	South of Batu Abah	**9.1**	23-Nov-08	8°47.848	115°36.409	2	2	10	28
Nusa Penida	South of Batu Abah	**9.2**	23-Nov-08	8°47.848	115°36.409	3	2	10	28
Nusa Penida	Malibu Point	**10.1**	24-Nov-08	8°42.833	115°35.623	2	4	20	29
Nusa Penida	Malibu Point	**10.2**	24-Nov-08	8°42.833	115°35.623	3	4	5	30
Nusa Penida	Batunggul	**11.1**	24-Nov-08	8°41.381	115°34.923	2	3	30	29
Nusa Penida	Batunggul	**11.2**	24-Nov-08	8°41.381	115°34.923	3	3	20	29
Nusa Penida	Buyuk	**12.1**	25-Nov-08	8°40.47	115°32.596	2	3	25	29
Nusa Penida	Buyuk	**12.2**	25-Nov-08	8°40.47	115°32.596	3	3	10	29
Nusa Penida	Sental	**13.1**	27-Nov-08	8°40.576	115°31.691	2	3	20	28
Nusa Penida	Sental	**13.2**	25-Nov-08	8°40.576	115°31.691	3	3	15	29
Lembongan	Ceningen channel	**14.1**	27-Nov-08	8°41.079	115°27.942	2	4	20	28
Lembongan	Ceningen channel	**14.2**	26-Nov-08	8°41.079	115°27.942	2	4	15	29
Lembongan	Mushroom Bay South	**15.2**	26-Nov-08	8°40.763	115°25.852	3	2	25	27
Nusa Penida	Crystal Bay Rock	**16.1**	29-Nov-08	8°42.905	115°27.338	2	2	20	28
Nusa Penida	Crystal Bay Rock	**16.2**	27-Nov-08	8°42.905	115°27.338	3	2	20	28
Nusa Penida	Sekolah Dasar	**17.1**	28-Nov-08	8°40.349	115°30.515	2	4	25	27
Nusa Penida	Sekolah Dasar	**17.2**	28-Nov-08	8°40.349	115°30.515	3	4	25	27
Bali SE	Terora, Sanur	**1.1**	29-Apr-11	8°46.228	115°13.805	3	4	8	29
Sanur	Terora, Sanur	**1.2**	29-Apr-11	8°46.228	115°13.805	4	4	6	29
Nusa Dua	Glady Willis, Nusa Dua	**2.1**	29-Apr-11	8°41.057	115°16.095	3	4	6	29
	Glady Willis, Nusa Dua	**2.2**	29-Apr-11	8°41.057	115°16.095	3	4	8	29
Sanur	Sanur Channel N side	**3.1**	29-Apr-11	8°42.625	115°16.282	2	4	8	29
Sanur	Sanur Channel	**3.2**	29-Apr-11	8°42.625	115°16.282	4	4	4	28
Nusa Dua	Kutuh Temple	**4.1**	30-Apr-11	8°50.617	115°12.336	4	4	6	28
	Nusa Dua - Public beach	**5.1**	30-Apr-11	8°50.617	115°12.336	3	4	12	29
Nusa Dua	Nusa Dua - Public beach	**5.2**	30-Apr-11	8°48.025	115°14.356	4	4	10	28
Nusa Dua	Melia Bali hotel	**6.1**	30-Apr-11	8°47.608	115°14.192	3	4	10	28
	Melia Bali hotel	**6.2**	30-Apr-11	8°47.608	115°14.192	2	4	8	29
Padang Bai	West Gili Mimpang (Batu Tiga)	**7.1**	1-Mei-11	8°31.527	115°34.519	1	2	20	29
Padang Bai	West Gili Mimpang (Batu Tiga)	**7.2**	1-Mei-11	8°31.527	115°34.519	3	2	20	28

table continued on next page

Appendix 5.1. *continued.*

Location	Station name	Station	Date	Latitude, S	Longitude, E	EXP	RD	VIS	SP
Padang Bai	East Gili Mimpang (Batu Tiga)	**8.1**	1-Mei-11	8°31.633	115°34.585	2	2	20	28
Padang Bai	East Gili Mimpang (Batu Tiga)	**8.2**	1-Mei-11	8°31.633	115°34.585	2	2	20	29
Padang Bai	Jepun, Amuk Bay, Candi Dasa	**9.1**	1-Mei-11	8°31.138	115°34.619	1	4	7	29
Padang Bai	Jepun, Amuk Bay, Candi Dasa	**9.2**	1-Mei-11	8°31.138	115°34.619	2	4	6	28
Padang Bai	Gili Tepekong, Candi Dasa	**10.1**	2-Mei-11	8°31.885	115°35.167	2	2	30	28
Padang Bai	Gili Tepekong, Candi Dasa	**10.2**	2-Mei-11	8°31.885	115°35.167	2	2	25	29
Padang Bai	Gili Biaha/ Tanjung Pasir Putih	**11.1**	2-Mei-11	8°30.27	115°36.771	1	2	15	29
Padang Bai	Gili Biaha/Tanjung Pasir Putih	**11.2**	2-Mei-11	8°30.27	115°36.771	3	2	15	28
NE Bali	Seraya	**12.1**	3-Mei-11	8°26.01	115°41.274	3	1	6	28
NE Bali	Seraya	**12.2**	3-Mei-11	8°26.01	115°41.274	2	1	10	29
NE Bali	Gili Selang North	**13.1**	3-Mei-11	8°23.841	115°42.647	1	3	25	29
NE Bali	Gili Selang North	**13.2**	3-Mei-11	8°23.841	115°42.647	3	1	16	28
NE Bali	Gili Selang South	**14.1**	3-Mei-11	8°24.079	115°42.679	3	1	12	29
NE Bali	Gili Selang South	**14.2**	3-Mei-11	8°24.079	115°42.679	2	2	20	29
NE Bali	Bunutan, Amed	**15.1**	4-Mei-11	8°20.731	115°40.826	1	1	20	30
NE Bali	Bunutan, Amed	**15.2**	4-Mei-11	8°20.731	115°40.826	3	2	20	30
NE Bali	Jemeluk, Amed	**16.1**	4-Mei-11	8°20.221	115°39.617	2	3	20	30
NE Bali	Jemeluk, Amed	**16.2**	4-Mei-11	8°20.221	115°39.617	1	3	20	30
NE Bali	Kepa, Amed	**17.1**	4-Mei-11	8°20.024	115°39.244	1	3	20	30
NE Bali	Kepa, Amed	**17.2**	4-Mei-11	8°20.024	115°39.244	3	3	20	30
NE Bali	Batu Kelibit, Tulamben	**18.1**	5-Mei-11	8°16.696	115°35.826	2	2	20	30
NE Bali	Batu Kelibit, Tulamben	**18.2**	5-May-11	8°16.696	115°35.826	2	2	20	30
NE Bali	Tukad Abu, Tulamben	**19.1**	5-May-11	8°17.603	115°36.599	1	1	15	30
NE Bali	Tukad Abu, Tulamben	**19.2**	5-May-11	8°17.603	115°36.599	3	2	10	30
NE Bali	Gretek	**20.1**	6-May-11	8°8.969	115°24.733	2	2	3	28
NE Bali	Gretek	**20.2**	6-May-11	8°8.969	115°24.733	2	2	5	30
NE Bali	Penutukang	**21.1**	6-May-11	8°8.27	115°23.622	2	2	6	29
NE Bali	Penutukang	**21.2**	6-May-11	8°8.27	115°23.622	2	2	5	30
NW Bali	Puri Jati	**22**	7-May-11	8°11.032	114°54.869	2	1	6	29
NW Bali	Kalang Anyar	**23**	7-May-11	8°11.344	114°53.841	2	1	4	29
NW Bali	Taka Pemutaran	**24.1**	8-May-11	8°7.775	114°40.007	2	2	20	29
NW Bali	Taka Pemutaran	**24.2**	8-May-11	8°7.775	114°40.007	3	2	16	29
NW Bali	Sumber Kima	**25.1**	8-May-11	8°6.711	114°36.451	2	4	15	29
NW Bali	Sumber Kima	**25.2**	8-May-11	8°6.711	114°36.451	3	4	12	29
NW Bali	Menjangan North	**26.1**	9-May-11	8°5.467	114°30.131	2	4	25	30
NW Bali	Menjangan North	**26.2**	9-May-11	8°5.467	114°31.131	3	4	18	30
NW Bali	Menjangan East	**28.1**	9-May-11	8°5.813	114°31.608	2	3	16	28
NW Bali	Menjangan East	**28.2**	9-May-11	8°5.813	114°31.608	3	3	10	30
NW Bali	Secret Bay, Muck dive	**29**	10-May-11	8°9.862	114°26.302	1	1	4	28
NW Bali	Secret Bay, Reef north shore	**30**	10-May-11	8°9.771	114°27.116	2	4	6	28
NW Bali	Pearl farm	**31.1**	11-May-11	8°13.911	114°27.249	2	3	3	28
NW Bali	Pearl farm	**31.2**	11-May-11	8°13.911	114°27.249	3	3	3	28
NW Bali	Pearl farm	**32.2**	11-May-11	8°14	114°27.463	2	1	4	29

Appendix 5.2. Visual estimates of percent cover of sessile benthic attributes and substratum types, and depth and station tallies for hermatypic coral species richness, Nusa Penida, November 2008 and Bali, April–May 2011. max - maximum depth (m); min – minimum depth (m). Sessile Benthos: HS – Hard Substrate; HC – Hard Coral; SC – Soft Coral; MA – Macro-Algae; TA – Turf Algae; CA – Coralline Algae; DC – recently Dead Coral; AD – All Dead coral. Substratum types: CP – Continuous Pavement; LB – Large Blocks (>2m diam.); SB – Small Blocks (<2m diam.); RBL – Rubble; SN – Sand.

Station name	Site	Max	Min	Slope	HS	HC	SC	MA	TA	CA	DC	AD	CP	LB	SB	RBL	SN	No. of species	Station total
Lembongan Bay Pantoon	1.2	13	5	5	95	60	10	20	5	5	1	1	80	10	5	0	5	81	81
Mushroom Bay North	2.2	6,5	2	3	90	50	5	20	5	2	0	1	80	5	5	0	10	74	74
Toya Pakeh	3.1	23	10	20	85	60	10	0	5	10	1	0	70	10	5	10	5	79	
Toya Pakeh	3.2	8	1	3	80	50	30	0	10	10	0	2	60	15	5	15	5	79	114
Mangrove N Lembongan	4.1	27	10	20	100	40	5	0	5	5	0	0	85	10	5	0	0	88	
Mangrove N Lembongan	4.2	8	1	10	80	50	10	0	5	5	0	0	70	5	5	10	10	90	134
Manta Point	5.1	34	10	10	90	10	5	0	20	0	0	0	100	0	0	0	0	70	70
Old Manta Bay	6.1	30	12	5	100	3	20	15	20	0	0	0	100	0	0	0	0	42	42
Crystal Bay South	7.1	29	10	30	70	50	20	0	5	10	0	0	65	0	5	25	5	52	
Crystal Bay South	7.2	8	1	5	90	60	30	5	5	5	1	2	70	15	5	5	5	96	123
Batu Abah	8.1	35	10	20	90	50	2	0	5	10	1	3	80	5	5	5	5	89	
Batu Abah	8.2	8	1,5	5	95	50	10	0	5	10	1	3	85	5	5	5	0	76	121
South of Batu Abah	9.1	29	10	10	85	15	5	0	20	5	1	3	55	20	10	10	5	80	
South of Batu Abah	9.2	8	1,5	5	90	20	5	0	20	10	1	2	50	30	10	5	5	67	116
Malibu Point	10.1	40	10	30	90	30	5	0	5	10	1	5	80	5	5	10	0	90	
Malibu Point	10.2	8	1	5	90	30	1	0	20	5	1	3	60	20	10	5	5	101	141
Batunggul	11.1	38	10	20	95	20	2	0	5	5	1	2	70	20	5	0	5	92	
Batunggul	11.2	8	1	10	95	50	0	0	20	10	0	0	70	20	5	5	0	95	140
Buyuk	12.1	38	10	20	95	30	30	0	5	5	0	0	80	10	5	0	5	62	
Buyuk	12.2	8	1	10	80	30	40	0	10	5	0	0	65	5	10	5	15	78	115
Sental	13.1	38	10	30	80	20	10	0	10	5	0	0	60	10	10	10	10	88	
Sental	13.2	8	1	5	70	20	30	0	10	5	1	3	50	10	10	20	10	72	126
Ceningen channel	14.1	31	10	10	70	20	10	0	10	5	1	3	55	10	5	20	10	73	
Ceningen channel	14.2	8	1	5	60	20	20	2	10	5	1	2	40	10	10	10	30	78	119
Mushroom Bay South	15.2	10	3	3	60	30	10	5	5	10	1	3	40	15	5	20	20	81	81
Crystal Bay Rock	16.1	45	10	30	90	20	10	0	5	10	0	0	75	0	5	5	5	82	
Crystal Bay Rock	16.2	10	2	5	90	30	20	0	5	10	0	0	80	5	5	5	5	61	103
Sekolah Dasar	17.1	38	10	20	80	30	3	0	0	5	0	0	70	5	5	0	20	73	
Sekolah Dasar	17.2	8	1	5	90	60	5	0	5	10	0	0	70	15	5	5	5	103	138
Terora, Sanur	1.1	13	6	20	90	15	5	1	20	20	1	5	50	20	20	3	7	880	
Terora, Sanur	1.2	6	2	2	100	30	20	5	10	10	0	0	90	5	5	0	0	83	126
Glady Willis, Nusa Dua	2.1	10	5	20	80	20	5	0	10	5	0	0	60	10	10	5	15	88	
Glady Willis, Nusa Dua	2.2	5	0,5	10	95	25	5	2	20	15	1	2	70	15	10	0	5	90	133
Sanur Channel N side	3.1	15	7	40	90	10	5	2	10	30	1	3	70	10	10	5	5	57	
Sanur Channel	3.2	6	2	2	100	30	5	0	10	10	0	0	90	5	5	0	0	44	79
Kutuh Temple	4.1	13	8	5	80	10	30	10	0	10	0	0	80	0	0	0	20	62	62
Nusa Dua - Public beach	5.1	16	7	30	95	10	20	10	10	20	1	2	85	10	0	0	5	67	
Nusa Dua - Public beach	5.2	7	2	2	100	10	5	5	20	10	0	0	90	10	0	0	0	65	102

table continued on next page

Appendix 5.2. *continued.*

Station name	Site	Max	Min	Slope	HS	HC	SC	MA	TA	CA	DC	AD	CP	LB	SB	RBL	SN	No. of species	Station total
Melia Bali hotel	6.1	15	7	5	90	30	10	5	5	10	0	0	80	5	5	0	10	66	
Melia Bali hotel	6.2	7	2	15	90	25	20	5	20	20	1	3	70	10	10	5	5	95	121
West Gili mimpang (Batu Tiga)	7.1	23	9	10	50	15	5	2	20	30	1	25	20	20	10	30	20	100	
West Gili Mimpang (Batu Tiga)	7.2	8	4	5	70	40	5	0	5	10	0	0	50	10	10	10	20	82	142
East Gili Mimpang (Batu Tiga)	8.1	30	10	30	70	30	5	1	10	10	0	0	50	10	10	20	10	84	
East Gili Mimpang (Batu Tiga)	8.2	9	5	20	90	35	5	2	20	20	1	5	50	20	20	5	5	79	122
Jepun, Amuk Bay, Candi Dasa	9.1	21	9	30	40	15	2	5	40	10	3	20	20	10	10	30	30	82	
Jepun, Amuk Bay, Candi Dasa	9.2	8	1	10	30	10	2	0	30	5	5	20	20	5	5	60	10	87	126
Gili Tepekong, Candi Dasa	10.1	33	11	20	70	30	3	0	5	10	0	0	50	10	10	10	20	99	
Gili Tepekong, Candi Dasa	10.2	10	3	30	100	50	5	1	10	10	1	3	70	30	0	0	0	83	137
Gili Biaha/ Tanjung Pasir Putih	11.1	24	9	10	50	15	3	1	30	20	1	10	10	20	20	20	30	108	
Gili Biaha/ Tanjung Pasir Putih	11.2	8	1	20	80	20	2	0	5	10	0	0	60	10	10	20	0	76	142
Seraya	12.1	16	10	5	20	30	30	0	10	5	0	0	0	10	10	0	80	67	
Seraya	12.2	8	3	10	80	30	40	1	10	10	1	2	0	50	30	0	20	79	110
Gili Selang North	13.1	31	9	25	50	15	15	1	10	10	1	2	20	20	10	10	40	78	
Gili Selang North	13.2	8	1	2	95	40	30	0	5	10	0	0	40	30	25	0	5	76	117
Gili Selang South	14.1	31	10	30	70	30	10	0	10	10	0	0	40	20	10	0	30	72	
Gili Selang South	14.2	9	3	15	90	35	15	2	20	20	1	2	50	20	20	5	5	92	125
Bunutan, Amed	15.1	32	9	20	50	5	5	1	10	10	1	2	10	20	20	20	30	46	
Bunutan, Amed	15.2	8	1	5	90	60	0	0	19	10	0	0	50	30	10	0	10	97	120
Jemeluk, Amed	16.1	31	10	40	20	30	0	0	30	10	0	0	0	10	10	80	0	104	
Jemeluk, Amed	16.2	8	1	10	80	35	5	3	20	20	1	10	50	20	10	10	10	132	181
Kepa, Amed	17.1	30	9	15	50	15	3	1	30	20	1	3	20	20	10	10	20	111	
Kepa, Amed	17.2	8	1	2	80	30	1	0	20	5	0	0	50	10	20	10	5	94	158
Batu Kelibit, Tulamben	18.1	35	10	60	100	40	0	0	10	5	0	0	80	10	10	0	0	117	
Batu Kelibit, Tulamben	18.2	9	1	15	95	20	2	1	30	20	1	3	70	10	15	2	3	95	157
Tukad Abu, Tulamben	19.1	33	9	25	10	2	5	1	5	10	1	2	0	5	5	10	40	68	
Tukad Abu, Tulamben	19.2	8	2	10	90	40	1	0	20	10	0	0	60	10	20	5	5	121	156
Gretek	20.1	24	10	20	40	20	1	0	20	10	10	5	10	20	10	0	60	80	
Gretek	20.2	9	2	10	90	20	3	5	30	10	1	5	60	20	10	5	5	121	150
Penuktukan	21.1	25	10	20	40	20	0	0	20	0	0	1	10	20	10	0	60	76	
Penuktukan	21.2	9	2	30	90	35	2	2	30	10	1	10	60	20	10	5	5	132	164
Puri Jati	22	26	1	10	0	2	0	0	0	0	0	0	0	0	0	0	60	2	2

table continued on next page

Appendix 5.2. *continued.*

Station name	Site	Max	Min	Slope	HS	HC	SC	MA	TA	CA	DC	AD	CP	LB	SB	RBL	SN	No. of species	Station total
Kalang Anyar	23	15	1	5	2	<1	0	0	0	0	0	0	0	0	2	0	40	8	8
Taka Pemutaran	24.1	35	10	30	70	20	5	0	10	5	1	5	50	10	10	10	20	90	
Taka Pemutaran	24.2	8	3	2	80	30	3	0	10	10	1	3	50	10	20	10	10	97	138
Sumber Kima	25.1	34	10	60	95	30	5	1	10	10	0	0	80	10	5	5	0	104	
Sumber Kima	25.2	8	1	5	80	30	5	1	10	5	0	0	50	10	20	10	10	109	154
Menjangan North	26.1	39	10	40	90	30	3	0	5	10	0	0	80	5	5	5	5	115	
Menjangan North	26.2	8	1	2	70	70	3	0	5	5	0	0	60	0	10	0	30	106	168
Menjangan East	28.1	38	10	90	100	20	10	0	10	10	0	0	100	0	0	0	0	82	
Menjangan East	28.2	8	1	20	95	20	40	0	20	5	0	0	90	0	5	0	5	111	150
Secret Bay, Muck dive	29	8	1	10	5	3	0	0	2	0	0	0	0	0	5	0	95	21	21
Secret Bay, Reef north shore	30	13	2	5	70	60	0	2	10	0	0	0	60	0	10	10	20	44	44
Pearl farm	31.1	21	10	20	80	20	20	0	20	0	0	5	70	5	5	10	10	47	
Pearl farm	31.2	8	2	10	90	20	20	0	20	0	0	5	60	20	10	0	10	48	75
Pearl farm	32.2	12	2	5	80	10	10	0	20	0	0	0	40	20	20	0	20	45	45

Appendix 5.3. Coral species check-list for Bali an adjacent regions, including Komodo, Wakatobi. Derewan and Bunaken NP. Species' records for each location have been updated with continuing taxonomic study. • – confirmed species; U – unconfirmed, based on observational and/or photographic evidence, and requiring confirmation; H – Hoeksema & Putra, 2000; 1998. KOM – Komodo, (Turak, 2006); WAK – Wakatobi, (Turak, 2004); BNP – Bunaken NP (DeVantier et al. 2006) and DER – Derewan (Turak, 2005).

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Family Astrocoeniidae Koby, 1890					
Genus *Stylocoeniella* Yabe and Sugiyama, 1935					
Stylocoeniella armata (Ehrenberg, 1834)	•	•	•	•	•
Stylocoeniella guentheri Bassett-Smith, 1890	•	•	•	•	•
Genus *Palauastrea* Yabe and Sugiyama, 1941			•		
Palauastrea ramosa Yabe and Sugiyama, 1941	•	•		•	•
Genus *Madracis* Milne Edwards and Haime, 1849					
Madracis kirbyi Veron and Pichon, 1976	•				•
Family Pocilloporidae Gray, 1842					
Genus *Pocillopora* Lamarck, 1816					
Pocillopora ankeli Scheer and Pillai, 1974	•	•	•		•
Pocillopora damicornis (Linnaeus, 1758)	•	•	•	•	•
Pocillopora danae Verrill, 1864	•	•	•	•	•
Pocillopora elegans Dana, 1846	•				•
Pocillopora eydouxi Milne Edwards and Haime, 1860	•	•	•	•	•
Pocillopora kelleheri Veron, 2002	•		•	•	•
Pocillopora meandrina Dana, 1846	•	•	•	•	•
Pocillopora verrucosa (Ellis and Solander, 1786)	•	•	•	•	•
Pocillopora woodjonesi Vaughan, 1918		•		•	•
Genus *Seriatopora* Lamarck, 1816					
Seriatopora aculeata Quelch, 1886	•	•	•	•	•
Seriatopora caliendrum Ehrenberg, 1834	•	•	•	•	•
Seriatopora dendritica Veron, 2002				•	•
Seriatopora guttatus Veron, 2002	•		•		•
Seriatopora hystrix Dana, 1846	•	•	•	•	•
Seriatopora stellata Quelch, 1886			•	•	•
Genus *Stylophora* Schweigger, 1819					
Stylophora pistillata Esper, 1797	•	•	•	•	•
Stylophora subseriata (Ehrenberg, 1834)	•	•	•	•	•
Family Acroporidae Verrill, 1902					
Genus *Montipora* Blainville, 1830					
Montipora aequituberculata Bernard, 1897	•	•	•	•	•
Montipora altasepta Nemenzo, 1967	•	•		•	•
Montipora angulata (Lamarck, 1816)	•				•
Montipora cactus Bernard, 1897		•	•	•	•
Montipora calcarea Bernard, 1897	•	•	•	•	•
Montipora caliculata (Dana, 1846)	•	•	•	•	•
Montipora capitata Dana, 1846	•	•	•	•	•
Montipora capricornis Veron, 1985	•				
Montipora cebuensis Nemenzo, 1976	•	•	•	•	•
Montipora confusa Nemenzo, 1967	•	•	•	•	•

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Montipora corbettensis Veron and Wallace, 1984	•	•	•	•	•
Montipora crassituberculata Bernard, 1897	•	•			•
Montipora danae (Milne Edwards and Haime, 1851)	•	•	•	•	•
Montipora deliculata Veron, 2002	•		•	•	•
Montipora digitata (Dana, 1846)	•	•	•	•	•
Montipora dilatata Studer, 1901		•			
Montipora efflorescens Bernard, 1897	•	•	•	•	•
Montipora effusa Dana, 1846	•				
Montipora florida Nemenzo, 1967	U	•	•	•	•
Montipora floweri Wells, 1954	•	•	•	•	•
Montipora foliosa (Pallas, 1766)	•	•	•	•	•
Montipora foveolata (Dana, 1846)	•	•	•	•	•
Montipora friabilis Bernard, 1897	•	•		•	•
Montipora gaimardi Bernard, 1897	•				
Montipora grisea Bernard, 1897	•	•	•	•	•
Montipora hirsuta Nemenzo, 1967	•				
Montipora hispida (Dana, 1846)	•	•	•	•	•
Montipora hodgsoni Veron, 2002	•		•	•	•
Montipora hoffmeisteri Wells, 1954	•	•	•	•	•
Montipora incrassata (Dana, 1846)	•	•	•	•	•
Montipora informis Bernard, 1897	•	•	•	•	•
Montipora mactanensis Nemenzo, 1979	•	•	•	•	•
Montipora malampaya Nemenzo, 1967				•	•
Montipora millepora Crossland, 1952	•	•	•	•	•
Montipora mollis Bernard, 1897	•	•		•	•
Montipora monasteriata (Forskål, 1775)	•	•	•	•	•
Montipora nodosa (Dana, 1846)	•	•	•	•	•
Montipora palawanensis Veron, 2002	•	•	•	•	•
Montipora peltiformis Bernard, 1897	•		•	•	
Montipora porites Veron, 2002	•		•	•	
Montipora samarensis Nemenzo, 1967	•	•	•	•	•
Montipora spongiosa (Ehrenberg, 1834)		•			
Montipora spongodes Bernard, 1897	•		•	•	•
Montipora spumosa (Lamarck, 1816)	•		•	•	•
Montipora stellata Bernard, 1897	•	•		•	•
Montipora tuberculosa (Lamarck, 1816)	•	•	•	•	•
Montipora turgescens Bernard, 1897	•	•	•	•	•
Montipora turtlensis Veron dan Wallace, 1984	•	•	•		•
Montipora undata Bernard, 1897	•	•	•	•	•
Montipora venosa (Ehrenberg, 1834)	•			•	•
Montipora verrucosa (Lamarck, 1816)	•	•		•	•
Montipora verruculosus Veron, 2002		•	•	•	•
Montipora vietnamensis Veron, 2002	•	•	•	•	•

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Genus *Anacropora* Ridley, 1884					
Anacropora forbesi Ridley, 1884	•	•		•	•
Anacropora matthai Pillai, 1973	•				•
Anacropora puertogalerae Nemenzo, 1964	•	•	•	•	•
Anacropora reticulate Veron dan Wallace, 1984	•	•	•	•	•
Anacropora spinosa Rehberg, 1892				•	•
Genus *Acropora* Oken, 1815					
Acropora abrolhosensis Veron, 1985			•	•	•
Acropora abrotanoides (Lamarck, 1816)	•	•	•	•	•
Acropora aculeus (Dana, 1846)	•	•	•	•	•
Acropora acuminata (Verril, 1864)	•	•	•	•	•
Acropora anthocercis (Brook, 1893)	•	•	•	•	•
Acropora aspera (Dana, 1846)	•	•		•	•
Acropora austera (Dana, 1846)	•	•	•	•	•
Acropora awi Wallace dan Wolstenholme, 1998	•				•
Acropora bifurcate Nemenzo, 1971					•
Acropora carduus (Dana, 1846)		•	•	•	•
Acropora caroliniana Nemenzo, 1976			•	•	•
Acropora cerealis (Dana, 1846)	•	•	•	•	•
Acropora clathrata (Brook, 1891)	•	•	•	•	•
Acropora convexa (Dana, 1846)				•	
Acropora cophodactyla (Brook, 1892)	U		•	•	•
Acropora copiosa Nemenzo, 1967	U		•		•
Acropora cytherea (Dana, 1846)	•	•	•	•	•
Acropora derawanensis Wallace, 1997			•		•
Acropora desalwii Wallace, 1994			•	•	
Acropora digitifera (Dana, 1846)	•	•	•	•	•
Acropora divaricata (Dana, 1846)	•	•	•	•	•
Acropora donei Veron dan Wallace, 1984	•	•	•	•	•
Acropora echinata (Dana, 1846)	•		•	•	•
Acropora efflorescens (Dana, 1846)	•				
Acropora elegans Milne Edwards dan Haime, 1860	•		•		•
Acropora elseyi (Brook, 1892)	•	•	•		•
Acropora florida (Dana, 1846)	•	•	•	•	•
Acropora formosa (Dana, 1846)	•	•	•	•	•
Acropora gemmifera (Brook, 1892)	•	•	•	•	•
Acropora glauca (Brook, 1893)	•				
Acropora grandis (Brook, 1892)		•	•	•	•
Acropora granulosa (Milne Edwards dan Haime, 1860)	•	•	•	•	•
Acropora halmareae Wallace & Wolstenholme, 1998			•		
Acropora hoeksemai Wallace, 1997	U		•	•	•
Acropora horrida (Dana, 1846)	•	•	•	•	•
Acropora humilis (Dana, 1846)	•	•	•	•	•

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Acropora hyacinthus (Dana, 1846)	•	•	•	•	•
Acropora indonesia Wallace, 1997	•	•		•	•
Acropora insignis Nemenzo, 1967	•	•	•	•	•
Acropora jacquelineae Wallace, 1994			•		
Acropora kimbeensis Wallace, 1991	•				
Acropora kirstyae Veron dan Wallace, 1984	•		•	•	•
Acropora latistella (Brook, 1891)	•	•	•	•	•
Acropora listeri (Brook, 1893)	•	•	•	•	•
Acropora loisetteae Wallace, 1994					•
Acropora lokani Wallace, 1994			•		
Acropora longicyathus (Milne Edwards dan Haime, 1860)	U	•	•		•
Acropora loripes (Brook, 1892)	•	•	•	•	•
Acropora lovelli Veron dan Wallace, 1984	U				
Acropora lutkeni Crossland, 1952	•	•	•	•	•
Acropora microclados (Ehrenberg, 1834)	•	•	•	•	•
Acropora microphthalma (Verril, 1859)	•	•	•	•	•
Acropora millepora (Ehrenberg, 1834)	•	•	•	•	•
Acropora minuta Veron, 2002	•				
Acropora mirabilis (Quelch, 1886)					•
Acropora monticulosa (Brüggemann, 1879)	•	•	•	•	•
Acropora nana (Studer, 1878)	•	•	•	•	•
Acropora nasuta (Dana, 1846)	•	•	•	•	•
Acropora nobilis (Dana, 1846)	•	•	•	•	•
Acropora ocellata (Klunzinger, 1879)		•			
Acropora orbicularis (Brook, 1892)	U				•
Acropora palmerae Wells, 1954	•	•			
Acropora paniculata Verril, 1902	•	•	•	•	•
Acropora papillare Latypov, 1992	•	•	•		
Acropora parahemprichii Veron, 2002	•				
Acropora pectinatus Veron, 2002			•		
Acropora pichoni Wallace, 1999					•
Acropora pinguis Wells, 1950	U				
Acropora plana Nemenzo, 1967			•		•
Acropora plumosa Wallace & Wolstenholme, 1998			•		•
Acropora polystoma (Brook, 1891)	•	•	•	•	•
Acropora pulchra (Brook, 1891)	•	•	•	•	•
Acropora retusa (Dana, 1846)	U				
Acropora robusta (Dana, 1846)	•	•	•	•	•
Acropora russelli Wallace, 1994	•	•			
Acropora samoensis (Brook, 1891)	•		•	•	•
Acropora sarmentosa (Brook, 1892)	•	•	•	•	•
Acropora secale (Studer, 1878)	•	•	•	•	•
Acropora selago (Studer, 1878)	•	•	•	•	•

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Acropora seriata (Ehrenberg, 1834)					•
Acropora simplex Wallace & Wolstenholme, 1998	•		•		•
Acropora solitaryensis Veron dan Wallace, 1984	•	•	•	•	•
Acropora spathulata (Brook, 1891)		•	•		•
Acropora speciosa (Quelch, 1886)	•	•	•	•	•
Acropora spicifera (Dana, 1846)	•	•	•	•	•
Acropora striata (Verrill, 1866)	•		•		•
Acropora subglabra (Brook, 1891)	•	•	•	•	•
Acropora subulata (Dana, 1846)	•	•	•	•	•
Acropora suharsonoi Wallace, 1994	•				
Acropora sukarnoi Wallace, 1997	•				
Acropora tenella (Brook, 1892)			•		•
Acropora tenuis (Dana, 1846)	•	•	•	•	•
Acropora turaki Wallace, 1994			•		•
Acropora tutuilensis Hoffmeister, 1925		•			
Acropora valenciennesi (Milne Edwards dan Haime, 1860)	•	•	•	•	•
Acropora valida (Dana, 1846)	•	•	•	•	•
Acropora vaighani Wells, 1954	•	•	•	•	•
Acropora vermiculata Nemenzo, 1967			•		
Acropora verweyi Veron dan Wallace, 1984	•	•	•		•
Acropora willisae Veron dan Wallace, 1984	•	•			•
Acropora yongei Veron dan Wallace, 1984	•	•	•	•	•
Genus *Isopora* Studer, 1878					
Isopora brueggemanni (Brook, 1893)	•	•	•	•	•
Isopora crateriformis (Gardiner, 1898)				•	•
Isopora cuneata (Dana, 1846)	•	•		•	•
Isopora palifera (Lamarck, 1816)	•	•	•	•	•
Isopora "Komodo"	•	•			
Genus *Astreopora* Blainville, 1830					
Astreopora cucullata Lamberts, 1980	•	•	•	•	•
Astreopora expansa Brüggemann, 1877				•	•
Astreopora gracilis Bernard, 1896	•	•	•	•	•
Astreopora incrustans Bernard, 1896	•	•			•
Astreopora listeri Bernard, 1896	•	•	•	•	•
Astreopora myriophthalma (Lamarck, 1816)	•	•	•	•	•
Astreopora ocellata Bernard, 1896			•		•
Astreopora randalli Lamberts, 1980		•	•	•	•
Astreopora suggesta Wells, 1954	•	•	•	•	•
Family Euphyllidae Veronm 2000					
Genus *Euphyllia* Dana, 1846					
Euphyllia ancora Veron dan Pichon, 1979	•	•	•	•	•
Euphyllia cristata Chevalier, 1971	•	•	•	•	•
Euphyllia divisa Veron dan Pichon, 1980	•	•	•	•	•

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Euphyllia glabrescens (Chamisso dan Eysenhardt, 1821)	•	•	•	•	•
Euphyllia paraancora Veron, 1990	•	•			•
Euphyllia yaeyamaensis (Shirai, 1980)			•	•	•
Euphyllia sp. New	•				
Genus *Catalaphyllia* Wells, 1971					
Catalaphyllia jardinei (Saville-Kent, 1893)		•	•		•
Genus *Nemenzophyllia* Hodgson and Ross, 1981					
Nemenzophyllia turbida Hodgson and Ross, 1981					•
Genus *Plerogyra* Milne Edwards and Haime, 1848					
Plerogyra simplex Rehberg, 1892	•		•	•	•
Plerogyra sinuosa (Dana, 1846)	•	•	•	•	•
Genus *Physogyra* Quelch, 1884					
Physogyra lichtensteini (Milne Edwards and Haime, 1851)	•	•	•	•	•
Family Oculinidae Gray, 1847					
Genus *Galaxea* Oken, 1815					
Galaxea acrhelia Veron, 2002			•	•	•
Galaxea astreata (Lamarck, 1816)	•		•	•	•
Galaxea fascicularis (Linnaeus, 1767)	•	•	•	•	•
Galaxea horrescens (Dana, 1846)		•	•	•	•
Galaxea longisepta Fenner & Veron, 2002	•	•		•	•
Galaxea paucisepta Claereboudt, 1990					•
Family Siderasteridae Vaughan and Wells, 1943					
Genus *Pseudosiderastrea* Yabe and Sugiyama, 1935					
Pseudosiderastrea tayami Yabe and Sugiyama, 1935	•				
Genus *Psammocora* Dana, 1846					
Psammocora contigua (Esper, 1797)	•	•		•	•
*Psammocora decussata*Yabe and Sugiyama, 1937			•		
Psammocora digitata Milne Edwards and Haime, 1851	•	•		•	•
Psammocora explanulata Horst, 1922	•	•	•	•	•
Psammocora haimiana Milne Edwards and Haime, 1851	•	•	•	•	•
Psammocora nierstraszi Horst, 1921	•	•	•	•	•
Psammocora obtusangula (Lamarck, 1816)	•	•	•	•	•
Psammocora profundacella Gardiner, 1898	•	•	•	•	•
Psammocora stellata Verrill, 1868	•				
Psammocora superficialis Gardiner, 1898	•	•	•		•
Genus *Coscinaraea* Milne Edwards and Haime, 1848					
Coscinaraea columna (Dana, 1846)	•	•	•	•	•
Coscinaraea crassa Veron and Pichon, 1980	•				•
Coscinaraea exesa (Dana, 1846)	•		•		•
Coscinaraea monile (Foskål, 1775)	•	•	•		•
Coscinaraea wellsi Veron and Pichon, 1980	•		•	•	•
Genus *Craterastrea* Head 1981					

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Family Agariciidae Gray, 1847					
Genus *Pavona* Lamarck, 1801					
Pavona bipartita Nemenzo, 1980	•	•	•	•	•
Pavona cactus (Forskål, 1775)	•	•	•	•	•
Pavona clavus (Dana, 1846)	•	•	•	•	•
Pavona danai Milne Edwards and Haime, 1860	•		•		
Pavona decussata (Dana, 1846)	•	•	•	•	•
Pavona duerdeni Vaughan, 1907	•	•	•	•	•
Pavona explanulata (Lamarck, 1816)	•	•	•	•	•
Pavona frondifera (Lamarck, 1816)	•	•			•
Pavona maldivensis (Gardiner, 1905)			•	•	•
Pavona minuta Wells, 1954	•	•	•	•	•
Pavona varians Verrill, 1864	•	•	•	•	•
Pavona venosa (Ehrenberg, 1834)	•	•	•	•	•
Genus *Leptoseris* Milne Edwards and Haime, 1849					
Leptoseris explanata Yabe and Sugiyama, 1941	•	•	•	•	•
Leptoseris foliosa Dinesen, 1980	•	•	•	•	•
Leptoseris gardineri Horst, 1921				•	•
Leptoseris hawaiiensis Vaughan, 1907	•	•	•	•	•
Leptoseris incrustans (Quelch, 1886)	•		•	•	•
Leptoseris mycetoseroides Wells, 1954	•	•	•	•	•
Leptoseris papyracea (Dana, 1846)	•	•			•
Leptoseris scabra Vaughan, 1907	•	•	•	•	•
Leptoseris solida (Quelch, 1886)		•	•	•	•
Leptoseris striata Fenner & Veron 2002	U	•	•	•	•
Leptoseris tubulifera Vaughan, 1907					•
Leptoseris yabei (Pillai and Scheer, 1976)		•	•		•
Genus *Coeloseris* Vaughan, 1918					
Coeloseris mayeri Vaughan, 1918	•	•	•	•	•
Genus *Gardineroseris* Scheer and Pillai, 1974					
Gardineroseris planulata Dana, 1846	•	•	•	•	•
Genus *Pachyseris* Milne Edwards and Haime, 1849					
Pachyseris foliosa Veron, 1990		•	•	•	•
Pachyseris gemmae Nemenzo, 1955	•	•	•	•	•
Pachyseris rugosa (Lamarck, 1801)	•	•	•	•	•
Pachyseris speciosa (Dana, 1846)	•	•	•	•	•
Family Fungiidae Dana, 1846					
Genus *Cycloseris* Milne Edwards and Haime, 1849					
Cycloseris colini Veron, 2002		•			•
Cycloseris costulata (Ortmann, 1889)	•	•	•	•	•
Cycloseris curvata (Hoeksema, 1989)	•				
Cycloseris cyclolites Lamarck, 1801	•	•			•
Cycloseris erosa (Döderlein, 1901)	•				

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Cycloseris hexagonalis (Milne Edwards and Haime, 1848)	•				
Cycloseris patelliformis (Boschma, 1923)	•				
Cycloseris sinensis (Milne Edwards and Haime, 1851)	•	•			•
Cycloseris somervillei (Gardiner, 1909)					•
Cycloseris tenuis (Dana, 1846)	•	•	•	•	
Cycloseris vaughani (Boschma, 1923)	•			•	
Genus *Diaseris*					
Diaseris distorta Alcock, 1893	•				•
Diaseris fragilis Alcock, 1893	•				•
Genus *Cantharellus* Hoeksema and Best, 1984					
Cantharellus jebbi Hoeksema, 1993			•		
Genus *Heliofungia* Wells, 1966					
Heliofungia actiniformis Quoy and Gaimard, 1833	•	•	•	•	•
Genus *Fungia* Lamarck, 1801					
Fungia concinna Verrill, 1864	•	•	•	•	•
Fungia corona Döderlein, 1901	•			•	•
Fungia danai Milne Edwards and Haime, 1851	•	•	•	•	•
Fungia fralinae Nemenzo, 1955	•	•	•	•	•
Fungia fungites (Linneaus, 1758*)*	•	•	•	•	•
Fungia granulosa Klunzinger, 1879	•	•	•	•	•
Fungia gravis Nemenzo, 1955	•	•	•	•	•
Fungia horrida Dana, 1846	•	•	•	•	•
Fungia klunzingeri Döderlein, 1901	•	•	•	•	•
Fungia moluccensis Horst, 1919	•	•	•	•	•
Fungia paumotensis Stutchbury, 1833	•	•	•	•	•
Fungia repanda Dana, 1846	•	•	•	•	•
Fungia scabra Döderlein, 1901					•
Fungia scruposa Klunzinger, 1879	•	•	•	•	•
Fungia scutaria Lamarck, 1801	•	•	•	•	•
Fungia spinifer Claereboudt and Hoeksema, 1987		•		•	•
Fungia taiwanensis Hoeksema and Dai, 1991	•	•			
Genus *Ctenactis* Verrill, 1864					
Ctenactis albitentaculata Hoeksema, 1989	H		•	•	•
Ctenactis crassa (Dana, 1846)	•	•	•	•	•
Ctenactis echinata (Pallas, 1766)	•	•	•	•	•
Genus *Herpolitha* Eschscholtz, 1825					
Herpolitha limax (Houttuyn, 1772)	•	•	•		•
Herpolitha weberi Horst, 1921	•	•	•	•	•
Genus *Polyphyllia* Quoy and Gaimard, 1833					
Polyphyllia novaehiberniae (Lesson, 1831)				•	
Polyphyllia talpina (Lamarck, 1801)	•	•	•	•	•
Genus *Sandalolitha* Quelch, 1884					
Sandalolitha dentata (Quelch, 1886)	•	•	•	•	•

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Sandalolitha robusta Quelch, 1886	•	•	•	•	•
Genus *Halomitra* Dana, 1846					
Halomitra clavator Hoeksema, 1989		•		•	•
Halomitra pileus (Linnaeus, 1758)	•	•	•	•	•
Genus *Zoopilus* Dana, 1864					
Zoopilus echinatus Dana, 1846	•	•	•	•	•
Genus *Lithophyllon* Rehberg, 1892					
Lithophyllon lobata Hoeksema, 1989					•
Lithophyllon mokai Hoeksema, 1989			•	•	•
Lithophyllon undulatum Rehberg, 1892				•	•
Genus *Podabacia* Milne Edwards and Haime, 1849					
Podabacia crustacea (Pallas, 1766)	•	•	•	•	•
Podabacia lankaensis Veron, 2002			•		
Podabacia motuporensis Veron, 1990	•	•		•	•
Family Pectiniidae Vaughan and Wells, 1943					
Genus *Echinophyllia* Klunzinger, 1879					
Echinophyllia aspera (Ellis and Solander, 1788)	•	•	•	•	•
Echinophyllia echinata (Saville-Kent, 1871)	•	•	•	•	•
Echinophyllia echinoporoides Veron and Pichon, 1979	•	•	•	•	•
Echinophyllia orpheensis Veron and Pichon, 1980			•		•
Genus *Echinomorpha* Veron, 2000					
Echinomorpha nishihirai (Veron, 1990)			•		
Genus *Oxypora* Saville-Kent, 1871					
Oxypora crassispinosa Nemenzo, 1979	•	•	•	•	•
Oxypora glabra Nemenzo, 1959	•	•	•	•	•
Oxypora lacera Verrill, 1864	•	•	•	•	•
Genus *Mycedium* Oken, 1815					
Mycedium elephantotus (Pallas, 1766)	•	•	•	•	•
Mycedium mancaoi Nemenzo, 1979	•	•	•	•	•
Mycedium robokaki Moll and Best, 1984	•	•	•	•	•
Mycedium steeni Veron, 2002					•
Genus *Pectinia* Oken, 1815					
Pectinia africanus Veron, 2002	U				
Pectinia alcicornis (Saville-Kent, 1871)	•	•	•	•	•
Pectinia ayleni (Wells, 1935)	•	•	•	•	•
Pectinia elongata Rehberg, 1892			•		•
Pectinia lactuca (Pallas, 1766)	•	•	•	•	•
Pectinia maxima (Moll and Borel Best, 1984)	•	•	•	•	•
Pectinia paeonia (Dana, 1846)	•	•	•	•	•
Pectinia teres Nemenzo and Montecillo, 1981	•		•	•	•
Family Merulinidae Verrill, 1866					
Genus *Hydnophora* Fischer de Waldheim, 1807					
Hydnophora exesa (Pallas, 1766)	•	•	•	•	•

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Hydnophora grandis Gardiner, 1904	•		•	•	•
Hydnophora microconos (Lamarck, 1816)	•	•	•	•	•
Hydnophora pilosa Veron, 1985	•	•	•		•
Hydnophora rigida (Dana, 1846)	•	•	•	•	•
Genus *Paraclavarina* Veron, 1985					
Genus *Merulina* Ehrenberg, 1834					
Merulina ampliata (Ellis and Solander, 1786)	•	•	•	•	•
Merulina scabricula Dana, 1846	•	•	•	•	•
Merulina scheeri Head, 1983		•			
Genus *Boninastrea* Yabe and Sugiyama, 1935					
Genus *Scapophyllia* Milne Edwards and Haime, 1848					
Scapophyllia cylindrica Milne Edwards and Haime, 1848	•		•	•	•
Family Dendrophylliidae Gray, 1847					
Genus *Turbinaria* Oken, 1815					
Turbinaria frondens (Dana, 1846)	•	•	•	•	•
Turbinaria heronensis Wells, 1958		•			
Turbinaria irregularis, Bernard, 1896	•	•	•	•	•
Turbinaria mesenterina (Lamarck, 1816)	•	•	•	•	•
Turbinaria patula (Dana, 1846)	•				•
Turbinaria peltata (Esper, 1794)	•	•	•	•	•
Turbinaria reniformis Bernard, 1896	•	•	•	•	•
Turbinaria stellulata (Lamarck, 1816)	•	•	•	•	•
Genus *Heteropsammia* Milne Edwards and Haime, 1848					
Heteropsammia cochlea (Spengler, 1781)	•	•			
Family Caryophylliidae Gray, 1847					
Genus *Heterocyathus* Milne Edwards and Haime, 1848					
Heterocyathus aequicostatus Milne Edwards & Haime, 1848	•	•			
Family Mussidae Ortmann, 1890					
Genus *Blastomussa* Wells, 1961					
Blastomussa wellsi Wijsmann-Best, 1973					
Genus *Micromussa* Veron, 2000					
Micromussa amakusensis (Veron, 1990)	•	•	•		•
Micromussa minuta (Moll and Borel-Best, 1984)			•	•	•
Genus *Acanthastrea* Milne Edwards and Haime, 1848					
*Acanthastrea bowerbanki*Milne Edwards and Haime, 1851			•		
Acanthastrea brevis Milne Edwards and Haime, 1849	•	•	•		•
Acanthastrea echinata (Dana, 1846)	•	•	•	•	•
Acanthastrea hemprichii (Ehrenberg, 1834)	•	•	•	•	•
Acanthastrea hillae Wells, 1955			•		
Acanthastrea ishigakiensis Veron, 1990	•			•	
Acanthastrea lordhowensis Veron & Pichon, 1982	•			•	•
Acanthastrea regularis Veron, 2002	•		•	•	•
Acanthastrea rotundoflora Chevalier, 1975	•		•		•

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Acanthastrea subechinata Veron, 2002	•	•		•	•
Genus *Lobophyllia* Blainville, 1830					
Lobophyllia corymbosa (Forskål, 1775)	•	•	•	•	•
Lobophyllia dentatus Veron, 2002				•	•
Lobophyllia flabelliformis Veron, 2002	•	•		•	•
Lobophyllia hataii Yabe and Sugiyama, 1936	•	•	•	•	•
Lobophyllia hemprichii (Ehrenberg, 1834)	•	•	•	•	•
Lobophyllia robusta Yabe and Sugiyama, 1936	•	•	•	•	•
Lobophyllia serratus Veron, 2002	U				•
Genus *Symphyllia* Milne Edwards and Haime, 1848					
Symphyllia agaricia Milne Edwards and Haime, 1849	•	•	•	•	•
Symphyllia hassi Pillai and Scheer, 1976			•		•
Symphyllia radians Milne Edwards and Haime, 1849	•	•	•	•	•
Symphyllia recta (Dana, 1846)	•	•	•	•	•
Symphyllia valenciennesii Milne Edwards and Haime, 1849	•	•	•	•	•
Genus *Scolymia* Haime, 1852					
Scolymia australis (Milne Edwards and Haime, 1849)					•
Scolymia vitiensis Brüggemann, 1878			•		•
Genus *Mycetophyllia* Milne Edwards and Haime, 1848					
Genus *Australomussa* Veron, 1985					
Australomussa rowleyensis Veron, 1985	•	•	•		•
Genus *Cynarina* Brüggemann, 1877					
Cynarina lacrymalis (Milne Edwards and Haime, 1848)	•	•	•		•
Family Faviidae Gregory, 1900					
Genus *Caulastrea* Dana, 1846					
Caulastrea curvata Wijsmann-Best, 1972				•	
Caulastrea furcata Dana, 1846	•	•	•	•	•
Caulastrea tumida Matthai, 1928			•	•	•
Genus *Favia* Oken, 1815					
Favia danae Verrill, 1872	•		•	•	•
Favia favus (Forskål, 1775)	•	•	•	•	
Favia helianthoides Wells, 1954					•
Favia laxa (Klunzinger, 1879)				•	
Favia lizardensis Veron, Pichon & Wijsman-Best, 1977	•	•	•	•	•
Favia maritima (Nemenzo, 1971)	•	•		•	•
Favia marshae Veron, 2002	•	•			
Favia matthaii Vaughan, 1918	•	•	•	•	•
Favia maxima Veron, Pichon & Wijsman-Best, 1977	•	•	•		•
Favia pallida (Dana, 1846)	•	•	•	•	•
Favia rosaria Veron, 2002	•				•
Favia rotumana (Gardiner, 1899)	•	•	•	•	•
Favia rotundata Veron, Pichon & Wijsman-Best, 1977	•	•	•	•	•
Favia speciosa Dana, 1846	•	•	•	•	•

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Favia stelligera (Dana, 1846)	•	•	•	•	•
Favia truncatus Veron, 2002	•	•	•	•	•
Favia veroni Moll and Borel-Best, 1984	•	•	•	•	•
Favia vietnamensis Veron, 2002			•	•	•
Genus *Barabattoia* Yabe and Sugiyama, 1941					
Barabattoia amicorum (Milne Edwards and Haime, 1850)			•	•	•
Barabattoia laddi (Wells, 1954)	•		•	•	•
Genus *Favites* Link, 1807					
Favites abdita (Ellis and Solander, 1786)	•	•	•	•	•
Favites acuticollis (Ortmann, 1889)	•				•
Favites chinensis (Verrill, 1866)	•	•	•	•	•
Favites complanata (Ehrenberg, 1834)	•	•	•	•	•
Favites flexuosa (Dana, 1846)	•	•	•	•	•
Favites halicora (Ehrenberg, 1834)	•	•	•	•	•
Favites micropentagona Veron, 2002			•		•
Favites paraflexuosa Veron, 2002	•			•	•
Favites pentagona (Esper, 1794)	•	•	•	•	•
Favites russelli (Wells, 1954)	•	•	•	•	•
Favites spinosa (Klunzinger, 1879)			•		•
Favites stylifera (Yabe and Sugiyama, 1937)	•		•	•	•
Favites vasta (Klunzinger, 1879)		•	•	•	•
Genus *Goniastrea* Milne Edwards and Haime, 1848					
Goniastrea aspera Verrill, 1905	•	•	•	•	•
Goniastrea australensis (Milne Edwards and Haime, 1857)	•	•	•	•	•
Goniastrea columella Crossland, 1948				•	
Goniastrea edwardsi Chevalier, 1971	•	•	•	•	•
Goniastrea favulus (Dana, 1846)	U			•	•
Goniastrea palauensis (Yabe and Sugiyama, 1936)		•			
Goniastrea pectinata (Ehrenberg, 1834)	•	•	•	•	•
Goniastrea retiformis (Lamarck, 1816)	•	•	•	•	•
Genus *Platygyra* Ehrenberg, 1834					
Platygyra acuta Veron, 2002	•	•	•	•	•
Platygyra carnosus Veron, 2002	•				
Platygyra contorta Veron, 1990	•	•	•	•	•
Platygyra daedalea (Ellis and Solander, 1786)	•	•	•	•	•
Platygyra lamellina (Ehrenberg, 1834)	•	•	•	•	•
Platygyra pini Chevalier, 1975	•	•	•	•	•
Platygyra ryukyuensis Yabe and Sugiyama, 1936	•	•	•	•	•
Platygyra sinensis (Milne Edwards and Haime, 1849)	•	•	•	•	•
Platygyra verweyi Wijsman-Best, 1976	•	•	•	•	•
Platygyra yaeyamaensis Eguchi and Shirai, 1977		•	•	•	•
Genus *Australogyra* Veron & Pichon, 1982					
Genus *Oulophyllia* Milne Edwards and Haime, 1848					

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Oulophyllia bennettae (Veron, Pichon & Wijsman-Best, 1977)	•	•	•	•	•
Oulophyllia crispa (Lamarck, 1816)	•	•	•	•	•
Oulophyllia laevis (Nemenzo, 1959)	•	•	•	•	•
Genus *Leptoria* Milne Edwards and Haime, 1848					
Leptoria irregularis Veron, 1990	•				•
Leptoria phrygia (Ellis and Solander, 1786)	•	•	•	•	•
Genus *Montastrea* Blainville, 1830					
Montastrea annuligera (Milne Edwards and Haime, 1849)	•		•	•	•
Montastrea colemani Veron, 2002	•	•	•	•	•
Montastrea curta (Dana, 1846)	•	•	•	•	•
Montastrea magnistellata Chevalier, 1971	•	•	•	•	•
Montastrea salebrosa (Nemenzo, 1959)		•	•	•	•
Montastrea valenciennesi (Milne Edwards and Haime, 1848)	•	•	•	•	•
Genus *Plesiastrea* Milne Edwards and Haime, 1848					
Plesiastrea versipora (Lamarck, 1816)	•	•	•	•	•
Genus *Oulastrea* Milne Edwards and Haime, 1848					
Oulastrea crispata (Lamarck, 1816)	•		•		
Genus *Diploastrea* Matthai, 1914					
Diploastrea heliopora (Lamarck, 1816)	•	•	•	•	•
Genus *Leptastrea* Milne Edwards and Haime, 1848					
Leptastrea aequalis Veron, 2002	•	•			•
Leptastrea bewickensis Veron & Pichon, 1977	•				
Leptastrea inaequalis Klunzinger, 1879		•			
Leptastrea pruinosa Crossland, 1952	•	•	•	•	•
Leptastrea purpurea (Dana, 1846)	•	•	•	•	•
Leptastrea transversa Klunzinger, 1879	•	•	•	•	•
Genus *Cyphastrea* Milne Edwards and Haime, 1848					
Cyphastrea agassizi (Vaughan, 1907)	•		•		•
Cyphastrea chalcidium (Forskål, 1775)	•	•	•	•	•
Cyphastrea decadia Moll and Best, 1984	•			•	•
Cyphastrea japonica Yabe and Sugiyama, 1932	•	•	•		•
Cyphastrea microphthalma (Lamarck, 1816)	•	•	•	•	•
Cyphastrea ocellina (Dana, 1864)	•	•			
Cyphastrea serailia (Forskål, 1775)	•	•	•	•	•
Genus *Echinopora* Lamarck, 1816					
Echinopora ashmorensis Veron, 1990				•	
Echinopora gemmacea Lamarck, 1816	•	•	•	•	•
Echinopora hirsutissima Milne Edwards and Haime, 1849					•
Echinopora horrida Dana, 1846	•	•	•	•	•
Echinopora lamellosa (Esper, 1795)	•	•	•	•	•
Echinopora mammiformis (Nemenzo, 1959)				•	•
Echinopora pacificus Veron, 1990	•		•	•	•
Echinopora taylorae (Veron, 2002)		•	•		•

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Family Trachyphylliidae Verrill, 1901					
Genus *Trachyphyllia* Milne Edwards and Haime, 1848					
Trachyphyllia geoffroyi (Audouin, 1826)	•	•	•	•	•
Family Poritidae Gray, 1842					
Genus *Porites* Link, 1807					
Porites massive		•	•	•	•
Porites annae Crossland, 1952	•	•			•
Porites aranetai Nemenzo, 1955	•				
Porites attenuata Nemenzo 1955		•	•	•	•
*Porites australiensis*Vaughan, 1918	•				
Porites cumulatus Nemenzo, 1955	•		•	•	•
Porites cylindrica Dana, 1846	•	•	•	•	•
Porites deformis Nemenzo, 1955	•				•
Porites densa Vaughan, 1918		•			
Porites evermanni Vaughan, 1907	•	•	•		•
Porites flavus Veron, 2002	•				
Porites horizontalata Hoffmeister, 1925	•			•	•
Porites latistella Quelch, 1886	•	•	•	•	•
Porites lichen Dana, 1846	•	•	•	•	•
Porites lobata Dana, 1846	•		•		
Porites lutea Milne Edwards & Haime, 1851	•				
Porites mayeri Vaughan, 1918					•
Porites monticulosa Dana, 1846	•		•	•	•
Porites murrayensis Vaughan, 1918			•		
Porites napopora Veron, 2002	•				•
Porites negrosensis Veron, 1990	•		•	•	•
Porites nigrescens Dana, 1846	•	•	•	•	•
Porites profundus Rehberg, 1892			•	•	
Porites rugosa Fenner & Veron, 2002	•	•	•	•	•
Porites rus (Forskål, 1775)	•	•	•	•	•
Porites sillimaniana Nemenzo, 1976	•				
Porites solida (Forskål, 1775)	•			•	•
Porites stephensoni Crossland, 1952		•		•	•
Porites tuberculosa Veron, 2002	•	•	•	•	•
Porites vaughani Crossland, 1952	•	•	•	•	•
Genus *Goniopora* Blainville, 1830					
Goniopora albiconus Veron, 2002	•		•	•	•
Goniopora burgosi Nemenzo, 1955	•	•	•	•	•
Goniopora columna Dana, 1846	•	•	•	•	•
Goniopora djiboutiensis Vaughan, 1907	•	•	•		•
Goniopora eclipsensis Veron and Pichon, 1982	•		•		•
Goniopora fruticosa Saville-Kent, 1893	•	•	•	•	•
Goniopora lobata Milne Edwards and Haime, 1860	•	•	•	•	•

table continued on next page

Appendix 5.3. *continued.*

Zooxanthellate scleractinia	BALI	KOM	WAK	BNP	DER
Goniopora minor Crossland, 1952	•	•	•	•	•
Goniopora palmensis Veron and Pichon, 1982	•		•	•	•
Goniopora pandoraensis Veron and Pichon, 1982	•		•	•	•
Goniopora pendulus Veron, 1985	•	•	•	•	•
Goniopora somaliensis Vaughan, 1907	•	•	•	•	•
Goniopora stokesi Milne Edwards and Haime, 1851	•	•	•	•	•
Goniopora stutchburyi Wells, 1955	•		•	•	•
Goniopora tenella (Quelch, 1886)		•	•	•	•
Goniopora tenuidens (Quelch, 1886)	•	•	•	•	•
Genus *Alveopora* Blainville, 1830					
Alveopora allingi Hoffmeister, 1925			•		
Alveopora catalai Wells, 1968		•	•		•
Alveopora daedalea (Forskål, 1775)		•			•
Alveopora excelsa Verrill, 1863	•		•		
Alveopora fenestrata (Lamarck, 1816)	•	•	•	•	•
Alveopora gigas Veron, 1985		•	•		•
Alveopora marionensis Veron & Pichon, 1982	•		•		•
Alveopora minuta Veron, 2002	•				•
Alveopora spongiosa Dana, 1846	•	•	•	•	•
Alveopora tizardi Bassett-Smith, 1890	•	•	•	•	•
Alveopora viridis Quoy and Gaimard, 1833	•				
	406	350	388	370	444

Editor's note 27 August 2012:

The new coral reef species referenced in this chapter has been named '*Euphyllia baliensis sp. nov.*' as described in the newly published paper below:

Turak, E., DeVantier, L. & Erdmann, M. 2012, 'Euphyllia baliensis sp. nov. (Cnidaria: Anthozoa: Sclearctinia: Euphylliidae): a new species of reef coral from Indonesia', *Zootaxa*, no. 3422, pp. 52-61.