A Marine Rapid Assessment (MRAP) of Timor-Leste

14 – 23 August 2012

A Report by Conservation International
Edited by MV Erdmann and C Mohan
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Executive Summary

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Introduction

Timor-Leste is situated at the heart of the Coral Triangle and home to some of the most significant marine biodiversity on earth. Eleven of its thirteen districts border the coastline and fishing communities are directly reliant on marine and coastal resources for both food security and their livelihoods. The Timorese Government has also identified nature-based tourism as one of the cornerstones for its future economic development, with plans to establish a tourism trail from Dili to the eastern-most tip of the country. Dive tourism forms an integral part of these plans.

In 2007, after just five years as an independent nation, Timor-Leste declared its first National Park – the Nino Konis Santana National Park (NKSNP). Located in the country's eastern extremity, NKSNP includes a 55,600 hectare marine component. While the decision to declare the National Park was a welcome move towards improved protection of Timor-Leste's important and valuable marine environments, there remain significant challenges to its successful implementation.

A key challenges for the NKSNP management is the current lack of zoning. NKSNP was established as an IUCN Category V Protected Area, meaning that people continue to live within, rely on, and actively use the resources of the Park. Multiple-use zoning is required to establish the 'rules' within this space, to afford the best possible protection for the natural environment without undermining the needs of the people who live there. These 'rules' can then inform how the park is managed.

Under the Coral Triangle Initiative (CTI), the National Government requested assistance from USAID's Coral Triangle Support Partnership (CTSP) to explore the possibilities for cost effective management solutions with strong community participation. CTSP has, in turn, co-facilitated a process whereby fishing communities in the National Park have completed multiple-use zoning of their local marine area. The zones include no-take zones, buffer zones, and special regulation zones with a mix of gear restrictions, temporal closures and species specific take limits. This community-based zoning is accompanied by community-based management plans and covers 22,360 hectares of the 55,600 hectare marine park.

To move this work forward, CTSP was requested to undertake a marine survey, and to provide a report – with recommendations – on the biodiversity, community/assemblage structure, and current condition of coral reefs and related ecosystems. This information will be used to verify the zoning decisions to date, provide data to inform zoning of the remaining 33,240 hectares, and inform development of the marine component of the NKSNP management plan. The survey was also tasked with providing recommendations about priority sites beyond the NKSNP which should be prioritised for increased protection – particularly as they relate to the development of marine tourism along the north coast of Timor-Leste.

Timor-Leste MRAP Objectives

The assessment, conducted from 14-23 August 2012, had the following three primary objectives:

- Assess the current status (including biodiversity, coral reef condition and conservation status/resilience of hard corals and coral reef fishes) of approximately 20 sites representing the full range of oceanographic and ecological conditions found in the Nino Konis Santana National Marine Park, compiling thorough species-level inventories of each of these groups.

- Compile spatially-detailed data on biological features which must be taken into consideration in development of the Nino Konis Santana National Park Management Plan. This includes not only an analysis of any differences in reef community structure across the 20 priority sites, but also specifically identifying areas of outstanding conservation importance and/or marine tourism interest due to rare or endemic hard coral or fish assemblages, presence of reef fish spawning aggregation or cleaning sites, reef communities exposed to frequent cold-water upwelling that are resilient to global climate change, or other outstanding biological features.

- Taking the above into account, provide concrete recommendations to the Timor-Leste government on development of the MPA's management plan (including zonation plan) and on developing marine tourism in the MPA.

Survey Results: General

- The MRAP was successfully completed during a 10-day period of 14-23 August 2012, with a presentation of preliminary findings to the Timor-Leste government on 24 August 2012. The survey team comprised 9 individuals, including 7 local and international marine taxonomists from Conservation International/Coral Triangle Support Partnership (CTSP) and the Timor-Leste Ministry of Agriculture and Fisheries, and 2 videographers. The survey was funded in its entirety by the United States Agency for International Development (USAID), through the CTSP.

- In total, twenty-two sites were successfully surveyed (see Table 1 below), including 14 sites within Nino Konis Santana National Park (both mainland coast and Pulau Jako), as well as 4 sites on the northern mainland coast east of Dili and 4 sites on Pulau Atauro. Unfortunately the southern coastline including Lore was not surveyed due to weather conditions. Two of the sites were assessed for corals only (sites 14 and 22), and two of the sites were assessed for fishes only (sites 12 and 13).

Table 1. Summary of survey sites for Timor-Leste Marine RAP 14-23 August 2012. GPS coordinates given for each site, as well as an indication of whether site was located within the NKS National Park.

Site No.	Date Surveyed	Location Name	NKS Site?	Coordinates
1	14 August 12	Hera West	N	08° 31.183' S, 125° 38.664' E
2	15 August 12	Com (Vailovaia)	Y	08° 21.301' S, 127° 03.631' E
3	15 August 12	Com (Koho Vari)	Y	08° 21.693' S, 127° 05.714' E
4	16 August 12	Loikere	Y	08° 21.131' S, 127° 09.326' E
5	16 August 12	East Loikere (Big Rock)	Y	08° 20.683' S, 127° 09.822' E
6	17 August 12	NW Jako Island (Vata)	Y	08° 24.582' S, 127° 19.425' E
7	17 August 12	SW Jako Island - Perevenu - candidate NTZ	Y	08° 26.298' S, 127° 18.610' E
8	18 August 12	Hilapuna - candidate NTZ	Y	08° 26.298' S, 127° 17.391' E
9	18 August 12	West Jako Island	Y	08° 24.597' S, 127° 19.001' E
10	18,19 Aug 12	Djonu Twin Rocks - candidate NTZ	Y	08° 22.850' S, 127° 14.821' E
11	17,20 Aug 12	Ete Asa Lepek	Y	08° 21.723' S, 127° 04.488' E
12	17,18 Aug 12	Com Harbor seagrass site - fish only	Y	08° 21.762' S, 127° 03.976' E
13	18 August 12	Com Deep Cave - fish only	Y	08° 21.952' S, 127° 07.154' E
14	19 August 12	Djonu East - corals only	Y	08° 23.252' S, 127° 16.543' E
15	19 August 12	Tutuala 3 Terraces	Y	08° 22.555' S, 127° 13.828' E
16	20 August 12	Tenu (Japanese Bunker)	N	08° 19.235' S, 127° 00.070' E
17	21 August 12	Lamsana Inlet East	N	08° 30.977' S, 126° 04.388' E
18	21 August 12	Lamsana Inlet West	N	08° 30.826' S, 126° 04.157' E
19	22 August 12	Belio Barrier Reef (Pulau Atauro)	N	08° 13.603' S, 125° 36.802' E
20	22 August 12	Belio "Saddle" Patch Reef (Pulau Atauro)	N	08° 12.933' S, 125° 37.580' E
21	23 August 12	Atauro Lagoon	N	08° 14.374' S, 125° 36.728' E
22	23 August 12	Atauro Belio Harbor - corals only	N	08° 13.281' S, 125° 36.830' E

- With over 250 man-hours of diving conducted during the MRAP, the team was overall very impressed with the extremely high biodiversity at the site level (including several new species and a number of range extensions) and pleased to note that the majority of those reefs with top conservation value have already been wisely included within the NKS National Park (and in fact many are already agreed upon by local communities to be included as no-take areas for fisheries replenishment). While there was abundant evidence of past crown of thorns starfish (COTS) outbreaks and legacy damage from blast fishing, most reefs (especially within the NKS National Park) appeared to be in an active state of recovery. Some reefs, especially those closer to Dili, suffered from sedimentation caused from erosion in the hinterlands - pointing to an urgent need for improved watershed management. On the positive side, the team also noted that most reefs surveyed were exposed to cooler temperatures (25-27°C) than reefs in nearby Indonesia as well as strong currents, two factors which likely will confer strong climate change resiliency to Timor-Leste reefs. Overall the team noted that Timor-Leste has made excellent progress in gazetting NKS National Park as a robust "anchor MPA" for its nascent national MPA network, and now needs to work on both consolidating this effort with a strategic zonation system and management plan for NKS while also making progress in gazetting new representative MPAs and focusing on watershed management to keep its marine ecosystems and their related fisheries healthy.

Survey Results: Reef Fish Biodiversity

- The biodiversity of reef fishes was assessed for 20 of the 22 survey sites using underwater visual census from 1-70m depth. A total of 741 species were recorded, representing 234 genera and 61 families. In addition, 40 species not recorded during the MRAP were noted by A.M. Ayling during a 2008 survey of the proposed Nino Konis Santana Marine Park and another 33 records were added by a September 2012 expedition from the Australian Museum. Therefore, the current known reef fish fauna of Timor-Leste includes 814 species.

- With the addition of historical records (123 additional species) from Timor-Leste and Indonesian West Timor, as well as Kupang market survey records (31 additional species) by B.C. Russell of the Northern Territory Museum, the resultant total is raised to 968 reef fish species belonging to 316 genera and 88 families. A total of 275 species recorded during the current MRAP represent new records for this region.

- A formula for predicting the total reef fish fauna based on the number of species in six key indicator families (Chaetodontidae, Pomacanthidae, Pomacentridae, Labridae, Scaridae, and Acanthuridae) indicates that at least 1232 species can be expected to occur in the region of Timor-Leste and West Timor.

- Wrasses (Labridae), Damselfishes (Pomacentridae), and gobies (Gobiidae) are the dominant groups in the region in both number of species (104, 94, and 89 respectively) and number of individuals.

- Species numbers at visually sampled sites during the survey ranged from 66 to 294, with an average of 212 species per site. This is the second highest average for any survey region to date anywhere on the globe. The top 7 sites recorded for reef fish diversity in Timor-Leste included Site 19 (Belio Barrier Reef, Pulau Atauro; 294 species); Site 4 (Loikere; 270 species); Site 11 (Ete Asa Lepek; 260 species); Site 9 (West Jako Island; 249 species); Site 16 (Tenu; 243 species); Site 13 (Com Deep Cave; 238 species); and Site 10 (Djonu Twin Rocks Tutuala; 237 species).

- 200 or more species per site is considered the benchmark for an excellent fish count. This total was achieved at 70 percent of the 2012 Timor-Leste MRAP sites - the highest percentage yet recorded by the authors anywhere in the world

- During the course of the survey, we photographed and collected three definite undescribed species (a damselfish in the genus *Chromis*, a goby in the genus *Vanderhorstia*, and a jawfish in the genus *Stalix* - noting that each of these have also been previously photographed in Indonesia) and three species that are potentially new (a dottyback in the genus *Labracinus*, another damselfish in the genus *Chromis*, and a damselfish in the genus *Chrysiptera*) but are currently being investigated with genetic techniques to determine if they do indeed represent distinct taxa. Moreover, we recorded at least 16 important range extensions of species previously not known or expected to occur in Timor-Leste - some having only been previously known from Brunei and the South China Sea. Included in these extensions are the following species: *Luzonichthys taeniatus, Pseudochromis pictus, Cirrhilabrus humanni, Cirrhilabrus tonozukai, Hoplolatilus chlupatyi, Chlorurus capistratoides, Pterapsaron longipinnis, Synchiropus tudorjonesi, Pseudanthias charlenae, Pomacentrus cheraphilus, Meiacanthus cyanopterus, Parapercis flavolineatus,* and *Trimma papayum.*

- Sharks, coral trout (*Plectropomus* species), and the highly threatened Napoleon Wrasse (*Cheilinus undulatus*) were rarely seen during the survey, an indication of significant fishing pressure and the urgent need for implementation of no-take zones within Timor-Leste's national MPA network for the purposes of fisheries replenishment.

- In summary, we were impressed with the extremely high within-site diversity of Timor-Leste's reefs, as well as the overall high diversity recorded. We have no doubt that additional survey work focused on the south coast as well as Pulau Atauro and other habitats not yet thoroughly sampled on the present MRAP would yield even more impressive diversity numbers (and likely new species and range extensions) for Timor-Leste. In the meantime, we recommend an initial focus on setting up well-enforced no-take zones and a broader zonation system with clear rules within the NKS National Park, as well as an initiative to gazette a new MPA at Pulau Atauro. We moreover note that Timor-Leste has excellent potential for development of marine tourism as a synergistic economic driver along with MPA implementation, whilst noting that it is important to set clear regulations from the outset that insure that local communities derive meaningful benefits from tourism in a way that encourages even better stewardship of their reefs.

Survey Results: Hard Coral Biodiversity

- A total of 39 sites (adjacent deep and shallow areas) at 20 stations (individual GPS locations) were surveyed along the NE coast of Timor-Leste inside and outside of Nino Konis Santana National Park and on Atuaro Island. Coral communities were assessed in a range of wave exposure, current and sea temperature regimes, and included most habitat types of the NE coast. Coral communities of the S coast, known to be of differing structure because of the different environmental regime, were not assessed due to weather and logistic constraints.

- Timor-Leste hosts a diverse reef coral fauna, with a confirmed total of 367 reef-building (hermatypic) coral species. An additional 27 species were unconfirmed, requiring further taxonomic study. Three species (*Echinophyllia*, *Goniopora* and *Montipora* spp.) show significant morphological differences from their closest congeners, and are likely new to science, though requiring additional taxonomic study. In total, there are likely to be ca. 400 hermatypic Scleractinia present in Timor-Leste waters.

- Using cluster analysis at the station level, four coral community types were identified. Each of the communities was characterized by a more-or-less distinctive suite of species and benthic attributes. Two communities occurred predominantly in NKSNP, one of which at Jako Island and the other along the NE coast. The other two communities were most common further west and at Atuaro Island.

- The above impacts notwithstanding, corals exhibited relatively low levels of recent injury overall, other than at Lamsana Inlet, where an active crown-of-thorns seastar outbreak was occurring. There was no evidence of past or recent major coral bleaching-related mortality, as typically triggered by elevated or depressed sea temperatures.

- There was no evidence or reports of past (1998) or recent (2010) large-scale high temperature bleaching-induced coral mortality around Timor-Leste. This is consistent with the presence of cool waters in most sites, which were typically 25-27° C at the time of the survey in August. This is three to four degrees cooler than many neighbouring locations, where sea surface temperatures consistently average 29-31°C, inter-seasonal and inter-annual variability notwithstanding.

- Waters to the north and south of Timor-Leste are major corridors of the Indonesia ThroughFlow (ITF), itself influenced by the cooling effects of mixing in the Banda Sea. If these cooling influences remain consistent, reliable features, Timor-Leste's oceanography may provide a cool water buffer and refuge against the increasing sea temperatures predicted from climate change over coming decades.

- Timor-Leste has shown great initiative in declaring Nino Konis Santana National Park, which, with effective management, can play a very important role in conservation and replenishment locally and regionally and serves as an outstanding anchor for Timor-Leste's nascent MPA Network. NKSNP has high quality reefs and forms an important link in the regional MPA network being developed in the Lesser Sunda marine ecoregion and the broader Coral Triangle Reefs of high conservation value were widespread in NKSNP and also at Atuaro Island.

- Those reefs with the highest conservation value (taking into consideration indices of replenishment value, rarity, species richness, and hard coral cover) include sites 7 (Jako Island SW), 14 (Djonu East), 4 (Loikere), 6 (Jako Island NW), 15 (Tutuala 3 Terraces), and 19 (Belio Barrier Reef on Atauro Island).

- Most of the high quality reefs we recorded (including 5 of the 6 highest conservation value reefs noted above) are located within the NKSNP, and thus are already afforded a degree of protection and will soon be the focus of strong management, monitoring and enforcement. Reefs at Atuaro Island are also of high conservation value for a number of different criteria, including the presence of two coral community types generally not well represented in NKSNP. As such, Atauro is strongly recommended for development into a new MPA, or even as an extension to NKSNP.

Survey Recommendations

- **Recommendation 1: There are four areas – the Com coastline, Tutuala coastline, Jako Island and Atauro Island – which are strongly deserving of special management attention.** Taking into account the results of both reef fish and coral surveys, the following sites rank amongst the highest in conservation value (based on diversity, biomass/cover, rarity, and replenishment potential): sites 4 (Loikere), 6 (Jako Island NW), 7 (Jako Island SW), 9 (West Jako Island), 10 (Djonu Twin Rocks), 11 (Ete Asa Lepek), 13 (Com Deep Cave), 14 (Djonu East), 15 (Tutuala 3 Terraces), and 19 (Belio Barrier Reef on Atauro Island). Importantly, these top sites group into four main areas: the Com coastline, Tutuala coastline, and Jako Island areas of NKSNP, and Atauro Island. These four areas are strongly deserving of special management attention, as described in the below recommendations.

- **Recommendation 2: That the top priority action for the Timor-Leste Government with regard to marine management, is establishing improved management of the NKSNP.** It is clear from the MRAP survey results that NKSNP is exceedingly well-sited and encompasses the majority of the high conservation value reefs in Timor-Leste, as well as generally good representation of the main coral and reef fish community types. As such, we strongly recommend that the top priority action for the Timor-Leste government at this critical juncture is to continue the strong community engagement already started by the CTSP program and aim to finalize a management plan with a clear and effective zonation system (and its associated rules) that has the strong support of local communities and that provides for strong enforcement (preferably involving local communities as well).

- **Recommendation 3: Establishment of significant 'no-take' zones in key areas will be important to ensure the recovery of larger reef fishes that both provide an important protein source for local communities while also serving as a primary attraction for divers and snorkelers**. The NKSNP (and any other MPAs gazetted as part of the Timor-Leste MPA network) should include significant "no-take" zones (NTZ's) where all forms of fishing and resource extraction are prohibited in order to allow a refuge for these stocks to recover, grow and reproduce - thereby repopulating the reefs of Timor-Leste and eventually providing increased catches to fishers operating outside of these no-take areas. To be optimally effective, these NTZ's need to cover minimally 20-30% of the important reef habitats of Timor-Leste, and should generally aim to have a minimum size of 10 hectares per no-take zone - with larger NTZ's providing more rapid and significant results. Our results show that the NTZ's previously suggested by local communities are very well sited and should be implemented as soon as possible. We moreover note that there are 3 areas in particular which currently have NTZ's agreed to by communities that in the future should be considered for possible expansion: the stretch of reef just east of Com (Ete Asa Lepek to Loikere); the Tutuala coastline, and Jako Island. While we understand that it may not be possible to include the entirety of each of these areas in NTZ's, we strongly urge a phased approach in implementation of NTZ's in NKSNP, whereby the community-suggested areas are implemented and enforced immediately, after which time the communities can be encouraged to consider expanding the NTZs in these 3 areas to cover larger sections of optimal reef fish habitat. Creating several larger fisheries replenishment areas using NTZ designation will have a larger beneficial result to local communities than having a large number of small community NTZs.

- **Recommendation 4: Establish improved protective mechanisms for Atauro Island.** Importantly, the team unanimously identified Atauro Island as the top priority area for further MPA development due to its extremely high biodiversity and highly strategic oceanographic setting in the center of the Ombai Strait (bathing these reefs with strong currents and frequent cool upwellings and thus affording it both outstanding connectivity with other reefs of the Lesser Sunda marine ecoregion and also likely strong climate change resilience). Atauro moreover has excellent potential for marine tourism development (due to its scenic nature, proximity to Dili, and excellent reefs and water clarity), and adding this as either a second MPA in the Timor-Leste network or even as an extension of NKSNP (if that is considered preferable for logistic or administrative reasons) would also ensure better representation of coral community types C and D, which are otherwise only minimally represented within the present boundaries of NKSNP.

- **Recommendation 5: Recognize that effective management will require long term government commitment and resources, and initiate steps to secure this.** It is imperative that the Timor-Leste government and all stakeholders recognize that effective management of the MPA network will require serious enforcement efforts and will be a relatively expensive undertaking that will need significant governmental funding to succeed. The government should strongly consider working with the marine tourism sector to develop MPA user fee systems (such as those already working effectively in MPAs like Bunaken and Raja Ampat in neighboring Indonesia) that could contribute significantly to the costs of enforcement and MPA management. Importantly, management and enforcement in the NKSNP and any other MPAs to be gazetted should strive to involve local communities as much as possible; while this will undoubtedly require significant investment in local capacity building, in the long run having community-led enforcement and management provides the strongest likelihood of long term sustainability and effectiveness of the MPA(s). It is moreover important to note that with effective implementation of the NKSNP management plan, a significant buildup in fish biomass is to be expected within a relatively short time frame of 3-5 years. Recovering fish stocks will likely make the area a target for illegal foreign fishing boats, which may require national level enforcement efforts beyond what can reasonably be expected of NKSNP park rangers.

- **Recommendation 6: Consider drafting a marine tourism master plan**. Timor-Leste has excellent potential to further develop its marine tourism industry. While the current marine tourism hub for the nation is focused around Dili, the smaller-scale tourism development now focusing on the reefs areas around Com and Pulau Jako within the NKSNP and on Atauro Island should be nurtured by the government and provided clear direction and incentives to ensure that they develop in an environmentally-sustainable manner that provides clear benefits to local communities. The government should strongly consider drafting a marine tourism master plan that provides clear regulations on environmentally-friendly accommodation construction and waste management, as well as stipulations to ensure that local communities derive clear benefits (by requiring, for instance, a minimum percentage of resort staff to be hired from local communities, etc). The master plan should carefully consider and strive to harmonize development of both community-run homestays as well as more capital-intensive dive resorts, and should set a clear "tourism carrying capacity" that limits the number of operating licenses. As noted previously, the master plan should also include the development of a marine tourism entrance fee system that is used to fund both MPA management and community improvement programs as has been done effectively in a number of well-established Coral Triangle MPAs.

- **Recommendation 7: Improve watershed management for catchments leading to Hera and Lamsana.** As many of the coastal reef areas closer to Dili (particularly Hera and Lamsana) are showing strong signs of sedimentation stress from erosion within the hinterlands, we strongly urge the Timor-Leste government to take urgent action to improve watershed management and especially to provide/rehabilitate riparian buffer zones that prevent further erosion of Timor-Leste's thin soil in agricultural areas. This will be important not only to improving the long-term sustainability of agriculture, but also for ensuring the food security which Timor-Leste's reefs have long provided for coastal communities and also preserving future marine tourism potential for these coastal reefs.

Chapter 1:
Coral Reef Fishes of Timor-Leste

Gerald R. Allen and Mark V. Erdmann

Humann's Fairy-wrasse (*Cirrhilabrus humanni*), currently known only from Timor-Leste and nearby Alor, Indonesia.

Summary

- A list of fishes was compiled for 20 sites around Timor-Leste during August 2012. The survey involved approximately 75 hours of diving to a maximum depth of 70 m.

- The survey yielded a total of 741 species belonging to 61 families and 234 genera. In addition, 40 species not recorded during the present survey were noted by A.M. Ayling during a 2008 survey of the proposed Nino Konis Santana Marine Park and another 33 records were added by a September 2012 expedition from the Australian Museum. Therefore, the current known fish fauna of Timor-Leste includes 814 species.

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- 200 or more species per site is considered the benchmark for an excellent fish count. This total was achieved at 70 percent of the 2012 Timor-Leste sites - the highest percentage yet recorded by the authors anywhere in the world. Five of the seven highest species counts during the MRAP were recorded from sites within the NKS National Park.

- During the course of the survey, we photographed and collected three definite undescribed species (a damselfish in the genus *Chromis*, a goby in the genus *Vanderhorstia*, and a jawfish in the genus *Stalix* - noting that each of these have also been previously photographed in Indonesia) and three species that are potentially new (a dottyback in the genus *Labracinus*, another damselfish in the genus *Chromis*, and a damselfish in the genus *Chrysiptera*) but are currently being investigated with genetic techniques to determine if they do indeed represent distinct taxa. Moreover, we recorded at least 16 important range extensions of species previously not known or expected to occur in Timor-Leste - some having only been previously known from Brunei and the South China Sea. Included in these extensions are the following species: *Luzonichthys taeniatus, Pseudochromis pictus, Cirrhilabrus humanni, Cirrhilabrus tonozukai, Hoplolatilus chlupatyi, Chlorurus capistratoides, Pterapsaron longipinnis, Synchiropus tudorjonesi, Pseudanthias charlenae, Pomacentrus cheraphilus, Meiacanthus cyanopterus, Parapercis flavolineatus,* and *Trimma papayum.*

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- In summary, we were impressed with the extremely high within-site diversity of Timor-Leste's reefs, as well as the overall high diversity recorded. We have no doubt that additional survey work focused on the south coast as well as Pulau Atauro and other habitats not yet thoroughly sampled on the present MRAP would yield even more impressive diversity numbers (and likely new species and range extensions) for Timor-Leste. In the meantime, we recommend an initial focus on setting up well-enforced no-take zones and a broader zonation system with clear rules within the NKS National Park, as well as an initiative to gazette a new MPA at Pulau Atauro. We moreover note that Timor-Leste has excellent potential for development of marine tourism as a synergistic economic driver along with MPA implementation, whilst noting that it is important to set clear regulations from the outset that insure that local communities derive meaningful benefits from tourism in a way that encourages even better stewardship of their reefs.

Introduction

The East Indian Archipelago, extending from the Andaman Sea to the Solomon Islands and northward to the Philippines, is the world's premier area for marine biodiversity, mainly due to the extraordinary wealth of coral reef organisms. Allen and Erdmann (2012) recorded 2,631 species of reef fishes from this region, a total that is far richer than for any other major biological province. Although lying relatively close to the hypothetical centre of diversity, Timor Leste represents a critical gap in our knowledge of this important region. Therefore, one of the primary goals of the current survey is to comprehensively document the reef fish fauna of an area that is expected to harbour a wealth of fishes, but has yet to be properly surveyed. The knowledge gained from the marine RAP should prove extremely valuable as a planning tool for future marine parks, as well as providing justification for those already established (e.g. Nino Santana National Park).

There is universal agreement that the centre of marine biodiversity is the Coral Triangle, an area composed of Sabah (Malaysian Borneo), Indonesia, Timor-Leste, Philippines, Papua New Guinea, and the Solomon Islands (Allen, 2008). This area contains a wealth of marine species that are most densely concentrated on coral reefs. Despite the contention that the Coral Triangle forms the heart of marine biodiversity, there is relatively poor documentation for most groups other than fishes and corals. There is also controversy regarding the precise limits of the Triangle and a lack of information that would allow the identification of the very richest faunal areas within the Coral Triangle. However, thanks to recent survey efforts by Conservation International and The Nature Conservancy, there is now a much better understanding of diversity levels within the proposed centre of the Triangle, which for fishes and corals at least appears to be centered on Halmahera and West Papua. The largest total to date is from the Raja Ampat Islands of West Papua where 1,472 species of reef fishes have been recorded to date (Allen & Erdmann, 2009 and continuing unpublished research). This number is especially remarkable considering the relatively small physical area occupied by this archipelago, which covers about 40,000 square kilometers.

Ichthyological exploration of the region of Timor-Leste & West Timor

There was minimal scientific interest in the fishes of Timor despite settlement by the Portuguese in 1852 and Dutch colonization beginning in 1653. However, this trend changed in the early nineteenth century during the great age of European exploration when ships regularly stopped at Kupang in order to replenish stores. Naturalists aboard these expeditions made some of the earliest known fish collections on the island. These specimens were eventually conveyed to Europe and were described by some of the great naturalists of the day.

The first recorded scientific collections of marine fishes from Timor were made by the French naturalist Françoise Péron who visited Kupang on board the *Géographe* between 21 August and 13 November 1801, and again between 6 May and 3 June 1803. Specimens collected by Péron were described by Cuvier and Valenciennes (1828-49). The naturalists Quoy and Gaimard aboard the French vessel *Uranie* also made collections of marine fishes during a visit to Kupang in 1818. An account of the fishes was given by Quoy and Gaimard (1824-25).

Timor was a focal point of major interest for Dutch scientist Pieter Bleeker (1819-1878) considered the grand master of East Indian ichthyology, based on his extensive publications and astute knowledge of the region's fishes. He was employed as an army medical officer during his tenure in Indonesia (1842-1860), based at Batavia (Jakarta). Although his own travels around the Indonesian Archipelago were limited, he had an excellent network of contacts that regularly sent specimens from remote government outposts. He devoted seven publications (Bleeker 1852, 1854, 1857, 1858, 1860 a & b, and 1863) to Timorese fishes. The first of these reported 32 species from the island and over the following 11 years the total was steadily increased to 312 species. Bleeker's Timor collections, which are now housed at Naturalis (formerly Rijksmuseum van Natuurlijke Histoire) in Leiden, Netherlands, originated from Kupang and Atapupu, (now Indonesian Timor) with the exception of six species from Dili.

Timor is the type locality for approximately 45 species, mostly described by Bleeker, Cuvier, Quoy and Gaimard, and Weber. Although many are now regarded as junior synonyms some are well known valid species including *Pseudechidna brummeri* (Muraenidae), *Cirrhitichthys aprinus* (Cirrhitidae), *Ostorhinchus wassinki* (Apogonidae), *Chaetodon ocellicaudus* (Chaetodontidae), *Chromis lepidolepis* (Pomacentridae), *Chrysiptera cyanea* and *C. unimaculata* (Pomacentridae), *Halichoeres timorensis* (Labridae), *Istigobius goldmanni* (Gobiidae), and *Naso annulatus* (Acanthuridae).

Other notable investigations included the Dutch *Siboga* Expedition in 1909 (Weber, 1913) and visits by the American Scripps Institution of Oceanography (*Argo* and *Naga* expeditions) between 1959 and 1961, which yielded collections of deepwater fishes. Barry Russell of the Northern Territory Museum, Darwin, Australia has long been interested in the fishes of the region and generously provided access to a manuscript currently in preparation that summarizes all historical records of Timor fishes as well as market sampling he conducted at Kupang in recent years, revealing a combined total of 614 species, representing 107 families. This total includes 462 reef-associated species with the remainder occurring either in fresh water, brackish estuaries, pelagic and deep sea habitats, and soft-bottom trawl grounds.

The only previous dive-based survey of Timor-Leste's reef fishes was conducted in November 2008 by Tony Ayling, a New Zealand marine biologist based in Australia. Ayling employed similar techniques as the present survey during an eight-day assessment of reef fishes of the proposed Nino Konis Santana Marine Park. A total of 410 species were recorded, but using a formula (CFDI, see below) based on the number of species in key indicator families, he estimated an overall total of 840 species.

Just two weeks after the present survey was completed, Timor-Leste was visited by a team from the Australian Museum in Sydney (AMS). A range of reef organisms were collected, including reef fishes. The preliminary results of this survey, including 216 species were kindly made available to us by Mark McGrouther of the Ichthyology Department of AMS and we have incorporated their additions in our list (Appendix Table 1).

Methods

The survey involved approximately 75 hours (two people) of scuba diving to a maximum depth of 70 m. A list of fishes was compiled for 20 sites (Appendix Table 1). The basic method consisted of underwater observations made usually during two, 60-100 minute dives at each site. The name of each observed species was recorded on an Excel spread sheet, using a master list of expected species from the region as a guide. The underwater technique usually involved rapid descent to 30-50 m, then a slow, meandering ascent back to the shallows. The majority of time was spent in the 5-12 m depth zone, which consistently harbors the largest number of species. Each dive included a representative sample of all major bottom types and habitat situations, for example rocky intertidal, reef flat, steep drop-offs, caves (utilizing a flashlight when necessary), rubble and sand patches. In addition to the routine inventory, we were especially vigilant for unusual/rare species, particularly in deeper sections of the reef (i.e. 30-50 m). Visual observations were supplemented with the occasional collection of cryptic, crevice-dwelling species with clove oil and rotenone. Spears were also employed for the collection of specimens of interest.

Only the names of fishes for which identification was absolutely certain were recorded. However, less than one percent of those observed could not be identified to species. This high level of recognition is based on combined diving experience (about 60 years) in the Indo-Pacific and an intimate knowledge of the reef fishes of this vast region as a result of extensive laboratory and field studies.

Results

In order to obtain a truly comprehensive list of Timor-Leste's reef fish resources we have combined the results of the current survey with several other data sources (Table 1): 1. A.M. Ayling 2008 survey of the proposed Nino Santana Marine Park; 2. September 2012 Australian Museum fish collecting expedition to Timor-Leste; 3. fish market records by B.C. Russell (Northern Territory Museum, Australia) from Kupang; 4. historical records of Timor fishes, chiefly by Bleeker (1852-1863) and Weber (1913) from Indonesian western Timor. Although Russell's fish market records and the majority of historical records are from western Timor, we predict that all of these species will eventually be recorded from Timor-Leste, and their incorporation with our data gives a much more accurate assessment of the true fauna. The total reef fish fauna of the Timor-Leste and West Timor Region reported herein consists of 968 species belonging to 88 families and 316 genera (see Appendix Table I). A total of 275 species observed during the current survey are new records for the region. Nearly every reef species from the region is discussed and illustrated by Allen & Erdmann (2012).

Table 1. Faunal elements of the region incorporated in this study.

Data Source	**No. spp.**
2012 CI MRAP survey	741
Ayling 2007 survey	40
Australian Museum Expedition 2012	33
B.C. Russell's Kupang market fishes	31
Historical records from literature	123
Current Total Fauna	**968**
General faunal composition	

The fish fauna of Timor-Leste consists mainly of species associated with coral reefs. The most abundant families in terms of number of species are wrasses (Labridae), damselfishes (Pomacentridae), gobies (Gobiidae), groupers (Serranidae), cardinalfishes (Apogonidae), butterflyfishes (Chaetodontidae), surgeonfishes (Acanthuridae), snappers (Lutjanidae), parrotfishes (Scaridae), and blennies (Blenniidae). These 10 families collectively account for 553 species or about 57 percent of the total reef fishes currently known from the region (Table 2).

Table 2. Most abundant families in the Greater Timor Region (Timor-Leste and Indonesian West Timor) and Timor-Leste.

Rank	Family	Species GTR	Species TL
1	Labridae	104	96
2	Pomacentridae	94	83
3	Gobiidae	89	77
4	Serranidae	60	50
5	Apogonidae	45	36
6	Chaetodontidae	36	35
7	Acanthuridae	35	33
8	Lutjanidae	33	23
9	Scaridae	30	28
10	Blenniidae	27	25

The relative abundance of Timor-Leste fish families is very similar to that found at other Indo-Pacific locations. Labridae, Pomacentridae, and Gobiidae are typically the most speciose families, although the order of these groups is variable according to location. Gobiidae is frequently the most abundant, which is not surprising given that approximately 600 species inhabit Indo-Pacific coral reefs.

The number of species found at each site during the 2012 survey is presented in Table 3. The total for each site ranged from 66 to 294, with an average of 212. This figure equals a previous survey of Halmahera as the second highest average for any survey region to date anywhere on the globe, with only the FakFak-Kaimana coastline of West Papua showing a higher average of 216 species (see Table 4).

Table 3. Number of fish species observed per site during 2012 Timor-Leste MRAP.

Site	Species	Site	Species	Site	Species	Site	Species
1	104	**7**	230	**13**	238	**20**	218
2	220	**8**	167	**15**	213	**21**	227
3	163	**9**	249	**16**	244		
4	270	**10**	237	**17**	201		
5	226	**11**	260	**18**	182		
6	199	**12**	66	**19**	294		

Two hundred or more species per site is considered the benchmark for an excellent fish count. This total was achieved at 70 percent of sites during the present survey - the highest percentage yet recorded by the authors anywhere in the world. Table 4 presents a comparison of various locations in the Coral Triangle that have been surveyed by the authors in recent years.

Table 4. Comparison of site data for marine surveys in the Coral Triangle 1997-2012.

Location	No. sites	Average spp./site	No. 200+ sites	Most spp. one site
Fak Fak-Kaimana Coast, W. Papua, Indonesia (CI 2006)	34	216	21 (62 %)	335
Timor-Leste (2012)	**20**	**212**	**14 (70 %)**	**294**
Halmahera, Indonesia (combined 2005/2008)	52	212	36 (69 %)	304
Milne Bay, PNG (CI 1997 and 2000)	110	192	46 (42 %)	270
Bird's Head, W. Papua, Indonesia (1998-2006)	161	189	83 (52 %)	335
NE Kalimantan (TNC 2003)	42	187	18 (43 %)	273
Solomon Islands (TNC 2004)	65	185	37 (57 %)	279
Raja Ampat Islands, W. Papua (CI 2001 and TNC 2002)	95	184	49 (52 %)	284
Cenderawasih Bay, W. Papua, Indonesia (CI 2006)	32	175	12 (38 %)	257
Togean/Banggai Is., Sulawesi (CI 1998)	47	173	9 (19 %)	266
Calamianes Is., Philippines (CI 1998)	21	158	4 (10.5 %)	208
Bali, Indonesia (CI 2011)	29	153	6 (21 %)	244
Anambas Islands, Indonesia (CI 2012)	20	149	2 (10 %)	240
Brunei (2008/2009)	33	123	0	186

Coral and rocky reefs were by far the richest habitats in terms of fish biodiversity. The best sites for fishes were invariably locations that harboured a rich community in relatively shallow water (> 15 m) as well as a steep outer reef slope affected by periodic strong currents. Coral reef was invariably the dominant substratum, although there was usually a mixture of other bottom types, particularly sand or rubble. Weed or seagrass habitat (e.g. site 12 at Com) and pure sand-rubble areas were comparatively poor for fishes, but were the home of a unique community of fishes, generally not seen elsewhere. Silty bays and harbors (e.g. site 18 at the Lamsana inlet or Manatuto River outlet) also had impoverished fish communities, although several species were unique to this environment.

The richest sites for fish diversity are indicated in Table 5. The outer barrier reef site at Atauro Island was the richest location and this island holds great promise for boosting Timor-Leste's fish total if further surveys are conducted. All but one of the remaining top sites are located within Nino Konis Santana National Park.

Table 5. Richest sites for fishes during 2012 survey of Timor-Leste.

Site No.	Location	Total fish spp.
19	Belio Outer Barrier Reef (Atauro Island)	294
4	Loikere	270
11	Ete Asa Lepek	260
9	West Jako Island	249
16	Tenu	244
13	Com Outer Reef	238
10	Djonu Twin Rocks	237

Coral Fish Diversity Index (CFDI)

In response to the need for a convenient method of assessing and comparing overall coral reef fish diversity between areas in the Indo-Pacific region the author (see Allen and Werner, 2002) has devised a rating system based on the number of species present belonging to the following six families: Chaetodontidae, Pomacanthidae, Pomacentridae, Labridae, Scaridae, and Acanthuridae. These families are particularly good indicators of overall fish diversity for the following reasons:

- They are taxonomically well documented.
- They are conspicuous diurnal fishes that are relatively easy to identify underwater.
- They include the "core" reef species, which more than any other fishes characterize the fauna of a particular locality. Collectively, they usually comprise more than 50 percent of the observable fishes.
- The families, with the exception of Pomacanthidae, are consistently among the 10 most speciose groups of reef fishes inhabiting a particular locality in the tropical Indo-west Pacific region.
- Labridae and Pomacentridae in particular are very speciose and utilize a wide range of associated habitats in addition to coral-rich areas.

The method of assessment consists simply of counting the total number of species present in each of the six families. It is applicable at several levels:

- single dive sites
- relatively restricted localities such as the southwestern Halmahera
- countries, major island groups, or large regions

CFDI values can be used to make a reasonably accurate estimate of the total coral reef fish fauna of a particular locality by means of a regression formula. This feature is particularly useful for large regions, such as the Philippines, where reliable totals are lacking. Because the CFDI groups can be comprehensively documented over a short period of time (usually about two weeks for areas such as Timor-Leste), the CFDI predictor value can be used to gauge the thoroughness of a particular short-term survey that is either currently in progress or already completed.

The above-mentioned regression formula was obtained from an analysis of 35 Indo-Pacific locations that have been comprehensively studied and for which reliable species lists exist. The data were first divided into two groups: those from relatively restricted localities (surrounding seas encompassing less than 2,000 km^2) and those from much larger areas (surrounding seas encompassing more than 50,000 km^2). Simple regression analysis revealed a highly significant difference ($P = 0.0001$) between these two groups. Therefore, the data were separated and subjected to an additional analysis. The Macintosh program Statview was used to perform simple linear regression analyses on each data set in order to determine a predictor formula, using CFDI as the predictor variable (x) for estimating the independent variable (y) or total coral reef fish fauna. The resultant formulae were obtained: 1. total

fauna of areas with surrounding seas encompassing more than 50,000 km^2 = 4.234(CFDI) - 114.446 (d.f = 15; R^2 = 0.964; P = 0.0001); 2. total fauna of areas with surrounding seas encompassing less than 2,000 km^2 = 3.39 (CFDI) - 20.595 (d.f = 18; R^2 = 0.96; P = 0.0001).

The following CFDI values were obtained for the region (Timor-Leste and Indonesian West Timor), after combining the results of our survey with those of other recent efforts (Russell fish market records, Ayling 2007 and 2012 Australian Museum) and old historical records (primarily Bleeker and Weber): Chaetodontidae (36), Pomacanthidae (19), Pomacentridae (94), Labridae (104), Scaridae (30), and Acanthuridae (35). The total CFDI (318) was then used to predict the expected species total with the following formula: total expected fauna = 4.234 (318) – 114.446. Therefore, the expected total species for the region is 1232 species. The CFDI method is especially useful when time is limited and there is heavy reliance on visual observations, as was the case for the present survey.

Table 6 presents a comparison of the Timor-Leste and West Timor region with various Indo-west and central Pacific locations that were surveyed by the author or colleagues.

Table 6. Coral fish diversity index (CFDI) values for selected localities in the Indo-west Pacific region. The total number of fishes thus far recorded from each region and estimated total based on the CFDI regression formula (see text for details) are also indicated.

Locality	CFDI	No. reef fishes	Estim. reef fishes
Raja Ampat Islands, Indonesia	374	1471	1469
Bali and Nusa Penida, Indonesia	339	1022	1320
Milne Bay Province, Papua New Guinea	333	1109	1313
Maumere Bay, Flores, Indonesia	333	1111	1108
Halmahera, Indonesia	327	974	1271
Fakfak-Kaimana, W. Papua, Indonesia	322	1007	1249
Timor-Leste and West Timor	**318**	**967**	**1232**
Berau, E. Kalimantan, Indonesia	316	875	1051
Togean and Banggai Islands, Indonesia	308	819	1190
Cenderawasih Bay, W. Papua, Indonesia	308	1002	1190
North Sulawesi, Indonesia	307	967	1020
Solomon Islands	301	1019	1160
Calamianes Islands-N. Palawan, Philippines	292	1003	1122
Komodo Islands, Indonesia	280	722	929
Yap State, Micronesia	280	787	929
Verde Passage, Luzon, Philippines	278	750	922
Sabah, Malaysia	275	865	1050
Madang, Papua New Guinea	257	787	850
Kimbe Bay, Papua New Guinea	254	687	840
Capricorn Group, Great Barrier Reef	232	803	765
Brunei, Darussalam	230	673	759
Chuuk State, Micronesia	230	615	759
Western Thailand (Andaman Sea)	226	775	843
Ashmore/Cartier Reefs, Timor Sea	225	669	742
Kashiwa-Jima Island, Japan	224	768	738
Scott/Seringapatam Reefs, Western. Australia	220	593	725
Anambas Islands, Indonesia	216	667	801
Samoa Islands	211	852	694
Chesterfield Islands, Coral Sea	210	699	691
Christmas Island, Indian Ocean	204	592	671
Pohnpei and nearby atolls, Micronesia	202	470	664

Layang Layang Atoll, Malaysia	202	458	664
Andaman Islands	200	535	732
Bodgaya Islands, Sabah, Malaysia	197	516	647
Pulau Weh, Sumatra, Indonesia	196	533	644
Izu Islands, Japan	190	464	623
Sipadan Island, Sabah, Malaysia	184	492	603
Rowley Shoals, Western Australia	176	505	576
Cocos-Keeling Atoll, Indian Ocean	167	528	545
North-West Cape, Western Australia	164	527	535
Lord Howe Island, Australia	139	395	450
Monte Bello Islands, W. Australia	119	447	382
Bintan Island, Indonesia	97	304	308
Kimberley Coast, Western Australia	89	367	281
Cassini Island, Western Australia	78	249	243
Johnston Island, Central Pacific	78	227	243
Midway Atoll	77	250	240
Rapa	77	209	240
Norfolk Island	72	220	223

The Timor-Leste Reef Fish Community

As mentioned above, the fish community is dominated by relatively few families, which is a typical situation on reefs throughout the Indo-Pacific region. However, the fish fauna of Timor-Leste represents a mixture of species that form a unique community when compared to other locations in the greater East Indian region. Several families in particular are very well represented on Timor-Leste's reefs, including fairy basslets (Serranidae, subfamily Anthiinae), dottybacks (Pseudochromidae), tilefishes (Malacanthidae), butterflyfishes (Chaetodontidae), damselfishes (Pomacentridae), and wrasses (Labridae).

Dramatically contrasting with the situation described in the previous paragraph, there were many species that were conspicuous by their scarcity or absence compared to most areas in the species-rich Coral Triangle. The latter group includes coral trouts (Serranidae; genus *Plectropomus*), lagoon-dwelling cardinalfishs (Apogonidae), trevallies (Carangidae), parrotfishes (Scaridae), blennies (Blenniidae), rabbitfishes (Siganidae), reef-frequenting tunas (Scombridae), and puffers (Tetraodontidae).

There was also a general lack of large commercial species, including sharks and Napoleon Wrasse (*Cheilinus undulatus*). Aside from a single sighting of a large stingray (*Taeniura myeni*), occasional sightings of certain carangids and a few sharks, large fishes were conspicuously absent at most sites. Although this trend, which is generally a direct indication of over fishing, is typical of the entire South-East Asian region, it was particularly evident at the sites surveyed at Timor-Leste.

A notable feature of Timor-Leste's reef fish fauna is the very high degree of homogeneity in species composition at the survey sites, which is a general reflection of habitat homogeneity. Typically, the survey sites consisted of a shallow, shoreline fringing reef, gradually sloping seaward to the edge of the outer slope. Due to this high degree of habitat homogeneity a suite of certain species were commonly found at most sites. For example, 87 species (12 %) were present at 75 % of sites and 41 of these (Table 7) occurred at 90 % of sites.

Table 7. Most commonly observed reef species at Timor-Leste (seen at 90 % or more of total dive sites).

Species	% Sites	Species	% Sites
Pseudanthias huchtii	100.0	*Variola albimarginata*	90.0
Dascyllus trimaculatus	100.0	*Chaetodon kleini*	90.0
Lutjanus carponotatus	95.0	*Chaetodon vagabundus*	90.0
Lutjanus decussatus	95.0	*Centropyge vroliki*	90.0
Scolopsis bilineatus	95.0	*Chromis ternatensis*	90.0
Parupeneus multifasciatus	95.0	*Neoglyphidodon nigroris*	90.0
Forcipiger flavissimus	95.0	*Plectroglyphidodon lacrymatus*	90.0
Heniochus varius	95.0	*Pomacentrus coelestis*	90.0
Centropyge bicolor	95.0	*Pomacentrus lepidogenys*	90.0
Centropyge tibicen	95.0	*Pomacentrus philippinus*	90.0
Amblyglyphidodon leucogaster	95.0	*Bodianus dyctynna*	90.0
Amphiprion clarkii	95.0	*Coris gaimardi*	90.0
Dascyllus reticulatus	95.0	*Gomphosus varius*	90.0
Pomacentrus amboinensis	95.0	*Thalassoma amblycephalum*	90.0
Labroides bicolor	95.0	*Parapercis clathrata*	90.0
Labroides dimidiatus	95.0	*Zanclus cornutus*	90.0
Thalassoma lunare	95.0	*Ctenochaetus striatus*	90.0
Balistapus undulatus	95.0	*Zebrasoma scopas*	90.0
Lutjanus gibbus	90.0	*Odonus niger*	90.0
Sargocentron caudimaculatum	90.0	*Sufflamen bursa*	90.0

Zoogeographic affinities of the Timor-Leste fish fauna

Timor-Leste belongs to the overall Indo-west Pacific faunal community. Its reef fishes are very similar to those inhabiting other areas within this vast region, stretching eastward from East Africa and the Red Sea to the islands of Micronesia and Polynesia. Although most families, and many genera and species are consistently present across the region, the species composition varies greatly according to locality.

Timor-Leste is part of the Indo-Australian region, the richest faunal province on the globe in ter-s of biodiversity. The nucleus of this region, or Coral Triangle, is composed of Indonesia, Timor-Leste, Philippines and Papua New Guinea. Species richness generally declines with increased distance from the Triangle, although the rate of attenuation is generally less in a westerly direction. The damselfish family Pomacentridae is typical in this regard. For example, Indonesia has the world's highest total with 138 species, with the following totals recorded for other areas (Allen, 1991): Papua New Guinea (109), northern Australia (95), W. Thailand (60), Fiji Islands (60), Maldives (43), Red Sea (34), Society Islands (30), and Hawaiian Islands (15). Damselfishes also provide evidence that Timor is very close to the much-debated center of marine diversity. Its total of 94 species is one of the highest recorded for any similar-sized area in the world, being surpassed only by various Indonesian locations including the Raja Ampat Islands (114 species), Cenderawasih Bay (100 species), and far northern Sulawesi (95 species). There are very few countries that can match these totals.

The reef fish fauna of Timor-Leste no doubt shares a very similar zoogeographic composition with that of the Raja Ampat Islands, Indonesia, which was recently analyzed by Allen (unpublished). The vast majority (about 60 %) of species have wide-ranging distributions in the Indo-Pacific region. A further 17 percent are widely distributed in the tropical west Pacific. Twenty percent have a more restricted regional distribution that is confined to the Indo-Australian Archipelago, of which Timor-Leste forms an integral part.

The large number of widely distributed species is not surprising considering that most coral reef fishes have a pelagic larval stage of variable duration. Dispersal capabilities and length of larval life of a given species are usually reflected in its geographic distribution.

There is little evidence of strict endemism among Timor-Leste reef fishes, which is understandable considering the close proximity to Indonesia's Lesser Sunda islands, particularly Alor, and the strong currents that provide connectivity between them. We did however record range extensions of a number of fishes previously considered to be endemic to the Lesser Sundas. Good examples of this include the wrasse *Cirrhilabrus humanni* and the dottyback *Pseudochromis pictus*, both of which are currently known only from Timor-Leste and nearby Alor. Similarly, the recently described fang blenny *Meiacanthus cyanopterus*, previously known from Bali to Alor, was also recorded in Timor-Leste, while several likely new species that we have also recorded from Bali were also recorded from Timor-Leste (see below section). These instances of Lesser Sunda endemic fishes being recorded from Timor-Leste provides strong support for the inclusion of Timor-Leste in the Lesser Sundas marine ecoregion.

New or rare species and notable range extensions

The following section contains brief accounts of recorded species that are either potentially new, relatively rare, or represent significant range extensions.

We note that it is increasingly difficult to find new reef fish species at depths less than 40-50 m, mainly due to the widespread use of scuba gear in the Indo-Malayan region over the past few decades. Judging from our experience, normally 1-2 new species can be expected during a typical 2-week long survey. The recent spate of more than 20 new species from the Bird's Head Peninsula of western New Guinea is atypical in this respect and is due to the remote location (hence few previous biological explorations) and unique tectonic history that has resulted in isolation events and subsequent speciation (Allen and Erdmann, 2012).

That said, the present Timor-Leste MRAP survey resulted in a number of exciting records, including both new species and significant range extensions. Some of the more notable include:

Chromis species 1 (Pomacentridae) – This striking fish is characterized by a light blue body with brilliant yellow pelvic, anal, and soft dorsal fins. The caudal fin has a similar yellow streak on the outer edge of each lobe. The species, which likely represents an undescribed taxon, is also known from Nusa Penida Island, Indonesia. The maximum known size is only about 4.5 cm TL, indicative of a juvenile stage. It probably grows to a larger size, but adults have not been observed. The species occurs on steep outer slopes in about 70 m depth. Two specimens were collected at Com (site 4) and it was also observed at sites 10, 11 and 15.

Chromis species 2 (Pomacentridae) – This species is very similar in general appearance to *Chromis* species 1, but differs in having entirely blue pelvic and anal fins rather than yellow fins. It is also differentiated by a small dark spot on the upper pectoral-fin base. A single specimen, approximately 4.5 cm TL was collected at Pulau Atauro (site 19) in 55 m depth. It is possibly the juvenile stage of a deep-water species such as *C. earina*, or may represent yet another undescribed species. Further investigation of this species at Atauro is needed to gain further insight on its status.

Chrysiptera species (Pomacentridae) – This damselfish was previously identified as *C. rex*, but our genetic studies indicate this taxon is probably divisible into at least four distinct species. The Timor-Leste population belongs to a clade that inhabits the Java Sea and Lesser Sunda Islands. We collected tissue samples and voucher specimens, which hopefully will help elucidate the status of the Indonesian and Timor-Leste populations. The species inhabits surge channels and reef areas exposed to mild wave action in about 2-5 m depth. The maximum size is about 7 cm TL.

Vanderhorstia species (Gobiidae) – A single specimen of this shrimp goby was collected near the Com Harbour jetty in an area mainly covered by seagrass. The species was previously known only on the basis of underwater photographs from Bali and the Ryukyu Islands. It was illustrated by Allen & Erdmann (2012) as *Vanderhorstia* species 1. It inhabits sand bottoms at depths between 1-15 m and is reported to attain 6 cm TL.

Stalix species (Opistognathidae) – This is an inhabitant of sandy substrates that lives in burrows. Four specimens were collected in 20 m depth at Hera (site 1). It was also recently collected by us at the Anambas Islands, Indonesia. This undescribed species is similar to *S. eremia*, known on the basis of a single specimen from Madang, Papua New Guinea. The Anambas and Timor-Leste fish appears to differ in having a vivid yellow/orange marking anteriorly on the dorsal fin. Specimens were sent to opistognathid expert William Smith-Vaniz, who has confirmed this is a new species and is planning to describe it in an upcoming revision of the genus.

Labracinus species (Pseudochromidae) – This species was formerly identified as *Labracinus cyclophthalmus* (Muller & Troschel, 1849), but preliminary genetic investigations indicate this species is divisible into several cryptic taxa, each with highly restricted geographic ranges. For example, populations from Nusa Penida and Komodo in the Lesser Sunda Group of Indonesia appear to be different from those from the Raja Ampat Islands. We collected specimens and genetic samples of the Timor-Leste fish and are awaiting the results of a comparative analysis with other geographic populations. The species generally reaches a maximum TL of about 23.5 cm, but populations from Timor-Leste, Komodo, and Nusa Penida are considerably smaller, usually not exceeding about 12-15 cm TL. While the Timor-Leste fish resembles the Komodo and Nusa Penida populations in its smaller size, its colouration is yet again subtly distinctive and we're awaiting the results of genetic analysis to determine the status of this taxon. The habitat consists of live coral reefs next to shore in about 2-5 m depth.

Luzonichthys taeniatus Randall & McCosker, 1992 (Serranidae) – This rare species was formerly known only from the Lucipara Islands, Indonesia. It was relatively common at Timor-Leste on steep outer reef slopes in about 20-50 m depth. The species reaches a maximum size of about 7 cm TL.

Pseudochromis pictus Gill & Randall, 1998 (Pseudochromidae) This rare dottyback was previously known only on the basis of two specimens from Alor Island, Indonesia. It was photographed and collected on the outer reef slope in 38 m depth at Lamsana Inlet West (site 18). The habitat consists of isolated coral and rock outcrops on relatively steep slopes. It reaches a maximum size of at least 8.3 cm TL.

Cirrhilabrus humanni Allen & Erdmann, 2012 (Labridae) – This recently described species was previously known only from Pura Island, Indonesia, where it is relatively uncommon. In contrast, it was found at the majority of sites at Timor-Leste, usually in large numbers. The typical habitat consists of outer reef slopes on rubble bottoms in 10-45 m depth. The maximum size is about 7 cm TL.

Cirrhilabrus tonozukai Allen & Kuiter, 1999 (Labridae) – This beautiful wrasse was previously known from Palau and Indonesian localities, including Raja Ampat, eastern Sulawesi, and Halmahera. A single male individual was photographed in 15 m depth at Atauro Island, which represents a significant southerly extension of the geographic range.

Hopololatilus chlupatyi Klausewitz, McCosker, Randall & Zetzsche, 1978 (Malacanthidae) – Although widely distributed in Indonesia (Bali to Banda Sea) and the Philippines, this species has rarely been photographed alive in its natural habitat. Fortunately this task was successfully achieved by MVE at Djonu Twin Rocks (site 10) in 70 m depth. The species generally occurs in pairs that occupy burrows on rubble bottoms. It is known in the marine aquarium trade as the "chameleon tilefish" due to its ability to rapidly change colours; this initially led us to believe this fish might be a new species but subsequently we've determined it to be *H. chlupatyi*.

Chlorurus capistratoides (Bleeker, 1847) (Scaridae) – This parrotfish was previously believed to be confined to the Indian Ocean, but recent surveys by the authors have considerably expanded the distribution eastward with sightings at the Anambas Islands, Sumatra, and Bali (Indonesia), Brunei, and northern Palawan (Philippines). Several individuals were sighted (and photographed) on shallow reefs during the current survey, representing the easternmost known extent of its range.

Pteropsaron longipinnis Allen & Erdmann, 2012 (Trichonotidae) – This minute (to about 3.3 cm TL) sand-diver inhabits sand/rubble bottoms of outer reef slopes in 70-75 m. It was previously known only from specimens collected by Mark Erdmann at Cenderwasih Bay, West Papua and Lembata (Alor Group), both in Indonesia. Several individuals were sighted (one collected) during the present survey at sites 10 and 15, and the first ever in situ photos were obtained of this species - also allowing us to verify that it frequently hovers and uses its elongate pelvic fins in a tripod-like fashion to support itself.

Synchiropus tudorjonesi Allen and Erdmann, 2012 (Callionymidae) - A striking dragonet previously known only from deep reefs (60-70m) of West Papua and Bali. We recorded this from 65m at Atauro Island. Importantly, this fish had never been photographed live and displaying its dorsal fin, which is an important colour character.

Pseudanthias charlenae Allen and Erdmann, 2008 (Serannidae) - A colourful fairy basslet from depths of 50-70m in areas of strong currents; we recorded this again at Pulau Atauro. As with the above dragonet, previously this fish was only known from West Papua and Bali.

Pomacentrus cheraphilus Allen, Erdmann and Hiloman, 2011 (Pomacentridae) - This relatively drab damselfish inhabits silty reefs, and was recorded in Timor-Leste from only one site (Site 1, Hera West). This represents perhaps the most interesting range extension we recorded; previously this species was known only from Brunei and Palawan (Philippines).

In addition to the abovementioned range extensions, we also recorded six additional extensions for which we do not have photographs. These include:

1) *Lutjanus* sp. A beautiful red snapper with yellow fins that is currently in the process of being described and was previously only known from West Papua, Papu New Guinea and the Solomons (recorded only at Site 3, Com);

2) *Opistognathus* sp. An undescribed jawfish previously only known from Bali and Brunei; recorded here from Site 18 (Lamsana Inlet West).

3) *Pseudochromis sp*. 2. A grey coloured dottyback found living upside down in deep caves and overhangs, previously known only from Raja Ampat, recorded here at Atauro Island.

4) *Meiacanthus cyanopterus* Smith-Vaniz and Allen, 2011. A deep-dwelling fang blenny normally seen in 50-70m depths; known as a Lesser Sunda endemic species found from Bali to Alor. Recorded in the Timor-Leste MRAP at Site 10.

5) *Parapercis flavolineatus* Randall, 2008. A sand-dwelling grubfish found typically below depths of 60m and previously known only from North Sulawesi and Bali; recorded in this MRAP at sites 10, 11, 15, 18, and 19.

6) *Trimma papayum* Winterbottom, 2011. A beautiful little coral goby with orange spots, normally found below 40m depth. Previously known from Flores, Alor, and Raja Ampat; recorded in Timor-Leste at Site 17 (Lamsana Inlet East).

Conservation potential and future surveys

The present MRAP survey shows that Timor-Leste has a rich and varied reef fish fauna, which is justifiably an integral part of the Coral Triangle, the world's richest region for marine biodiversity. Particularly impressive was the consistently high species counts for individual dive sites, resulting in the second highest average count (212 species) for anywhere sampled thus far in the Indo-Pacific region.

Using the CFDI methodology for predicting overall faunal totals we estimate that at least 1,232 species will eventually be recorded for the region and most of these could be expected at Timor-Leste. The current total for Timor-Leste is 814 reef fish species, but with several more weeks of survey effort there is a good possibility that a total of more than 1000 species could be achieved. This total would elevate the country to the world's elite group that have an excess of 1,000 coral reef fishes. Allen (2008) provided details of the exclusive "1000 species club", which contains Indonesia, Australia, Philippines, Papua New Guinea, Malaysia, Japan, Taiwan, Solomon Islands, Palau, Vanuatu, Fiji, New Caledonia, and the Federated States of Micronesia.

The area certainly holds great promise for conservation action, and hopefully our survey efforts will attract attention to the outstanding reef resources and act as a catalyst for additional surveys and more focused conservation action. Timor-Leste can be congratulated for already taking the initiative of declaring a significant portion of its coastline as a national park. Our survey indicates that the Nino Konis Santana National Park area was wisely selected and holds great promise as a major re-seeding area and refuge. Several sites including Jako Island, Hilapuna, and Djonu Twin Rocks (site 10) seem particularly well suited for designation as "no take zones". Indeed, the entire coastline from Tutuala to Jako Island would constitute an optimally-sized no-take area for fisheries replenishment purposes; we of course are not familiar with the local cultural situation to know if this is feasible, but recommend consideration of this entire area as a large no-take area.

While the NKS National Park represents an outstanding anchor site for the nascent Timor-Leste MPA network, we feel strongly that Atauro Island is strongly deserving of focused conservation initiatives in the near future. Though we only made 4 dives in a 1.5 day period, the island showed tremendous diversity (Site 19, the Belio Barrier Reef, had the highest diversity of any site during the MRAP at 294 species), and many of the species recorded there were not seen at any other sites. Of particular conservation interest were the lagoonal habitats near Bello Harbour (eg, Sites 21 and 22); this important habitat type was absent from Nino Konis Santana National Park and most of the other sites we surveyed. As such, in order to protect a representative sample of Timor-Leste's marine habitats (and in so doing also ensure the long-term viability of populations of the greatest diversity of fishes and other organisms), we strongly recommend the development of an MPA at Pulau Atauro in the near future.

Predictably, we detected signs of intense fishing pressure on many reefs, which is the norm throughout the Coral Triangle region. For example, we frequently witnessed previously bomb-damaged reefs and rarely saw large groupers and sharks.

The Napoleon Wrasse ranges throughout the Indo-west and central Pacific and commands a huge price in the Asian live-fish trade. It is one of the largest reef fishes, reaching a length of 230 cm and weight in excess of 190 kg. Sadly, this fish has been fished to dangerously low levels throughout the Coral Triangle, where it was formerly common. The species is an excellent indicator of fishing pressure. During the current survey only four individuals were seen with an average size of about 45 cm. No juveniles were seen during dives on sheltered inshore reefs, which is the typical habitat for young fish. This paucity of small fish may well indicate a lack of recruitment due to dangerously low population levels of adult fish.

Table 8 presents a comparison of sightings on various rapid assessment surveys between 1997 and 2012. By far the highest concentrations of this fish have been noted at the Phoenix Islands in the central Pacific, where there is an almost negligible human population and vast areas of nearly pristine reefs (although the reefs were severely affected by coral bleaching in 2002).

Table 8. Frequency of Napoleon Wrasse (*Cheilinus undulatus*) recorded during surveys of various locations in the Indo-Pacific (G. Allen data).

Location	No. sites where seen	% of total sites	Approx. no. seen
Phoenix Islands, Kiribati - 2002	47	83.92	412
Pohnpei, Micronesia - 2005	28	68.29	63
Milne Bay, PNG – 1997	28	52.83	85
Yap, Micronesia - 2007	23	50.00	47
Milne Bay, PNG – 2000	28	49.12	90
Northern Halmahera, Indonesia - 2008	8	33.33	11
Timor-Leste - 2012	**4**	**20.00**	**4**
Raja Ampat Islands, Indonesia – 2001	7	15.55	7
Southwestern Halmahera, Indonesia - 2005	4	14.28	4
Togean/Banggai Islands, Indonesia – 1998	6	12.76	8
Calamianes Is., Philippines – 1998	3	7.89	5
Brunei – 2008 & 2009	1	2.72	1
Anambas Islands, Indonesia - 2012	1	0.05	1
Weh Island, Sumatra, Indonesia – 1999	0	0.00	0

In summary, we were impressed with the extremely high within-site diversity of Timor-Leste's reefs, as well as the overall high diversity recorded. We have no doubt that additional survey work focused on the south coast as well as Pulau Atauro and other habitats not yet thoroughly sampled on the present MRAP would yield even more impressive diversity numbers (and likely new species and range extensions) for Timor-Leste. In the meantime, we recommend an initial focus on setting up well-enforced no-take zones and a broader zonation system with clear rules within the NKS National Park, as well as an initiative to gazette a new MPA at Pulau Atauro. We moreover note that Timor-Leste has excellent potential for development of marine tourism as a synergistic economic driver along with MPA implementation, whilst noting that it is important to set clear regulations from the outset that insure that local communities derive meaningful benefits from tourism in a way that encourages even better stewardship of their reefs.

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Annex 1: List of the Reef Fishes of Timor-Leste

This list includes all species of shallow (to 70 m depth) coral reef fishes recorded from the region covering Timor-Leste and Indonesian West Timor from the following sources:
1. 2012 Timor-Leste CI Marine RAP
2. additional historical records, mainly from Indonesian Timor indicated by single asterisk (*)
3. additional B.C. Russell records from Kupang fish market indicated by double asterisk (**)
4. additional records from 2008 A.M. Ayling Survey of proposed Nino Konis Santana Marine Park
5. additional records from 2012 Australian Museum (AMS) Timor-Leste Expedition.

The phylogenetic sequence of the families appearing in this list follows Eschmeyer (Catalog of Fishes, California Academy of Sciences, 1998) with slight modification. Genera and species are arranged alphabetically within each family. New records (not recorded in 2-4 above) for the region are indicated by blue highlight.

Column A = Historical Records
Column B = Ayling 2008
Column C = AMS 2012

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Ginglymostomatidae (1 spp.)																										
Nebrius ferrugineum		1														1								1	1	1
Scyliorhinidae (1 spp.)																										
Atelomycterus marmoratus*	1																							0	0	1
Carcharhinidae (3 spp.)																										
Carcharhinus amblyrhynchos		1														1								1	1	1
Carcharhinus melanopterus		1										1												1	1	1
Triaenodon obesus		1							1			1	1			1								1	1	1
Sphyrnidae (1 spp.)																										
Sphyrna zygaena*	1																							0	0	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Rhynchobatidae (1 spp.)																											
Rhynchobatus australiae*	1																								0	0	1
Dasyatidae (4 spp.)																											
Himantura uarnak		1																							0	1	1
Neotrygon kuhlii		1			1				1		1														1	1	1
Taeniura lymma		1			1				1			1							1						1	1	1
Taeniura meyeni																1									1	1	1
Myliobatidae (1 spp.)																											
Aetobatis narinari		1																							0	1	1
Mobulidae (1 spp.)																											
Manta birostris														1											1	1	1
Moringuidae (3 spp.)																											
Moringua abbreviata*	1																								0	0	1
Moringua bicolor*	1																								0	0	1
Moringua javanica*	1																								0	0	1
Muraenidae (20 spp.)																											
Echidna amblyodon*	1																								0	0	1
Echidna nebulosa*	1																								0	0	1
Echidna polyzona*	1																								0	0	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Enchelycore canina*	1																							0	0	1
Gymnomuraena zebra*	1																							0	0	1
Gymnothorax buroensis			1																			1		1	1	1
Gymnothorax javanicus		1				1			1															1	1	1
Gymnothorax moluccensis											1													1	1	1
Gymnothorax pictus*	1																							0	0	1
Gymnothorax richarsonii											1													1	1	1
Gymnothorax ruepelliae*	1																							0	0	1
Gymnothorax thrysoideus*	1																							0	0	1
Gymnothorax undulatus*	1																							0	0	1
Gymnothorax zonipectis			1																			1		1	1	1
Pseudechidna brummeri*	1																							0	0	1
Rhinomuraena quaesita		1																						0	1	1
Scuticara tigrina*	1																							0	0	1
Uropterygius macrocephalus											1													1	1	1
Uropterygius micropterus*	1																							0	0	1
Ophichthidae (5 spp.)																										
Brachysomophis crocodilus			1																					0	1	1
Muraenichthys macrostomus*	1																							0	0	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Phyllophichthus xenodontus																						1			1	1	1
Scolecenchelys macroptera*	1																								0	0	1
Yirrkala lumbricoides*	1																								0	0	1
Congridae (3 spp.)																											
Conger cinereus*	1																								0	0	1
Gorgasia maculata		1			1					1		1	1												1	1	1
Heteroconger hassi		1			1	1				1		1		1		1									1	1	1
Clupeidae (1 spp.)																											
Herklotsichthys quadrimaculatus*	1																								0	0	1
Chanidae (1 spp.)																											
Chanos chanos*	1																								0	0	1
Plotosidae (1 spp.)																											
Plotosus lineatus														1											1	1	1
Synodontidae (6 spp.)																											
Saurida gracilis			1																						0	1	1
Saurida nebulosa															1										1	1	1
Synodus dermatogenys			1				1	1	1	1	1	1							1		1	1			1	1	1
Synodus jaculum			1				1				1	1	1			1		1	1			1			1	1	1
Synodus rubromarmoratus			1													1									1	1	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Trachinocephalus myops															1										1	1	1
Carapidae (2 spp.)																											
Carapus sluiteri*	1																								0	0	1
Encheliophis homei*	1																								0	0	1
Ophidiidae (1 spp.)																											
Brotula multibarbata*	1																								0	0	1
Bythitidae (1 spp.)																											
Ungusurculus sundaensis																					1				1	1	1
Batrachoididae (1 spp.)																											
Halophryne diemensis*	1																								0	0	1
Antennariidae (3 spp.)																											
Antennarius biocellatus*	1																								0	0	1
Antennarius hispidus*	1																								0	0	1
Histiophryne cryptacanthus*	1																								0	0	1
Mugilidae (3 spp.)																											
Ellochelon vaigiensis*	1																								0	0	1
Moolgarda seheli								1																	1	1	1
Oedalechilus labiosus*	1																								0	0	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Atherinidae (3 spp.)																										
Atherinomorus duodecimalis*	1																							0	0	1
Atherinomorus lacunosus*	1																							0	0	1
Hypoatherina temminckii*	1																							0	0	1
Belonidae (3 spp.)																										
Strongylura incisa*	1																							0	0	1
Tylosurus acus												1											1	1	1	1
Tylosurus crocodilus									1	1	1	1	1											1	1	1
Hemiramphidae (2 spp.)																										
Hemiramphus far*	1																							0	0	1
Hyporhamphus dussumieri*	1																							0	0	1
Holocentridae (19 spp.)																										
Myripristis adusta		1		1						1				1										1	1	1
Myripristis berndti		1	1		1		1	1			1	1		1		1		1	1				1		1	1	1
Myripristis botche					1							1		1											1	1	1
Myripristis hexagona																								1	1	1	1
Myripristis kuntee		1	1	1	1	1	1	1	1	1	1	1	1	1		1			1					1	1	1	1
Myripristis murdjan		1												1											1	1	1
Myripristis pralinia		1	1		1																				1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Myripristis violacea			1											1											1	1	1
Myripristis vittata																		1				1		1	1	1	1
Neoniphon sammara		1			1		1	1		1		1		1		1		1	1			1	1	1	1	1	1
Sargocentron caudimaculatum		1	1		1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Sargocentron cornutum*	1																								0	0	1
Sargocentron diadema		1	1		1									1		1						1			1	1	1
Sargocentron microstoma																		1						1	1	1	1
Sargocentron punctatissimum																						1			1	1	1
Sargocentron rubrum*	1																								0	0	1
Sargocentron spiniferum		1	1							1								1		1		1		1	1	1	1
Sargocentron tieroides			1																						0	1	1
Sargocentron violaceum														1											1	1	1
Aulostomidae (1 spp.)																											
Aulostomus chinensis		1																							0	1	1
Fistulariidae (1 spp.)																											
Fistularia commersonii		1						1																	1	1	1
Centriscidae (2 spp.)																											
Aeoliscus strigatus														1											1	1	1
Centriscus scutatus*	1																								0	0	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Solenostomidae (2 spp.)																										
Solenostomus cyanopterus			1																			1			1	1	1
Solenostomus paradoxus			1												1										1	1	1
Syngnathidae (7 spp.)																										
Acentronura breviperula															1						1				1	1	1
Bhanotia fasciolata																				1					1	1	1
Corythoichthys haematopterus*	1																								0	0	1
Doryrhamphus melanopleura*	1																								0	0	1
Dunckerocampus boylei			1																						0	1	1
Halicampus mataafae*	1																								0	0	1
Hippocampus taeniopterus																				1					1	1	1
Scorpaenidae (16 spp.)																										
Dendrochirus biocellatus						1																			1	1	1
Parascorpaena bandanensis*	1																								0	0	1
Parascorpaena mossambica																				1					1	1	1
Parascorpaena picta*	1																								0	0	1
Pterois antennata		1	1	1		1		1					1					1			1				1	1	1
Pterois volitans		1	1			1		1							1				1					1	1	1	1
Rhinopias frondosa*	1																								0	0	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Scorpaenodes albaiensis			1																						0	1	1
Scorpaenodes guamensis																						1			1	1	1
Scorpaenopsis diabolus		1									1														1	1	1
Scorpaenodes kelloggi			1																						0	1	1
Scorpaenodes parvipinnis			1																						0	1	1
Scorpaenodes varipinnis			1																						0	1	1
Scorpaenopsis neglecta			1																						0	1	1
Scorpaenopsis possi																					1	1	1		1	1	1
Scorpaenopsis vittipinna			1																						0	1	1
Sebastapistes strongia			1								1														1	1	1
Synanceiidae (1 spp.)																											
Synanceia verrucosa*	1																								0	0	1
Tetrarogidae (1 spp.)																											
Ablabys taenianotus*	1																								0	0	1
Platycephalidae (4 spp.)																											
Cociella punctata*	1																								0	0	1
Onigocia pedimacula								1																	1	1	1
Thysanophrys celebicus			1																						0	1	1
Thysanophrys chiltonae			1																						0	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Caracanthidae (1 spp.)																											
Caracanthus unipinna										1	1		1					1				1			1	1	1
Latidae (1 spp.)																											
Psammoperca waigiensis*	1																								0	0	1
Serranidae (60 spp.)																											
Aethaloperca rogaa		1				1		1	1	1	1	1	1			1						1			1	1	1
Anyperodon leucogrammicus		1					1	1															1		1	1	1
Cephalopholis argus		1	1					1	1	1		1	1	1		1		1				1		1	1	1	1
Cephalopholis cyanostigma														1													
Cephalopholis leopardus		1	1				1	1		1	1	1		1		1		1	1		1	1	1		1	1	1
Cephalopholis miniata		1	1		1	1	1		1	1	1	1	1			1		1	1		1	1		1	1	1	1
Cephalopholis polleni																		1				1			1	1	1
Cephalopholis sexmaculata			1										1					1				1		1	1	1	1
Cephalopholis sonnerati			1		1	1	1	1				1													1	1	1
Cephalopholis spiloparaea		1	1		1	1	1	1					1	1		1		1	1	1		1	1	1	1	1	1
Cephalopholis urodeta		1	1		1		1	1	1	1	1	1	1	1		1		1	1	1		1	1	1	1	1	1
Diploprion bifasciatum*	1																								0	0	1
Epinephelus areolatus*	1																								0	0	1
Epinephelus bleekeri**	1																								0	0	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Epinephelus caeruleopunctatus		1	1		1	1				1	1	1													1	1	1
Epinephelus coioides**	1																								0	0	1
Epinephelus corallicola*	1																								0	0	1
Epinephelus fasciatus		1	1		1	1	1							1		1			1	1		1	1	1	1	1	1
Epinephelus fuscoguttatus										1												1			1	1	1
Epinephelus hexagonatus		1	1																						0	1	1
Epinephelus lanceolatus													1												1	1	1
Epinephelus macrospilos		1																							0	1	1
Epinephelus maculatus		1	1		1																				1	1	1
Epinephelus malabaricus		1																							0	1	1
Epinephelus merra		1	1		1		1	1	1	1	1	1	1	1		1			1	1	1	1	1	1	1	1	1
Epinephelus ongus		1	1																						1	1	1
Epinephelus quoyanus*	1																								0	0	1
Epinephelus rivulatus*	1																								0	0	1
Epinephelus spilotoceps		1											1												1	1	1
Epinephelus tauvina																			1						1	1	1
Epinephelus tukula																			1						1	1	1
Epinephelus undulosus*	1																								0	0	1
Gracila albomarginata		1	1				1					1	1	1		1		1	1				1	1	1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Grammistes sexlineatus*	1																								0	0	1
Liopropoma mitratum			1																						0	1	1
Luzonichthys taeniatus		1																1							1	1	1
Plectranthias longimanus			1										1												1	1	1
Plectropomus areolatus			1																			1			1	1	1
Plectropomus laevis		1	1																						0	1	1
Plectropomus oligocanthus																							1		1	1	1
Pogonoperca punctata		1					1	1	1		1	1						1	1	1		1		1	1	1	1
Pseudanthias bicolor					1		1	1	1			1	1		1	1		1							1	1	1
Pseudanthias charlenae																						1			1	1	1
Pseudanthias cooperi									1			1													1	1	1
Pseudanthias dispar		1	1				1	1		1		1	1					1				1	1		1	1	1
Pseudanthias flavoguttatus																						1			1	1	1
Pseudanthias huchtii		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
Pseudanthias hypselosoma					1	1	1	1				1		1	1					1			1		1	1	1
Pseudanthias lori		1					1	1					1			1		1							1	1	1
Pseudanthias luzonensis		1												1						1					1	1	1
Pseudanthias parvirostris							1															1			1	1	1
Pseudanthias pleurotaenia		1	1		1	1	1	1					1	1		1		1	1	1			1	1	1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Pseudanthias randalli																1		1				1		1	1	1	1
Pseudanthias smithvanizi		1										1	1					1	1			1		1	1	1	1
Pseudanthias squamipinnis		1	1				1	1	1	1	1	1	1			1		1	1			1	1	1	1	1	1
Pseudanthias tuka		1	1			1	1	1						1				1		1		1	1	1	1	1	1
Pseudogramma polyacanthus			1																1						1	1	1
Serranocirrhitus latus																						1		1	1	1	1
Variola albimarginata		1	1		1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Variola louti		1			1	1	1	1	1	1	1	1	1	1		1		1	1	1		1	1	1	1	1	1
Centrogeniidae (1 spp.)																											
Centrogenys vaigiensis*	1																								0	0	1
Cirrhitidae (8 spp.)																											
Cirrhitichthys aprinus											1														1	1	1
Cirrhitichthys falco								1											1						1	1	1
Cirrhitichthys oxycephalus		1								1	1	1	1			1		1	1	1			1	1	1	1	1
Cirrhitus pinnulatus		1							1																1	1	1
Cyprinocirrhites polyactis					1	1	1	1	1	1			1							1		1	1	1	1	1	1
Oxycirrhites typus		1												1				1							1	1	1
Paracirrhites arcatus		1										1						1							1	1	1
Paracirrhites forsteri		1			1	1	1	1	1	1	1	1	1	1		1		1	1	1		1	1		1	1	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Plesiopidae (4 spp.)																										
Calloplesiops altivelis			1																					0	1	1
Plesiops cephalotaenia			1																					0	1	1
Plesiops coeruleolineatus											1											1		1	1	1
Plesiops corallicola											1													1	1	1
Terapontidae (3 spp.)																										
Pelates quadrilineatus*	1																							0	0	1
Terapon jarbua*	1																							0	0	1
Terapon theraps*	1																							0	0	1
Opistognathidae (6 spp.)																										
Opistognathus randalli			1				1					1		1				1		1		1		1	1	1
Opistognathus solorensis																				1				1	1	1
Opistognathus sp. 5																					1			1	1	1
Opistognathus variabilis			1							1														1	1	1
Opistognathus wassi						1																		1	1	1
Stalix sp.				1																				1	1	1
Priacanthidae (2 spp.)																										
Priacanthus blochii														1										1	1	1
Priacanthus hamrur		1		1																				1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Apogonidae (45 spp.)																											
Apogon crassiceps			1					1	1		1							1	1	1		1			1	1	1
Apogon doryssa			1																						0	1	1
Apogon semiornatus			1		1																		1		1	1	1
Archamia biguttata			1				1																		1	1	1
Archamia fucata							1																		1	1	1
Archamia macroptera							1																		1	1	1
Archamia melasma							1																		1	1	1
Cheilodipterus alleni			1																						0	1	1
Cheilodipterus artus					1		1							1											1	1	1
Cheilodipterus macrodon							1				1			1							1				1	1	1
Cheilodipterus quinquelineatus			1	1	1		1							1							1	1		1	1	1	1
Foa brachygramma															1										1	1	1
Neamia octospina			1																						0	1	1
Nectamia bandanensis*	1																								0	0	1
Nectamia fusca											1									1					1	1	1
Nectamia luxuria			1																						0	1	1
Nectamia savayensis			1																		1				1	1	1
Nectamia similis							1																		1	1	1
Nectamia viria																					1				1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Ostorhinchus angustatus			1								1	1													1	1	1
Ostorhinchus apogonides							1					1													1	1	1
Ostorhinchus aureus					1							1													1	1	1
Ostorhinchus bryx															1										1	1	1
Ostorhinchus ceramensis*	1																								0	0	1
Ostorhinchus chrysotaenia			1		1	1	1																		1	1	1
Ostorhinchus dispar			1													1		1				1		1	1	1	1
Ostorhinchus fasciatus															1										1	1	1
Ostorhinchus fleurieu												1													1	1	1
Ostorhinchus fraenatus							1					1		1					1						1	1	1
Ostorhinchus franssedai																1									1	1	1
Ostorhinchus hartzfeldii															1										1	1	1
Ostorhinchus hoevenii															1										1	1	1
Ostorhinchus kallopterus			1				1					1		1		1			1					1	1	1	1
Ostorhinchus moluccensis															1										1	1	1
Ostorhinchus multilineatus			1																						0	1	1
Ostorhinchus nigrofasciatus			1			1	1	1		1	1	1		1		1		1	1	1	1	1	1		1	1	1
Ostorhinchus novemfasciatus																			1					1	1	1	1
Ostorhinchus ocellicaudus												1													1	1	1
Ostorhinchus talboti			1																						0	1	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Ostorhinchus taeniophorus											1											1			1	1	1
Ostorhinchus wassinki											1	1		1											1	1	1
Pseudamiops gracilicauda			1													1									1	1	1
Rhabdamia gracilis												1													1	1	1
Siphamia cyanopththalma			1																						0	1	1
Siphamia tubifer															1										1	1	1
Malacanthidae (8 spp.)																											
Hoplolatilus chlupatyi													1					1							1	1	1
Hoplolatilus cuniculus		1			1	1	1	1		1				1								1			1	1	1
Hoplolatilus marcosi		1			1	1	1	1					1					1				1			1	1	1
Hoplolatilus purpureus							1	1																	1	1	1
Hoplolatilus randalli							1						1	1				1				1			1	1	1
Hoplolatilus starcki		1					1		1									1				1	1	1	1	1	1
Malacanthus brevirostris		1			1	1	1	1	1	1	1	1	1	1		1		1	1			1	1	1	1	1	1
Malacanthus latovittatus		1					1			1															1	1	1
Sillaginidae (1 spp.)																											
Sillago sihama*	1																								0	0	1
Echeneidae (1 spp.)																											
Echeneis naucrates		1																							0	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Carangidae (21 spp.)																											
Alectes ciliaris*	1																								0	0	1
Alectes indicus**	1																								0	0	1
Carangoides bajad					1																				1	1	1
Carangoides coeruleopinnatus															1										1	1	1
Carangoides fulvoguttatus**	1																								0	0	1
Carangoides oblongus							1																		1	1	1
Caranx ignobilis		1											1			1			1						1	1	1
Caranx lugubris													1												1	1	1
Caranx melampygus		1	1	1		1	1	1	1	1	1	1	1	1		1		1	1	1		1	1	1	1	1	1
Caranx papuensis		1																							0	1	1
Caranx sexfasciatus									1	1		1													1	1	1
Caranx tille**	1																								0	0	1
Decapterus macarellus			1										1									1	1	1	1	1	1
Elagatis bipinnulata		1						1	1	1	1	1	1			1									1	1	1
Gnathanodon speciosus													1												1	1	1
Scomberoides commersonnianus**	1																								0	0	1
Scomberoides lysan		1											1												1	1	1
Scomberoides tol*	1																								0	0	1
Seriola dumerili**	1																								0	0	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Trachinotus blochii**	1																							0	0	1
Ulua mentalis																			1					1	1	1
Leiognathidae (2 spp.)																										
Gazza minuta*	1																							0	0	1
Photopectoralis bindus*	1																							0	0	1
Lutjanidae (33 spp.)																										
Aphareus furca		1	1				1	1		1		1		1		1		1				1	1	1	1	1
Aprion virescens		1			1		1		1	1	1	1	1					1					1	1	1	1
Lutjanus argentimaculatus		1																						0	1	1
Lutjanus biguttatus**	1																							0	0	1
Lutjanus bohar		1			1	1	1	1	1	1	1	1	1	1		1		1	1			1	1	1	1	1
Lutjanus boutton*	1																							0	0	1
Lutjanus carponotatus					1																			1	1	1
Lutjanus decussatus		1	1		1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1
Lutjanus ehrenbergii		1	1							1		1	1											1	1	1
Lutjanus erythropterus**	1																							0	0	1
Lutjanus fulviflamma		1		1	1	1			1	1		1		1						1	1			1	1	1
Lutjanus fulvus		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1			1	1	1
Lutjanus gibbus		1	1		1	1	1	1	1	1	1	1	1	1	1	1		1	1		1	1	1	1	1	1
Lutjanus kasmira		1			1																			1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Lutjanus lemniscatus**	1																								0	0	1
Lutjanus lutjanus		1			1							1	1					1							1	1	1
Lutjanus lunulatus		1			1																				1	1	1
Lutjanus madras														1											1	1	1
Lutjanus malabaricus**	1																								0	0	1
Lutjanus monostigma		1			1		1	1	1		1	1	1	1		1		1	1		1		1		1	1	1
Lutjanus "papuensis"					1																				1	1	1
Lutjanus quinquelineatus						1									1										1	1	1
Lutjanus rivulatus		1			1		1	1				1		1		1		1							1	1	1
Lutjanus russelli**	1																								0	0	1
Lutjanus timorensis*	1																								0	0	1
Lutjanus vitta**	1																								0	0	1
Macolor macularis		1			1	1						1	1	1		1		1	1			1	1	1	1	1	1
Macolor niger		1			1					1		1				1						1	1		1	1	1
Paracaesio sordida		1											1									1		1	1	1	1
Paracaesio xanthura													1											1	1	1	1
Pinjalo lewisi**	1																								0	0	1
Pinjalo pinjalo		1																							0	1	1
Symphorichthys spilurus**	1																								0	0	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Caesionidae (11 spp.)																											
Caesio caerulaurea		1	1									1		1											1	1	1
Caesio cuning**	1																								0	0	1
Caesio lunaris		1			1	1	1		1		1	1	1	1							1	1	1	1	1	1	1
Caesio teres		1	1		1		1	1		1		1	1	1				1			1	1	1	1	1	1	1
Pterocaesio chrysozona**	1																								0	0	1
Pterocasesio digramma**	1																								0	0	1
Pterocasesio marri**	1																								0	0	1
Pterocaesio pisang					1									1						1					1	1	1
Pterocaesio randalli			1													1							1	1	1	1	1
Pterocaesio tessellata			1																						0	1	1
Pterocaesio tile		1	1		1		1	1	1	1	1	1	1	1		1			1		1	1	1	1	1	1	1
Gerreidae (3 spp.)																											
Gerres filamentosus**	1																								0	0	1
Gerres oblongus*	1																								0	0	1
Gerres oyena*	1																								0	0	1
Haemulidae (11 spp.)																											
Diagramma melanacrum												1	1						1						1	1	1
Diagramma pictum		1		1						1															1	1	1
Plectorhinchus albovittatus		1																							0	0	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Plectorhinchus chaetodontoides		1		1			1																1		1	1	1
Plectorhinchus chrysotaenia					1							1		1		1					1		1		1	1	1
Plectorhinchus gibbosus										1			1					1							1	1	1
Plectorhinchus lessonii		1			1														1						1	1	1
Plectorhinchus lineatus		1		1					1	1		1		1									1	1	1	1	1
Plectorhinchus picus																			1						1	1	1
Plectorhinchus polytaenia																					1				1	1	1
Plectorhinchus vittatus		1			1		1									1			1					1	1	1	1
Lethrinidae (18 spp.)																											
Gnathodentex aurolineatus		1	1		1	1			1	1		1													1	1	1
Gymnocranius elongatus**	1																								0	0	1
Gymnocranius griseus										1															1	1	1
Lethrinus atkinsoni		1																							0	1	1
Lethrinus erythracanthus		1			1									1											1	1	1
Lethrinus erythropterus			1																			1			1	1	1
Lethrinus harak			1	1				1	1					1	1			1	1		1				1	1	1
Lethrinus lentjan			1																						0	1	1
Lethrinus microdon			1				1																		1	1	1
Lethrinus nebulosus**	1																								0	0	1
Lethrinus obsoletus		1			1			1											1		1			1	1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Lethrinus olivaceus		1								1		1	1	1				1	1			1	1	1	1	1	1
Lethrinus ornatus		1	1											1					1						1	1	1
Lethrinus rubrioperculatus**	1																								0	0	1
Lethrinus variegatus															1										1	1	1
Lethrinus xanthochilus		1						1	1				1	1									1	1	1	1	1
Monotaxis grandoculis		1	1		1		1			1	1	1	1	1		1		1	1	1		1	1	1	1	1	1
Monotaxis heterodon				1	1	1		1		1	1	1	1	1		1			1		1	1	1	1	1	1	1
Nemipteridae (15 spp.)																											
Pentapodus aureofasciatus				1										1							1			1	1	1	1
Pentapodus bifasciatus*	1																								0	0	1
Pentapodus emeryii**	1																								0	0	1
Pentapodus trivittatus			1	1																					1	1	1
Scolopsis affinis		1			1	1		1			1					1			1	1	1				1	1	1
Scolopsis auratus**	1																								0	0	1
Scolopsis bilineatus		1		1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Scolopsis ciliatus				1																1	1				1	1	1
Scolopsis lineatus		1							1				1	1					1	1				1	1	1	1
Scolopsis margaritifer				1																					1	1	1
Scolopsis monogramma				1	1	1									1				1						1	1	1
Scolopsis taeniopterus**																									0	0	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Scolopsis trilineatus			1																			1			1	1	1
Scolopsis vosmeri															1										1	1	1
Scolopsis xenochrous		1		1	1	1	1	1	1	1	1		1	1		1		1	1	1					1	1	1
Mullidae (14 spp.)																											
Mulloidichthys flavolineatus			1			1																1			1	1	1
Mulloidichthys vanicolensis		1	1	1	1			1	1			1		1		1									1	1	1
Parupeneus barberinoides																								1	1	1	1
Parupeneus barberinus		1		1	1	1				1	1	1	1	1		1			1	1	1	1	1		1	1	1
Parupeneus crassilabris		1			1	1	1	1	1	1		1	1	1		1		1	1	1	1	1	1		1	1	1
Parupeneus cyclostomus		1	1		1	1	1	1	1	1			1	1		1				1			1		1	1	1
Parupeneus heptacanthus															1						1				1	1	1
Parupeneus indicus		1		1		1		1		1									1			1			1	1	1
Parupeneus macronemus									1	1		1													1	1	1
Parupeneus multifasciatus		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Parupeneus pleurostigma		1	1													1			1						1	1	1
Upeneus sulphureus*	1																								0	0	1
Upeneus tragula				1																	1				1	1	1
Upeneus vittatus			1																						0	1	1
Pempheridae (4 spp.)																											
Parapriacanthus ransonneti												1				1									1	1	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Pempheris oualensis										1								1						1	1	1	1
Pempheris schwencki**	1																								0	0	1
Pempheris vanicolensis				1	1			1		1		1						1	1					1	1	1	1
Kyphosidae (2 spp.)																											
Kyphosus cinerascens		1	1										1			1		1							1	1	1
Kyphosus vaigensis										1		1	1	1		1									1	1	1
Toxotidae (1 spp.)																											
Toxotes jaculatrix*	1																								0	0	1
Chaetodontidae (36 spp.)																											
Chaetodon adiergastos		1							1	1		1	1			1									1	1	1
Chaetodon auriga		1							1		1	1				1			1				1	1	1	1	1
Chaetodon baronessa		1		1	1	1	1	1	1	1	1	1	1	1		1						1	1		1	1	1
Chaetodon bennetti		1										1										1			1	1	1
Chaetodon citrinellus		1			1								1	1		1					1				1	1	1
Chaetodon decussatus										1															1	1	1
Chaetodon ephippium		1					1	1		1			1	1		1			1	1	1	1	1		1	1	1
Chaetodon kleinii		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1		1	1	1	1
Chaetodon lineolatus		1												1					1						1	1	1
Chaetodon lunula		1				1	1	1	1		1	1	1	1		1			1	1	1		1	1	1	1	1
Chaetodon lunulatus		1	1		1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Chaetodon melanotus		1		1	1		1	1	1	1		1	1	1										1	1	1	1
Chaetodon meyeri		1					1	1	1	1	1	1	1	1		1			1	1	1				1	1	1
Chaetodon ocellicaudus		1		1																		1		1	1	1	1
Chaetodon ornatissimus		1	1	1		1			1	1	1	1		1		1									1	1	1
Chaetodon oxycephalus		1			1															1	1				1	1	1
Chaetodon punctatofasciatus		1		1	1	1	1	1	1					1								1			1	1	1
Chaetodon rafflesi		1					1	1	1					1		1				1	1	1	1	1	1	1	1
Chaetodon selene		1																							0	1	1
Chaetodon semion		1					1			1															1	1	1
Chaetodon speculum		1					1	1	1	1		1		1											1	1	1
Chaetodon trifascialis		1					1			1	1		1			1		1			1	1	1		1	1	1
Chaetodon ulietensis		1			1				1	1		1	1	1					1				1	1	1	1	1
Chaetodon unimaculatus		1	1	1		1	1	1					1			1			1		1	1	1	1	1	1	1
Chaetodon vagabundus		1		1	1	1	1	1	1	1	1	1		1		1		1	1	1	1	1	1	1	1	1	1
Chaetodon xanthurus		1			1	1	1									1		1						1	1	1	1
Coradion chrysozonus																		1			1				1	1	1
Coradion melanopus		1																							0	1	1
Forcipiger flavissimus		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Forcipiger longirostris		1			1		1		1				1	1		1		1				1		1	1	1	1
Hemitaurichthys polylepis		1		1	1											1						1	1		1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Heniochus acuminatus		1								1		1													1	1	1
Heniochus chrysostomus		1			1					1		1		1				1	1	1		1	1	1	1	1	1
Heniochus diphreutes																							1		1	1	1
Heniochus singularius		1					1			1															1	1	1
Heniochus varius		1		1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Pomacanthidae (19 spp.)																											
Apolemichthys trimaculatus		1			1	1	1	1	1	1	1	1	1	1		1		1	1		1	1		1	1	1	1
Centropyge bicolor		1		1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Centropyge bispinosa		1					1	1	1	1	1	1	1	1				1	1	1		1	1	1	1	1	1
Centropyge fisheri		1			1	1	1	1		1		1	1	1		1		1	1			1			1	1	1
Centropyge multifasciata			1																			1			1	1	1
Centropyge nox			1										1	1				1				1	1	1	1	1	1
Centropyge tibicen		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Centropyge vroliki		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1		1	1	1	1
Chaetodontoplus melanosoma									1																1	1	1
Genicanthus bellus																						1			1	1	1
Genicanthus lamarck		1			1	1	1	1	1					1		1			1	1	1	1	1		1	1	1
Genicanthus melanospilos														1								1			1	1	1
Pomacanthus annularis		1																							0	1	1
Pomacanthus imperator		1			1	1	1	1	1	1		1	1	1		1			1	1	1	1			1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Pomacanthus navarchus		1			1																				1	1	1
Pomacanthus semicirculatus		1			1	1										1			1	1		1			1	1	1
Pomacanthus sexstriatus							1																				
Pomacanthus xanthometopon					1																		1		1	1	1
Pygoplites diacanthus		1		1	1	1	1	1	1	1			1	1		1		1	1		1	1	1	1	1	1	1
Pomacentridae (94 spp.)																											
Abudefduf septemfasciatus		1																							0	1	1
Abudefduf sexfasciatus		1			1					1		1	1							1					1	1	1
Abudefduf sordidus		1																							0	1	1
Abudefduf vaigiensis		1					1		1	1	1	1	1			1		1	1	1	1	1	1	1	1	1	1
Acanthochromis polyacanthus		1	1	1	1	1			1	1	1	1	1	1						1	1	1	1	1	1	1	1
Amblyglyphidodon aureus		1		1	1	1	1	1		1		1	1	1		1		1	1	1	1	1	1	1	1	1	1
Amblyglyphidodon curacao		1					1	1				1	1	1					1	1	1	1		1	1	1	1
Amblyglyphidodon leucogaster		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Amblypomacentrus breviceps															1										1	1	1
Amphiprion clarkii		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Amphiprion melanopus		1	1	1	1	1		1										1				1	1		1	1	1
Amphiprion ocellaris		1		1	1	1	1		1	1		1		1		1					1	1	1	1	1	1	1
Amphiprion perideraion		1	1	1	1	1	1	1						1		1		1	1			1	1	1	1	1	1
Amphiprion polymnus															1										1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Amphiprion sandaracinos		1					1															1	1		1	1	1
Cheiloprion labiatus																						1			1	1	1
Chromis alpha		1	1				1	1						1		1		1	1		1	1	1	1	1	1	1
Chromis amboinensis		1	1				1	1						1		1		1	1	1	1	1	1	1	1	1	1
Chromis analis		1	1				1	1					1			1		1	1	1	1	1	1	1	1	1	1
Chromis atripectoralis		1			1		1	1				1		1						1	1	1		1	1	1	1
Chromis atripes		1	1		1	1	1	1	1	1		1	1	1		1		1	1	1	1	1	1	1	1	1	1
Chromis caudalis		1	1		1		1	1	1	1	1	1	1	1				1	1			1	1	1	1	1	1
Chromis cinerascens*	1																								0	0	1
Chromis delta		1	1		1		1	1					1			1		1		1	1	1	1	1	1	1	1
Chromis earina																						1			1	1	1
Chromis elerae		1											1			1		1	1			1	1	1	1	1	1
Chromis lepidolepis		1		1	1	1	1	1						1		1		1	1	1	1	1	1	1	1	1	1
Chromis lineata		1						1		1															1	1	1
Chromis margaritifer		1	1	1	1	1	1		1	1			1	1		1		1	1			1	1	1	1	1	1
Chromis retrofasciata		1	1				1	1						1					1			1	1	1	1	1	1
Chromis sp.(blue & yellow juvenile)							1						1	1				1				1			1	1	1
Chromis ternatensis		1	1		1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Chromis viridis		1	1					1		1		1								1		1		1	1	1	1
Chromis weberi		1		1	1	1	1	1			1	1	1	1		1		1	1	1	1	1	1	1	1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Chromis xanthochira		1	1		1	1	1	1		1	1	1	1	1		1		1	1			1	1	1	1	1	1
Chromis xanthura		1			1		1	1	1	1			1	1		1		1	1	1	1	1	1	1	1	1	1
Chrysipera biocellata		1																							0	1	1
Chrysiptera brownriggii		1					1	1	1	1			1	1				1	1						1	1	1
Chrysiptera caeruleolineata		1					1																		1	1	1
Chrysiptera cyanea		1					1		1				1	1						1					1	1	1
Chrysiptera glauca		1									1														1	1	1
Chrysiptera hemicyanea																								1	1	1	1
Chrysiptera oxycephala*	1																								0	0	1
Chrysiptera rex		1			1		1	1	1	1			1	1		1		1	1	1	1	1	1	1	1	1	1
Chrysiptera rollandi			1	1										1							1	1	1	1	1	1	1
Chrysiptera talboti		1	1	1	1	1	1	1	1	1		1		1		1		1	1	1	1	1	1	1	1	1	1
Chrysiptera unimaculata		1					1				1		1	1						1				1	1	1	1
Dascyllus aruanus		1												1	1					1		1			1	1	1
Dascyllus melanurus																						1			1	1	1
Dascyllus reticulatus		1	1		1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
Dascyllus trimaculatus		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
Dischistodus fasciatus*	1																								0	1	1
Dischistodus melanotus			1																			1			1	1	1
Dischistodus perspicillatus																						1			1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Dischistodus prosopotaenia*	1																								0	0	1
Hemiglyphidodon plagiometopon																						1			1	1	1
Lepidozygus tapeinosoma		1	1							1	1	1						1				1			1	1	1
Neoglyphidodon crossi		1					1	1	1			1							1	1	1		1		1	1	1
Neoglyphidodon melas		1		1	1	1	1	1	1	1			1	1					1	1	1	1	1	1	1	1	1
Neoglyphidodon nigroris		1	1	1	1	1	1	1	1	1	1	1	1	1				1	1	1	1	1	1	1	1	1	1
Neoglyphidodon thoracotaeniatus		1					1							1								1		1	1	1	1
Neopomacentrus azysron		1					1						1		1				1						1	1	1
Neopomacentrus violascens															1										1	1	1
Plectroglyphidodon dickii		1					1	1	1	1	1	1	1					1		1	1	1	1	1	1	1	1
Plectroglyphidodon johnstonianus		1																							0	1	1
Plectroglyphidodon lacrymatus		1			1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Plectroglyphidodon leucozona		1																1							1	1	1
Pomacentrus adelus							1							1						1	1				1	1	1
Pomacentrus alexanderae			1																					1	1	1	1
Pomacentrus amboinensis		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Pomacentrus auriventris		1				1	1	1	1		1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Pomacentrus bankanensis		1				1	1	1	1	1	1	1	1	1					1	1	1	1			1	1	1
Pomacentrus brachialis		1	1	1	1	1	1	1						1		1		1	1	1	1	1	1	1	1	1	1
Pomacentrus cheraphilus				1																					1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Pomacentrus chrysurus		1																				1			1	1	1
Pomacentrus coelestis		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1		1	1	1
Pomacentrus lepidogenys		1	1	1	1	1	1	1	1	1		1	1	1		1		1	1	1	1	1	1	1	1	1	1
Pomacentrus littoralis*	1																								0	0	1
Pomacentrus melanochir*	1																								0	0	1
Pomacentrus moluccensis		1	1	1	1	1	1	1	1	1		1	1	1				1	1	1	1	1	1	1	1	1	1
Pomacentrus nagasakiensis		1		1																1	1				1	1	1
Pomacentrus nigromanus			1																						0	1	1
Pomacentrus nigromarginatus			1		1	1	1	1	1	1		1	1	1		1		1	1		1	1	1	1	1	1	1
Pomacentrus pavo															1										1	1	1
Pomacentrus philippinus		1	1	1	1	1	1	1	1	1		1	1	1		1		1	1	1	1	1	1	1	1	1	1
Pomacentrus reidi		1	1	1	1	1	1	1					1	1		1		1		1	1	1	1	1	1	1	1
Pomacentrus tripunctatus		1																							0	1	1
Pomacentrus vaiuli		1		1	1	1	1	1	1	1	1	1	1	1		1				1	1	1	1	1	1	1	1
Premnas biaculeatus		1			1	1								1		1						1	1	1	1	1	1
Pristotis obtusirostris			1																						0	1	1
Stegastes albifasciatus		1									1														1	1	1
Stegastes fasciolatus		1					1	1		1								1	1						1	1	1
Stegastes nigricans																						1			1	1	1
Stegastes punctatus*	1																								0	0	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Labridae (104 spp.)																											
Anampses caeruleopunctatus		1								1				1		1			1						1	1	1
Anampses geographicus		1																							0	1	1
Anampses melanurus		1			1	1			1			1	1			1			1	1					1	1	1
Anampses meleagrides		1																	1			1		1	1	1	1
Anampses twistii		1		1	1	1		1	1	1		1	1	1		1			1			1	1	1	1	1	1
Bodianus anthioides		1			1				1	1						1		1							1	1	1
Bodianus axillaris		1		1	1	1	1	1	1	1	1	1	1			1			1	1	1	1		1	1	1	1
Bodianus bilunulatus		1					1		1										1						1	1	1
Bodianus bimaculatus									1				1	1		1		1	1			1		1	1	1	1
Bodianus dyctynna		1	1	1	1		1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Bodianus mesothorax		1	1			1	1	1	1	1		1		1		1		1	1	1	1	1	1	1	1	1	1
Cheilinus chlorourus								1							1					1					1	1	1
Cheilinus fasciatus		1		1		1	1	1	1					1		1			1	1		1	1	1	1	1	1
Cheilinus oxycephalus		1				1	1						1	1					1	1	1	1			1	1	1
Cheilinus trilobatus		1			1		1							1		1			1		1	1	1		1	1	1
Cheilinus undulatus		1								1			1			1			1						1	1	1
Cheilio inermis		1											1		1										1	1	1
Choerodon anchorago			1																			1			1	1	1
Choerodon zamboangae			1																						0	1	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Cirrhilabrus exquisitus		1				1	1				1	1				1		1	1			1	1	1	1	1	1
Cirrhilabrus filamentosus						1	1									1						1			1	1	1
Cirrhilabrus flavidorsalis				1			1							1											1	1	1
Cirrhilabrus lubbocki			1	1			1							1				1				1	1	1	1	1	1
Cirrhilabrus humanni					1	1	1	1		1	1	1		1		1						1		1	1	1	1
Cirrhilabrus pylei							1											1							1	1	1
Cirrhilabrus rubrimarginatus		1					1	1	1	1				1		1		1	1			1	1	1	1	1	1
Cirrhilabrus solorensis		1	1	1	1	1	1	1	1	1		1	1			1		1	1	1	1	1	1	1	1	1	1
Cirrhilabrus tonozukai																						1			1	1	1
Coris aygula		1																							0	1	1
Coris batuensis		1		1	1		1	1	1	1	1	1	1						1	1	1		1		1	1	1
Coris dorsomacula		1									1					1									1	1	1
Coris gaimardi		1			1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Coris pictoides							1					1													1	1	1
Diproctacanthus xanthurus		1																							0	1	1
Epibulus brevis														1						1			1	1	1	1	1
Epibulus insidiator		1	1		1	1	1		1	1		1		1		1		1					1		1	1	1
Gomphosus varius		1			1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Halichoeres argus*	1																								0	0	1
Halichoeres biocellatus					1	1			1									1	1			1	1		1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Halichoeres binotopsis*	1																								0	0	1
Halichoeres chloropterus*	1																								0	0	1
Halichoeres chrysus		1			1	1	1	1	1	1	1	1	1	1		1		1		1	1	1	1		1	1	1
Halichoeres claudia		1							1										1				1		1	1	1
Halichoeres hartzfeldii		1										1													1	1	1
Halichoeres hortulanus		1	1		1	1	1		1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Halichoeres leucurus*	1																								0	0	1
Halichoeres margaritaceus		1														1			1						1	1	1
Halichoeres marginatus		1			1		1		1	1		1	1	1						1	1	1	1	1	1	1	1
Halichoeres melanochir		1	1											1						1	1				1	1	1
Halichoeres melanurus		1		1																					1	1	1
Halichoeres melasmapomus							1									1		1	1						1	1	1
Halichoeres miniatus		1					1	1	1	1	1	1	1						1	1					1	1	1
Halichoeres nebulosus		1					1		1	1		1	1	1											1	1	1
Halichoeres nigrescens*	1																								0	0	1
Halichoeres pallidus																		1	1						1	1	1
Halichoeres papilionaceus*	1																								0	0	1
Halichoeres podostigma		1																	1	1		1			1	1	1
Halichoeres prosopeion		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1			1	1	1
Halichoeres richmondi		1						1						1					1	1		1		1	1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Halichoeres scapularis		1			1	1		1	1			1		1		1				1	1	1			1	1	1
Halichoeres solorensis		1								1															1	1	1
Halichoeres timorensis		1																		1					1	1	1
Halichoeres trimaculatus		1			1				1			1								1	1				1	1	1
Hemigymnus fasciatus		1					1	1		1	1	1	1	1		1				1			1		1	1	1
Hemigymnus melapterus		1			1		1			1		1	1	1		1			1	1	1	1	1	1	1	1	1
Hologymnosus annulatus		1							1	1	1	1	1			1									1	1	1
Hologymnosus doliatus		1			1		1	1	1	1		1				1			1						1	1	1
Labrichthys unilineatus		1					1	1						1		1				1	1	1	1	1	1	1	1
Labroides bicolor		1		1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Labroides dimidatus		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Labroides pectoralis		1			1		1	1	1	1		1	1	1				1	1	1	1	1	1	1	1	1	1
Labropsis alleni		1			1			1	1	1				1								1		1	1	1	1
Labropsis manabei		1					1		1					1								1			1	1	1
Labropsis xanthonota		1																1							1	1	1
Leptojulis cyanopleura										1		1								1					1	1	1
Macropharyngodon meleagris		1			1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1		1	1	1
Macropharyngodon negrosensis		1	1							1		1	1			1						1			1	1	1
Novaculichthys taeniourus		1			1							1				1									1	1	1
Oxycheilinus arenatus																						1			1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Oxycheilinus bimaculatus				1		1	1	1		1		1		1	1				1	1	1		1		1	1	1
Oxycheilinus celebicus													1	1										1	1	1	1
Oxycheilinus digramma		1	1	1	1	1	1	1				1	1	1		1			1	1	1	1	1	1	1	1	1
Oxycheilinus unifasciatus							1	1				1	1	1		1			1	1		1			1	1	1
Paracheilinus flavianalis		1	1	1	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	1
Pseudocheilinus evanidus		1	1				1	1	1	1	1	1				1		1	1	1	1	1	1	1	1	1	1
Pseudocheilinus hexataenia		1	1			1	1		1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Pseudocheilinus octotaenia		1			1	1	1		1	1	1	1	1						1					1	1	1	1
Pseudocoris bleekeri																							1		1	1	1
Pseudocoris heteroptera		1																	1				1		1	1	1
Pseudocoris yamashiroi		1			1		1						1	1		1									1	1	1
Pseudodax moluccanus		1		1		1	1	1								1			1						1	1	1
Pseudojuloides kaleidos							1																		1	1	1
Pseudojuloides mesostigma								1														1			1	1	1
Pteragogus cryptus		1																						1	1	1	1
Pteragogus enneacanthus		1	1											1					1						1	1	1
Stethojulis bandanensis		1			1		1		1	1	1	1	1	1				1	1	1	1	1			1	1	1
Stethojulis interrupta		1														1			1			1			1	1	1
Stethojulis strigiventer		1													1					1					1	1	1
Stethojulis trilineata		1						1								1									1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Thalassoma amblycephalus		1	1	1	1	1	1	1	1	1		1	1	1		1		1	1	1	1	1	1	1	1	1	1
Thalassoma hardwicke		1			1		1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Thalassoma jansenii		1			1		1	1	1	1		1		1		1		1	1			1	1	1	1	1	1
Thalassoma lunare		1	1	1		1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
Thalassoma purpureum		1						1	1	1		1													1	1	1
Scaridae (30 spp.)																											
Bolbometopon muricatum																			1						1	1	1
Calotomus carolinus			1											1				1							1	1	1
Calotomus spinidens*	1																								0	0	1
Cetoscarus ocellatus		1				1		1		1		1	1	1		1						1			1	1	1
Chlorurus bleekeri		1		1	1	1	1	1		1				1		1			1	1	1	1	1		1	1	1
Chlorurus capistratoides		1						1																	1	1	1
Chlorurus japanensis		1											1			1				1					1	1	1
Chlorurus microrhinos		1			1	1				1		1	1	1		1			1			1	1		1	1	1
Chlorurus oedema		1																							0	0	1
Chlorurus sordidus		1	1		1	1		1	1	1	1	1	1	1		1		1	1	1	1	1		1	1	1	1
Hipposcarus longiceps		1																1							1	1	1
Leptoscarus vaigiensis*	1																								0	0	1
Scarus chameleon		1																							0	1	1
Scarus dimidatus		1						1			1	1				1									1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Scarus festivus		1																					1		1	1	1
Scarus flavipectoralis		1			1				1			1												1	1	1	1
Scarus forsteni		1				1	1	1	1		1	1		1		1		1	1	1	1	1	1		1	1	1
Scarus frenatus		1			1							1											1		1	1	1
Scarus fuscocaudalis																						1			1	1	1
Scarus globiceps		1																							0	1	1
Scarus niger		1	1		1	1	1	1	1	1				1		1	1	1	1	1	1	1	1		1	1	1
Scarus oviceps		1	1			1	1							1		1						1			1	1	1
Scarus prasiognathos		1			1																		1		1	1	1
Scarus psittacus		1	1											1											1	1	1
Scarus quoyi		1														1									1	1	1
Scarus rivulatus		1														1									1	1	1
Scarus rubroviolaceus		1					1				1					1		1	1				1		1	1	1
Scarus schlegeli		1	1													1						1	1		1	1	1
Scarus spinus		1	1										1						1						1	1	1
Scarus tricolor		1			1			1	1	1	1	1	1			1		1				1			1	1	1
Trichonotidae (2 spp.)																											
Pteropsaron longipinnis													1					1							1	1	1
Trichonotus sp.													1												1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Pinguipedidae (10 spp.)																											
Parapercis clathrata			1		1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Parapercis cylindrica			1																	1					1	1	1
Parapercis flavolineata													1	1				1			1	1			1	1	1
Parapercis lineopunctata				1																					1	1	1
Parapercis millepunctata					1	1	1	1	1	1	1	1	1	1				1	1	1	1	1	1	1	1	1	1
Parapercis multiplicata			1																			1		1	1	1	1
Parapercis schauinslandii					1	1	1	1	1	1	1	1	1					1				1			1	1	1
Parapercis snyderi																				1	1				1	1	1
Parapercis tetracantha																1			1		1				1	1	1
Parapercis xanthozona																				1	1				1	1	1
Tripterygiidae (8 spp.)																											
Enneapterygius bahasa													1												1	1	1
Enneapterygius flavoccipitis														1					1						1	1	1
Enneapterygius tutuilae											1														1	1	1
Helcogramma gymnauchen*	1																								0	0	1
Helcogramma obtusirostre?													1												1	1	1
Helcogramma sp.																		1							1	1	1
Helcogramma striatum							1	1	1	1	1	1	1		1	1		1	1	1	1	1		1	1	1	1
Ucla xenogrammus								1																	1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Blenniidae (27 spp.)																											
Aspidontus taeniatus			1								1														1	1	1
Atrosalarias fuscus														1								1			1	1	1
Blenniella chrysospilos																		1							1	1	1
Cirripectes filamentosus														1											1	1	1
Cirripectes springeri									1																1	1	1
Cirripectes stigmaticus																						1			1	1	1
Ecsenius bicolor					1		1					1	1			1						1			1	1	1
Ecsenius midas												1													1	1	1
Ecsenius pictus																		1							1	1	1
Ecsenius trilineatus							1	1		1	1	1		1					1						1	1	1
Ecsenius yaeyamaenis							1	1					1						1						1	1	1
Entomacrodus caudofasciatus													1												1	1	1
Entomacrodus striatus													1												1	1	1
Istiblennius dussumieri*	1																								0	0	1
Istiblennius edentulus											1		1												1	1	1
Meiacanthus atrodorsalis					1	1	1	1		1	1	1	1	1		1		1	1			1	1	1	1	1	1
Meiacanthus cyanopterus													1												1	1	1
Meiacanthus grammistes				1			1															1		1	1	1	1
Nannosalarias nativitatus														1				1		1					1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Petroscirtes mitratus															1										1	1	1
Petroscirtes variabilis															1										1	1	1
Petroscirtes xestus															1										1	1	1
Plagiotremus laudanus																						1			1	1	1
Plagiotremus rhinorhynchus			1		1	1	1		1	1	1	1	1						1			1			1	1	1
Plagiotremus tapeinosoma																1									1	1	1
Salarias fasciatus																						1			1	1	1
Salarias guttatus*	1																								0	0	1
Callionymidae (3 spp.)																											
Callionymus annulatus*	1																								0	0	1
Synchiropus ocellatus*	1																								0	0	1
Synchiropus tudorjonesi																						1			1	1	1
Gobiidae (89 spp.)																											
Amblyeleotris fontanesii															1										1	1	1
Amblyeleotris guttata							1							1					1	1	1				1	1	1
Amblyeleotris masuii																				1					1	1	1
Amblyeleotris periophthalma																					1				1	1	1
Amblyeleotris wheeleri			1				1				1					1			1	1	1		1	1	1	1	1
Amblyeleotris yanoi																1									1	1	1
Amblygobius nocturnus															1										1	1	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Amblygobius phalaena															1										1	1	1
Amblygobius sphynx															1										1	1	1
Asterropteryx ensifera					1	1	1	1		1	1	1			1										1	1	1
Asterropteryx spinosa							1																		1	1	1
Asterropteryx striata						1		1		1	1	1	1	1						1	1				1	1	1
Bathygobius coalitius											1														1	1	1
Bathygobius cotticeps													1												1	1	1
Bathygobius petrophilus*	1																								0	0	1
Bryaninops amplus															1										1	1	1
Callogobius okinawae			1										1												1	1	1
Cryptocentrus cinctus			1																	1					1	1	1
Cryptocentrus sericus				1																1	1				1	1	1
Ctenogobiops feroculus				1																					1	1	1
Ctenogobiops maculosus																					1				1	1	1
Ctenogobiops pomastictus																				1	1				1	1	1
Drombus sp.															1										1	1	1
Eviota atriventris							1		1									1			1			1	1	1	1
Eviota distigma														1											1	1	1
Eviota guttata								1			1	1							1		1		1	1	1	1	1
Eviota latifasciata										1															1	1	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Eviota "fallax"													1						1						1	1	1
Eviota prasites			1																					1	1	1	1
Eviota punctulata																								1	1	1	1
Eviota sebreei							1	1		1	1	1	1					1							1	1	1
Eviota sp. 1 (white spots on head)								1			1			1				1					1	1	1	1	1
Eviota sp. 2 (cf punctulata)																		1							1	1	1
Eviota sp. 3 (cf "jewettae")																						1			1	1	1
Eviota zonura*	1																								0	0	1
Fusigobius aurea																		1							1	1	1
Fusigobius duospilus																			1				1		1	1	1
Fusigobius neophytus					1														1				1		1	1	1
Fusigobius signipinnis			1				1		1	1	1	1	1	1						1	1	1	1		1	1	1
Gnatholepis cauerensis			1				1	1			1		1					1	1	1	1		1		1	1	1
Gobiodon acicularis																						1			1	1	1
Gobiodon erythrospilus*	1																								0	0	1
Gobiodon quinquestrigatus																								1	1	1	1
Gobiodon sp. 3 (E. Indies book)																						1		1	1	1	1
Istigobius decoratus			1								1								1		1				1	1	1
Istigobius goldmanni*	1																								0	0	1
Istigobius nigrocellus															1										1	1	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Istigobius ornatus*	1																							0	0	1
Lotilia graciliosa																						1		1	1	1
Mahidolia mystacinus				1											1									1	1	1
Paragobiodon echinocephalus*	1																							0	0	1
Paragobiodon melanosoma			1					1																1	1	1
Paragobiodon xanthosoma*	1																							0	0	1
Periophthalmus argentilineatus			1																					0	1	1
Pleurosicya labiata																			1					1	1	1
Pleurosicya micheli							1	1		1														1	1	1
Pleurosicya mossambica							1	1		1														1	1	1
Priolepis cinctus																			1					1	1	1
Priolepis semidoliatus*	1																							0	0	1
Stonogobiops xanthorhinica																			1					1	1	1
Tomiyamichthys tanyspilus															1									1	1	1
Trimma anaima							1		1	1								1						1	1	1
Trimma annosum																			1					1	1	1
Trimma caudomaculatum																				1		1		1	1	1
Trimma emeryi																						1		1	1	1
Trimma halonevum							1													1	1			1	1	1
Trimma macrophthalma										1	1		1										1	1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Trimma marinae																						1			1	1	1
Trimma okinawae							1		1	1	1	1							1						1	1	1
Trimma papayum																				1					1	1	1
Trimma rubromaculatus							1	1																	1	1	1
Trimma sp. (yellow with ear spot)																						1	1		1	1	1
Trimma stobbsi																				1		1		1	1	1	1
Trimma taylori																1		1				1		1	1	1	1
Trimma tevegae																1		1							1	1	1
Trimma yanoi																			1			1	1		1	1	1
Trimma xanthocrum																								1	1	1	1
Tryssogobius colini																				1					1	1	1
Tryssogobius sarah													1					1				1			1	1	1
Valenciennea helsdingenii												1													1	1	1
Valenciennea longipinnis*	1																								0	0	1
Valenciennea muralis*	1																								0	0	1
Valenciennea puellaris					1							1								1	1				1	1	1
Valenciennea sexguttata															1	1				1					1	1	1
Valenciennea strigata					1		1	1	1	1		1		1	1				1						1	1	1
Vanderhorstia ambanoro	1														1										1	1	1
Vanderhorstia dorsomacula	1																								1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Vanderhorstia phaeosticta				1											1										1	1	1
Vanderhorstia sp. (E. Indies book)															1										1	1	1
Microdesmidae (2 spp.)																											
Gunnellichthys curiosus							1																		1	1	1
Gunnellichthys viridescens				1																					1	1	1
Ptereleotridae (10 spp.)																											
Nemateleotris decora		1			1	1	1	1	1	1	1	1	1			1		1	1			1		1	1	1	1
Nemateleotris magnifica		1			1		1	1	1				1			1		1	1			1	1	1	1	1	1
Oxymetopon typus*	1																								0	0	1
Parioglossus philippinus															1										1	1	1
Ptereleotris evides		1			1			1	1	1			1	1		1						1	1		1	1	1
Ptereleotris grammica								1					1					1							1	1	1
Ptereleotris hanae					1																				1	1	1
Ptereleotris heteroptera		1			1	1	1	1	1	1	1	1	1	1		1		1	1					1	1	1	1
Ptereleotris rubristigma												1													1	1	1
Ptereleotris zebra		1											1					1							1	1	1
Ephippidae (4 spp.)																											
Platax batavianus															1										1	1	1
Platax boersi		1		1								1		1		1									1	1	1
Platax pinnatus		1		1	1																	1			1	1	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Platax teira		1																						0	1	1
Scatophagidae (1 spp.)																										
Scatophagus argus*	1																							0	0	1
Siganidae (14 spp.)																										
Siganus argenteus		1	1													1			1	1				1	1	1
Siganus canaliculatus			1												1									1	1	1
Siganus corallinus		1	1	1																			1	1	1	1
Siganus guttatus		1		1										1				1		1				1	1	1
Siganus javus**	1																							0	0	1
Siganus labyrinthodes**	1																							0	0	1
Siganus margaritiferus*	1																							0	0	1
Siganus puellus		1	1													1								1	1	1
Siganus punctatissimus					1									1		1		1					1	1	1	1	1
Siganus punctatus		1								1										1				1	1	1	1
Siganus spinus		1																						0	1	1
Siganus vermiculatus*	1																							0	0	1
Siganus virgatus		1	1			1																		1	1	1
Siganus vulpinus		1	1		1	1		1	1			1		1					1	1	1	1	1	1	1	1	1
Zanclidae (1 spp.)																										
Zanclus cornutus		1			1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Acanthuridae (35 spp.)																											
Acanthurus auranticavus		1																							0	1	1
Acanthurus barine		1																	1						1	1	1
Acanthurus blochii		1																							0	1	1
Acanthurus leucocheilus		1																1	1						1	1	1
Acanthurus lineatus		1			1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1		1	1	1	1
Acanthurus maculiceps		1																							0	1	1
Acanthurus mata		1			1	1	1		1			1	1	1		1			1	1	1	1	1		1	1	1
Acanthurus nigricans		1			1	1	1	1	1	1				1		1		1	1			1		1	1	1	1
Acanthurus nigricauda		1						1	1	1															1	1	1
Acanthurus nigrofuscus		1					1	1						1				1	1			1	1	1	1	1	1
Acanthurus olivaceus		1			1	1				1	1	1	1			1			1						1	1	1
Acanthurus pyroferus		1	1		1	1	1	1	1	1		1	1	1		1			1	1	1	1	1	1	1	1	1
Acanthurus thompsoni		1			1		1		1	1		1	1	1		1		1	1			1	1	1	1	1	1
Acanthurus triostegus		1	1				1		1	1		1	1					1	1	1					1	1	1
Acanthurus xanthopterus		1																							0	1	1
Ctenochaetus binotatus		1	1		1	1	1	1	1	1	1	1	1	1					1	1	1		1	1	1	1	1
Ctenochaetus cyanocheilus		1	1				1	1	1	1			1	1				1		1	1			1	1	1	1
Ctenochaetus striatus		1	1		1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Ctenochaetus tominiensis		1												1										1	1	1	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Naso annulatus		1									1					1								1	1	1	1
Naso brachycentron		1									1	1		1				1	1					1	1	1	1
Naso brevirostris		1					1			1									1			1	1		1	1	1
Naso caeruleacauda		1										1													1	1	1
Naso caesius		1																							0	1	1
Naso hexacanthus		1								1	1	1	1						1			1	1	1	1	1	1
Naso lituratus		1			1	1	1	1	1	1	1	1	1	1		1			1	1	1	1	1	1	1	1	1
Naso lopezi		1					1	1	1	1		1	1					1						1	1	1	1
Naso minor		1			1				1	1												1			1	1	1
Naso tonganus		1																							0	1	1
Naso thynnoides		1			1				1	1		1									1	1	1		1	1	1
Naso unicornis		1																			1				1	1	1
Naso vlamingii		1			1					1						1			1			1	1	1	1	1	1
Paracanthurus hepatus		1										1				1									1	1	1
Zebrasoma scopas		1			1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Zebrasoma veliferum		1					1			1	1	1								1			1		1	1	1
Sphyraenidae (4 spp.)																											
Sphyraena barracuda												1		1											1	1	1
Sphyraena forsteri*	1																								0	1	1
Sphyraena jello																1									1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Sphyraena qenie																1									1	1	1
Scombridae (6 spp.)																											
Euthynnus affinis		1																							0	1	1
Grammatorcynus bilineatus									1	1	1	1												1	1	1	1
Gymnosarda unicolor		1							1			1	1												1	1	1
Rastrelliger brachysoma**	1																								0	0	1
Rastrelliger kanagurta*	1																								0	0	1
Scomberomorus commerson		1					1		1			1	1												1	1	1
Bothidae (1 spp.)																											
Asterorhombus filifer			1																						0	1	1
Soleidae (4 spp.)																											
Aseraggodes suzumotoi							1																		1	1	1
Brachirus heterolepis*	1																								0	0	1
Heteromycteris hartzfeldii*	1																								0	0	1
Soleichthys heterorhinus*	1																								0	0	1
Samaridae (1 spp.)																											
Samariscus triocellatus			1																						0	0	1
Balistidae (16 spp.)																											
Balistapus undulatus		1	1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Balistoides conspicillum		1			1	1	1		1	1			1			1			1	1			1	1	1	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Balistoides viridescens		1			1	1		1	1	1	1	1	1	1		1							1	1	1	1	1
Canthidermis maculatus*	1																								0	0	1
Melichthys niger		1	1				1	1	1	1	1	1	1					1		1	1			1	1	1	1
Melichthys vidua		1	1				1	1	1	1	1	1	1			1		1	1	1	1	1	1	1	1	1	1
Odonus niger		1			1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Pseudobalistes flavimarginatus		1			1	1		1		1						1								1	1	1	1
Pseudobalistes fuscus											1														1	1	1
Rhinecanthus aculeatus															1										1	1	1
Rhinecanthus rectangulus		1																							0	1	1
Rhinecanthus verrucosus		1																		1					1	1	1
Sufflamen bursa		1			1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	1
Sufflamen chrysopterus		1			1		1		1	1	1	1			1	1			1	1	1	1	1		1	1	1
Sufflamen fraenatus		1			1		1																		1	1	1
Xanthichthys auromarginatus		1																				1	1	1	1	1	1
Monacanthidae (8 spp.)																											
Acreichthys tomentosus*	1																								0	0	1
Aleuterus scriptus		1																							0	1	1
Amanses scopas			1				1	1		1						1					1				1	1	1
Cantherhines pardalis		1		1	1			1	1	1	1	1		1								1	1		1	1	1
Oxymonacanthus longirostris		1																							0	1	1

Family and Species	A	B	C	Site																					Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Paraluteres prionurus			1																			1			1	1	1
Pervagor janthinosoma			1											1				1					1		1	1	1
Pervagor melanocephalus		1	1																			1			1	1	1
Ostraciidae (4 spp.)																											
Lactoria cornuta*	1																								0	0	1
Ostracion cubicus		1																	1			1			1	1	1
Ostracion meleagris								1	1							1		1			1	1			1	1	1
Ostracion solorensis													1	1							1	1	1	1	1	1	1
Tetraodontidae (13 spp.)																											
Arothron hispidus																						1			1	1	1
Arothron immaculatus															1										1	1	1
Arothron manilensis															1										1	1	1
Arothron mappa													1					1							1	1	1
Arothron nigropunctatus		1								1	1	1				1			1	1	1	1			1	1	1
Arothron stellatus																				1					1	1	1
Canthigaster axilogus																					1				1	1	1
Canthigaster bennetti															1					1					1	1	1
Canthigaster compressa*	1																								0	0	1
Canthigaster epilamprus														1								1			1	1	1
Canthigaster leoparda																									1	1	1

Family and Species	A	B	C	Site																				Present Survey	MRAP + Ayling + AMS	Timor-Leste & West Timor
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			
Canthigaster papua			1	1																1				1	1	1	1
Canthigaster valentini																				1		1	1		1	1	1
Diodontidae (3 spp.)																											
Diodon holocanthus*	1																								0	0	1
Diodon hystrix*	1																								0	0	1
Diodon liturosus			1																						0	1	1
TOTALS	**154**	**410**	**216**	**104**	**220**	**163**	**270**	**226**	**199**	**230**	**167**	**249**	**237**	**260**	**66**	**238**	**0**	**213**	**244**	**201**	**182**	**294**	**218**	**227**	**741**	**814**	**968**

Chapter 2:
Reef-building Corals in Timor-Leste

Emre Turak and Lyndon DeVantier

Health coral community from the waters of Timor-Leste

Summary

This report describes the results of surveys of biodiversity and status of coral communities of Timor-Leste, surveyed in August 2012. This nation forms part 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 improving functionality of the Nino Konis Santana National Marine Park (NKSNMP). The survey was funded by the U.S. Agency for International Development (USAID) as part of a collaborative project between Coral Triangle Support Partnership (CTSP) and the National Government, particularly the National Directorate for Fisheries and Aquaculture (Ministry for Agriculture and Fisheries) to improve marine management practices contributing to sustainable livelihoods.

A total of 39 sites (adjacent deep and shallow areas) at 20 stations (individual GPS locations) were surveyed along the NE coast inside and outside of Nino Konis Santana National Park and on Atuaro Island. Coral communities were assessed in a range of wave exposure, current and sea temperature regimes, and included most habitat types of the NE coast. Coral communities of the S coast, known to be of differing structure because of the different environmental regime, were not assessed due to weather and logistic constraints.

Species Richness:
Timor-Leste hosts a diverse reef coral fauna, with a confirmed total of 367 reef-building (hermatypic) coral species. An additional 27 species were unconfirmed, requiring further taxonomic study. Three species (*Echinophyllia*, *Goniopora* and *Montipora* spp.) show significant morphological differences from their closest congeners, and are likely new to science, though requiring additional taxonomic study. In total, there are likely to be ca. 400 hermatypic Scleractinia present in Timor-Leste waters.

Within-station (point) richness around Timor-Leste averaged 153 species (s.d. 32 spp.), ranging from a low of 95 species at Hera W (Station 1) to a high of 214 species at Djonu East (Station 14). Other species-rich stations included Tutuala 3 Terraces (194 spp., Station 15), Loikere (193 spp., Station 4) and Belio Barrier Reef (190 spp., Station 19). These results for station and overall richness are similar to those from Bunaken National Park, higher than for Komodo and Banda Islands, and lower than Raja Ampat, Teluk Cenderwasih, Fak-Fak/Kaimana and Halmahera (all with ca. 450 spp. or more).

Commnity Structure:
Using cluster analysis at the station level, four coral community types were identified. Each of the communities was characterized by a more-or-less distinctive suite of species and benthic attributes. Two communities occurred predominantly in NKSNMP, one of which at Jako Island and the other along the NE coast. The other two communities were most common further west and at Atuaro Island.

Coral Cover:
Cover of living hard corals averaged 28 %. Dead coral cover averaged 9 % overall, such that the overall ratio of live : dead cover of hard corals was positive (3 : 1), indicative of a reef tract in moderate to good condition in terms of coral cover. Soft corals cover averaged 13 % overall. Areas of high soft coral cover occurred on rubble beds, likely created by earlier destructive fishing and/or coral predation and/or storm damage. Evidence of recent and not-so-recent blast fishing and some coral diseases were also present, the latter typically on tabular species of *Acropora*.

Coral Injury:
The above impacts notwithstanding, corals exhibited relatively low levels of recent injury overall, other than at Lamsana Inlet, where an active crown-of-thorns seastar outbreak was occurring. There was no evidence of past or recent major coral bleaching-related mortality, as typically triggered by elevated or depressed sea temperatures.

Interregional comparisons:

Timor-Leste's coral faunal composition is typical of the larger region, with most species recorded being found elsewhere in the CT. In terms of coral composition (presence), Timor-Leste's coral fauna is most similar to those of Bali and Komodo, in the Lesser Sunda Islands. In terms of coral community structure however, Timor-Leste's coral fauna shows closest similarity to Northern Komodo, Northern Bali, Bunaken, Wakatobi and Banda Islands, suggesting that the Timor-Leste coral fauna is more under the influence of the ITF rather than the Indian Ocean.

Climate Change Resilience:

There was no evidence or reports of past (1998) or recent (2010) large-scale high temperature bleaching-induced coral mortality around Timor-Leste. This is consistent with the presence of cool waters in most sites, which were typically 25-27**°** C at time of survey in August. This is three to four degrees cooler than many neighbouring locations, where sea surface temperatures consistently average 29-31 **°**C, inter-seasonal and inter-annual variability notwithstanding.

Waters to the north and south of Timor-Leste are major corridors of the Indonesia ThroughFlow (ITF), itself influenced by the cooling effects of mixing in the Banda Sea. If these cooling influences remain consistent, reliable features, Timor-Leste's oceanography may provide a cool water buffer and refuge against the increasing sea temperatures predicted from climate change over coming decades.

Conservation Priorities:

Timor-Leste has shown great initiative in declaring Nino Konis Santana National Park, which, with effective management, can play a very important role in conservation and replenishment locally and regionally. NKSNMP has high quality reefs and forms an important link in the regional MPA network being developed in the Lesser Sunda marine ecoregion and the broader Coral Triangle. Reefs of high conservation value were widespread in NKSNMP and also at Atuaro Island.

Most of the high quality reefs already form part of a MPA (NKSNMP) and thus a lot of the hard work has been done in respect of achieving successful conservation outcomes, at least in the short term. Reefs at Atuaro Island are also of high conservation value for a number of different criteria. The latter area has strong potential for development into a new MPA, or even as an extension to NKSNMP.

A significant amount of work has been achieved to date in building awareness and fostering goodwill among coastal villagers and others who use marine resources. This should be continued. It is also important to increase monitoring, surveillance and enforcement capacities as far as practicable to minimize poaching; and to address, as far as practicable, the ongoing impacts. These include:

1. Destructive fishing –with evidence of recent blasting near Com (eg. Station 11)
2. Sedimentation from hinterland erosion / runoff, most notable at Lamsana Inlet (eg. Station 17) but also likely on reefs further to the west, not surveyed during the present study.

Consideration may be given to a 'User-pays' system (eg. Bunaken National Park, Raja Ampat MPA Network) whereby visitors pay a nominal fee for access. This can provide significant funds for MPA management and benefits to local communities. Given the growing importance of ocean-based toursim (diving and swimming), particular focus should be paid to developing ecologically sensitive tourism at an appropriate scale, and to maintaining healthy and attractive reef-scapes for these activities, and hence a focus on non-destructive, non-extractive activities.

Introduction

Timor-Leste, located at latitude 8-9 S, 126 E, is situated in the Coral Triangle (CT, Fig. 1), earth's richest tropical marine realm (Allen 2007, Green and Mous 2007, Veron et al. 2009). Bordered on its south and west by the Indonesian part of Timor, Timor-Leste's coastline extends for approximately 700 km, including the islands of Ataura and Jaco and the western province of Oecussi. Offshore waters are typically deep, and form an important corridor of the Indonesian ThroughFlow (ITF), a major conduit of Pacific waters to the Indian Ocean. To the north lie Wetar Strait and the Banda Sea, which, through its influence on the ITF, plays an important role in the oceanography of Timor-Leste. To the south lies the Timor Sea.

Surrounded by deep waters channeling the ITF, Timor-Leste *"is an important migratory corridor for whales, dolphin and six threatened turtle species. Although small compared to other countries in the CT, Timor-Leste boasts rich and relatively pristine marine areas as well as economic potential in marine and coastal ecotourism."* (Esters and Erdmann 2012).

The coral ecoregion that includes Timor-Leste, namely 'North Lesser Sunda Islands and the Savu Sea', was known, prior to this study, to host at least 527 species of scleractinian reef-building corals (Veron et al. 2009). Reef coral diversity of Timor-Leste itself remained little known, although at least 124 species had previously been recorded during a 2008 survey (Ayling et al. 2009).

Figure 1. The Coral Triangle (Veron et al. 2009). Timor-Leste is located near the lower centre in the North Sunda Islands and Savu Sea Coral Ecoregion (purple colour). Crosshatching indicates that we considered the ecoregion to be data deficient.

Today, areas of the larger ecoregion display a high degree of genetic distinctiveness from adjacent ecoregions for at least some reef-associated species, as exemplified by stomatopod crustaceans.

"Information from other taxa should reveal whether these findings apply to other Indonesian reef species, but the association of stomatopod populations with old ocean basins suggests that reef populations throughout Indonesia cannot simply be assumed to be interconnected units; … [it is important to] *… also take biogeography and historical oceanography into account"* (Barber et al. 2000).

Historical oceanography, tectonics and eustacy

The island of Timor, positioned on the north-western edge of the Australian tectonic plate, drifted northward during the Miocene and Pliocene, attaining its present position relatively recently (Hall 2001, Audley-Charles 2004), and transporting a different biota to that of islands to its west. It has, over the past few million years, always been surrounded by deep waters during the episodic Pleistocene glaciations (Fig. 2). For example, bathymetry on the north coast declines steeply into a three km deep marine trench at approximately 20 km from shore (RDTL & CDU 2006; Keep *et al.* 2009, Boggs et al. 2009).

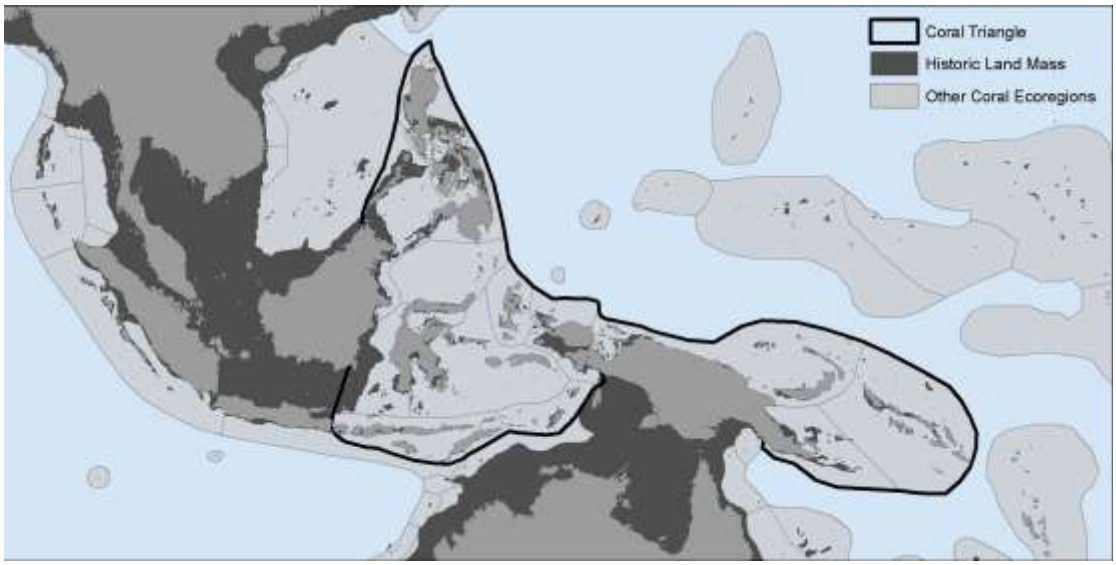

Figure 2. Approximate extent of exposed land (dark shading) during the major Pleistocene glaciations. Figure courtesy of Veron et al. (2009).

"The island of Timor is part of the Banda Arc. The Australian continental crust extends as far north as the north coast of Timor, and is thought to be uplifting Timor. … Over 40% of the country has extremely steep slopes … that are vulnerable to erosion and constantly being worn down by the monsoonal rains, with numerous rivers draining to the seas to the north and south (UNDP & RDTL, 2006)." (Boggs et al. 2009).

Environmental Conditions and Oceanography

The major sea currents flow to the south, influenced by the ITF, which exports water from the North and central-west Pacific through Indonesia, providing a major water source for the north-east Indian Ocean and further afield (Fig. 3).

"Some of its waters enter the Indian Ocean through the Lombok Strait, but most flow eastward into the Banda Sea, where they cool and freshen … This modified ITF enters the Indian Ocean through the Ombai Strait and the Timor Passage …. From here, some ITF flows southward in the Leeuwin Current …, bringing heat and moisture to western Australia, but most joins the South Equatorial Current and transits across the Indian Ocean."(Oppo and Rosenthal 2010).

Figure 3. Main corridors of the Indonesian ThroughFlow. Courtesy Oppo and Rosenthal 2010, *Science* 328 (Downloaded from www.sciencemag.org).

There is a general north – south through-flow, but with some (mostly sub-surface) flow in the opposite direction. Perhaps paradoxically, the main areas of through-flow may be considered as both contributing to and restricting dispersal (see later). Local currents may prove as important as the influence of the ITF in connecting and isolating marine populations.

"[While] *broad-scale oceanographic data may provide reasonable dispersal predictions…, other data may oversimplify 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).

Strong ocean mixing typically influences both nutrient concentrations and sea surface temperature in the broader ecoregion. Sea surface productivity, as exemplified by Chlorophyll A concentration, is patchy both spatially and temporally. In September 2012, Chlorophyll A concentration of 0.2-0.3 mg m^{-3} was slightly higher around Timor-Leste than waters to the south (Fig. 4), (NOAA Bloomwatch, http://coastwatch.pfeg.noaa.gov/coastwatch/), while Chlorophyll A levels were higher again in parts of the Banda Sea, around 0.4-0.6 mg m^{-3} (Fig. 3b), perhaps reflecting mixing of ITF waters there.

The southern coastlines are under the influence of long period ocean swell episodically exceeding three metres height from the Indian Ocean, generated by tropical – temperate storms, many of which are thousands of km away. By contrast, within the marginal seas to the north, waves are generally < 2 m high and generated by local weather patterns and the 'trade winds' of the monsoons, and sea conditions are often calm.

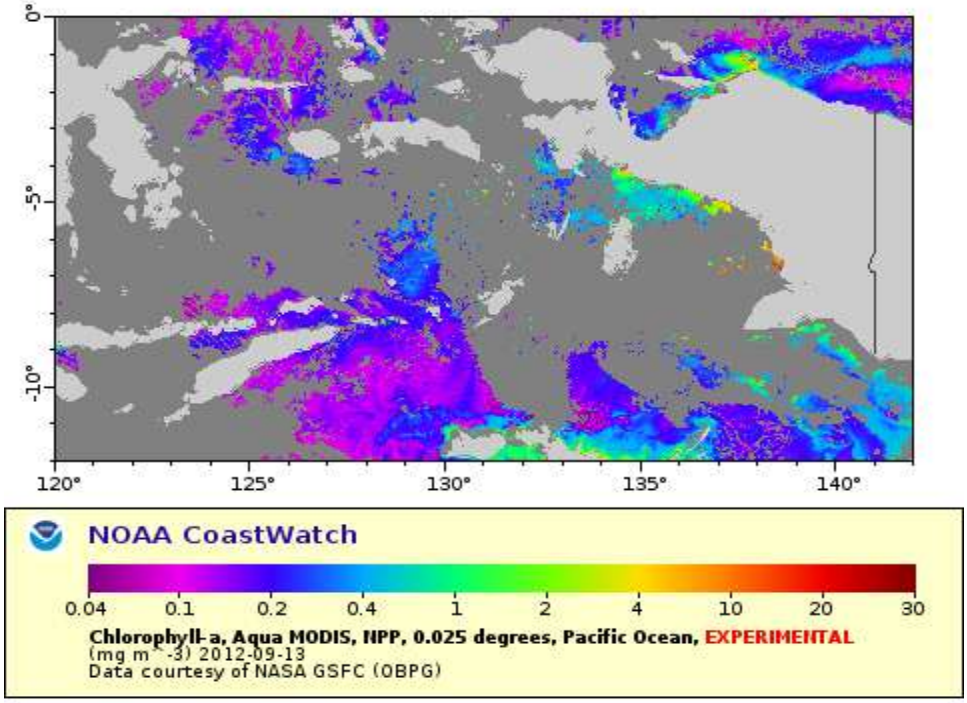

Figure 4. Chlorophyll A concentration, 13th September 2012. Downloaded from NOAA CoastWatch.

Sea-surface temperature (SST) within the Banda Sea typically varies from a low of 26.5 °C in August to a high of 29.5 °C in December and May (Gordon and Susanto 2001). Along the north coast of Timor-Leste, water temeratures ranged between 25 and 28 degrees C during the survey period of August 2012, consistent with variation in exposure to the ITF flow from the Banda Sea and localized upwelling. These temperatures are one to several degrees cooler than surrounding areas unaffected by the ITF or localized upwelling.

Inter-annual variability in air and sea temperature is caused by the influence of large-scale climate phenomena, notably the El Niño–Southern Oscillation and the Indian Ocean Dipole, and increasingly to the rapid continuing heating of earth's climate, commonly termed global warming.

Located betweem 8-10 degrees South, Timor-Leste is sufficiently close to the equator to be only occasionally affected by major tropical storms.

"Tropical cyclones can affect Timor-Leste between November and April, however their effect tends to be weak. In the 41-year period between 1969 and 2010, 31 tropical cyclones passed within 400 km of Dili, an average of less than one cyclone per season" (Pacific Climate Change Science Program partners 2011, http://www.cawcr.gov.au/projects/PCCSP/pdf/5_PCCSP_East_Timor_8pp.pdf).

There are two distinct dry and wet seasons annually, driven by the annual movement of the inter-tropical convergence zone - the South-east and North-west monsoons. The northwest monsoon during the wet season typically extends from October-November to February-March and the southeast monsoon during the dry season from May to October, with a transition period of 1–2 months between seasons characterized by variable and lower winds. During the survey period in August 2012 however, winds at times blew from the north – north-east, generating a low northerly swell, and with episodic rain on the adjacent north coast.

According to Boggs et al. (2009):
"The north coast of Timor-Leste experiences a dry tropical climate with a mean temperature above 24 °C and is influenced by the Northern Monomodal Rainfall Pattern which sees a single wet season from December to May. Annual rainfall in the north coast lowlands can be as low as <1000 mm, whereas higher altitudes might receive rainfall up to 2000 mm/year. Downpours are often extremely heavy (Barnett et al., 2003). In contrast, the southern coast is exposed to two wet seasons (Nov-Apr, May-Jul) and around 1500mm of rain annually.

The northern and southern coast differ not only climatically, but also, with respect to coastal and nearshore environments. Topographically, the north coast is rocky and steep along most of its shoreline. The continental shelf is narrow, with coastal plains virtually non-existent or very narrow, except for around areas such as Manatuto and Dili, with numerous white sandy beaches with interspersed rocky outcrops are scattered along the coast. The north coast is characterised by karst geology and uplifted ancient coral reefs (see Audley-Charles, 2004; Hamson, 2004; Keep, et al., 2009)."

Sea- and Reefscapes

Within the Lesser Sunda ecoregion, seven smaller areas titled 'seascapes' were defined, based on the above oceanographic, geomorphological and biogeographic patterns, the most eastern of which included Timor-Leste (DeVantier et al. 2008). On its northern extent, the seascape is under the influence of the Banda Sea and the smaller, semi-enclosed Wetar Strait, and on its south extent the Timor Sea.

Around the island of Timor itself, a further reef habitat stratification identified four 'reefscapes' (DeVantier et al. 2008), three of which incorporated fringing reefs and associated seagrass and mangrove habitats of Timor-Leste (Fig. 5). Two of these were surveyed during the present study: Fatu and Timor East reefscapes, the latter coinciding with the recently designated (2007) Nino Konis Santana National Marine Park. Within NKSNMP, the south coast is more exposed to winds and swells than the more sheltered north coast.

Given this oceanographic setting, strongest biogeographic similarity is likely to occur within the north-facing (relatively sheltered) and south-facing (relatively exposed) coasts respectively. High dissimilarity is likely to occur between these two areas, with transitional areas in the semi-exposed locations. Such dissimilarity between north and south coast sites in respect of benthic composition was found during an extensive survey in 2008 (Ayling et al. 2009). These general trends will be affected, on small scales (10s of km), by localized oceanographic and topographic features, including upwelling, and by ecological histories of particular sites. For example, coral communities at many N coast locations were impacted by population outbreaks of the predatory crown-of-thorns seastar from 2004 to at least 2008, with active outbreaks occurring at the time of the 2008 survey (Ayling et al. 2009).

Another key differentiating factor in the type and distribution of coastal marine habitats is substratum. Shallow areas of soft substrate may support seagrass beds, the adjacent coasts fringed by mangroves. Other areas are formed predominantly by kaarst, indicating earlier periods of reef growth and deposition. These porous areas may facilitate significant subterranean runoff of freshwaters during intense rainfall on the adjacent coast and hinterland, augmenting runoff carried in the episodically flowing river systems, limiting reef growth in some areas.

Dedicated habitat mapping using remote sensing (Landsat imagery and aerial photography) and ground-truthing (Boggs et al. 2009) revealed the following:

"The marine nearshore zone is characterised by a narrow reef flat (often < 60m wide, but up to almost 1km), dominated by seagrass in shallower water (approximately 2,200ha) and corals in deeper water and on the escarpment (approximately 2,000ha). A mixed-cover class, which included low covers of coral or seagrass and bare areas, occupied 1,250 ha. … The very limited extent of coral reef, seagrass and mangrove habitats on the north coast of Timor Leste, impose strong limits on available marine resources and levels of harvest (particularly reef fisheries, mangroves) and in the light of increasing human resource use, underscore the urgent need for precautionary and effective conservation management.

Importantly, the coastal mapping has revealed significant and ongoing coastal habitat loss in Timor-Leste. As such, total mangrove extent has reduced from 9,000ha in 1940, to 3,035ha in 2000 (FA0 2003) to just 1,802 ha recorded in 2008, ie. ~40% loss between 2000-2008, or disturbingly, an approximate 80% loss of total mangrove habitat since 1940. Mangrove trees are harvested for timber and fuel wood and in some instances hinterland mangroves have been removed for brackish water shrimp and/or fish ponds." (Boggs et al. 2009).

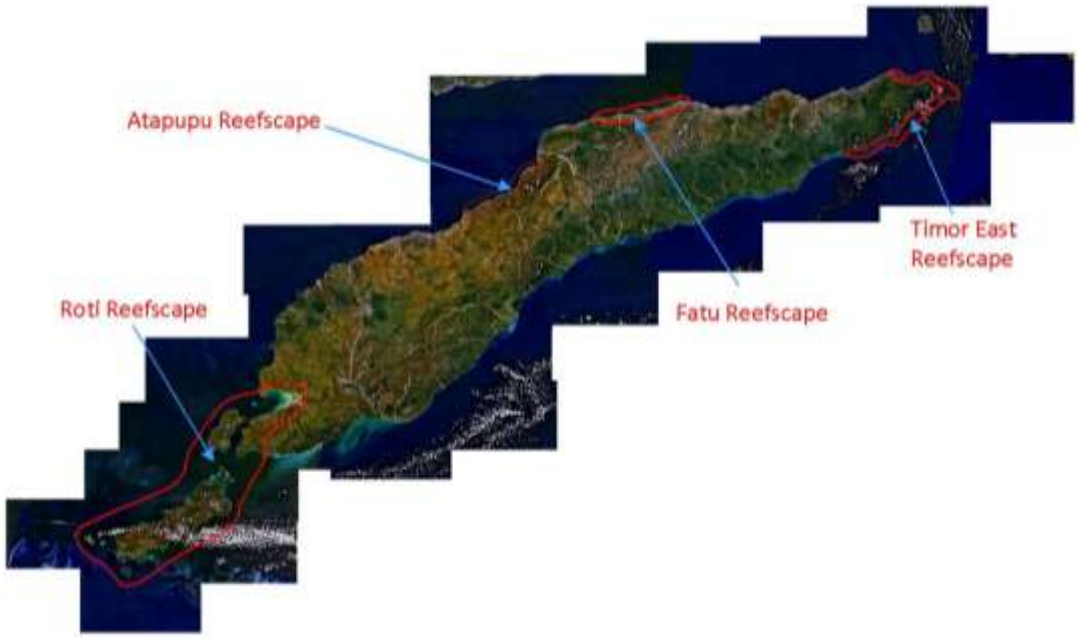

Figure 5. Reefscapes of Timor, Roti and adjacent small islands. From DeVantier et al. 2008 and courtesy of the Nature Conservancy.

Socio-economy

Timor-Leste restored its Independence in 2002 following decades of struggle and two years of United Nations administration. Timor-Leste's population is just over one million, approximately 60% of whom are less than 25 years old.

"Timor-Leste is now in the early stages of nationhood and state building. This period is a fragile time for the country which is currently relying on the international community for development assistance." (Esters and Erdmann 2012).

The north coast of Timor-Leste is highly valued for its contribution to local livelihoods, particularly through ecotourism and fisheries (Boggs et al. 2009).

" … local communities rely on the sea as a source of household income and food security. … subsistence fishermen operating within the boundaries of the NKS are slowly increasing their catch efforts. Electricity has been made available and now fishermen can catch more fish, store it and sell it to buyers from different districts (Dili and Baucau). The passage from a subsistence based fisheries to market oriented fisheries coupled with population growth and … infrastructure plans for the [Nino Konis Santana Marine] *National Park have potential to impact NKS fragile marine and coastal ecosystems."* (Esters and Erdmann 2012).

There is also considerable 'semi-industrial' poaching of fishes by foreign vessels, the amount of which remains unquantified. As noted by Ayling et al. (2009) following marine surveys in 2008:

"It is suggested that these reefs have been subjected to enough fishing pressure to reduce numbers of vulnerable target species and of commercially valuable invertebrates. However, the reefs are generally in good condition and have a number of unusual features."

Detailed coastal habitat mapping by Boggs et al. (2009) also revealed that intensive agriculture (2,200ha) and built up areas (1730ha) were prominent features of the northern coast.

Planning for future sustainability

The Timor-Leste Government, with international and national support, is presently working towards a comprehensive long-term development strategy, including greatly improving spatial planning in both the terrestrial and marine areas. Towards these goals, the present survey of Nino Konis Santana National Marine Park (NKSNMP) was funded by the U.S. Agency for International Development (USAID) as part of a collaborative project between the Coral Triangle Support Partnership (CTSP) and the National Government.

"The Coral Triangle Support Partnership (CTSP) a USAID funded program has helped the Government of Timor-Leste, through its National Directorate of Fisheries and Aquaculture to conduct broad-scale habitat analysis of the marine component of the National Park. CTSP also co-facilitated with District level Government staff, community meetings to establish community zones and help the Government in its marine spatial planning efforts for the marine component" (Esters and Erdmann 2012).

Located in Timor-Leste's eastern area, NKSNMP comprises some 556 km^2 of diverse marine habitats, extending for three nautical miles offshore, and bordering approximately 100 km of coast. NKSNMP was conceived as IUCN category V protected area (Edyvane et al. 2009, Esters and Erdmann 2012):

"Community members, fisheries staff and CTSP staff have been engaged for 2 years in identifying priority sites based on rapid biological surveys and local knowledge, these sites often referred to as community marine managed areas (cMMAs) follow the National Directorates instruction to explore the possibility of exploring cost effective management solutions with strong community participation.

To advance the cMMAs network agenda, the National Directorate for Fisheries and Aquaculture requested Conservation International to lead a team of local and international experts to survey sites in NKS National Park and provide clear recommendations on priority sites for future management, potential tourist sites and next steps for the design of the National Park. This information will be used towards the development of the NKS Marine component Management plan and to justify/socialize these plans to local government and local community stakeholders (Esters and Erdmann 2012).

Rationale and assessment objectives

The MRAP assessment, conducted during the period of 14-24 August 2012, had the following three primary objectives:

- Assess the current status (including biodiversity, coral reef condition and conservation status/resilience of hard corals and coral reef fishes) of approximately 20 sites representing the full range of oceanographic and ecological conditions found in the NKSNMP. 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 development of the NKSNMP Management Plan. This includes not only an analysis of any differences in reef community structure across the 20 priority sites, but also specifically identifying areas of outstanding conservation importance and/or marine tourism interest due to rare or endemic hard coral or fish assemblages, presence of reef fish spawning aggregation or cleaning sites, reef communities exposed to frequent cold-water upwelling that are resilient to global climate change, or other outstanding biological features.
- Taking the above into account, provide concrete recommendations to the Timor-Leste government on development of the MPA's management plan (including zonation plan) and on developing marine tourism in the MPA (Esters and Erdmann 2012).

In addressing these objectives, this study documents coral species composition, community structure and ecological status of the reef-building corals of Timor-Leste in August 2012. These results were compared with those of previous surveys in the “Coral Triangle” region, specifically with those from Berau, East Kalimantan (2004 TNC REA), 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 Sangihe-Talaud region of North Sulawesi (2001 TNC REA), Bali (2008/2011 MRAP), Anambas (2012 MRAP) and Brunei (2009-2010 marine surveys) with a specific goal of quantitatively assessing ecological and taxonomic similarities in coral assemblages between Timor-Leste and neighboring regions within and adjacent to the Coral Triangle.

Based on the above information, concrete recommendations are provided to the Timor-Leste government on next steps in developing the Nino Konis Santana National Park Management Plan and fostering marine tourism development in the park. This includes identification of those reef (and other related ecosystem) areas that should be considered top priorities for inclusion in no-take or fisheries or tourism management zones within the MPA.

Methods

Rapid Ecological Assessment (REA) surveys were conducted using SCUBA at 20 reef locations (herein named ‘stations’, each with a specific GPS position) around Timor-Leste in August 2012 (Fig. 6, Annex 1). At all but one station (Station 22), deep and shallow areas, herein named ‘sites’ (designated as site #.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 39 sites. Deep sites 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 sites (depths), unless otherwise specified with the specific depth designator (site #.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 site, 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 site, 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 sites (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 site: 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).

1. Taxanomic 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 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 site 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 1).

Table 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		

Taxonomic certainty: Despite continuing advances in 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. This is particularly so with increasing use of molecular genetic techniques to examine systematic relationships (eg. Fukami et al. 2008). Results from these techniques have resulted in a major ongoing

period of flux in coral taxonomy, particularly at higher taxonomic levels (eg. family). At genus and species levels however, the traditional classification scheme remains relatively stable, although different workers do provide different taxonomic classifications and synonymies for certain coral 'species' (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 Timor-Leste colleagues, 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 CTSP Office, Dili.

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 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.

Table 2. Categories of benthic attributes

Attribute		**Ranks used in calculating**	
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-algae	Sand	76 – 100 %	5

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

The sites 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 sites (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.

Replenishment Index CI

The presence of high species richness, abundance and cover of reef-building corals may afford some sites greater importance than others in terms of their role as reproductive sources for local replenishment of populations. A local replenishment index, *CI* which rates sites based on a combination of their reef-building coral cover and individual species' rank abundance scores (DeVantier et al. 1998) was calculated for each site (depth):

$$CI = \sum A_i H_i / 100$$

where A_i = abundance rank for the ith reef-building coral taxon (as in Table 1), and H_i = rank hard coral cover category (1-5, as in Table 2), at each site. This index gives highest scores to sites that have high cover, species richness and abundance of reef-building corals. CI values for each site were averaged to produce Station totals.

Rarity Index

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

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

where *Ai* = abundance rank for the ith coral taxon at a given site (1-5, as in Table 2), and *Pi* = the proportion of all sites 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 sites which are least representative or most unusual faunistically (ie. with high abundance of taxa which are rare in the data set). RI values for each site were averaged to produce Station totals.

Coral Injury

Each coral species in the sites 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 site to 1: all colonies of the species were dead, see Methods above). Sites were compared for the amounts of injury to their coral communities, for the proportion of the total number of species present in each site that were injured, and the average injury to those coral species in each site.

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 site 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. Timor-Leste
ii. Various regional analyses of adjacent regions of the CT, including Anambas Islands, Brunei, Derewan, Bali, Komodo, Wakatobi, Sangihe-Talaud, Banda Islands, Bunaken National Park, Raja Ampat, Cenderwasih Bay and Fak-Fak/Kaimana (Fig. 7).

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).

Figure 6. Location of survey stations, Timor-Leste, August 2012.

For the regional comparisons, a further two sets of analyses were undertaken:

1. Using the presence of species in each location:
    a. for Timor-Leste with Bali, Komodo, Banda Islands, Bunaken and Wakatobi, for a total of six locations; and
    b. for Timor-Leste with the previous five regions plus 9 others - Cenderwasih Bay, Fak/Kaimana and Raja Ampat (all Birds Head Seascape, Indonesia), Sangihe-Talaud Islands (Sulawesi Sea), Derewan (Barau, East Kalimantan), El Nido (Palawan, Philippines), Brunei Darusalam and Anambas Islands, W Indonesia (latter three regions in South China Sea), for a total of 15 locations.

2. Using the species-abundance at the individual station level of analyses for Timor-Leste, with Bali, Komodo, Banda Islands, Bunaken and Wakatobi (153 stations).

Some additional temporal comparisons were made with the results of prior surveys of coral communities of Timor-Leste conducted by Ayling et al. (2009).

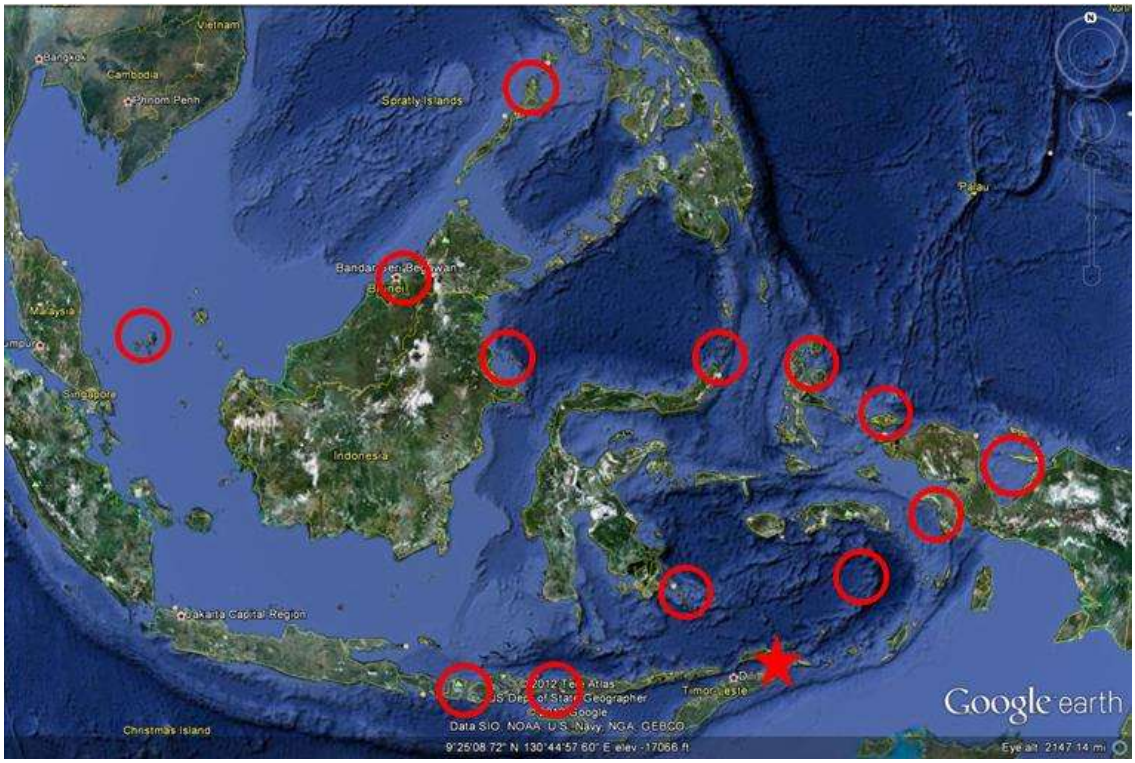

Figure 7. General areas of surveys conducted in and adjacent to the Coral Triangle, including Timor-Leste (red star), Bali and Nusa Penida, Komodo, Banda Islands, Wakatobi, Derewan, Bunaken, Sangihe-Talaud, Halmahera, Raja Ampat, Teluk Cenderewasih and Fak-Fak/Kaimana, Anambas Islands, Brunei Darusallam and El Nido, Palawan Philippines. 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).

Results

Environmental Setting

A broad range of reef development occurred throughout the survey area, ranging from incipient reefs with some accretion to large sub-tidal and inter-tidal reefs with flats wider than 50 m (Table 3, Annex I). 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 near horizontal (< 5^{o} reef flats) to 70^{o} to the horizontal (near-vertical reef walls), the latter being uncommon (Annex 1). The communities were distributed over exposure regimes from sheltered to exposed, related to the degree of protection provided by coastal features. Periods of N wind generated waves to 2 m height along sections of the coast during the survey period.

Most coral communities were developed in areas of hard reefal or non-reefal substrate (mean of 78% cover) with only small areas of sand (mean 14%), and were subject to variable levels of current flow, ranging from calm to > 2 knots, the latter likely related to tidal flows and coastal marine geomorphology. There were usually negligible levels of sedimentation with silt from land-based run-off, other than at Lamsana inlet East (Station 17) on the N coast. The typically low silt levels contributed to the relatively high water clarity, which averaged 16 m, ranging from 4 m to 30 m during the survey period (Table 3).

Table 3. Summary statistics for environmental variables, Timor-Leste, August 2012.

Environmental variable	Mean (s.d.)	Range	Median	Mode
Reef development (rank 1-4)	3.3 (0.7)	2 - 4	4	4
Slope angle (degrees)	18 (15)	2 - 70	10	10
Exposure (rank 1 - 4)	2.4 (0.7)	1 - 4	2	2
Water Clarity (Visibility m)	16 (7)	4 - 30	15	20
Hard substrate (%)	78 (18)	30 - 100	80	80
Sand (%)	14 (16)	0 - 60	10	5
Silt (%)	2 (8)	0 - 50	0	0
Water temperature (C)	26.6 (0.7)	25 - 28	27	27

Cover of corals and other sessile benthos

Cover of living hard corals was typically moderate to high (eg. Plates 1 and 2), averaging 28 % (Fig. 8), and ranging from 5 – 70 % at individual sites. Stations with high live coral cover were widespread (Annex II). Highest cover (50 % or more) occurred at sites 6.1 and 6.2 (Jako Isl. N), 7.1 and 7.2 (Jako Isl. S) and 10.2 (Hotobumalai, Tutuala 1). Cover was dominated in some sites by large monospecific stands, notably the blue coral *Heliopora coerulea* at Jako Isl. N. At Jako Isl. S, by contrast, high cover was comprised of a highly diverse species mix.

Overall, rubble and dead corals contributed ca. 15 % cover, more than half of which was in the form of dead coral (9 %). Sites with relatively high cover of standing dead corals (20 % or more) were at Com (Sites 2.1, 2.2 and 3.2), Lamsana inlet East and West (Sites 17.1, 17.2 and 18.2) and Belio Lagoon S (Site 21.1) (Annex II). Previous mortality of live corals was mostly attributable to crown-of-thorns seastar and possibly *Drupella* snail predation, blast fishing, particularly around Com, and possibly coral diseases. Crown-of-thorns seastars were present at several sites, and were in outbreak numbers at Lamsana Inlet E (Site 17.2, Plate 3). As noted above, seastar outbreaks have been occurring along this coast since at least 2004 (Ayling et al. 2009), and appear to be in decline at present in all but one of the stations surveyed. Only very low levels of coral diseases were apparent, developed primarily on tabular species of *Acropora*. No evidence of recent coral bleaching was found, and no characteristic

scarring indicative of previous mass bleaching during the 1998 El Nino event or other periods of elevated sea temperatures, perhaps related to Timor-Leste's oceanography (see Discussion). There was some evidence of recent blast fishing, for example at Station 11 near Com (Plate 4).

There was only low cover of recently killed corals (mean of < 1%) at most sites, and the continuing disturbances notwithstanding, the overall ratio of live : dead cover of hard corals remained positive at ca 3 : 1, indicative of a reef tract in moderate to good condition in terms of coral cover. Sites with high cover of rubble (20 % or more) included Irimasi (Sites 11.1 and 11.2), Belio Lagoon S (Site 21.1) and Belio inner Channel (Site 22.2). The ratio of live hard coral cover to dead corals plus rubble was also positive at ca 2 : 1, and is consistent with these reefs supporting ca. 40-50 % mean live hard coral cover during periods of low disturbance, as is presently the case at Jako Island and Hotobumalai, Tutuala 1 (Annex II).

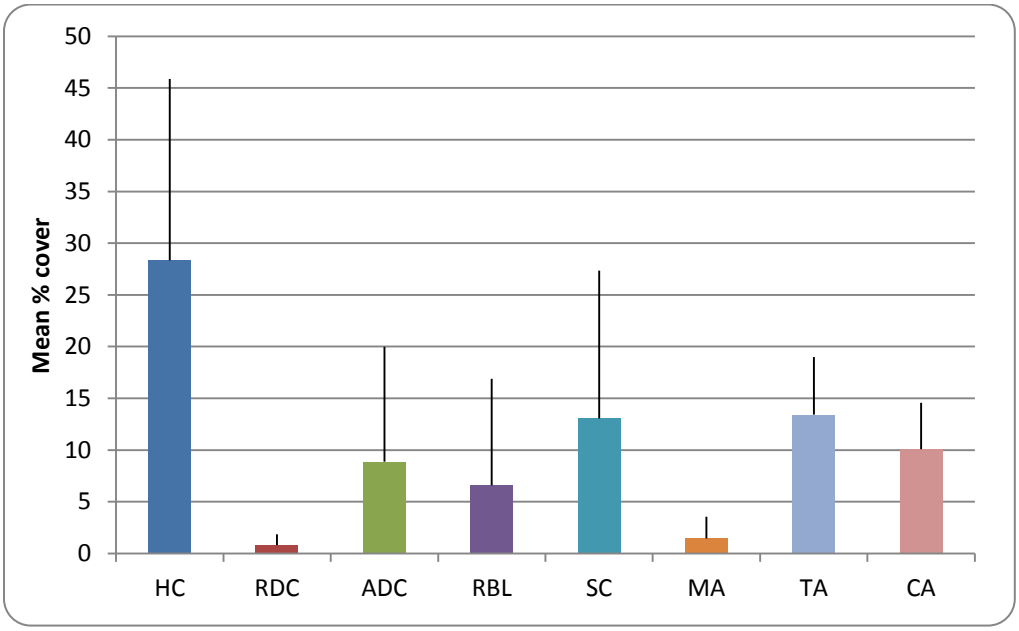

Figure 8. Mean % cover (+ s.d.) of sessile benthos, Timor-Leste, August 2012. HC – Hard Coral; RDC – Recently Dead Coral; ADC – All Dead standing Coral; RBL – coral Rubble; SC – Soft Coral; MA – Macro-Algae; TA – Turf Algae; CA – Coralline Algae.

Soft coral cover was moderate, averaging 13 % overall, and high in patches, notably on coral rubble beds. Stations with high cover (30 % or more) included Hera W, Com, Japanese Bunker and Belio Lagoon S (Sites 1.1, 1.2, 2.1, 2.2, 16.2, 21.1) (Annex II).

Plate 1. High cover of reef-building corals, site 10.2, composed predominantly of *Porites* spp.

Plate 2. High cover of reef-building corals, site 10.2, composed predominantly by branching *Porites* spp.

Plate 3. Crown-of-thorns seastar feeding on *Goniopora* in site 17.1.

Diversity of soft corals and related taxa was moderate to high at these, and several other, sites (see later). There was only low cover of macro-algae at most sites, averaging < 2 % overall. Only the station at Hera W had moderate MA cover (10 %, Site 1.1). Cover of turf and coralline algae was low to moderate overall, averaging 13 % and 10 % cover respectively (Fig. 8).

Plate 4. Large circular 'crater' surrounded by broken coral consistent with recent blast fishing, Site 11.2 near Com.

Species Richness

Timor-Leste hosts a rich coral fauna of 367 confirmed hermatypic scleractinian species. A further 27 species were recorded during the field surveys but remain unconfirmed at present (Annex III), such that there are likely to be some 400 hermatypic Scleractinia present, in total.

Three species may be new to science: *Echinophyllia* sp., *Goniopora* sp. and *Montipora* sp. (Plates 5-7). Each shows significant morphological variation in skeletal and / or soft tissue characters from the closest known species in their genera: *Echinophyllia costata*, *Goniopora fruticosa* and *Montipora Porites* respectively. Further taxonomic work is required to determine whether these are in fact new species, or rather Timorese morphs of their closest congeners.

Of the 367 confirmed species recorded (Annex III), almost all, with the possible exception of undescribed species, are shared with nearby areas of the CT (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. Unidentified *Echinophyllia* sp., from site 21.1.

Plate 6. Unidentified *Goniopora* sp., from site 17.1.

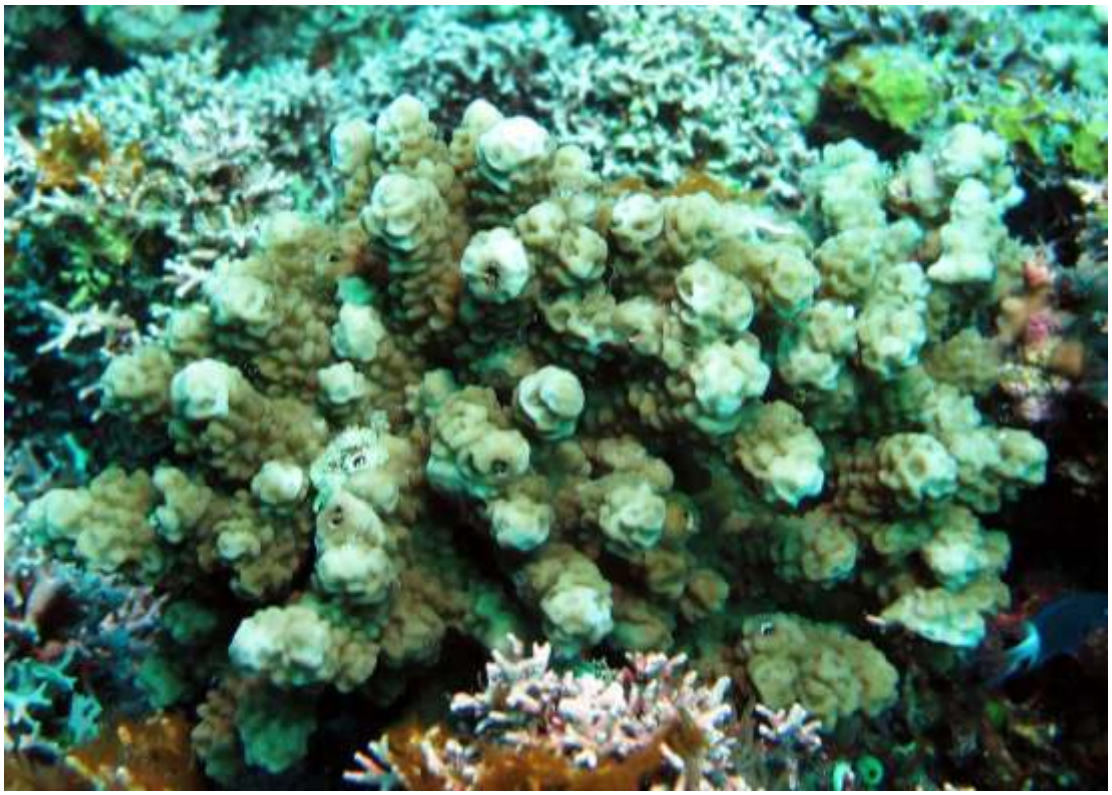

Plate 7. Unidentified *Montipora* sp., from site 3.2.

Within-station (point) richness around Timor-Leste averaged 153 species (s.d. 32 spp.), ranging from a low of 95 species at Hera W (Station 1) to a high of 214 species at Tutuala 1 (Station 14). Other species-rich stations included Tutuala 2 (194 spp., Station 15), Umamutin (193 spp., Station 4) and Belio Patch S (190 spp., Station 19). These results for station and overall richness are similar to those from Bunaken National Park, higher than for Komodo and Banda Islands, and lower than Raja Ampat, Teluk Cenderwasih, Fak-Fak/Kaimana and Halmahera (Table 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). These included 2 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. (Table 5). An additional 50 genera of alcyonacean soft corals, plus zoanthids, corallimorpharians, anemones, hydroids and related sessile benthos were also recorded. Diversity and abundance of sponges was also exceptionally high (Ayling et al. 2009).

Rarity: The Rarity Index, which rated stations in respect of the occurrence of species otherwise rare in the Timor-Leste data set, revealed a broad range of RI scores (mean 5.1, range 2.3 – 8.3, Table 6), with Tutuala 1 (Station 14) being most unusual faunistically, followed closely by Tutuala 2, Belio Patch S and Umamutin (Stations 15, 19 and 4) (Table 6).

Table 4. Comparison of diversity and other ecological characteristics of Timor-Leste with other Indo-West Pacific coral reef areas. KO – Komodo National Park; BI - Banda Isl., Banda Sea, Maluku; BL – Bali; AN – Anambas Islands; DE – Derewan, East Kalimantan; W - Wakatobi area, S. Sulawesi; BN - Bunaken National Park; S-T - Sangihe-Talaud Isl.; RA - Rajah Ampat, Papua; TC – Teluk Cenderawasih, Papua; FK – FakFak Kaimana, Papua. Data from Turak and DeVantier 2003, Turak and DeVantier in prep, Turak 2002, Turak and Shouhoko 2003, Turak et al. 2003, Turak 2006, Turak and DeVantier 2008, 2011, 2012.

Attribute	T-L	KO	BI	BL	AN	DE	W	BN	ST	RA	TC	FK
Total number of species	367	342	301	406	339	449	396	392	445	487	469	469
Average no. of species per station	153	100	106	112	163	164	124	155	100	131	178	171
% of stations with over 1/3 rd species	100	43	61	38	100	78	41	85	8	18	79	65
Average % hard coral cover	28	32	40.3	28	35	36	32	41	21	33	27	26
Number of stations surveyed	20	21	18	48	20	36	27	20	52	51	33	34
Area covered (x1000 km^2) approx.	2	2	0.4	3.7	17	20	10	0.9	23	30	27	12

Reefs of Lamsana Inlet E, one of the more sheltered locations, also scored highly, indicating locally unusal coral composition and abundance (Table 6). More than one-third of coral species (148 spp.) were locally uncommon or rare, occurring in four or less of the 20 stations. Fifty-five species were recorded from only one station, 42 species from two stations, 34 species from three stations and 17 species from four stations.

Among the rare species present were the branching dendrophylliid *Duncanopsammia axifuga* and columnar faviid *Echinopora ashmorensis*, both recorded only at Lamsana Inlet E (Site 17.2). For *D. axifuga*, this is the first record for the region. Conversely, some typically common coral species of the CT were very rare or possibly absent, their distributions ranges potentially disjunct at Timor-Leste. These included the acroporid *Acropora abrolhosensis*, trachyphylliid *Trachyphyllia geoffroyi* and siderastreid *Psammocora superficialis*. These species may occur in Timor-Leste waters, but were not found during the present survey. Finally, the typically uncommon acroporid *Acropora desalwii* was a relatively common component of reef slope assemblages, consistent with its type locality of the Banda Islands.

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 coral replenishment index CI (Table 7 and see Methods). These were widespread across Timor-Leste, with highest scoring stations at Jako Island, Tutuala and Umamutin. Importantly, there was consistently strong recruitment by juvenile corals into areas denuded by previous crown-of-thorns seastar predation (Plate 8).

Table 5. Azooxanthellate scleractinian hard corals, non-scleractinian hard corals, soft corals and other biota recorded in Timor-Leste. Results are presented as the total sum of relative abundance scores and the number of stations in which each taxon occurred**.**

	abn	stations
Hard coral Taxa		
Dendrophylliidae		
Tubastrea micrantha	2	2
Tubastrea coccinae	3	3
Milleporidae		
Millepora dichotoma	10	7
Millepora exesa	19	13
Millepora intricata	9	5
Millepora platyphylla	19	13
Millepora tenera	12	7
Stylastraeidae		
Distichopora	5	3
Stylaster	8	6
Helioporidae		
Heliopora coerulea	48	19
Tubiporidae		
Tubipora musica	35	18
Soft coral Taxa		
Clavulariidae		
Carijoa	2	1
Clavularia	27	13
Alcyoniidae		
Dampia	3	2
Klyxum	1	1
Lobophytum	30	17
Sarcophyton	42	20
Sinularia spp.	48	20
Sinularia flexibilis	20	9
Sinularia tree	1	1
Nephtheidae		
Capnella	28	16
Dendronephthya	27	13
Lemnalia	11	7
Litophyton	2	1
Nephthea	34	17
Paralemnalia	47	18
Scleronephthya	18	10
Stereonepthya	7	4
Umbellulifera	3	2
Nidaliidae		
Chironephthya	5	4
Nephthyigorgia	1	1
Siphonogorgia	8	5
Xeniidae		
Anthelia	14	8
Heteroxenia	6	3
Xenia	33	16

	abn	stations
Soft coral Taxa (continued)		
Briareidae		
Briareum	39	19
Anthothelidae		
Alertigorgia	4	3
Iciligorgia	1	1
Solenocaulon	3	3
Supergorgiidae		
Subergorgia	2	1
Annella	7	5
Melithaeidae		
Acabaria	3	2
Melithaea	12	10
Mopsella	3	3
Acanthogorgiidae		
Acanthogorgia	3	2
Muricella	6	4
Plexauridae		
Menella	2	1
Paraplexaura	3	2
Gorgoniidae		
Pinnigorgia	3	2
Rumphella	11	7
Ellisellidae		
Dichotella	5	4
Elisella	4	3
Junceella	10	6
Ifalukellidae		
Ifalukella	1	1
Isididae		
Isis	36	16
Antipathidae		
Antipathes	7	4
Cirrhipathes	12	10
Zoanthidae		
Palythoa	37	19
Zoanthus	3	2
Coralimorpharians	4	3
Anemones	12	8
Plumulariidae		
Aglophenia	28	13
Lytocarpus	6	4

Table 6. Station ranking (scores) for Rarity Index RI from highest to lowest for 20 stations, Timor-Leste, August 2012.

Station name	Station No.	RI
Djonu East	14	8.3
3 Terraces	15	7.4
Belio Barrier Reef	19	7.2
Loikere	4	7.2
Lamsana inlet East	17	6.6
Belio - Lagoon S	21	6.0
Hilapuna	8	5.9
Djonu Twin Rocks	10	5.7
Belio - inner channel N	22	5.5
East Loikere	5	5.4
Lamsana inlet West	18	5.4
Jako Isl. SW	7	5.1
Ete Asa Lepek	11	4.4
Jako Isl. NW	6	4.1
Belio "Saddle" Patch R.	20	3.6
Hera West	1	3.3
W. Jako Isl.	9	3.2
Com Vailovaia	2	3.0
Com Koho Vari	3	2.7
Tenu, Japanese Bunker	16	2.3

Table 7. Station ranking (scores) for Replinishment Index CI for 20 stations, Timor-Leste, August 2012.

Station name	Station No.	CI
Jako Isl. SW	7	7.1
Djonu East	14	6.0
Jako Isl. NW	6	5.5
Loikere	4	5.5
3 Terraces	15	5.3
Djonu Twin Rocks	10	4.9
Ete Asa Lepek	11	4.5
Hilapuna	8	4.3
Belio Barrier Reef	19	4.2
East Loikere	5	4.1
Belio - Lagoon S	21	3.6
Lamsana inlet West	18	3.4
W. Jako Isl.	9	3.0
Com Vailovaia	2	2.5
Lamsana inlet East	17	2.1
Belio - inner channel N	22	1.7
Com Koho Vari	3	1.6
Hera West	1	1.6
Belio "Saddle" Patch R.	20	1.3
Tenu, Japanese Bunker	16	0.9

Coral Injury

Corals of Timor-Leste exhibited low levels of recent injury overall, particularly in terms of the proportion of species injured of the total species present at each site. These proportions were low to very low at all sites (Fig. 9). This is consistent with the low levels of recently dead corals (< 2%, Fig. 5) and high positive ratio of live : dead coral cover. Some individual species did however exhibit high levels of recent injury at particular sites, caused mainly by predation by crown-of-thorns seastars and blast fishing, the former most notably at Stations 17 and 18, and the latter at Station 11 (Plates 3, 4).

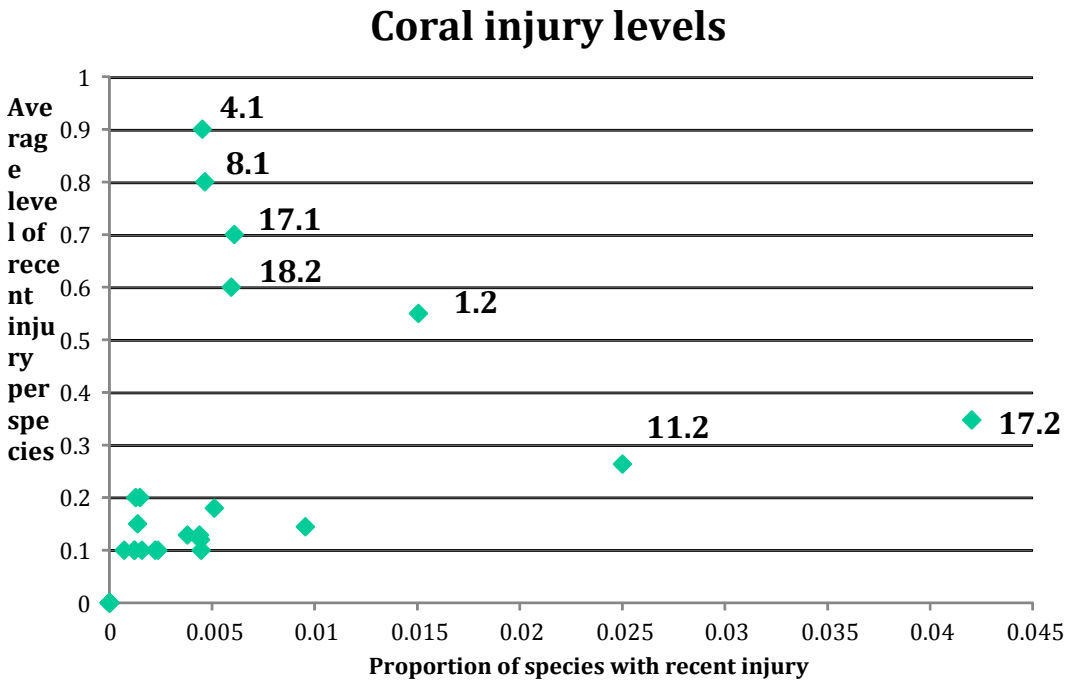

Figure 9. Scatterplot of levels of recent injury to reef-building corals in 39 sites, Timor-Leste, August 2012. Sites with highest injury levels are named.

Litter and pollution

There were no or very low levels of litter and pollution at most sites, consistent with the remoteness and small human populations of most areas surveyed. Lamsana Inlet (Stations 17 and 18) had higher levels of litter, including old fishing nets and lines and plastic bags (Plate 9, and see Annex II). Notably, the latter stations are outside NKSNMP and are subject to more human activity.

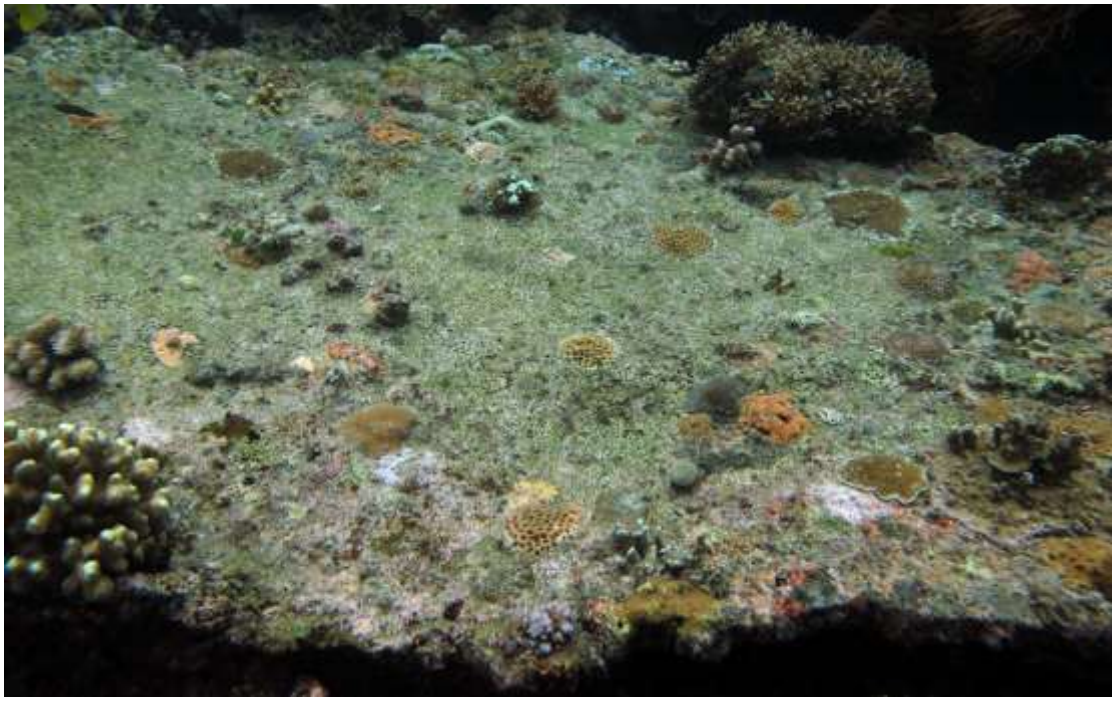

Plate 8. Recruitment by juvenile corals to an old dead *Acropora* table, Site 5.2.

Plate 9. Abondened fishing net caught on the reef at site 17.2.

Coral community structure

The cluster analysis for Timor-Leste revealed four main coral community groups (Fig. 10) at station level. Each community was characterized by a distinctive suite of species and benthic attributes (Tables 8, 9, Fig. 11), although some species were more or less ubiquitous across several community types, notably *Porites* spp. and various faviids. Because of their commoness, these taxa were not useful in differentiating among the different communities, although they do contribute significantly to coral cover in the region (Plates 10-17).

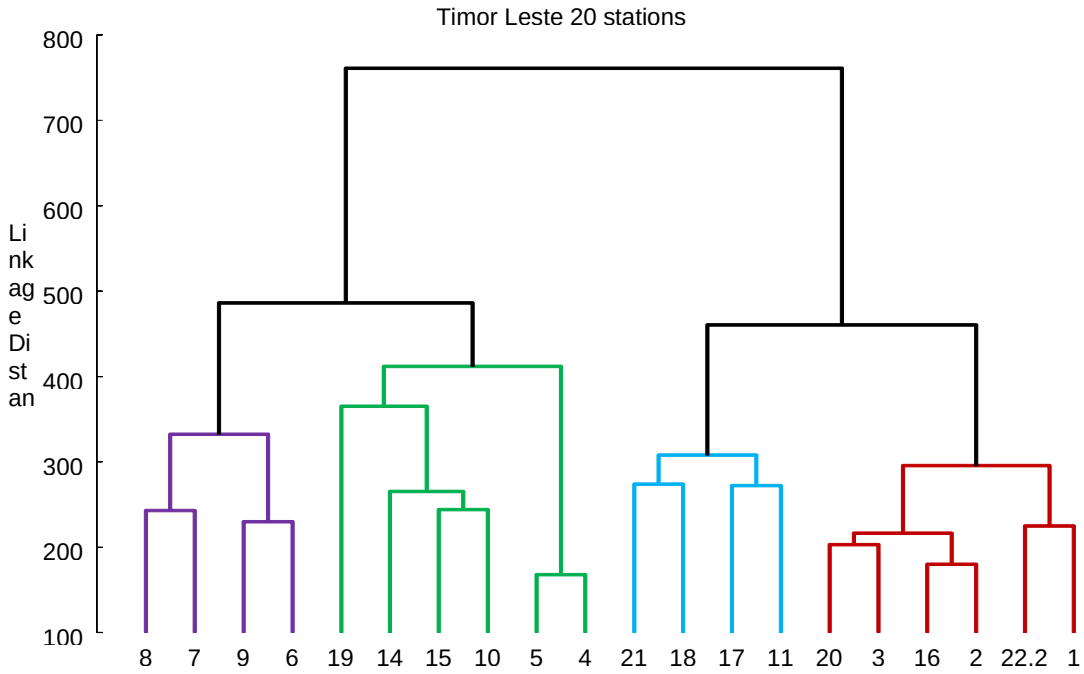

Figure 10. Dendrogram illustrating results of cluster analysis of coral communities, 20 stations, Timor-Leste, August 2012. Community A is represented by purple, Community B by green, Community C by blue and Community D by red. Note that Station 22 was a shallow site surveyed at only depth (22.2 on the dendrogram).

The four communities show a moderate degree of geographic separation across the survey area (Fig. 11), with two communities occurring mainly inside and two outside the NKSNP. Community A occurred predominantly on the NE coast around Jako Island, Community B along the N coast of NKSNP, and Communities C and D along the more western portion of the N coast and on Atuaro Island (Fig. 11).

Figure 11. Distribution of coral community types at 20 stations, Timor-Leste. Each station has one shaded 'community rectangle' indicating the identity of the community present, where Community A is represented by purple, B by green, C by blue, and D by red coloured rectangles.

Community A: *Digitate Acropora* community

Located mainly in the vicinity of Jako Island in NKSNP, this community occurred predominantly in waters of moderately good clarity (mean visibility of 16 m) along the more exposed NE tip of Timor-Leste (mean exposure of 3.3), on well-developed reefs (mean of 3.8) with relatively gentle slopes (mean of 10 degrees) (Fig. 12, Table 8). Characteristic indicator species included the digitate *Acropora digitifera* and *A. gemmifera*, the robust staghorn *Acropora abrotanoides* and massive *Montastrea annuligera* (Table 9). Community A had highest cover of living hard corals (mean 46 %) and was moderately species rich (mean of 150 reef coral spp. per station) (Plates 10, 11). Although the blue coral *Heliopora coerulea* was a predominant feature of the N coast of Jako Island, it was also a common component of Community C and hence not a strong indicator species (Table 9). As noted above, the S coast of Jako Island hosted a highly diverse coral assemblage. Reefs around Jako Island have remained in good condition over the four years since their quality was reported by Ayling et al. (2009).

CommunityB: Pectiniid community

This community of the N mainland coast of NKSNP clustered with Community A in the dendrogram (Fig. 10) and both occur predominantly in NKSNP. Community B had moderately high live coral cover (mean 33 %) and highest species richness (mean 191 spp.). It occurred on well developed reefs (mean of 3) with high levels of hard substrate (mean of 88 %) and steeper, deeper slopes than the other communities (mean slope angle of 25 degrees, and extending on some reefs to much deeper than 39 m). Sea conditions were semi-exposed (mean of 2.3), and water clarity was typically high (mean of 18 m) (Table 8). This community was characterized by the foliose - encrusting pectiniids *Oxypora lacera*, *Pectinia lactuca* and *Mycedium robokaki* and the tabular *Acropora granulosa* (Table 9). Various massive and branching poritids (*Porites* spp.) and mushroom fungiids (*Halomitra* and *Fungia* spp.) were also common (Plates 12, 13).

Community C: Fungiid community

This community occurred predominantly on the western part of the survey region outside NKSNP, around Com and Lamsana Inlet and also on Atuaro Island. Community C had moderately high reef coral species richness (mean of 150 spp. per station), and cover of living hard corals (mean 24 %). It had highest cover of dead corals (mean of 21 %) and rubble (mean of 13 %). It occurred on well

developed reefs (mean of 3.9) in moderately sheltered waters (mean of 1.8) of good clarity (mean of 16 m) (Table 8, Fig. 12). It was characterized by a mix of mushroom fungiids, the foliose dendrophylliid *Turbinaria mesenterina* and columnar poritid *Goniopora columna* (Table 9) (Plates 14, 15). It had highest levels of silt (mean of 8 %) and litter, both mainly at Lamsana Inlet.

Community D: *Symphyllia - Diploastrea* community

This community occurred predominantly with Community C along the western part of the survey area and on Atuaro Island, outside NKSNP (Fig.11). It had lowest species richness (mean of 119 spp. per station) and lowest cover of living hard corals (mean of 14 %). It also had relatively high cover of dead corals and rubble (means of 10 % and 6 %), and highest cover of soft corals, comprised predominantly of *Sarcophyton* and *Sinularia* spp. (mean of 23 %) (Table 8). Community D was characterized by the massive mussid *Symphyllia recta* and faviid *Diploastrea heliopora* (Table 9, Plates 16, 17). The corymbose branching acroporids *Acropora cerealis* and *A. millepora* and pocilloporid 'needle corals' *Seriatopora* spp. were also common. It is likely that this community, with Community C, is widespread along the N coast of Timor-Leste.

Table 8. Summary statistics (mean values) for environmental and benthic cover variables for four coral communities, Timor-Leste, August 2012. Differentiating characteristics are in bold type.

	Coral community attributes			
	A	**B**	**C**	**D**
No. of stations				
Maximum depth (m)	27	**39**	31	30
Minimum depth (m)	1	1	1	3
Slope (degrees angle)	10	**25**	17	14
Hard substrate (%)	79	**88**	73	69
% cover benthos				
Hard coral	**46**	33	24	**14**
Soft coral	7	9	11	**23**
Macro algae	0	1	1	**3**
Turf algae	9	12	**21**	13
Coralline algae	9	10	11	10
Recently dead coral	1	1	2	0
All dead coral	5	3	**21**	10
% cover substrate				
Continuous pavement	49	**65**	51	**36**
Large blocks	19	13	11	15
Small blocks	11	10	11	19
Rubble	4	4	**13**	6
Sand	17	8	7	24
Silt	0	0	**8**	0
Environmental variables				
Exposure	**3.13**	2.25	1.75	2.45
Reef develop.	3.88	3.08	3.88	2.91
Visibility (m)	16	18	16	**13**
Water temp. C	26.75	26.67	26.50	26.45
Estimate of litter (1-5)	0.00	0.17	**1.75**	0.33
Mean no. of reef-building coral species	150	**191**	150	**119**

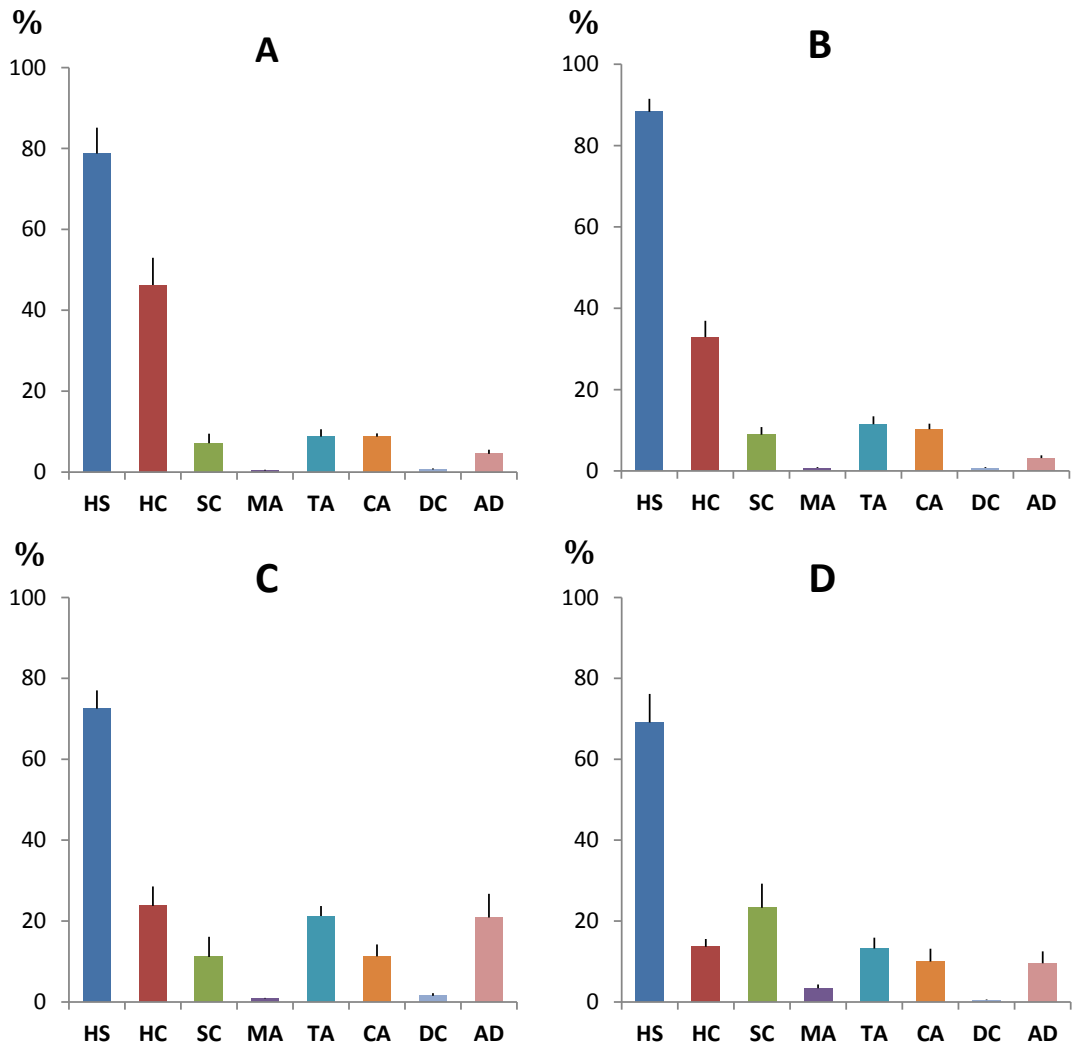

Figure 12. Mean % bottom cover of benthic attributes in four coral community types, Timor Leste. HS: Hard Substrate, HC: Hard Corals, SC: Soft Coral, MA: Macro Algae, TA: Turf Algae, CA: Coralline Algae, DC: Recently Dead Coral: AD: All Dead Coral. Error bars are Standard Error (SE).

Table 9. Characteristic coral species in four coral community types identified in Timor-Leste, August 2012. Taxa used as indicators for the relevant community types are in **bold.**

	A (4 stns)			B (6 stns)	
Zooxanthellate scleractinia	**abn**	**stns**	**Species name**	**abn**	**stns**
Isopora palifera	**13**	**4**	*Porites vaughani*	**18**	**6**
Pocillopora verrucosa	**11**	**4**	*Fungia danai*	**16**	**6**
Galaxea fascicularis	**10**	**4**	*Porites nigrescens*	**16**	**6**
Fungia fungites	**10**	**4**	***Acropora granulosa***	**15**	**6**
Montastraea annuligera	**10**	**4**	*Pocillopora verrucosa*	**14**	**6**
Porites nigrescens	**10**	**4**	*Seriatopora caliendrum*	**14**	**6**
Stylophora pistillata	**9**	**4**	*Fungia fungites*	**14**	**6**
Acropora digitifera	**9**	**4**	***Halomitra pileus***	**14**	**6**
Favites abdita	**9**	**4**	***Oxypora lacera***	**14**	**6**
Goniastrea pectinata	**9**	**4**	*Porites rus*	**14**	**6**
Porites vaughani	**9**	**4**	*Stylophora pistillata*	**13**	**6**
Pocillopora eydouxi	**8**	**4**	***Mycedium robokaki***	**13**	**6**
Montipora grisea	**8**	**4**	***Pectinia lactuca***	**13**	**6**
Montipora tuberculosa	**8**	**4**	*Goniastrea pectinata*	**13**	**6**
Acropora abrotanoides	**8**	**4**	*Echinopora lamellosa*	**13**	**6**
Acropora gemmifera	**8**	**4**	*Porites* massive	**13**	**6**
Acropora loripes	**8**	**4**	*Porites cylindrica*	**13**	**6**
Pavona varians	**8**	**4**	*Montipora tuberculosa*	**12**	**6**
Coeloseris mayeri	**8**	**4**	*Acropora loripes*	**12**	**6**
Fungia danai	**8**	**4**	*Acropora subulata*	**12**	**6**
Others			**Others**		
Heliopora coerulea	**13**	**4**	*Paralemnalia*	**16**	**6**
Paralemnalia	**13**	**4**	*Sinularia* spp.	**14**	**6**
Sponge massive	**10**	**4**	Sponge massive	**14**	**6**
Sinularia spp.	**9**	**4**	*Heliopora coerulea*	**13**	**6**
CRA	**9**	**3**	*Sarcophyton*	**13**	**6**
Briareum	**8**	**4**	***Xenia***	**13**	**6**
Diademnum	**8**	**4**	***Briareum***	**13**	**6**
Palythoa	**7**	**4**	*Nephthea*	**12**	**6**
Sarcophyton	**6**	**4**	Sponge encrusting	**12**	**6**
Xestospongia	**6**	**4**	*Tubipora musica*	**11**	**6**
Capnella	**6**	**3**	*Lobophytum*	**11**	**6**
Sponge encrusting	**6**	**3**	*Palythoa*	**11**	**6**
Polycarpa	**6**	**3**	CRA	**11**	**4**
Tubipora musica	**5**	**3**	*Dendronephthya*	**10**	**5**
Clavularia	**5**	**3**	*Sinularia flexibilis*	**10**	**4**
Nephthea	**5**	**3**	*Millepora platyphylla*	**9**	**6**
Aglophenia	**5**	**2**	*Carterospongia*	**9**	**6**
Tridacna squamosa	**4**	**4**	*Isis*	**9**	**4**
Scleronephthya	**4**	**2**	*Millepora exesa*	**8**	**5**
Xenia	**4**	**2**	*Capnella*	**8**	**5**

Table 9. continued.

C (4 stns)			D (6 stns)		
Species name	**abn**	**stns**	**Species name**	**abn**	**stns**
Fungia danai	**11**	**4**	*Pocillopora verrucosa*	**13**	**6**
Porites cylindrica	**11**	**4**	*Fungia danai*	**13**	**6**
Porites nigrescens	**11**	**4**	*Galaxea fascicularis*	**12**	**6**
Fungia fungites	**10**	**4**	*Goniastrea pectinata*	**12**	**6**
Porites vaughani	**10**	**4**	*Porites* massive	**12**	**6**
Stylophora pistillata	**9**	**4**	*Porites cylindrica*	**12**	**6**
Galaxea fascicularis	**9**	**4**	***Acropora cerealis***	**11**	**5**
Fungia horrida	**9**	**4**	***Seriatopora caliendrum***	**10**	**6**
Fungia paumotensis	**9**	**4**	*Montipora tuberculosa*	**10**	**6**
Ctenactis crassa	**9**	**4**	***Acropora millepora***	**10**	**6**
Pectinia lactuca	**9**	**4**	*Isopora palifera*	**10**	**6**
Turbinaria mesenterina	**9**	**4**	*Fungia granulosa*	**10**	**6**
Porites massive	**9**	**4**	*Mycedium elephantotus*	**10**	**6**
Goniopora columna	**9**	**4**	*Pectinia lactuca*	**10**	**6**
Pocillopora verrucosa	**8**	**4**	***Symphyllia recta***	**10**	**6**
Isopora palifera	**8**	**4**	*Goniastrea retiformis*	**10**	**6**
Euphyllia cristata	**8**	**4**	***Diploastrea heliopora***	**10**	**6**
Pavona varians	**8**	**4**	***Seriatopora hystrix***	**10**	**5**
Heliofungia actiniformis	**8**	**4**	*Pavona varians*	**10**	**5**
Fungia granulosa	**8**	**4**	*Montipora monasteriata*	**9**	**6**
Others			**Others**		
Heliopora coerulea	**10**	**4**	***Sinularia* spp.**	**15**	**6**
Sarcophyton	**10**	**4**	***Sarcophyton***	**13**	**6**
Sinularia spp.	**10**	**4**	*Isis*	**13**	**6**
Isis	**10**	**4**	Sponge massive	**13**	**5**
Sponge encrusting	**9**	**4**	*Heliopora coerulea*	**12**	**5**
Tubipora musica	**8**	**4**	*Tubipora musica*	**11**	**5**
Briareum	**8**	**4**	*Dendronephthya*	**11**	**5**
Palythoa	**8**	**4**	*Nephthea*	**11**	**5**
Aglophenia	**8**	**4**	*Paralemnalia*	**11**	**5**
Sponge massive	**8**	**4**	*Xenia*	**11**	**5**
Halimeda	**8**	**4**	*Palythoa*	**11**	**5**
Acanthaster planci	**8**	**2**	***Lobophytum***	**10**	**5**
Carterospongia	**7**	**4**	*Briareum*	**10**	**5**
Clavularia	**7**	**3**	CRA	**10**	**4**
Sinularia flexibilis	**7**	**3**	*Polycarpa*	**9**	**5**
Paralemnalia	**7**	**3**	*Aglophenia*	**9**	**4**
CRA	**7**	**3**	*Capnella*	**8**	**5**
Peyssonnelia	**7**	**3**	*Carterospongia*	**8**	**4**
Lobophytum	**6**	**4**	*Clavularia*	**8**	**3**
Capnella	**6**	**3**	Sponge encrusting	**8**	**3**

Plate 10. Example of coral community A, Site 7.2, here showing one of the common corals *Acropora abrotanoides.*

Plate 11. Example of coral community A, Site 9.2, here showing high cover of reef corals in shallow waters, mainly *Isopora palifera* and *Heliopora coerulea*.

Plate 12. Example of coral community B, site 4.1, here showing one of the common corals *Mycedium robokaki.*

Plate 13. Example of coral community B, site 14.2, here with *Xenia, Paralemnalia* and otrher soft corals

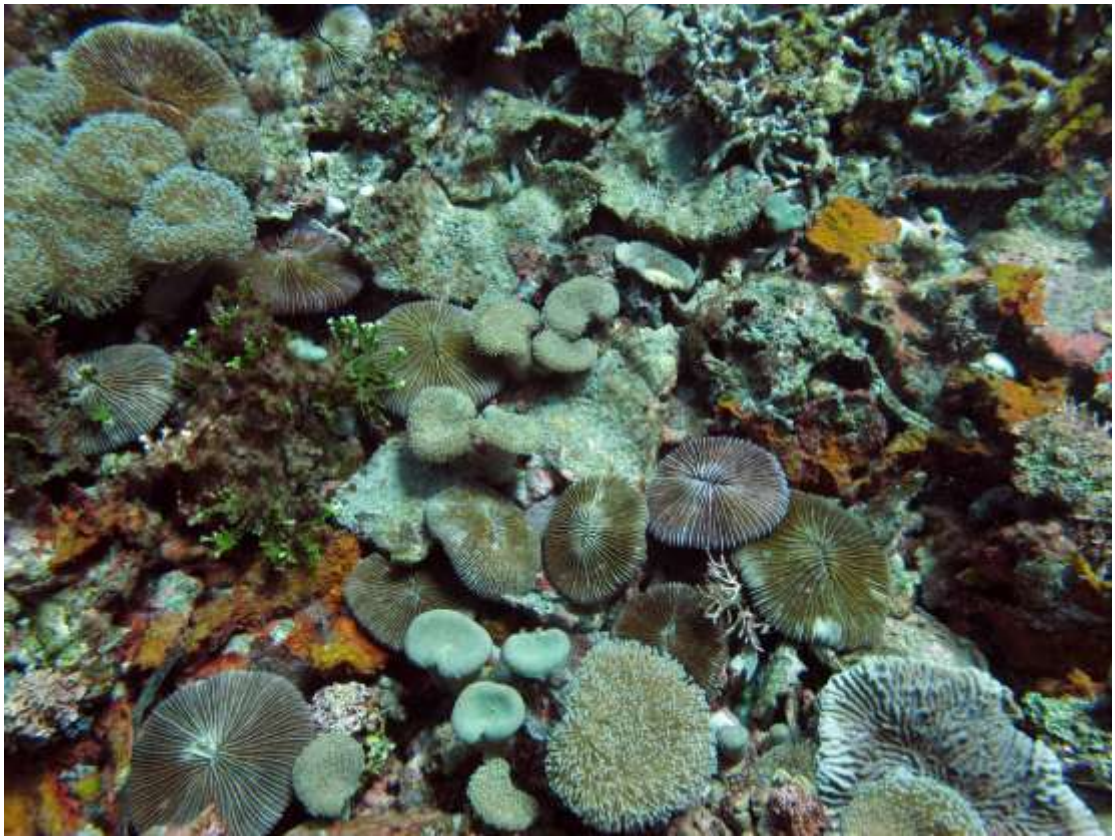

Plate 15. Example of coral community C, site 21.1 with fungiids predominant.

Plate 14. Example of coral community C, site 21.2 with *Isis* predominant.

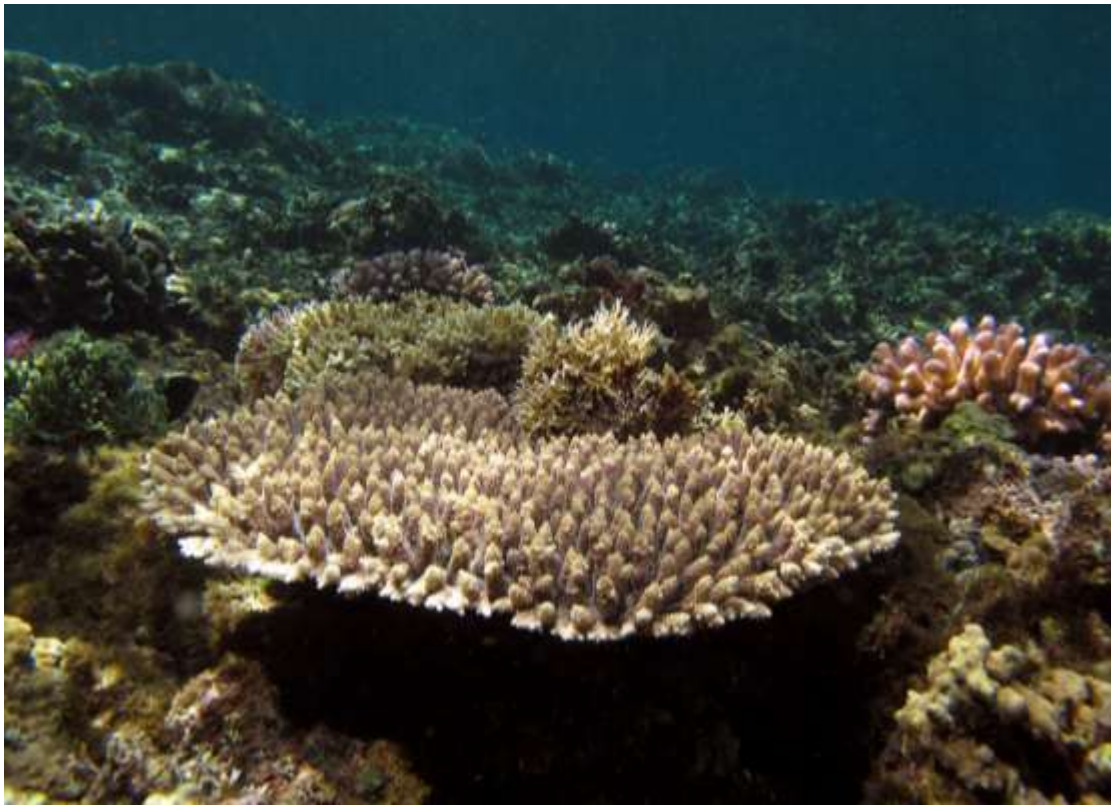

Plate 16. Example of coral community D, site 22.2, wit *Acropora millepora, Seriatopora* and othetr pocilloporids.

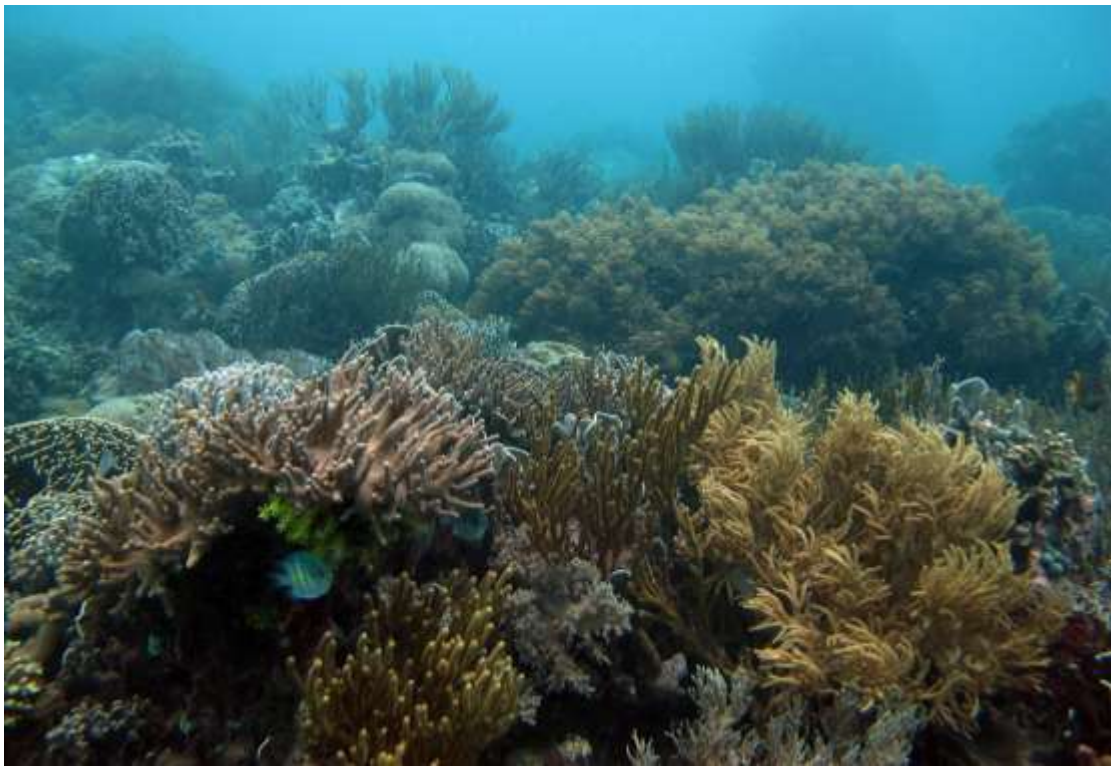

Plate 17. Example of coral community D, site 2.2, with dominant Alcyonarian soft corals and *Isis* in the shallows.

Regional comparisons between Timor-Leste and adjacent locations

Timor-Leste shares almost all coral species with other areas of the CT (Annex III), with the possible exception of potentially undescribed species of *Echinophyllia*, *Goniopora* and *Montipora* found during the present study (Plates 5-7). Comparisons of levels of similarity in coral composition and community structure were conducted with nearby regions of the CT. For these regional comparisons, two sets of analyses were undertaken (Also see Methods):

1) Using the presence of species in each location for two analyses:
Firstly, for Timor-Leste with Bali, Komodo, Banda Islands, Bunaken and Wakatobi, for a total of six locations (Figure 13); and
Secondly, for Timor-Leste with the previous five regions plus 9 others - Cenderwasih Bay, Fak/Kaimana and Raja Ampat (all Birds Head Seascape, Indonesia), Sangihe-Talaud Islands (Sulawesi Sea), Derewan (Barau, East Kalimantan), El Nido (Palawan, Philippines), Brunei Darusalam and Anambas Islands, W Indonesia (latter three regions in South China Sea), for a total of 15 locations (Figure 14).

2) Using the species-abundance at the individual station level for Timor-Leste, with Bali and Nusa Penida, Komodo, Banda Islands, Bunaken NP and Wakatobi (153 stations, Figure 15).

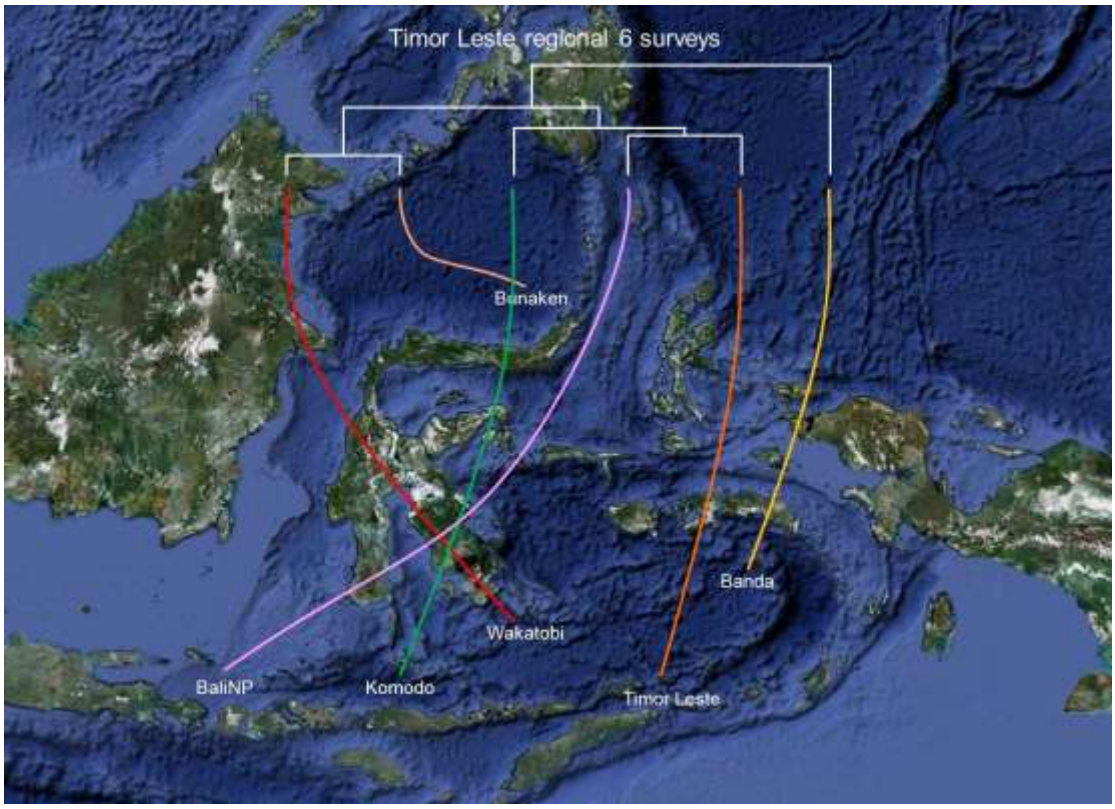

Figure 13. Dendrogram illustrating degree of similarity of Timor-Leste with five other locations in terms of reef coral species presence.

Species presence:
Corals of Timor-Leste were most similar to those of Bali and Komodo in terms of their species composition, consistent with their shared occurrence in the N Lesser Sunda Islands ecoregion. These three locations formed a larger cluster with Bunaken and Wakatobi (both Sulawesi). Banda Islands was least similar, likely reflecting the lower species richness there (Table 4, Fig. 13).

In the larger regional analysis of Timor-Leste with 14 other locations, two main clusters of locations were apparent (Fig. 14). In one main cluster, as with the previous smaller analysis (Fig. 13), Timor-Leste shared closest similarity with Bali and then with Komodo (Fig. 14). These in turn were most similar to Wakatobi and Bunaken. Anambas Islands formed a separate sub-cluster with Brunei, both locations occurring in the South China Sea, with the relatively low diversity locations of Banda Islands as the final member of the first main cluster. The second major group of locations (left of Fig. 14) included Derewan, Sangihe-Talaud, Halmahera, Raja Ampat, Fak-Fak/Kaimana and Teluk Cenderwasih and El Nido, reflecting their higher overall species richness (and habitat diversity).

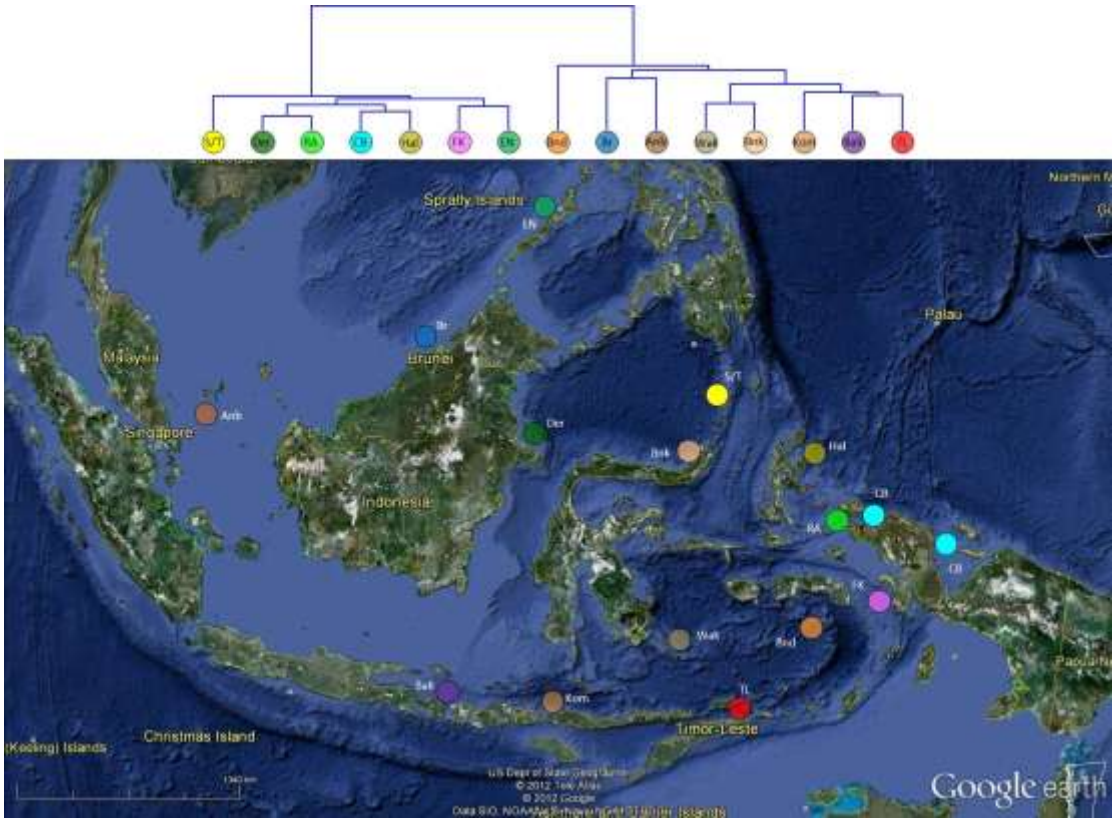

Figure 14. Dendrogram illustrating degree of similarity of Timor-Leste with 14 other locations in terms of reef coral species presence, where: Bali – Bali and Nusa Penida, Kom – Komodo, Wak – Wakatobi, Bnk – Bunaken, Bnd – Banda Islands, Der – Derewan, S/T – Sangihe-Talaud, Hal – Halmahera, RA – Raja Ampat, FK – Fak-Fak/Kaimana and CB –Teluk Cenderawasih, EN – El Nido, Palawan, Philippines, Anb – Anambas Islands, W Indonesia, and Br – Brunei Darusallam.

Species – abundance:
The station-level analyses produced more complex patterns of similarity. In the smaller analysis of 153 stations from Timor-Leste and nearby locations (Fig. 15),
Timor-Leste stations were distributed in different subsclusters and clusters (Fig. 15, left cluster), grouping most strongly with Northern Komodo, Northern Bali, Bunaken, Wakatobi and Banda Islands. South Komodo, South Bali and Nusa Penida remained distinct (Fig. 15, right cluster). This suggests that the Timor-Leste coral fauna is more under the influence of the ITF rather than the Indian Ocean.

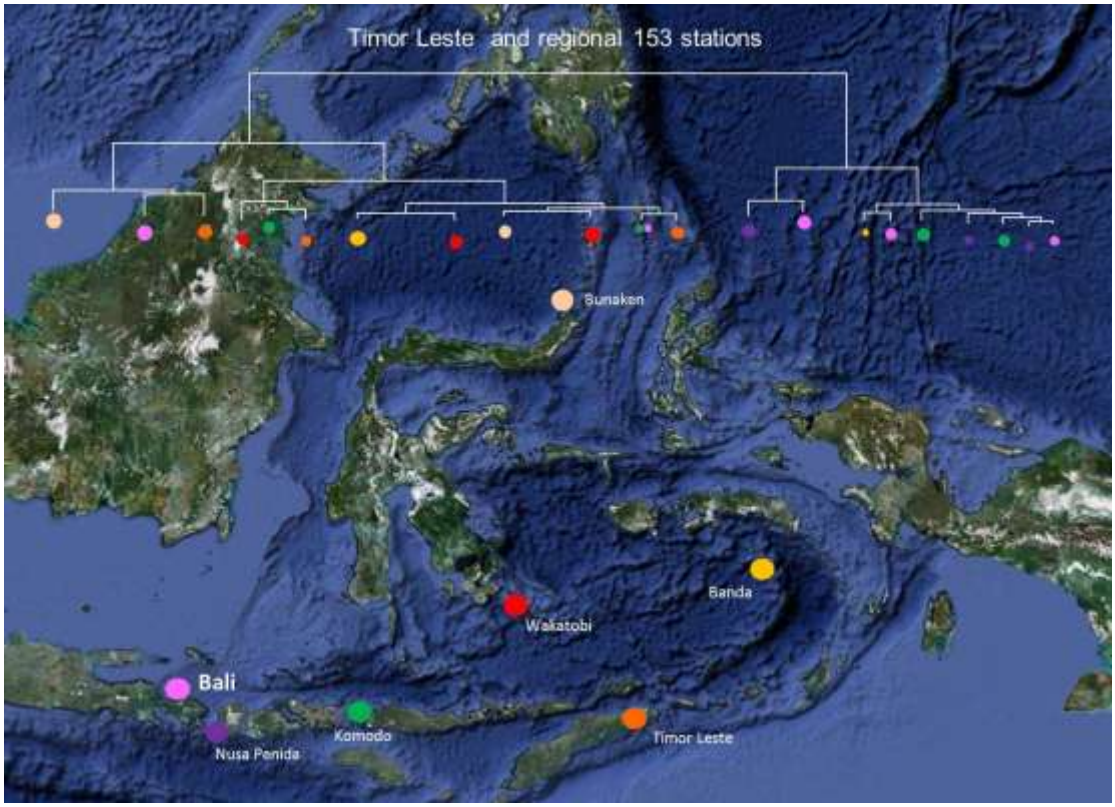

Figure 15. Dendrogram illustrating results of cluster analysis of coral communities of 153 stations across six locations: Timor-Leste, Bali and Nusa Penida, Komodo, Wakatobi, Bunaken and Banda Islands.

Discussion

Species richness and community structure

Timor-Leste's reef-building coral species richness of 367 confirmed and 27 unconfirmed species (Annex III) suggests an overall tally for reef-builing corals of ca. 400 species. This is a much higher estimate than the previous tally of 124 species (Ayling et al. 2009), relating to differences in survey methodology. The present method facilitates active searching for species within an area of approx. one ha at each station, whereas the previous method as employed by Ayling et al. (2009) is restricted to identifying only those species intercepted by line transects, effectively a much smaller survey area. All methods have advantages and diadvantages, and while the present method is far more effective at estimating total richness, the former provides quantitative estimates of abundance and cover, as opposed to our visual estimates (see later).

Timor-Leste's coral richness estimate of ca 400 species is higher than Komodo (342 spp., also in the Lesser Sunda Islands), and Banda Islands (301 spp.) and similar to Bunaken NP, Wakatobi and Bali. It is lower than Derewan or areas of the Papuan Bird Head Seascape (Table 4), reflecting the much greater habitat diversity of the latter locations.

Hence the present richness tally is consistent with Timor-Leste's location in the CT, given the relatively restricted habitat diversity and area available. And in respect of habitat area, it is important to note that the present survey was restricted to the north coast and Atuaro Island, the latter assessed only briefly.

A further ca. 130 reef coral 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 Timor-Leste during the present survey. Some of these may well be present, but were not found. Others may have localized disjunctions at Timor-Leste, possibly related to lack of suitable habitat and/or failures of dispersal and / or recruitment (see later). Although the survey was as thorough as practicable during the limited time available, rare species or those with locally limited distributions may well have been missed.

Hence the present tally should be considered a conservative estimate of total species richness. Additional survey effort around Atuaro Island and the south coast may increase the richness tally further, particularly given the differences in coral community structure between N and S coast sites identified by Ayling et al. (2009):

"There are distinct reef communities on the north and south facing reefs of the proposed marine park with differences in fish and benthic communities as well as in the abundance of the common invertebrates. This implies that one of the major determining factors of the reef communities in this area is exposure to the predominant SE seas throughout much of the year."

Species composition at Timor-Leste shows closest similarity with Bali and Komodo (presence in each location, Figs. 13, 14). Although overall composition is most similar among these locations of the Lesser Sunda Islands, species abundance and community structure are not. Rather community structure is most similar to stations of Bunaken, N Sulawesi and the Banda Sea (Fig. 15). This likely reflects the different environmental conditions and habitat types of many stations in Bali and Komodo in respect of the sea temperature regime (localized cool water upwelling), current flow and attenuation in wave energy.

Coral Cover

Cover of living corals in 2012 was estimated at 28 %, an increase of approximately 10 % on a previous estimate made in late 2008 (Ayling et al. 2009), suggesting some recovery in the interim period. Caveats on this speculation include differences in survey locations, with the previous survey focused on both N and S coast sites, as opposed to the present survey's focus on N coast and Atuaro Island. Another important caveat, as noted above, is the difference in methods employed between the two surveys. Importantly, Ayling noted very high variability at the site level, a conclusion supported by the present survey, with cover of living hard corals ranging between ca. 5 and 70 %.

Ayling et al. (2009) also noted that there were few diseased coral colonies and found no evidence of coral bleaching, although predation by *Drupella* snails and crown-of-thornsd seastars had damaged corals of some S and N coast sites respectively. There were also patches of broken coral that may have resulted from explosives fishing episodes or (more likely) damage resulting from a storm.

During the present study, no evidence of coral bleaching was found, and although crown-of-thorns seastars were present at several sites, only Lamsana Inlet had a large population. There were however, large patches of broken corals that were consistent with recent blast fishing damage, most notably at Station 11 near Com (plate 4).

Climate Change Resilience

There was no evidence or reports of past (1998) or recent (2010) large-scale high temperature bleaching-induced coral mortality around Timor-Leste. This is consistent with the presence of cool waters in most sites, which were typically 25-27 degrees C at time of survey in August (Annex I). This is three to four degrees cooler than many neighbouring locations, where sea surface temperatures consistently average 29-31 degrees C, inter-seasonal and inter-annual variability notwithstanding.

It is, however, clear from the latest climate science that climate change will continue to increase in coming decades. Failures to introduce binding international agreements in respect of greenhouse gas emissions on the one hand, and the continuing expansion in fossil fuel exploration and use on the other, mean that the global trajectory for climate change is at the high end of IPCC projections. In this respect, areas that have natural features that can ameliorate these effects will become increasingly important.

As noted above, waters to the north and south of Timor-Leste are major corridors of the ITF, itself influenced by the cooling effects of mixing in the Banda Sea (Oppo and Rosenthal 2010). If these cooling influences remain consistent, reliable features, Timor-Leste's oceanography may provide a cool water buffer and refuge against the increasing sea temperatures predicted from climate change over coming decades. Additionally, consistent surface current flow along both N and S coasts of Timor-Leste may be important in dispersal and the replenishment of marine populations as far afield as NW Australia.

Conservation Priority

The potential for Timor-Leste, as indeed other locations under the influence of the ITF, to act as a climate-change refuge provides added importance and impetus for reef conservation locally and regionally.

In this important respect Timor-Leste has shown great initiative in declaring Nino Konis Santana National Park, which, with effective management, can play a very important role in conservation and replenishment locally and regionally. NKSNMP has high quality reefs and forms an important link in the regional MPA network being developed in the CT and further afield. Reefs of high conservation value were widespread in NKSNMP and also at Atuaro Island (Table 10 and Fig. 16).

Table 10. Conservation values of survey stations. 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; Hard coral cover is the average of the two sites at each location (except station 22). Station numbers and community types correspond with those in Figures. High scores are bolded.

Station name	Station No	CI	RI	HC cover	Species richness	Community type
Jako Island SW	7	**7.1**	12	**70**	161	A
Djonu East	14	**6**	**1**	32.5	**214**	B
Loikere	4	**5.5**	**4**	32.5	**193**	B
Jako Island NW	6	**5.5**	14	**52.5**	151	A
Tutuala 3 Terraces	15	**5.3**	**2**	32.5	**195**	B
Djonu Twin Rocks	10	4.9	8	**42.5**	174	B
Ete Asa Lepek	11	4.5	13	**37.5**	144	C
Hilapuna	8	4.3	7	27.5	162	A
Belio Barrier Reef	19	4.2	**3**	27.5	**190**	B
East Loikere	5	4.1	10	30	178	B
Atauro Belio Lagoon S	21	3.6	6	20	163	C
Lamsana inlet West	18	3.4	11	25	159	C
W. Jako Island	9	3	17	35	125	A
Com Vailovaia	2	2.5	18	20	122	D
Lamsana inlet East	17	2.1	**5**	12.5	133	C
Atauro Belio Harbor	22	1.7	9	10	122	D
Hera West	1	1.6	16	20	95	D
Com Koho Vari	3	1.6	19	15	121	D
Belio "Saddle" Patch R.	20	1.3	15	10	139	D
Tenu, Japanese Bunker	16	0.9	20	5	114	D

Figure 16. Reefs of high conservation priority, indicated by red stars.

Notably, most of the high quality reefs already form part of a MPA (NKSNMP) and thus a lot of the hard work has been done in respect of achieving successful conservation outcomes, at least in the short term. Reefs at Atuaro Island are also of high conservation value for a number of different criteria (Table 10). The latter area has strong potential for development of, or extension to, NKSNMP.

Clearly, there are many competing uses for coastal and marine resources, and these will continue to grow in coming years as Timor-Leste's population expands. Hence it will become increasingly challenging to achieve an appropriate balance among different levels of protection and use. In the latter respect, consideration may be given to inclusion of additional representative and complementary areas encompassing main coral community types and reefs of high conservation value (diversity, replenishment, rare species etc.) in core zones as a matter of priority.

A significant amount of work has been achieved to date in building awareness and fostering goodwill among coastal villagers and others who use marine resources. This should be continued. It is also important to increase monitoring, surveillance and enforcement capacities as far as practicable to minimize poaching; and to address, as far as practicable, the ongoing impacts. These include:

1. Destructive fishing –with evidence of recent blasting near Com (eg. Station 11)
2. Sedimentation from hinterland erosion / runoff, most notable at Lamsana Inlet (eg. Station 17) but also likely on reefs further W, not surveyed during the present study.

Consideration may 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. Given the growing importance of ocean-based toursim (diving and swimming), particular focus should be paid to developing ecologically sensitive tourism at an appropriate scale, and to maintaining healthy and attractive reef-scapes for these activities, and hence a focus on non-destructive, non-extractive activities.

Acknowledgements

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Annexes

Annex 1

Characteristics of survey sites. Timor-Leste August 2012. EXP – Exposure rank; RD – Reef Development rank; VIS – Underwater Visibility (water clarity); WT – Water Temperature (see Methods).

Location	Site name	site	DATE	Latitude S	Longitude E	EXP	RD	VIS	WT
Timor N	Hera West	**1.1**	14/08/2012	8° 31.183	125° 38.664	2	2	5	27
Timor N	Hera West	**1.2**	14/08/2012	8° 31.183	125° 38.664	3	2	5	28
Timor NW	Com Vailovaia	**2.1**	15/08/2012	8° 21.301	127° 3.631	2	3	15	27
Timor NW	Com Vailovaia	**2.2**	15/08/2012	8° 21.301	127° 3.631	3	3	12	27
Timor SNK	Com Koho Vari	**3.1**	15/08/2012	8° 21.693	127° 5.714	2	4	15	27
Timor SNK	Com Koho Vari	**3.2**	15/08/2012	8° 21.693	127° 5.714	3	4	8	26
Timor SNK	Loikere	**4.1**	16/08/2012	8° 21.131	127° 9.326	2	3	10	27
Timor SNK	Loikere	**4.2**	16/08/2012	8° 21.131	127° 9.326	2	3	15	27
Timor SNK	East Loikere	**5.1**	16/08/2012	8° 20.683	127° 9.822	2	3	20	27
Timor SNK	East Loikere	**5.2**	16/08/2012	8° 20.683	127° 9.822	2	3	15	27
Timor SNK	Jako NW	**6.1**	17/08/2012	8° 24.582	127° 19.425	3	4	25	27
Timor SNK	Jako NW	**6.2**	17/08/2012	8° 24.582	127° 19.425	3	4	25	27
Timor SNK	Jako SW	**7.1**	17/08/2012	8° 26.298	127° 18.61	3	3	6	26
Timor SNK	Jako SW	**7.2**	17/08/2012	8° 26.298	127° 18.61	4	4	10	27
Timor SNK	Hilapuna	**8.1**	18/08/2012	8° 26.298	127° 17.391	3	4	6	26
Timor SNK	Hilapuna	**8.2**	18/08/2012	8° 26.298	127° 17.391	4	4	12	27
Timor SNK	W. Jako	**9.1**	18/08/2012	8° 24.597	127° 19.001	2	4	20	27
Timor SNK	W. Jako	**9.2**	18/08/2012	8° 24.597	127° 19.001	3	4	25	27
Timor SNK	Djonu Twin Rocks	**10.1**	18/08/2012	8° 22.85	127° 14.821	2	4	30	27
Timor SNK	Djonu Twin Rocks	**10.2**	18/08/2012	8° 22.85	127° 14.821	3	2	12	27
Timor SNK	Ete Asa Lepek	**11.1**	20/08/2012	8° 21.723	127° 4.488	2	3	20	26
Timor SNK	Ete Asa Lepek	**11.2**	20/08/2012	8° 21.723	127° 4.488	2	4	20	27
Timor SNK	Djonu East	**14.1**	19/08/2012	8° 23.252	127° 16.543	2	3	15	26
Timor SNK	Djonu East	**14.2**	19/08/2012	8° 23.252	127° 16.543	3	3	20	27
Timor SNK	3 Terraces	**15.1**	19/08/2012	8° 22.555	127° 13.828	2	3	15	27
Timor SNK	3 Terraces	**15.2**	19/08/2012	8° 22.555	127° 13.828	3	2	15	26
Timor NW	Tenu, Japanese Bunker	**16.1**	20/08/2012	8° 19.235	127° 0.07	2	3	15	27
Timor NW	Tenu, Japanese Bunker	**16.2**	20/08/2012	8° 19.235	127° 0.07	3	3	8	26
Timor N	Lamsana inlet East	**17.1**	21/08/2012	8° 30.977	126° 4.388	1	4	4	26
Timor N	Lamsana inlet East	**17.2**	21/08/2012	8° 30.977	126° 4.388	1	4	8	27
Timor N	Lamsana inlet West	**18.1**	21/08/2012	8° 30.826	126° 4.157	2	4	25	27
Timor N	Lamsana inlet West	**18.2**	21/08/2012	8° 30.826	126° 4.157	3	4	5	26
Atauro	Belio Barrier Reef	**19.1**	22/08/2012	8° 13.603	125° 36.802	2	4	25	25
Atauro	Belio - Barrier Reef	**19.2**	22/08/2012	8° 13.603	125° 36.802	2	4	25	27
Atauro	Belio "Saddle" Patch R.	**20.1**	22/08/2012	8° 12.933	125° 37.58	2	2	20	25
Atauro	Belio "Saddle" Patch R.	**20.2**	22/08/2012	8° 12.933	125° 37.58	3	2	20	25
Atauro	Atauro Belio Lagoon S	**21.1**	23/08/2012	8° 14.547	125° 36.555	2	4	20	26
Atauro	Atauro Belio Lagoon S	**21.2**	23/08/2012	8° 14.547	125° 36.555	1	4	25	27
Atauro	Atauro Belio Harbor	**22.2**	23/08/2012	8° 13.282	125° 36.885	2	4	20	26

Annex 2a

Visual estimates of percent cover of sessile benthic attributes and substratum types, and depth and site tallies for hermatypic coral species richness, Timor-Leste, August 2012. 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.

Site name	site	max	min	Slope	HS	HC	SC	MA	TA	CA	DC	AD	No. of species	Station total
Hera West	**1.1**	20	10	10	40	20	40	10	5	0	1	2	67	
Hera West	**1.2**	10	5	20	80	20	30	5	10	0	1	1	54	95
Com Vailovaia	**2.1**	31	10	10	40	20	40	5	10	5	0	20	81	
Com Vailovaia	**2.2**	8	2	5	80	20	40	5	5	5	0	20	90	122
Com Koho Vari	**3.1**	38	10	30	60	20	20	5	10	5	0	10	69	
Com Koho Vari	**3.2**	8	2	2	70	10	10	5	20	10	0	30	85	121
Loikere	**4.1**	37	10	40	95	40	5	1	5	5	0	5	130	
Loikere	**4.2**	10	2	10	90	25	10	0	15	10	2	5	154	193
East Loikere	**5.1**	35	10	40	95	30	5	0	5	5	0	5	117	
East Loikere	**5.2**	10	1	10	95	30	20	1	15	10	2	7	142	178
Jako NW	**6.1**	35	10	10	90	50	5	1	5	10	0	5	99	
Jako NW	**6.2**	10	2	15	80	55	20	1	10	10	2	10	104	151
Jako SW	**7.1**	22	10	10	90	70	2	0	5	5	0	5	106	
Jako SW	**7.2**	10	1	10	100	70	5	1	5	5	1	3	123	161
Hilapuna	**8.1**	17	10	10	80	40	2	0	10	10	0	5	109	
Hilapuna	**8.2**	9	1	10	70	15	3	0	20	10	1	5	108	162
W. Jako	**9.1**	32	10	10	40	30	5	0	5	10	0	0	74	
W. Jako	**9.2**	10	1	5	80	40	15	0	10	10	1	3	89	125
Djonu Twin Rocks	**10.1**	39	10	70	95	15	5	0	10	20	1	2	116	
Djonu Twin Rocks	**10.2**	8	1	5	95	70	1	0	5	10	0	0	104	174
Ete Asa Lepek	**11.1**	39	10	20	60	40	1	1	10	10	0	0	117	
Ete Asa Lepek	**11.2**	10	1	10	80	35	5	1	25	15	2	15	80	144
Djonu East	**14.1**	37	10	30	80	40	5	1	5	10	0	0	147	
Djonu East	**14.2**	10	1	5	90	25	15	1	15	10	1	3	161	214
3 Terraces	**15.1**	40	10	40	85	25	10	1	20	15	1	3	125	
3 Terraces	**15.2**	8	1	5	100	40	1	0	20	10	0	0	138	195
Tenu, Japanese Bunker	**16.1**	40	10	30	80	5	5	1	30	30	1	5	79	
Tenu, Japanese Bunker	**16.2**	8	2	5	90	5	60	0	20	5	0	10	66	114
Lamsana inlet East	**17.1**	25	10	10	50	5	1	1	30	5	0	50	79	
Lamsana inlet East	**17.2**	10	1	20	70	20	5	1	30	10	5	20	98	133
Lamsana inlet West	**18.1**	33	10	40	70	20	10	0	20	20	3	7	97	
Lamsana inlet West	**18.2**	8	2	5	80	30	2	1	20	0	0	20	119	159
Belio Barrier Reef	**19.1**	46	10	30	60	30	20	2	3	3	1	5	145	
Belio - Barrier Reef	**19.2**	10	0.5	20	80	25	10	2	20	15	1	3	127	190
Belio "Saddle" Patch R.	**20.1**	40	10	30	100	10	5	0	25	30	1	2	99	
Belio "Saddle" Patch R.	**20.2**	8	5	2	90	10	5	0	5	10	1	5	89	139
Atauro Belio Lagoon S	**21.1**	27	10	20	80	5	40	1	20	5	0	40	67	
Atauro Belio Lagoon S	**21.2**	10	1	10	90	35	25	1	15	25	2	15	147	163
Atauro Belio Harbor	**22.2**	10	1	5	30	10	1	1	5	10	0	0	122	122

Annex 2b

Visual estimates of percent cover of sessile benthic attributes and substratum types, and depth and site tallies for hermatypic coral species richness, Timor-Leste, August 2012. max - maximum depth (m); min – minimum depth (m). HS – Hard Substrate; Substratum types: CP – Continuous Pavement; LB – Large Blocks (> 2m diam.); SB – Small Blocks (< 2m diam.); RBL – Rubble; SN – Sand.

Site name	site	max	min	Slope	HS	CP	LB	SB	RBL	SN	SLT	No. of species
Hera West	**1.1**	20	10	10	40	10	10	20	0	60	0	67
Hera West	**1.2**	10	5	20	80	30	20	30	0	20	0	54
Com Vailovaia	**2.1**	31	10	10	40	0	20	20	0	60	0	81
Com Vailovaia	**2.2**	8	2	5	80	40	20	20	0	20	0	90
Com Koho Vari	**3.1**	38	10	30	60	0	20	40	10	30	0	69
Com Koho Vari	**3.2**	8	2	2	70	10	40	20	0	30	0	85
Loikere	**4.1**	37	10	40	95	80	5	0	0	5	0	130
Loikere	**4.2**	10	2	10	90	40	30	20	5	5	0	154
East Loikere	**5.1**	35	10	40	95	80	10	5	0	5	0	117
East Loikere	**5.2**	10	1	10	95	60	25	10	5	0	0	142
Jako NW	**6.1**	35	10	10	90	70	15	5	5	5	0	99
Jako NW	**6.2**	10	2	15	80	40	30	10	5	15	0	104
Jako SW	**7.1**	22	10	10	90	70	15	5	5	5	0	106
Jako SW	**7.2**	10	1	10	100	70	20	10	0	0	0	123
Hilapuna	**8.1**	17	10	10	80	50	10	20	0	20	0	109
Hilapuna	**8.2**	9	1	10	70	50	10	10	10	20	0	108
W. Jako	**9.1**	32	10	10	40	0	20	20	0	60	0	74
W. Jako	**9.2**	10	1	5	80	40	30	10	10	10	0	89
Djonu Twin Rocks	**10.1**	39	10	70	95	95	0	0	2	3	0	116
Djonu Twin Rocks	**10.2**	8	1	5	95	80	10	5	0	5	0	104
Ete Asa Lepek	**11.1**	39	10	20	60	50	0	10	35	5	0	117
Ete Asa Lepek	**11.2**	10	1	10	80	50	20	10	20	0	0	80
Djonu East	**14.1**	37	10	30	80	50	20	10	0	20	0	147
Djonu East	**14.2**	10	1	5	90	60	15	15	5	5	0	161
3 Terraces	**15.1**	40	10	40	85	60	10	15	15	5	0	125
3 Terraces	**15.2**	8	1	5	100	90	5	5	0	0	0	138
Tenu, Japanese Bunker	**16.1**	40	10	30	80	70	10	10	10	10	0	79
Tenu, Japanese Bunker	**16.2**	8	2	5	90	80	5	5	0	0	0	66
Lamsana inlet East	**17.1**	25	10	10	50	20	10	20	0	0	50	79
Lamsana inlet East	**17.2**	10	1	20	70	40	15	15	10	10	10	98
Lamsana inlet West	**18.1**	33	10	40	70	50	10	10	10	15	5	97
Lamsana inlet West	**18.2**	8	2	5	80	65	10	5	0	20	0	119
Belio Barrier Reef	**19.1**	46	10	30	60	40	20	10	10	30	0	145
Belio - Barrier Reef	**19.2**	10	0.5	20	80	50	10	20	10	10	0	127
Belio "Saddle" Patch R.	**20.1**	40	10	30	100	100	0	0	0	0	0	99
Belio "Saddle" Patch R.	**20.2**	8	5	2	90	60	10	20	0	10	0	89
Atauro Belio Lagoon S	**21.1**	27	10	20	80	70	5	5	20	0	0	67
Atauro Belio Lagoon S	**21.2**	10	1	10	90	60	15	15	5	5	0	147
Atauro Belio Harbor	**22.2**	10	1	5	30	0	10	20	50	20	0	122

Annex 3

Coral species check-list for Timor-Leste, August 2012.

1 - confirmed species; **U** - unconfirmed, based on observational and/or photographic evidence, and requiring confirmation;

Zooxanthellate Scleractinia	Timor Leste
Family Astrocoeniidae Koby, 1890	
Genus *Stylocoeniella* Yabe and Sugiyama, 1935	
Stylocoeniella armata (Ehrenberg, 1834)	**1**
Stylocoeniella guentheri Bassett-Smith, 1890	**1**
Genus *Palauastrea* Yabe and Sugiyama, 1941	
Palauastrea ramosa Yabe and Sugiyama, 1941	**1**
Genus *Madracis* Milne Edwards and Haime, 1849	
Family Pocilloporidae Gray, 1842	
Genus *Pocillopora* Lamarck, 1816	
Pocillopora ankeli Scheer and Pillai, 1974	**1**
Pocillopora damicornis (Linnaeus, 1758)	**1**
Pocillopora danae Verrill, 1864	**1**
Pocillopora eydouxi Milne Edwards and Haime, 1860	**1**
Pocillopora fungiformis Veron, 2000	**1**
Pocillopora kelleheri Veron, 2000	**1**
Pocillopora meandrina Dana, 1846	**1**
Pocillopora verrucosa (Ellis and Solander, 1786)	**1**
Pocillopora woodjonesi Vaughan, 1918	**1**
Genus *Seriatopora* Lamarck, 1816	
Seriatopora aculeata Quelch, 1886	**1**
Seriatopora caliendrum Ehrenberg, 1834	**1**
Seriatopora dendritica Veron, 2000	**U**
Seriatopora guttatus Veron, 2000	**U**
Seriatopora hystrix Dana, 1846	**1**
Genus *Stylophora* Schweigger, 1819	
Stylophora pistillata Esper, 1797	**1**
Stylophora subseriata (Ehrenberg, 1834)	**1**
Family Acroporidae Verrill, 1902	
Genus *Montipora* Blainville, 1830	
Montipora aequituberculata Bernard, 1897	**1**
Montipora calcarea Bernard, 1897	**1**
Montipora caliculata (Dana, 1846)	**1**
Montipora capitata Dana, 1846	**1**
Montipora cebuensis Nemenzo, 1976	**1**
Montipora cocosensis Vaughan, 1918	**U**
Montipora confusa Nemenzo, 1967	**1**
Montipora crassituberculata Bernard, 1897	**1**
Montipora danae (Milne Edwards and Haime, 1851)	**1**
Montipora digitata (Dana, 1846)	**1**
Montipora efflorescens Bernard, 1897	**1**

Montipora effusa Dana, 1846	**1**
Montipora florida Nemenzo, 1967	**1**
Montipora floweri Wells, 1954	**1**
Montipora foliosa (Pallas, 1766)	**1**
Montipora foveolata (Dana, 1846)	**1**
Montipora gaimardi Bernard, 1897	**1**
Montipora grisea Bernard, 1897	**1**
Montipora hirsuta Nemenzo, 1967	**U**
Montipora hispida (Dana, 1846)	**1**
Montipora hoffmeisteri Wells, 1954	**1**
Montipora incrassata (Dana, 1846)	**1**
Montipora informis Bernard, 1897	**1**
Montipora millepora Crossland, 1952	**1**
Montipora mollis Bernard, 1897	**1**
Montipora monasteriata (Forskål, 1775)	**1**
Montipora palawanensis Veron, 2000	**1**
Montipora peltiformis Bernard, 1897	**1**
Montipora porites Veron, 2000	**U**
Montipora spongodes Bernard, 1897	**1**
Montipora spumosa (Lamarck, 1816)	**1**
Montipora tuberculosa (Lamarck, 1816)	**1**
Montipora turgescens Bernard, 1897	**1**
Montipora turtlensis Veron and Wallace, 1984	**1**
Montipora undata Bernard, 1897	**1**
Montipora verrucosa (Lamarck, 1816)	**1**
Montipora vietnamensis Veron, 2000	**1**
Genus *Anacropora* Ridley, 1884	
Anacropora forbesi Ridley, 1884	**1**
Anacropora matthai Pillai, 1973	**1**
Genus *Acropora* Oken, 1815	
Acropora abrotanoides (Lamarck, 1816)	**1**
Acropora aculeus (Dana, 1846)	**1**
Acropora acuminata (Verrill, 1864)	**1**
Acropora anthocercis (Brook, 1893)	**1**
Acropora aspera (Dana, 1846)	**1**
Acropora austera (Dana, 1846)	**1**
Acropora carduus (Dana, 1846)	**1**
Acropora caroliniana Nemenzo, 1976	**1**
Acropora cerealis (Dana, 1846)	**1**
Acropora clathrata (Brook, 1891)	**1**
Acropora cophodactyla (Brook, 1892)	**U**
Acropora cytherea (Dana, 1846)	**1**
Acropora dendrum (Bassett-Smith, 1890)	**U**
Acropora desalwii Wallace, 1994	**1**
Acropora digitifera (Dana, 1846)	**1**
Acropora divaricata (Dana, 1846)	**1**

Acropora donei Veron and Wallace, 1984	**1**
Acropora echinata (Dana, 1846)	**1**
Acropora elegans Milne Edwards and Haime, 1860	**U**
Acropora elseyi (Brook, 1892)	**1**
Acropora florida (Dana, 1846)	**1**
Acropora formosa (Dana, 1846)	**1**
Acropora gemmifera (Brook, 1892)	**1**
Acropora glauca (Brook, 1893)	**1**
Acropora globiceps (Dana, 1846)	**1**
Acropora granulosa (Milne Edwards and Haime, 1860)	**1**
Acropora horrida (Dana, 1846)	**1**
Acropora humilis (Dana, 1846)	**1**
Acropora hyacinthus (Dana, 1846)	**1**
Acropora indonesia Wallace, 1997	**1**
Acropora insignis Nemenzo, 1967	**1**
Acropora kimbeensis Wallace, 1999	**1**
Acropora latistella (Brook, 1891)	**1**
Acropora listeri (Brook, 1893)	**1**
Acropora lokani Wallace, 1994	**1**
Acropora longicyathus (Milne Edwards and Haime, 1860)	**1**
Acropora loripes (Brook, 1892)	**1**
Acropora lutkeni Crossland, 1952	**1**
Acropora microclados (Ehrenberg, 1834)	**1**
Acropora microphthalma (Verrill, 1859)	**1**
Acropora millepora (Ehrenberg, 1834)	**1**
Acropora monticulosa (Brüggemann, 1879)	**1**
Acropora nana (Studer, 1878)	**1**
Acropora nasuta (Dana, 1846)	**1**
Acropora nobilis (Dana, 1846)	**1**
Acropora paniculata Verrill, 1902	**1**
Acropora papillare Latypov, 1992	**1**
Acropora polystoma (Brook, 1891)	**1**
Acropora pulchra (Brook, 1891)	**1**
Acropora robusta (Dana, 1846)	**1**
Acropora rosaria (Dana, 1846)	**U**
Acropora russelli Wallace, 1994	**1**
Acropora samoensis (Brook, 1891)	**1**
Acropora sarmentosa (Brook, 1892)	**1**
Acropora secale (Studer, 1878)	**1**
Acropora selago (Studer, 1878)	**1**
Acropora solitaryensis Veron and Wallace, 1984	**1**
Acropora speciosa (Quelch, 1886)	**1**
Acropora spicifera (Dana, 1846)	**1**
Acropora striata (Verrill, 1866)	**1**
Acropora subglabra (Brook, 1891)	**1**
Acropora subulata (Dana, 1846)	**1**

Acropora sukarnoi Wallace, 1997	**1**
Acropora tenuis (Dana, 1846)	**1**
Acropora torresiana Veron, 2000	**U**
Acropora turaki Wallace, 1994	**1**
Acropora valenciennesi (Milne Edwards and Haime, 1860)	**1**
Acropora valida (Dana, 1846)	**1**
Acropora vaughani Wells, 1954	**1**
Acropora verweyi Veron and Wallace, 1984	**1**
Acropora yongei Veron and Wallace, 1984	**1**
Genus *Isopora* Studer, 1878	
Isopora brueggemanni (Brook, 1893)	**1**
Isopora cuneata (Dana, 1846)	**1**
Isopora palifera (Lamarck, 1816)	**1**
Genus *Astreopora* Blainville, 1830	
Astreopora cucullata Lamberts, 1980	**U**
Astreopora gracilis Bernard, 1896	**1**
Astreopora incrustans Bernard, 1896	**U**
Astreopora listeri Bernard, 1896	**1**
Astreopora myriophthalma (Lamarck, 1816)	**1**
Astreopora ocellata Bernard, 1896	**1**
Astreopora randalli Lamberts, 1980	**1**
Astreopora suggesta Wells, 1954	**1**
Family Euphylliidae Milne Edwards, 1857	
Genus *Euphyllia* Dana, 1846	
Euphyllia ancora Veron and Pichon, 1979	**1**
Euphyllia cristata Chevalier, 1971	**1**
Euphyllia divisa Veron and Pichon, 1980	**1**
Euphyllia glabrescens (Chamisso and Eysenhardt, 1821)	**1**
Euphyllia paradivisa Veron, 1990	**1**
Genus *Nemenzophyllia* Hodgson and Ross, 1981	
Genus *Plerogyra* Milne Edwards and Haime, 1848	
Plerogyra sinuosa (Dana, 1846)	**1**
Genus *Physogyra* Quelch, 1884	
Physogyra lichtensteini (Milne Edwards and Haime, 1851)	**1**
Family Oculinidae Gray, 1847	
Genus *Galaxea* Oken, 1815	
Galaxea astreata (Lamarck, 1816)	**1**
Galaxea fascicularis (Linnaeus, 1767)	**1**
Galaxea horrescens (Dana, 1846)	**1**
Galaxea longisepta Fenner & Veron, 2000	**1**
Family Siderastreidae Vaughan and Wells, 1943	
Genus *Psammocora* Dana, 1846	
Psammocora contigua (Esper, 1797)	**1**
Psammocora digitata Milne Edwards and Haime, 1851	**1**
Psammocora haimiana Milne Edwards and Haime, 1851	**1**
Psammocora nierstraszi Horst, 1921	**1**

Psammocora profundacella Gardiner, 1898 **1**

Psammocora stellata Verrill, 1868 **1**

Psammocora superficialis Gardiner, 1898 **1**

Genus *Coscinaraea* Milne Edwards and Haime, 1848

Coscinaraea columna (Dana, 1846) **1**

Family Agariciidae Gray, 1847

Genus *Pavona* Lamarck, 1801

Pavona bipartita Nemenzo, 1980 **1**

Pavona cactus (Forskål, 1775) **1**

Pavona clavus (Dana, 1846) **1**

Pavona decussata (Dana, 1846) **1**

Pavona duerdeni Vaughan, 1907 **1**

Pavona explanulata (Lamarck, 1816) **1**

Pavona frondifera (Lamarck, 1816) **1**

Pavona minuta Wells, 1954 **1**

Pavona varians Verrill, 1864 **1**

Pavona venosa (Ehrenberg, 1834) **1**

Genus *Leptoseris* Milne Edwards and Haime, 1849

Leptoseris explanata Yabe and Sugiyama, 1941 **1**

Leptoseris foliosa Dinesen, 1980 **1**

Leptoseris gardineri Horst, 1921 **1**

Leptoseris hawaiiensis Vaughan, 1907 **1**

Leptoseris incrustans (Quelch, 1886) **1**

Leptoseris mycetoseroides Wells, 1954 **1**

Leptoseris papyracea (Dana, 1846) **1**

Leptoseris scabra Vaughan, 1907 **1**

Leptoseris solida (Quelch, 1886) **1**

Leptoseris striata Fenner & Veron 2000 **1**

Leptoseris tubulifera Vaughan, 1907 **1**

Leptoseris yabei (Pillai and Scheer, 1976) **1**

Genus *Coeloseris* Vaughan, 1918

Coeloseris mayeri Vaughan, 1918 **1**

Genus *Gardineroseris* Scheer and Pillai, 1974

Gardineroseris planulata Dana, 1846 **1**

Genus *Pachyseris* Milne Edwards and Haime, 1849

Pachyseris foliosa Veron, 1990 **1**

Pachyseris rugosa (Lamarck, 1801) **1**

Pachyseris speciosa (Dana, 1846) **1**

Family Fungiidae Dana, 1846

Genus *Cycloseris* Milne Edwards and Haime, 1849

Cycloseris costulata (Ortmann, 1889) **1**

Cycloseris cyclolites Lamarck, 1801 **1**

Cycloseris hexagonalis (Milne Edwards and Haime, 1848) **1**

Cycloseris patelliformis (Boschma, 1923) **1**

Cycloseris sinensis (Milne Edwards and Haime, 1851) **1**

Cycloseris tenuis (Dana, 1846)	**U**
Cycloseris vaughani (Boschma, 1923)	**1**
Genus *Diaseris* Milne Edwards and Haime, 1849	
Diaseris distorta Alcock, 1893	**1**
Diaseris fragilis Alcock, 1893	**1**
Genus *Heliofungia* Wells, 1966	
Heliofungia actiniformis Quoy and Gaimard, 1833	**1**
Genus *Fungia* Lamarck, 1801	
Fungia concinna Verrill, 1864	**1**
Fungia corona Döderlein, 1901	**1**
Fungia danai Milne Edwards and Haime, 1851	**1**
Fungia fralinae Nemenzo, 1955	**1**
Fungia fungites (Linneaus, 1758*)*	**1**
Fungia granulosa Klunzinger, 1879	**1**
Fungia gravis Nemenzo, 1955	**1**
Fungia horrida Dana, 1846	**1**
Fungia klunzingeri Döderlein, 1901	**1**
Fungia moluccensis Horst, 1919	**1**
Fungia paumotensis Stutchbury, 1833	**1**
Fungia repanda Dana, 1846	**1**
Fungia scabra Döderlein, 1901	**1**
Fungia scruposa Klunzinger, 1879	**1**
Fungia scutaria Lamarck, 1801	**1**
Fungia spinifer Claereboudt and Hoeksema, 1987	**U**
Genus *Ctenactis* Verrill, 1864	
Ctenactis albitentaculata Hoeksema, 1989	**1**
Ctenactis crassa (Dana, 1846)	**1**
Ctenactis echinata (Pallas, 1766)	**1**
Genus *Herpolitha* Eschscholtz, 1825	
Herpolitha limax (Houttuyn, 1772)	**1**
Herpolitha weberi Horst, 1921	**1**
Genus *Polyphyllia* Quoy and Gaimard, 1833	
Polyphyllia novaehiberniae (Lesson, 1831)	**U**
Polyphyllia talpina (Lamarck, 1801)	**1**
Genus *Sandalolitha* Quelch, 1884	
Sandalolitha dentata (Quelch, 1886)	**1**
Sandalolitha robusta Quelch, 1886	**1**
Genus *Halomitra* Dana, 1846	
Halomitra clavator Hoeksema, 1989	**1**
Halomitra pileus (Linnaeus, 1758)	**1**
Genus *Zoopilus* Dana, 1864	
Zoopilus echinatus Dana, 1846	**1**
Genus *Lithophyllon* Rehberg, 1892	
Lithophyllon mokai Hoeksema, 1989	**1**
Genus *Podabacia* Milne Edwards and Haime, 1849	
Podabacia crustacea (Pallas, 1766)	**1**

Podabacia motuporensis Veron, 1990	**1**
Family Pectiniidae Vaughan and Wells, 1943	
Genus *Echinophyllia* Klunzinger, 1879	
Echinophyllia aspera (Ellis and Solander, 1788)	**1**
Echinophyllia costata Fenner and Veron, 2000	**U**
Echinophyllia echinata (Saville-Kent, 1871)	**1**
Echinophyllia echinoporoides Veron and Pichon, 1979	**1**
Genus *Oxypora* Saville-Kent, 1871	
Oxypora crassispinosa Nemenzo, 1979	**1**
Oxypora glabra Nemenzo, 1959	**1**
Oxypora lacera Verrill, 1864	**1**
Genus *Mycedium* Oken, 1815	
Mycedium elephantotus (Pallas, 1766)	**1**
Mycedium mancaoi Nemenzo, 1979	**1**
Mycedium robokaki Moll and Best, 1984	**1**
Mycedium steeni Veron, 2000	**1**
Genus *Pectinia* Oken, 1815	
Pectinia alcicornis (Saville-Kent, 1871)	**1**
Pectinia ayleni (Wells, 1935)	**1**
Pectinia lactuca (Pallas, 1766)	**1**
Pectinia maxima (Moll and Borel Best, 1984)	**1**
Pectinia paeonia (Dana, 1846)	**1**
Family Merulinidae Verrill, 1866	
Genus *Hydnophora* Fischer de Waldheim, 1807	
Hydnophora exesa (Pallas, 1766)	**1**
Hydnophora grandis Gardiner, 1904	**1**
Hydnophora microconos (Lamarck, 1816)	**1**
Hydnophora pilosa Veron, 1985	**1**
Hydnophora rigida (Dana, 1846)	**1**
Genus *Merulina* Ehrenberg, 1834	
Merulina ampliata (Ellis and Solander, 1786)	**1**
Merulina scabricula Dana, 1846	**1**
Genus *Scapophyllia* Milne Edwards and Haime, 1848	
Scapophyllia cylindrica Milne Edwards and Haime, 1848	**1**
Family Dendrophylliidae Gray, 1847	
Genus *Turbinaria* Oken, 1815	
Turbinaria frondens (Dana, 1846)	**1**
Turbinaria irregularis Bernard, 1896	**1**
Turbinaria mesenterina (Lamarck, 1816)	**1**
Turbinaria peltata (Esper, 1794)	**1**
Turbinaria reniformis Bernard, 1896	**1**
Turbinaria stellulata (Lamarck, 1816)	**1**
Genus *Duncanopsammia* Wells, 1936	
Duncanopsammia axifuga (Milne Edwards & Haime, 1848)	**1**
Family Mussidae Ortmann, 1890	

Genus *Blastomussa* Wells, 1961	
Blastomussa wellsi Wijsmann-Best, 1973	**1**
Genus *Micromussa* Veron, 2000	
Micromussa amakusensis (Veron, 1990)	**U**
Micromussa minuta (Moll and Borel-Best, 1984)	**1**
Genus *Acanthastrea* Milne Edwards and Haime, 1848	
Acanthastrea echinata (Dana, 1846)	**1**
Acanthastrea hemprichii (Ehrenberg, 1834)	**1**
Acanthastrea ishigakiensis Veron, 1990	**1**
Acanthastrea regularis Veron, 2000	**1**
Acanthastrea rotundoflora Chevalier, 1975	**1**
Acanthastrea subechinata Veron, 2000	**1**
Genus *Lobophyllia* Blainville, 1830	
Lobophyllia corymbosa (Forskål, 1775)	**1**
Lobophyllia dentatus Veron, 2000	**1**
Lobophyllia diminuta Veron, 1985	**U**
Lobophyllia flabelliformis Veron, 2000	**1**
Lobophyllia hataii Yabe and Sugiyama, 1936	**1**
Lobophyllia hemprichii (Ehrenberg, 1834)	**1**
Lobophyllia robusta Yabe and Sugiyama, 1936	**1**
Lobophyllia serratus Veron, 2000	**1**
Genus *Symphyllia* Milne Edwards and Haime, 1848	
Symphyllia agaricia Milne Edwards and Haime, 1849	**1**
Symphyllia radians Milne Edwards and Haime, 1849	**1**
Symphyllia recta (Dana, 1846)	**1**
Symphyllia valenciennesii Milne Edwards and Haime, 1849	**1**
Genus *Cynarina* Brüggemann, 1877	
Cynarina lacrymalis (Milne Edwards and Haime, 1848)	**1**
Family Faviidae Gregory, 1900	
Genus *Caulastrea* Dana, 1846	
Caulastrea furcata Dana, 1846	**1**
Genus *Favia* Oken, 1815	
Favia favus (Forskål, 1775)	**1**
Favia lizardensis Veron, Pichon & Wijsman-Best, 1977	**1**
Favia matthaii Vaughan, 1918	**1**
Favia maxima Veron, Pichon & Wijsman-Best, 1977	**1**
Favia pallida (Dana, 1846)	**1**
Favia rotumana (Gardiner, 1899)	**1**
Favia rotundata Veron, Pichon & Wijsman-Best, 1977	**1**
Favia speciosa Dana, 1846	**1**
Favia stelligera (Dana, 1846)	**1**
Favia truncatus Veron, 2000	**1**
Favia veroni Moll and Borel-Best, 1984	**U**
Genus *Barabattoia* Yabe and Sugiyama, 1941	
Barabattoia amicorum (Milne Edwards and Haime, 1850)	**1**
Genus *Favites* Link, 1807	

Favites abdita (Ellis and Solander, 1786)	**1**
Favites acuticollis (Ortmann, 1889)	**U**
Favites chinensis (Verrill, 1866)	**1**
Favites complanata (Ehrenberg, 1834)	**1**
Favites flexuosa (Dana, 1846)	**1**
Favites halicora (Ehrenberg, 1834)	**1**
Favites micropentagona Veron, 2000	**1**
Favites paraflexuosa Veron, 2000	**1**
Favites pentagona (Esper, 1794)	**1**
Favites russelli (Wells, 1954)	**1**
Favites stylifera (Yabe and Sugiyama, 1937)	**1**
Favites vasta (Klunzinger, 1879)	**1**
Genus *Goniastrea* Milne Edwards and Haime, 1848	
Goniastrea aspera Verrill, 1905	**1**
Goniastrea edwardsi Chevalier, 1971	**1**
Goniastrea favulus (Dana, 1846)	**1**
Goniastrea minuta Veron, 2000	**U**
Goniastrea pectinata (Ehrenberg, 1834)	**1**
Goniastrea retiformis (Lamarck, 1816)	**1**
Genus *Platygyra* Ehrenberg, 1834	
Platygyra acuta Veron, 2000	**1**
Platygyra carnosus Veron, 2000	**U**
Platygyra contorta Veron, 1990	**1**
Platygyra daedalea (Ellis and Solander, 1786)	**1**
Platygyra lamellina (Ehrenberg, 1834)	**1**
Platygyra pini Chevalier, 1975	**1**
Platygyra ryukyuensis Yabe and Sugiyama, 1936	**1**
Platygyra sinensis (Milne Edwards and Haime, 1849)	**1**
Platygyra verweyi Wijsman-Best, 1976	**1**
Platygyra yaeyamaensis Eguchi and Shirai, 1977	**1**
Genus *Oulophyllia* Milne Edwards and Haime, 1848	
Oulophyllia bennettae (Veron, Pichon & Wijsman-Best, 1977)	**1**
Oulophyllia crispa (Lamarck, 1816)	**1**
Oulophyllia levis (Nemenzo, 1959)	**1**
Genus *Leptoria* Milne Edwards and Haime, 1848	
Leptoria phrygia (Ellis and Solander, 1786)	**1**
Genus *Montastrea* Blainville, 1830	
Montastraea annuligera (Milne Edwards and Haime, 1849)	**1**
Montastraea colemani Veron, 2000	**1**
Montastraea curta (Dana, 1846)	**1**
Montastraea magnistellata Chevalier, 1971	**1**
Montastrea salebrosa (Nemenzo, 1959)	**1**
Montastrea valenciennesi (Milne Edwards and Haime, 1848)	**1**
Genus *Plesiastrea* Milne Edwards and Haime, 1848	
Plesiastrea versipora (Lamarck, 1816)	**1**
Genus *Oulastrea* Milne Edwards and Haime, 1848	

Diploastrea heliopora (Lamarck, 1816)	**1**
Genus *Leptastrea* Milne Edwards and Haime, 1848	
Leptastrea bewickensis Veron & Pichon, 1977	**1**
Leptastrea pruinosa Crossland, 1952	**1**
Leptastrea purpurea (Dana, 1846)	**1**
Leptastrea transversa Klunzinger, 1879	**1**
Genus *Cyphastrea* Milne Edwards and Haime, 1848	
Cyphastrea agassizi (Vaughan, 1907)	**1**
Cyphastrea chalcidicum (Forskål, 1775)	**1**
Cyphastrea decadia Moll and Best, 1984	**1**
Cyphastrea japonica Yabe and Sugiyama, 1932	**1**
Cyphastrea microphthalma (Lamarck, 1816)	**1**
Cyphastrea serailia (Forskål, 1775)	**1**
Genus *Echinopora* Lamarck, 1816	
Echinopora ashmorensis Veron, 1990	**1**
Echinopora gemmacea Lamarck, 1816	**1**
Echinopora hirsutissima Milne Edwards and Haime, 1849	**U**
Echinopora horrida Dana, 1846	**1**
Echinopora lamellosa (Esper, 1795)	**1**
Echinopora pacificus Veron, 1990	**1**
Family Trachyphylliidae Verrill, 1901	
Genus *Trachyphyllia* Milne Edwards and Haime, 1848	
Trachyphyllia geoffroyi (Audouin, 1826)	**1**
Family Poritidae Gray, 1842	
Genus *Porites* Link, 1807	
Porites **massive**	**1**
Porites annae Crossland, 1952	**1**
Porites australiensis Vaughan, 1918	**U**
Porites cocosensis Wells, 1950	**U**
Porites cylindrica Dana, 1846	**1**
Porites deformis Nemenzo, 1955	**1**
Porites densa Vaughan, 1918	**1**
Porites eridani Umbgrove, 1940	**U**
Porites evermanni Vaughan, 1907	**1**
Porites latistella Quelch, 1886	**1**
Porites lichen Dana, 1846	**1**
Porites lobata Dana, 1846	**1**
Porites lutea Milne Edwards & Haime, 1851	**1**
Porites monticulosa Dana, 1846	**1**
Porites negrosensis Veron, 1990	**1**
Porites nigrescens Dana, 1846	**1**
Porites profundus Rehberg, 1892	**U**
Porites rugosa Fenner & Veron, 2000	**1**
Porites rus (Forskål, 1775)	**1**
Porites sillimaniana Nemenzo, 1976	**1**
Porites solida (Forskål, 1775)	**1**

Porites tuberculosa Veron, 2000	**1**
Porites vaughani Crossland, 1952	**1**
Genus *Goniopora* Blainville, 1830	
Goniopora albiconus Veron, 2000	**1**
Goniopora columna Dana, 1846	**1**
Goniopora djiboutiensis Vaughan, 1907	**1**
Goniopora eclipsensis Veron and Pichon, 1982	**1**
Goniopora fruticosa Saville-Kent, 1893	**1**
Goniopora lobata Milne Edwards and Haime, 1860	**1**
Goniopora minor Crossland, 1952	**1**
Goniopora palmensis Veron and Pichon, 1982	**1**
Goniopora pandoraensis Veron and Pichon, 1982	**1**
Goniopora pendulus Veron, 1985	**1**
Goniopora planulata (Ehrenberg, 1834)	**1**
Goniopora somaliensis Vaughan, 1907	**1**
Goniopora stokesi Milne Edwards and Haime, 1851	**1**
Goniopora stutchburyi Wells, 1955	**1**
Goniopora tenuidens (Quelch, 1886)	**1**
Genus *Alveopora* Blainville, 1830	
Alveopora allingi Hoffmeister, 1925	**1**
Alveopora fenestrata (Lamarck, 1816)	**1**
Alveopora gigas Veron, 1985	**1**
Alveopora minuta Veron, 2000	**1**
Alveopora spongiosa Dana, 1846	**1**
Alveopora tizardi Bassett-Smith, 1890	**1**
Total confirmed species	**367**
Unconfirmed	**27**

Chapter 3:
Site Descriptions of Timor-Leste MRAP Sites

1. Hera West

Date: 14 August 2012. Time: 15:30 hours, dive duration 70 minutes, depth range 1-20m; visibility 10m; slight current; moderate strong wave energy; relatively turbid. *Site description*: Fringing reef with lagoonal character; we dived on the protected lagoonal side, with reef starting at 7m and going down to 20m. Mix of hard coral tapering into sand and halimedia and various ahermatypic corals, live coral cover only reaching 30%. One large bluefin trevally and a school of batfish.

2. Com (Vailovaia)

Date: 15 August 2012. Time: 09:00 hours, dive duration 124 minutes, depth range 1-46m; visibility 15m; slight current; moderate strong wave energy; clear water deeper. *Site description*: Fringing reef that showed signs of previous damage, with lots of rubble and only perhaps 15-20% live coral cover - though there were several very large (3-5m diameter) Porites heads. Relatively steep slope with not much coral below 20m depth, turning to sponge and halimeda beds with occasional soft corals. High densities of snappers including big schools of *Lutjanus fulvus* and a number of large *L. bohar* and *L. rivulatus* and *Variola* groupers.

3. Com (Koho Vari)

Date: 15 August 2012. Time: 15:30 hours, dive duration 75 minutes, depth range 1-45m; visibility 10m; moderately strong current; strong wave energy; relatively turbid. *Site description*: Fringing reef with extremely steep sand/coral slope. Corals in shallow reaching 20% live coral cover, quickly transitioning to mostly sand by 12m. Large schools of juvenile snappers and a few large *Variola* grouper.

4. Loikere

Date: 16 August 2012. Time: 0900 hours, dive duration 140 minutes, depth range 1-66m; visibility 20m; mild current; moderate wave energy; generally clear water. *Site description*: Fringing reef with moderate to excellent live hard coral cover; reef flat approximately 60m wide, sloping gradually from shore to 9m before steeply descending to 80m+. Some large damaged swaths, but alternating with excellent live hard coral cover. One large spanish mackerel and a number of larger snapper observed.

5. East Loikere (Big Rock)

Date: 16 August 2012. Time: 1630 hours, dive duration 84 minutes, depth range 1-50m; visibility 20m; moderate to strong current; moderate wave energy. *Site description*: Fringing reef off NE tip of Timor-Leste; reef flat approximately 80m wide with gradual slope from 0-8m, then steep slope to 70m+. Excellent live hard coral cover on the reef flat, reaching up to 80-90% live cover; down the slope the hard coral rapidly disappears, with rubble/*Halimeda*/soft coral/sponge slope below 25m. One large bluefin trevally and a number of decent-sized snappers nearby. One large green turtle observed.

6. NW Jako Island (Vata)

Date: 17 August 2012. Time: 1100 hours, dive duration 83 minutes, depth range 1-40m; visibility 20m; moderate current; moderate wave energy. *Site description*: Fringing reef off uplifted karst island. Spur and groove zone in shallows, with shallows a mix of live and dead hard coral. From 3-10m, good live hard coral cover, including quite a bit of Heliopora. Steep slope from 10-25m, grading out into current-swept hard bottom with scattered sponges and low coral growth. One white tip shark, a big school of rainbow runners and a number of large jacks observed.

7. SW Jako Island (Perevenu)

Date: 17 August 2012. Time: 1530 hours, dive duration 90 minutes, depth range 1-26m; visibility 10m; slight current; moderate to strong wave energy. *Site description*: Fringing reef exposed to moderately strong wave energy. Spectacular coral cover reaching 100% live hard cover in the shallows (1-4m), grading slowly into much larger Porites bommies that attenuate by about 15m depth, at which point reef grades mostly into sand and rubble with scattered sponges and soft corals and coraliths. Four Napoleon wrasse observed (one larger male), large schools of Naso surgeons and numerous jacks and rainbow runners - very fishy.

8. Hilapuna

Date: 18 August 2012. Time: 0800 hours, dive duration 67 minutes, depth range 1-20m; visibility 8m; moderately strong current; moderate wave energy, high turbidity. *Site description*: Very gradually sloping fringing reef off southeast coast of Timor-Leste, just west of Jako Island channel. Some spur and groove zone development, scattered large bommies and coral outcrops with mostly rubble on bottom. Gradual slope eventually increases in steepness at about 14m, continuing down to perhaps 30m, with *Halimeda* and *Acropora russelli* on sand and rubble. Large school of unicorn fish but otherwise not many commercially-important fishes. Note: tide pools along shore at low tide - collected fishes with clove oil there.

9. West Jako Island (channel)

Date: 18 August 2012. Time: 1100 hours, dive duration 84 minutes, depth range 1-35m; visibility 20m; moderate to strong current; moderate wave energy. *Site description*: Fringing reef off west coast of Jako island, at mouth of narrow current-swept strait. Beautiful *Acropora palifera* and *Heliopora*-dominated shallows that serve as shelter for massive schools of snapper, sweetlips and fusiliers. Gradual slope to 40m, mostly sand with some rubble and scattered large coral bommies. Overall very fish site, with one blacktip shark and 2 whitetip reef sharks observed, as well as huge schools of snapper and fusiliers and unicornfish and a deep colony of *Gorgasia maculata* garden eels that numbered in the thousands.

10. Djonu Twin Rocks

Date: 18, 19 August 2012. Time: 1600 hours, dive duration 145 minutes, depth range 1-65m; visibility 20m; slight current; moderate wave energy. *Site description*: Fringing reef off east tip of Timor-Leste; wave-pounded boulders in the shallows drop down to a high coral cover reef flat that slopes to about 12m before then sharply descending into a sheer wall that drops to about 55m before becoming a steep sand and rubble slope. Fishy site in the afternoon, with one large 100kg+ Queensland Giant Groper (*Epinephelus lanceolatus*), large Napoleon wrasse, huge Spanish mackerel, numerous jacks and snappers, and a single green turtle observed.

11. Ete Asa Lepek

Date: 17, 20 August 2012. Time: 0900 hours, dive duration 193 minutes, depth range 1-65m; visibility 15m; slight current; moderate wave energy; medium turbidity. *Site description*: Fringing reef in a partially protected embayment with moderate turbidity. Very gradual slope with extensive hard coral gardens from 2-30m (reef dips to 13m, levels out, then rises back up to 9m before descending again), after which it becomes a rubble slope to at least 65m. Slightly to the east there is extensive bomb damage. Good small fish life, with some larger fish around, including one manta ray and one hawksbill turtle observed.

12. Com Harbor Seasgrass (Fish Only)

Date: 17, 18 August 2012. Time: 1530 hours, dive duration 205 minutes, depth range 1-35m; visibility 10m; slight current; slight wave energy; medium turbidity. *Site description*: Seagrass bed in shallows that becomes soft bottom gradual slope from 5-35m, with occasional hard substrate bommies. Very interesting macro site with large numbers of new fish records (mostly gobies) and a range of interesting invertebrates (fire urchins, crabs, nudibranchs). One green turtle observed.

13. Com Deep Caves (Fish Only)

Date: 18 August 2012. Time: 0930 hours, dive duration 72 minutes, depth range 1-40m; visibility 15m; moderate current; moderate wave energy. *Site description*: Fringing reef to east of Com with very wide reef flat and gradual sand/rubble slope to 50m+. Between 30-40m there are two large caves. Quite fishy site with 3 different sharks observed (one each grey reef shark, nurse shark, and whitetip reef shark) and a large reef ray and two green turtles observed.

14. Djonue East (Coral Only)

Date: 19 August 2012. Time: 0920 hours, dive duration 115 minutes, depth range 1-30m; visibility 15m; moderate current; moderate wave energy. *Site description*: Fringing reef off Tutuala coastline, with shoreline a tiny embayment with white sand beach. Moderately steep reef slope to 50m+, mostly sand and rubble with scattered coral heads. No large fish observed.

15. Tutuala 3 Terraces

Date: 19 August 2012. Time: 1400 hours, dive duration 82 minutes, depth range 1-55m; visibility 20m; moderate to strong current; moderate wave energy. *Site description*: Narrow fringing reef off eastern tip of Timor-Leste; large wave-pounded boulders in the shallows drop off immediately to 2m and then reef slopes to about 8m (mostly bare calcium carbonate "bench" substrate with scattered live coral), where the reef crest has high coral cover. Reef then slopes sharply to about 50m, with mostly rubble and sand slope and some hard coral ridges. Several large jacks and emperors observed, along with one small hawksbill turtle - but generally not that many fish.

16. Tenu (Japanese Bunker)

Date: 20 August 2012. Time: 1530 hours, dive duration 91 minutes, depth range 1-52m; visibility 10m; strong current; moderately high wave energy; high turbidity. *Site description*: Fringing reef off a current-swept point. Shallow reef mostly dead with soft coral coverage and large expanses of sand; sloping down relatively sharply to at least 55m. Mostly coral bench with very little rugosity; cover mostly sea whips and sponges and soft corals. Further to the west very slightly was a series of terraces/ledges going down that proved to be very good fish habitat. A number of larger fish observed here in the current, including a large school of bumphead parrotfish, a Napoleon wrass, and a large school of jacks.

17. Lamsana Inlet East

Date: 21 August 2012. Time: 0900 hours, dive duration 135 minutes, depth range 1-45m; visibility 5m; strong current; moderate wave energy. *Site description*: Silted fringing coastal reef (near mangrove-lined river outlet) with wide (75m) intertidal reef flat with gradual slope; 10-15% live coral cover from 2m down to about 20m, where reef levelled off and cover increased to about 30%. Reef eventually sloped down again tapered into sand at 25m, though with scattered coral outcrops down to 45m. No large fish observed. Numerous COTS observed in shallows.

18. Lamsana Inlet West

Date: 21 August 2012. Time: 1530 hours, dive duration 94 minutes, depth range 1-40m; visibility 5m; moderate current; moderate wave energy. *Site description*: As with previous site, highly sediment-covered fringing coastal reef with lots of sponges and filter feeding organisms. Wide intertidal reef flat, then relatively gradual reef slope from 2-10m with approximately 20% live coral cover and large stretches of sand. Reef slope increasingly steep from 10-40m with scattered reef outcrops and mostly sponges, at most 10% live coral cover. One green turtle and numerous COTS observed in shallows.

19. Pulau Atauro Belio Outer Barrier Reef (ferry channel marker)

Date: 22 August 2012. Time: 0830 hours, dive duration 155 minutes, depth range 1-70m; visibility 30m; moderate current; slight wave energy; low turbidity. *Site description*: Barrier reef just off Pulau Atauro east side where ferry terminal/harbor is situated. Site was located at the southern tip of the barrier reef,with outside a steep slope/dropoff to 100m+, and inside a steep sand slope, with top of reef coming up to intertidal range but only perhaps 30m wide. Reef top with excellent (60-75%) live hard coral cover including many small Acroporid table colonies; slope with alternating hard coral and sand/rubble areas. High fish diversity, and high biomass of planktivores feeding in current, but not many large fish. One hawksbill turtle and one large Napoleon wrasse observed.

20. Pulau Atauro Belio "Saddle" Patch Reef

Date: 22 August 2012. Time: 1530 hours, dive duration 95 minutes, depth range 1-52m; visibility 20m; strong current; moderate wave energy. *Site description*: Northern section of Atauro's eastern barrier reef. Top of reef at 6m with relatively good coral cover (30-40% live) though lots of old dead and broken coral underneath. Steep, relatively barren and current-swept slope with sponges and low growing corals. Large numbers of big snappers (*Lutjanus bohar*) aggregating at top of slope.

21. Pulau Atauro Lagoon

Date: 23 August 2012. Time: 0800 hours, dive duration 91 minutes, depth range 1-62m; visibility 20m; moderate current; moderate wave energy. *Site description*: Lagoon site just south of Belio Harbor. Excellent hard coral cover within lagoon (up to 75% live cover) and on top of reef flat before reef descends steeply to 100m+. Numerous new fish records in lagoon, and a new coral species as well. Not many large fish seen - a few large emperors only, as well as a single hawkbill turtle.

22. Pulau Ataruo Belio Harbor (corals only)

Date: 23 August 2012. Time: 1130 hours, dive duration 75 minutes, depth range 1-32m; visibility 15m; moderate current; minimal wave energy. *Site description*: Across the channel from Site 20. Moderately steep reef slope into sand/rubble bottom. Live hard coral cover averaging only 25-30%.