3. WHAT ARE THE NEARSHORE RESOURCES?
CORAL REEF ECOSYSTEM ASSESSMENTS[1]

What did we do, and why is this information important?

Nearshore and coral reef fishes provide sustenance and livelihoods for the people of the coastal communities of Timor-Leste. The condition of fish populations is related to overall reef health, which is influenced by interconnected oceanographic, climatic, and ecological processes, as well as the interactions of various human activities on land and in the ocean. Assessing and monitoring reef fish assemblages along with the benthic communities and ocean conditions is important in establishing a more complete baseline of the coral reef ecosystem and the fish community it supports. This baseline can then be used as a starting point for monitoring changes to the coral reef community over time and better understanding status and the long-term trends of fish and coral populations.

In 2013, NOAA-CREP conducted surveys, which generated baseline data on the composition and abundance of the reef fish and the associated benthic community cover (Figure 7). The baseline data gathered from the reef fish and benthic surveys in Timor-Leste can inform management in a variety of ways. For example, information on reef fish abundance and size-frequency distributions can inform decisions about the status of a fishery, such as whether the resources are being sustainably fished or potentially over-exploited. The integrated reef fish and benthic data can inform managers about the different patterns of habitat utilization by different species and guide the development of marine managed areas or other management measures aimed at protecting key species or habitats of interest. Benthic cover is the most widely used metric for assessing coral reef condition because it is relatively easy to acquire, and changes in cover often reflect environmental and/or human-induced disturbance regimes that influence the overall structure and function of the reef ecosystem (Jokiel et al., 2015; Rogers, et al., 1994).

Assessment of benthic habitat characteristics at the sites where fish surveys were conducted was done using two complementary methods. The first, rapid visual assessments, were made by divers who visually estimated the percent cover of major benthic categories (e.g., coral, macroalgae, sand, other). The second method consisted of divers who conducted a photo transect through the middle of survey transects. Analysis of photo-quadrat provides taxonomically finer-scale information on the benthic community composition, but requires time for processing the images post-survey. Because of this time lag, only the visually-estimated benthic data were reported in McCoy et al. (2015). Post processing of the photo-quadrat data has since been completed and those finer-scale data are reported here.

[1] Except where noted, the content in this chapter has been adapted from the Methods, Summary and Results & Discussion sections of McCoy et al. (2015).

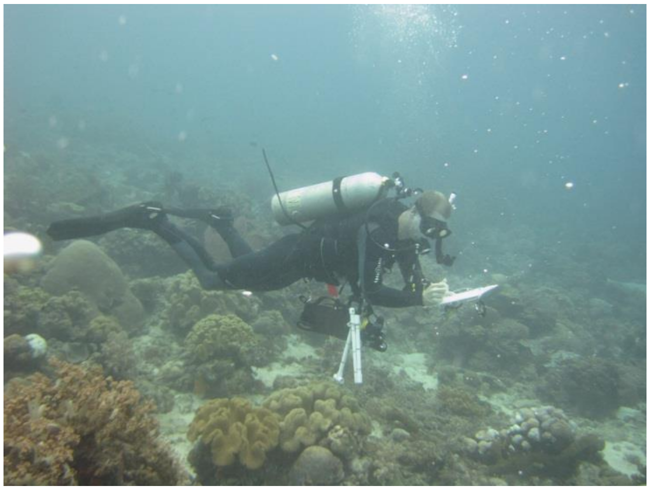

Figure 7. A NOAA-CREP SCUBA diver conducting a reef fish survey in Timor-Leste.

Where, when and how did we do it?

Survey Design

The surveys used a common stratified random survey design, where sites were randomly selected from hard-bottom habitats within two depth strata (Ayotte, et al., 2015). Due to the large area of coastline and logistical/fiscal constraints, survey efforts were focused on eight sections of coastline (hereafter referred to as sectors) within 7 districts (Figure 8). Each sector was treated as an independent survey area, and was separated by at least 18 km of coastline from adjacent sectors, except for East and West Atauro, which were separated by 2 km. The target survey areas were hard-bottom habitats in either shallow (0–6 m) or mid-depth (6–18 m) range. For most NOAA-CREP reef fish assessments, survey allocation is determined by area of hard-bottom reef habitat within 3 depth ranges; shallow, mid, and deep (18–30 m). The deep area of reef habitat was not surveyed during the Timor-Leste surveys due to safety restrictions set by the NOAA Diving Program that require timely accessibility to a recompression chamber. Bathymetry and hard-bottom reef habitat maps were not available at the time of the mission planning (and have since been developed under the activity, *Satellite Mapping of Nearshore Habitats*), so sites were randomly selected within an estimated 30 m depth contour. Once the divers arrived at the randomly located survey sites, they assessed the benthos to determine whether habitat and visibility were suitable and moved to the selected depth range. See Appendix G for details on the methodology to survey reef fish and to estimate benthic cover.

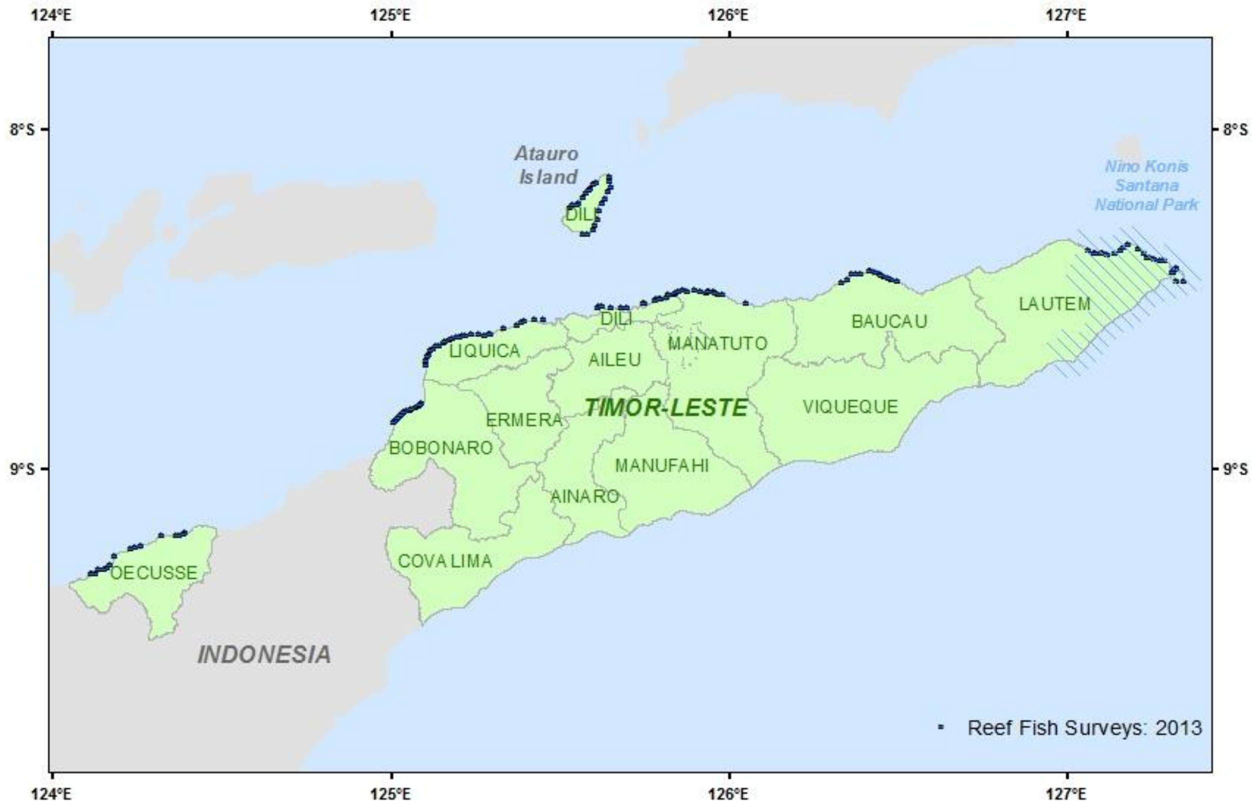

Figure 8. Map of locations where NOAA-CREP conducted reef fish surveys along the north coast of Timor-Leste and around Atauro Island in June 2013.

2013 Activities

In total, reef fish surveys were conducted at 150 sites along Timor-Leste's north shore from June 4–27, 2013 (Appendix H). Photographs of the benthos were collected and analyzed for benthic cover at 139 of those sites. See Appendix H for a list of the sites surveyed. Surveys were not conducted along the southern coastline due to weather and logistical/fiscal limitations.

What did we find?

Reef Fish Assemblages

Total Reef Fish Biomass

Total reef fish biomass at the 150 sites varied between 1.1 g m^{-2} and 283.9 g m^{-2}. There were many sites with relatively low-to-moderate biomass and only a few sites where total fish biomass was at the high end of the scale, compared with other locations surveyed by NOAA-CREP across the Pacific islands. The median value (the level at which half of the sites had lower biomass and half of the sites had higher biomass) was 31.5 g m^{-2} (Figure 9).

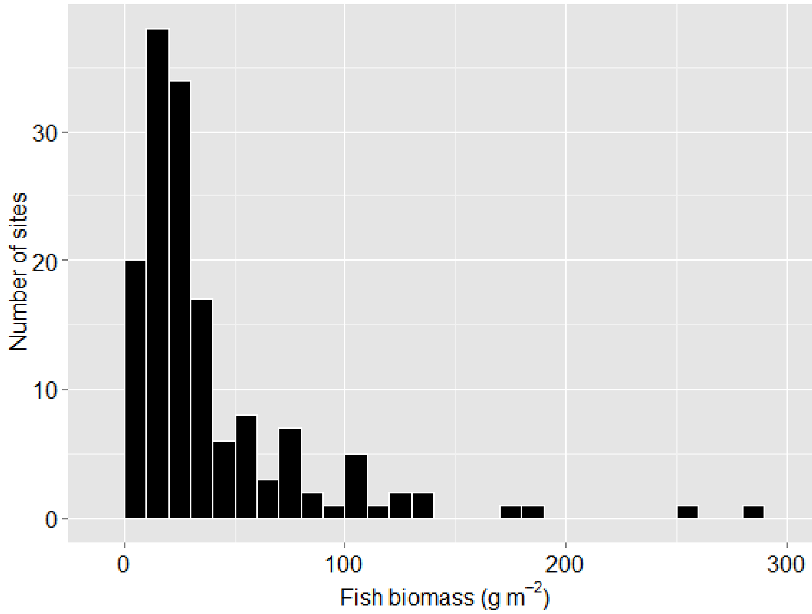

Figure 9. Distribution of total reef fish biomass observed per site.

Fish Biomass by Geographic Region and Trophic Group

Total reef fish biomass for Timor-Leste averaged 41.1 g m^{-2} (standard error [SE] 3.1), which is slightly higher than other populated areas in the Pacific (30.6 g m^{-2} [SE 2.1]), but more comparable to populated than remote areas (119.2 g m^{-2} [SE 11]; Figure 10).

Reef fish biomass by trophic group classifications include: 'primary consumers' are herbivores that eat marine plants and detritivores that eat detritus (largely comprised of surgeonfishes and parrotfishes); 'secondary consumers' are omnivores that eat marine plants and animals and invertivores that eat benthic invertebrate organisms (includes most wrasses, butterflyfishes, triggerfishes, and filefishes); 'planktivores' that eat drifting marine plants (phytoplankton) and animals (zooplankton) (includes several unicornfishes, damselfishes, fusiliers, and several soldierfishes); and 'piscivores' that eat other fish (includes most jacks, groupers, emperors, barracudas, sharks, moray eels, and lizardfishes).

Planktivores made up the majority of the overall fish biomass (50.3%), followed by primary consumers (22.3%), secondary consumers (18.8%), and lastly, piscivores (8.6%; Figure 10).

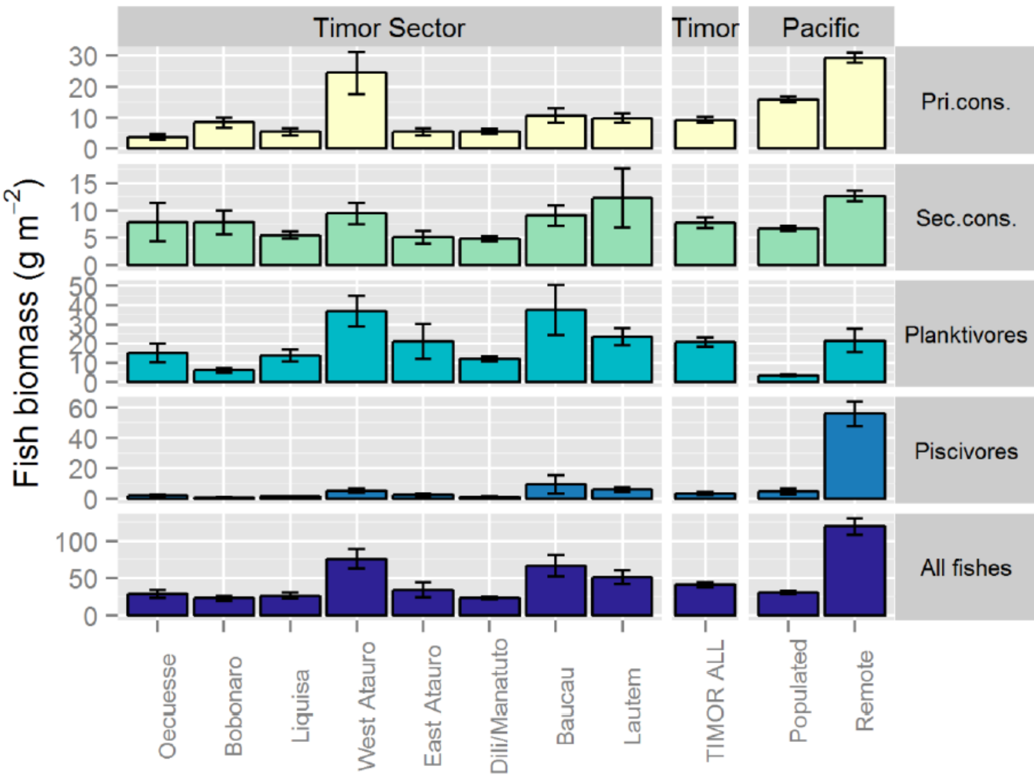

Figure 10. Average reef fish biomass by fish trophic group per Timor-Leste sector. Sectors are ordered from west to east. The average among all sectors is shown as TIMOR ALL. Populated average is pooled from 923 sites from highly human-populated Pacific islands, and remote average is pooled from 858 sites from sparsely-human populated Pacific islands. Note different scales on *y*-axes. Error bars show standard error (SE). See text for explanation on tropic classification groups.

The west side of Atauro Island had the highest average fish biomass (75.9 g m^{-2} [SE 12.90]), while Dili/Manatuto (23.4 g m^{-2} [SE 2.0]) and Bobonaro (23.0 g m^{-2} [SE 3.1]) sectors had the lowest (Figure 11). The high biomass in West Atauro may be related to the relatively high structural complexity of the reef, which was dominated by a steep wall.

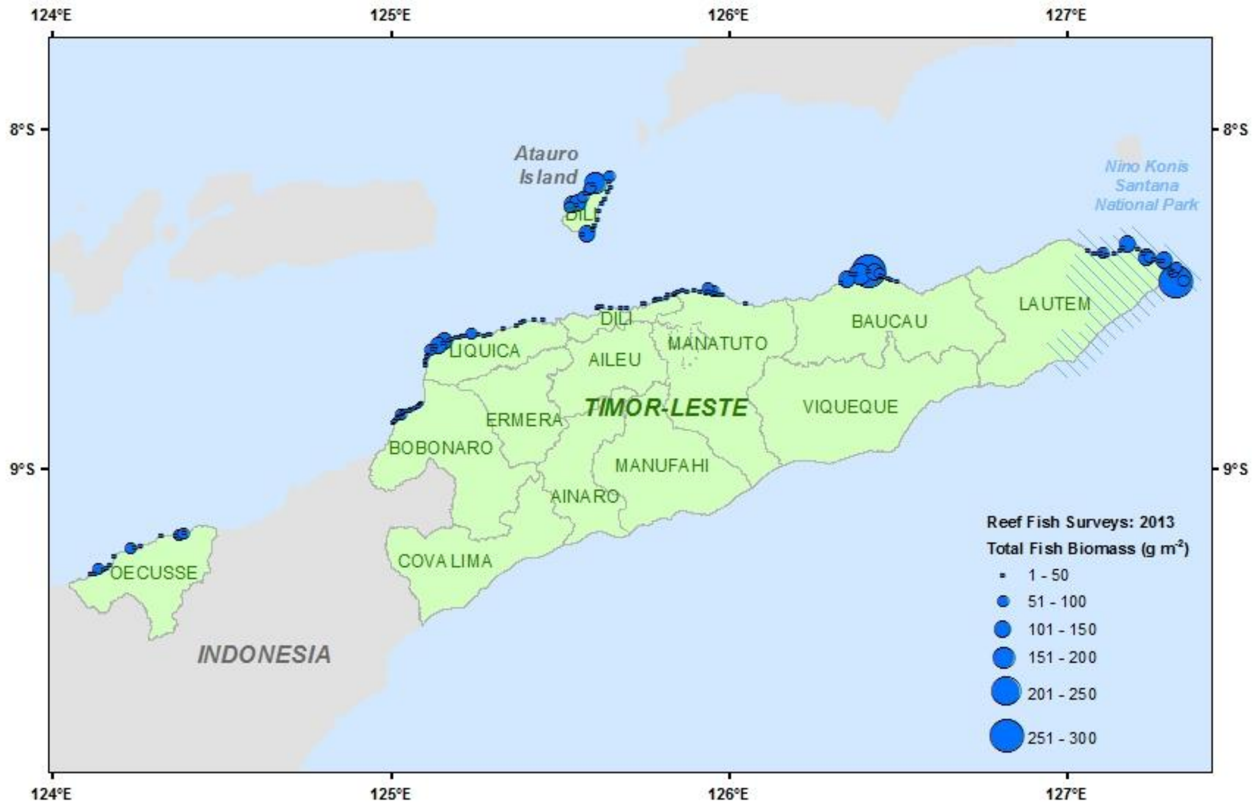

Figure 11. Total reef fish biomass per survey site.

Fish Biomass by Family

The surgeonfish family had the highest overall fish biomass (8.2 g m^{-2} [SE 1.1]) and made up 19.8% of the total fish biomass (Figure 12). Overall, the average biomass observations of snappers, breams, groupers, parrotfishes, and emperors (often important as fishery targets) were comparable to other populated areas in the Pacific, although average fish biomass in West Atauro was comparable to other remote areas in the Pacific for these families (Figure 12) suggesting that there is either high biological productivity at West Atauro or that fish assemblages are relatively unimpacted by human activities there.

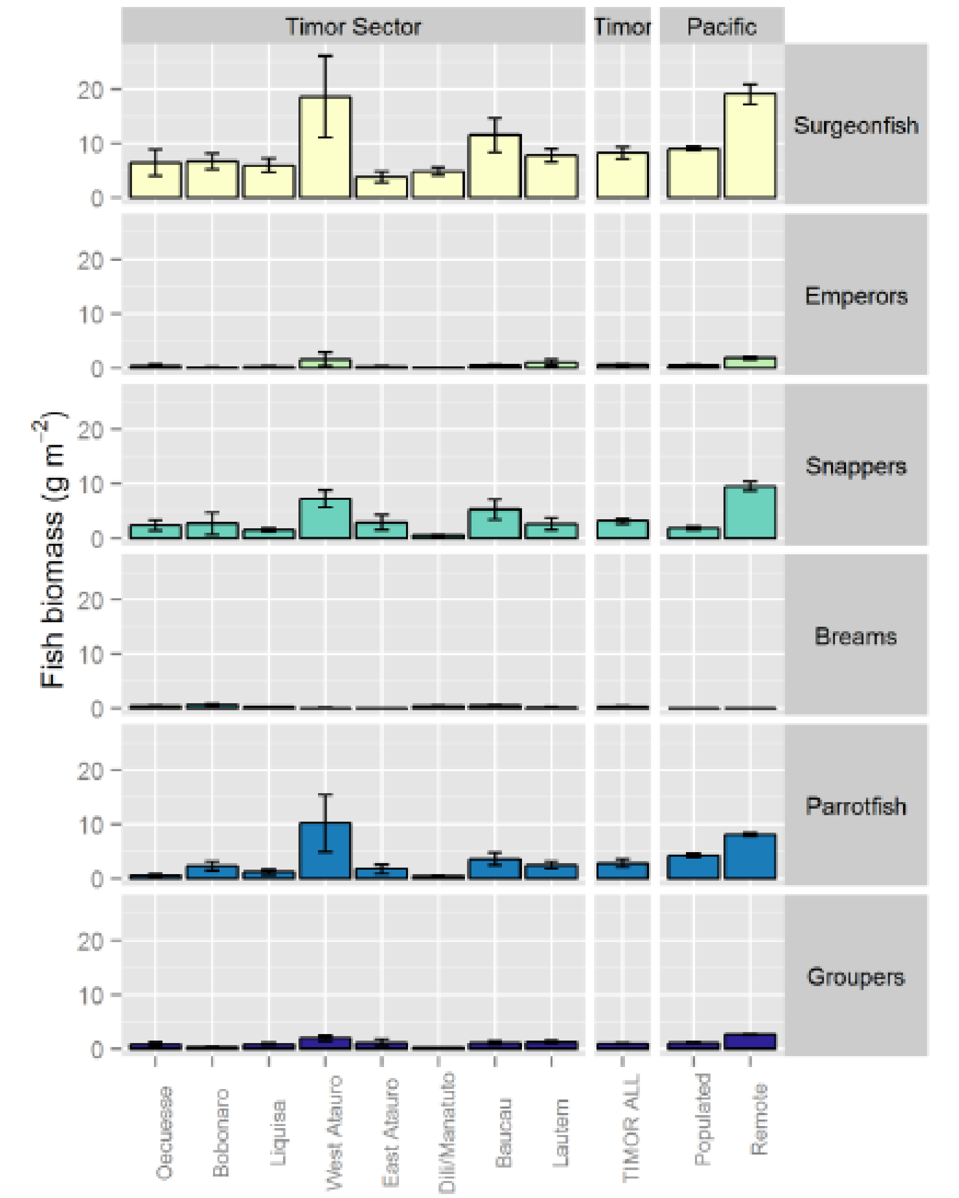

Figure 12. Average reef fish biomass (standard error) by family per sector. Sectors are ordered from west to east. Timor-Leste average among all sectors is shown as TIMOR ALL. Populated average is pooled from 923 sites from highly human-populated Pacific islands, and remote average is pooled from 858 sites from sparsely-human populated Pacific islands. Error bars show standard error (SE).

Fish Biomass by Size Class

Fish biomass was pooled into three size classes: small- (0–20 cm), medium- (>20–50 cm), and large-bodied reef fish (> 50 cm). Small-bodied reef fish made up the majority of the biomass overall, and in each sector (Figure 13). Overall, the biomass of small-bodied reef fish in Timor-Leste was comparable to the results of NOAA-CREP surveys at remote, unpopulated areas in the Pacific islands. Biomass estimates for medium- and large-bodied reef fishes were generally comparable to values from other human-populated areas in the Pacific islands surveyed by NOAA-CREP.

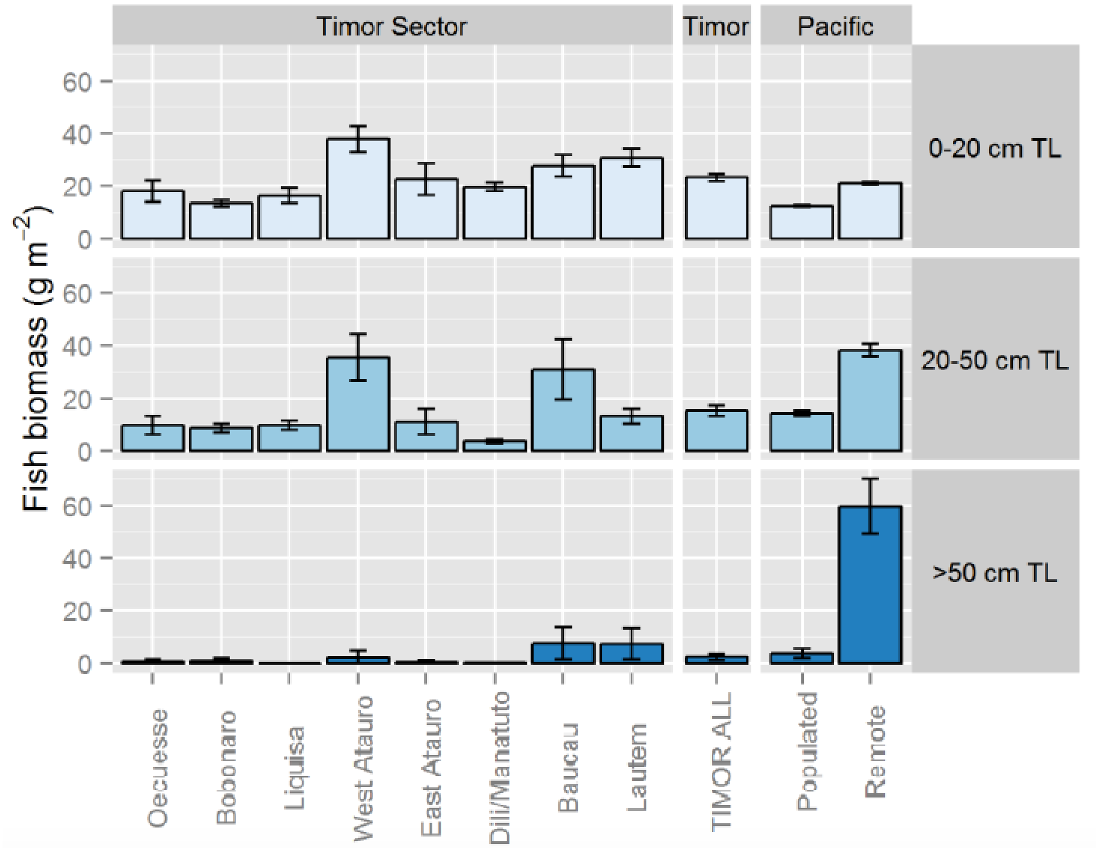

Figure 13. Mean reef fish biomass by size class per sector ordered from west to east along the north coast of Timor-Leste. Timor-Leste average among all sectors is shown as TIMOR ALL. Populated average is pooled from 923 sites from highly human-populated Pacific islands, and remote average is pooled from 858 sites from sparsely human-populated Pacific islands. Error bars show standard error (SE). TL: total length.

Fish Species Richness

Timor-Leste sites had extremely high species richness compared with other Pacific islands locations surveyed by NOAA-CREP. The average species richness among all sectors, 57 species per survey site, was higher than any other region that NOAA-CREP surveys (typically around 25 to 45; Figure 14).

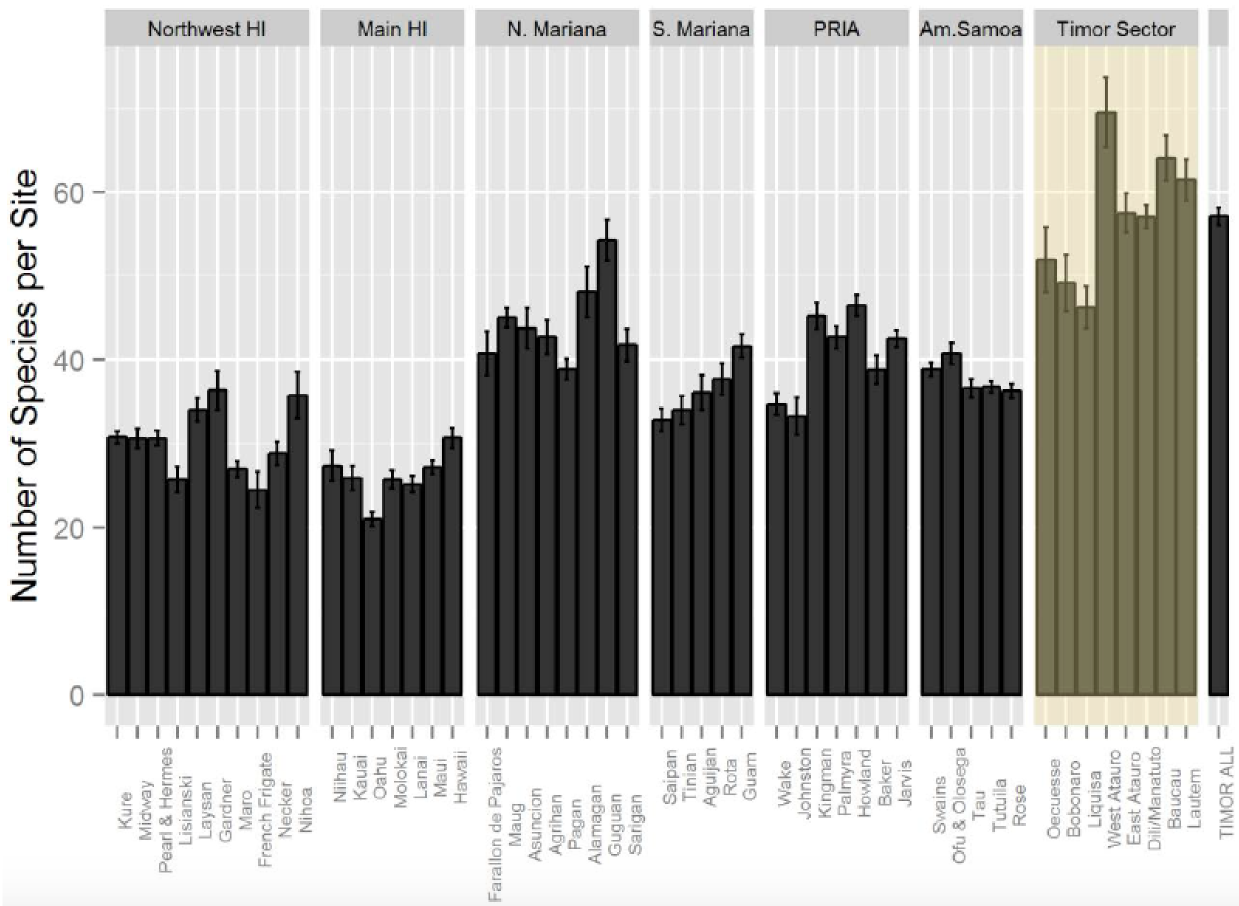

Figure 14. Average species richness per site by sector/island for all Pacific islands areas surveyed by NOAA-CREP.

In addition to the results provided here from McCoy et al. (2015), information about the top reef fish species by quantity (i.e., biomass) for each municipality (district) are provided in Table 2.

Table 2. Top 20 reef fish species by district based on mean biomass (g m^{-2}) from NOAA-CREP reef fish surveys in Timor-Leste, including the standard error (SE) of the mean.

OECUSSE		
RANK	SPECIES	MEAN BIOMASS g m^{-2} (SE)
1	*Plectorhinchus gibbosus*	3.5 (3.5)
2	*Acanthurus mata*	3.0 (2.0)
3	*Caesio teres*	2.5 (1.7)
4	*Chromis ternatensis*	1.4 (1.1)
5	Apogonidae*	0.9 (0.7)
6	*Ctenochaetus striatus*	0.8 (0.3)
7	*Acanthurus thompsoni*	0.8 (0.8)
8	*Macolor macularis*	0.5 (0.5)
9	*Lutjanus bohar*	0.5 (0.5)
10	*Acanthurus blochii*	0.4 (0.3)
11	*Pterocaesio tile*	0.4 (0.3)
12	*Pseudanthias huchtii*	0.4 (0.1)
13	*Pomacentrus melanochir*	0.4 (0.4)
14	*Balistapus undulatus*	0.3 (0.1)
15	*Lutjanus lutjanus*	0.3 (0.3)
16	*Lethrinus olivaceus*	0.3 (0.3)
17	*Lutjanus fulvus*	0.3 (0.1)
18	*Thalassoma lunare*	0.3 (0.0)
19	*Dascyllus trimaculatus*	0.3 (0.2)
20	*Dascyllus reticulatus*	0.3 (0.2)

BOBONARO		
RANK	SPECIES	MEAN BIOMASS g m^{-2} (SE)
1	*Lutjanus rivulatus*	1.6 (1.6)
2	*Ctenochaetus striatus*	1.4 (0.5)
3	*Acanthurus blochii*	1.0 (0.5)
4	*Naso hexacanthus*	0.9 (0.5)
5	*Chlorurus bleekeri*	0.8 (0.6)
6	*Diagramma melanacrum*	0.7 (0.7)
7	*Scarus rubroviolaceus*	0.7 (0.5)
8	*Naso thynnoides*	0.7 (0.7)
9	*Melichthys vidua*	0.6 (0.2)
10	*Acanthurus lineatus*	0.5 (0.3)
11	*Caesio teres*	0.5 (0.4)
12	*Acanthurus mata*	0.5 (0.3)
13	*Acanthurus pyroferus*	0.5 (0.1)
14	*Melichthys niger*	0.3 (0.1)
15	*Balistapus undulatus*	0.3 (0.0)
16	*Dascyllus trimaculatus*	0.3 (0.1)
17	*Pomacanthus semicirculatus*	0.3 (0.2)
18	*Macolor macularis*	0.2 (0.2)
19	*Acanthurus nigrofuscus*	0.2 (0.1)
20	*Chlorurus japanensis*	0.2 (0.2)

LIQUICA		
RANK	SPECIES	MEAN BIOMASS g m^{-2} (SE)
1	*Melichthys niger*	2.9 (1.8)
2	*Pterocaesio tile*	2.6 (1.2)
3	*Acanthurus mata*	1.8 (0.8)
4	*Caesio teres*	1.0 (0.9)
5	*Naso hexacanthus*	0.9 (0.6)
6	*Scarus rubroviolaceus*	0.8 (0.4)
7	*Melichthys vidua*	0.8 (0.2)
8	*Ctenochaetus binotatus*	0.6 (0.3)
9	*Ctenochaetus striatus*	0.5 (0.2)
10	*Acanthurus lineatus*	0.5 (0.2)
11	*Chaetodon kleinii*	0.4 (0.0)
12	*Cephalopholis argus*	0.4 (0.2)
13	*Lutjanus lutjanus*	0.4 (0.2)
14	*Naso brachycentron*	0.3 (0.3)
15	*Dascyllus reticulatus*	0.3 (0.1)
16	*Acanthurus nigrofuscus*	0.3 (0.1)
17	*Balistoides viridescens*	0.3 (0.3)
18	*Pseudanthias huchtii*	0.3 (0.1)
19	*Pomacanthus sexstriatus*	0.3 (0.3)
20	*Lutjanus rivulatus*	0.2 (0.2)

MANATUTO		
RANK	SPECIES	MEAN BIOMASS g m^{-2} (SE)
1	*Pseudanthias huchtii*	1.3 (0.7)
2	*Acanthochromis polyacanthus*	1.3 (0.3)
3	*Euthynnus affinis*	1.1 (1.1)
4	Ctenochaetus sp*	0.8 (0.6)
5	*Chromis weberi*	0.7 (0.3)
6	*Caesio teres*	0.6 (0.6)
7	*Ctenochaetus striatus*	0.6 (0.2)
8	*Dascyllus trimaculatus*	0.5 (0.2)
9	*Dascyllus reticulatus*	0.5 (0.2)
10	Acanthurus sp*	0.5 (0.4)
11	*Chaetodon kleinii*	0.5 (0.1)
12	*Cirrhilabrus solorensis*	0.5 (0.4)
13	*Pomacentrus amboinensis*	0.5 (0.2)
14	*Melichthys vidua*	0.5 (0.1)
15	*Zebrasoma scopas*	0.5 (0.2)
16	*Acanthurus pyroferus*	0.5 (0.1)
17	*Naso lituratus*	0.5 (0.3)
18	*Chromis ternatensis*	0.5 (0.2)
19	*Pseudanthias squamipinnis*	0.5 (0.2)
20	*Chromis viridis*	0.4 (0.3)

**indicates genus or family level of identification*

BAUCAU		
RANK	SPECIES	MEAN BIOMASS g m^{-2} (SE)
1	*Pterocaesio tile*	10.7 (8.6)
2	*Sphyraena qenie*	6.2 (6.2)
3	*Caesio teres*	4.2 (2.2)
4	*Acanthurus mata*	2.5 (1.2)
5	*Macolor macularis*	2.4 (1.0)
6	*Caesio lunaris*	2.4 (1.5)
7	*Naso lopezi*	1.8 (1.8)
8	*Chromis weberi*	1.2 (0.4)
9	*Lutjanus bohar*	1.2 (0.8)
10	Anthias sp*	0.9 (0.7)
11	*Lutjanus gibbus*	0.9 (0.5)
12	*Naso tonganus*	0.9 (0.8)
13	*Pseudanthias squamipinnis*	0.8 (0.3)
14	*Naso hexacanthus*	0.8 (0.8)
15	*Zebrasoma scopas*	0.7 (0.3)
16	*Chromis ternatensis*	0.7 (0.3)
17	*Pomacentrus coelestis*	0.7 (0.4)
18	*Ctenochaetus striatus*	0.7 (0.3)
19	*Acanthurus leucocheilus*	0.7 (0.5)
20	*Pseudanthias huchtii*	0.6 (0.3)

LAUTEM		
RANK	SPECIES	MEAN BIOMASS g m^{-2} (SE)
1	*Cheilinus undulatus*	5.0 (5.0)
2	*Caesio teres*	3.7 (1.9)
3	*Pterocaesio tile*	2.3 (1.8)
4	*Heteroconger hassi*	1.8 (1.3)
5	*Pseudanthias lori*	1.4 (1.4)
6	*Ctenochaetus striatus*	1.4 (0.4)
7	*Pseudanthias huchtii*	1.4 (0.6)
8	*Chromis ternatensis*	1.2 (0.5)
9	*Chromis margaritifer*	1.1 (0.5)
10	*Melichthys niger*	1.0 (0.5)
11	*Acanthurus lineatus*	0.9 (0.4)
12	*Macolor macularis*	0.9 (0.5)
13	*Scomberomorus commerson*	0.8 (0.8)
14	*Chromis weberi*	0.8 (0.2)
15	*Naso vlamingii*	0.8 (0.6)
16	*Chlorurus microrhinos*	0.8 (0.4)
17	*Balistapus undulatus*	0.7 (0.1)
18	*Acanthurus pyroferus*	0.7 (0.1)
19	*Naso thynnoides*	0.6 (0.6)
20	*Zebrasoma scopas*	0.6 (0.2)

DILI		
RANK	SPECIES	MEAN BIOMASS g m^{-2} (SE)
1	Apogonidae*	1.5 (1.3)
2	*Caesio teres*	0.8 (0.5)
3	*Naso hexacanthus*	0.8 (0.5)
4	*Ctenochaetus striatus*	0.8 (0.2)
5	*Acanthurus pyroferus*	0.7 (0.2)
6	*Chaetodon kleinii*	0.6 (0.1)
7	*Acanthochromis polyacanthus*	0.6 (0.3)
8	*Melichthys vidua*	0.6 (0.1)
9	*Melichthys niger*	0.5 (0.3)
10	*Pomacentridae*	0.5 (0.2)
11	*Zebrasoma scopas*	0.5 (0.1)
12	*Balistapus undulatus*	0.4 (0.2)
13	*Gymnothorax javanicus*	0.4 (0.4)
14	*Acanthurus nigrofuscus*	0.4 (0.2)
15	*Neoglyphidodon melas*	0.4 (0.1)
16	Cirrhilabrus sp*	0.4 (0.1)
17	*Ctenochaetus binotatus*	0.4 (0.1)
18	*Neoglyphidodon nigroris*	0.3 (0.2)
19	*Amblyglyphidodon leucogaster*	0.3 (0.2)
20	*Scolopsis bilineatus*	0.3 (0.0)

ATAURO		
RANK	SPECIES	MEAN BIOMASS g m^{-2} (SE)
1	*Pterocaesio tile*	2.6 (1.5)
2	*Caesio teres*	2.3 (1.4)
3	*Scarus rubroviolaceus*	2.1 (1.3)
4	*Naso unicornis*	2.1 (2.1)
5	*Naso hexacanthus*	2.1 (1.0)
6	*Caesio lunaris*	2.0 (1.4)
7	*Melichthys niger*	1.9 (0.7)
8	*Chromis ternatensis*	1.7 (1.0)
9	*Macolor macularis*	1.7 (0.6)
10	*Ctenochaetus striatus*	1.5 (0.5)
11	*Melichthys vidua*	1.2 (0.3)
12	*Chromis analis*	1.1 (1.0)
13	*Lutjanus gibbus*	1.1 (0.6)
14	*Odonus niger*	1.0 (0.9)
15	*Lutjanus bohar*	1.0 (0.3)
16	*Pseudanthias huchtii*	1.0 (0.4)
17	*Chlorurus sordidus*	0.9 (0.4)
18	*Naso vlamingii*	0.8 (0.6)
19	*Thalassoma amblycephalum*	0.8 (0.3)
20	*Lepidozygus tapeinosoma*	0.7 (0.4)

**indicates genus or family level of identification*

Benthic Community Composition

Benthic Cover

Coral communities were assessed along a diverse range of physical, biological, and anthropogenic influences including an extensive portion of the shallow to mid-depth (0–18 m) marine hard-bottom habitats along the north coast of Timor-Leste, including Atauro Island (Figure 16). Hard (scleractinian) coral cover ranged from 0.0 to 42.3% across sites, with an average of 15.6% (SE 0.8). Notably, Lautem and Atauro exhibited the highest mean coral cover at 20.3% (SE 2.1) and 20.5% (SE 2.0), respectively. Baucau and Liquica had the lowest at 10.4% (SE 1.8) and 10.7% (SE 1.6), respectively (Figure 17 and Table 3).

These observations corroborate Erdmann and Mohan (2013) who indicated that some of the highest quality reefs in Timor-Leste in terms of coral cover and diversity are found in the Nino Konis Santana National Park in Lautem and in reefscapes off the island of Atauro harbor (Figure 15).

Figure 15. Site VIL-10 located on the Belio Barrier Reef complex off east Atauro Island is an example of a high-quality reef in Timor-Leste, rich in diversity and with abundant coral cover.

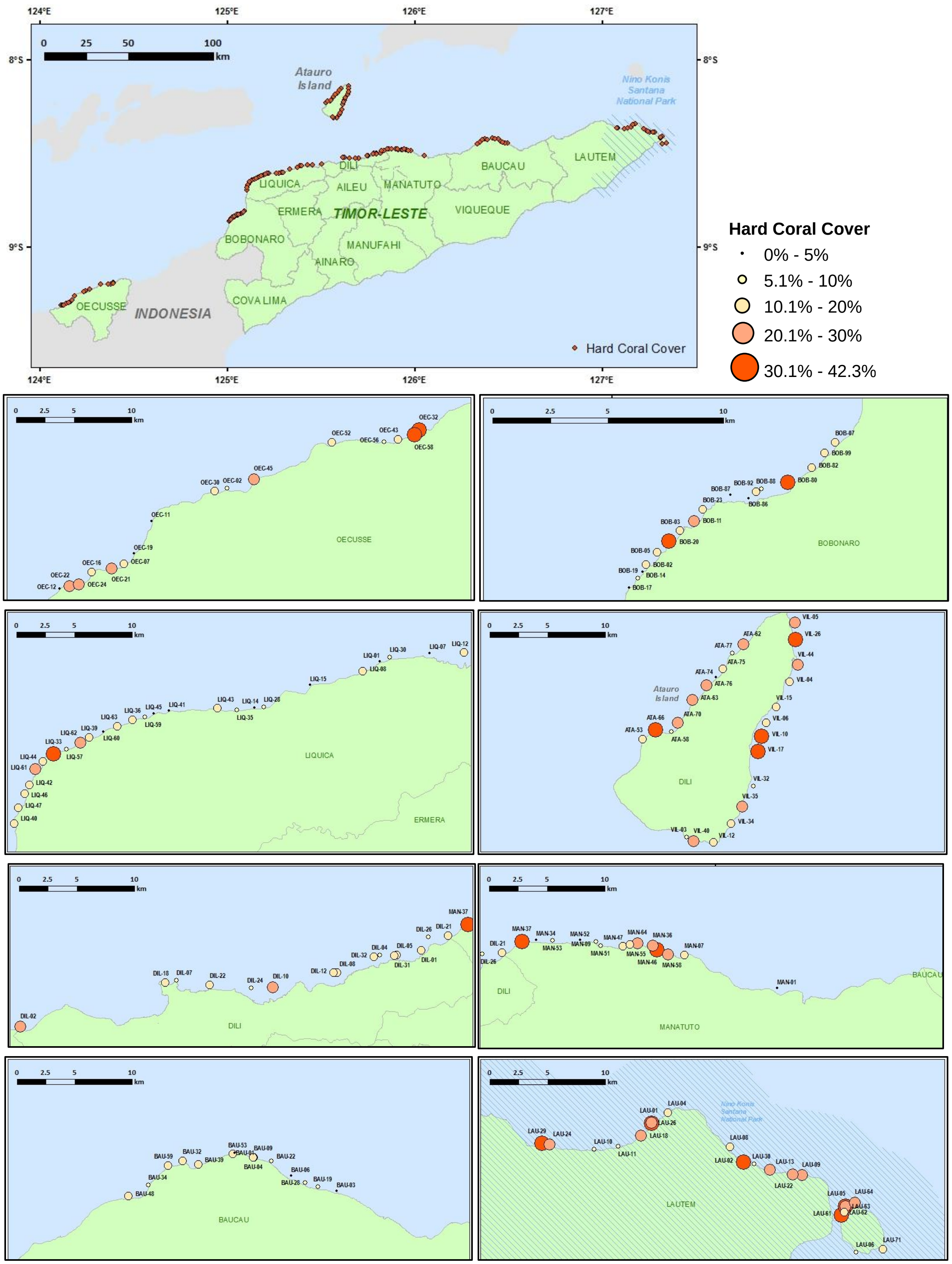

Figure 16. Map of locations where NOAA-CREP collected benthic images along the north coast of Timor-Leste and around Atauro Island in June 2013 that were analyzed for benthic cover (*top*). The panels show hard coral cover (%) per site for each district surveyed (*from left to right, Oecusse, Bobonaro, Liquica, Atauro, Dili, Manatuto, Baucau, and Lautem).* Data were derived from analysis of benthic images.

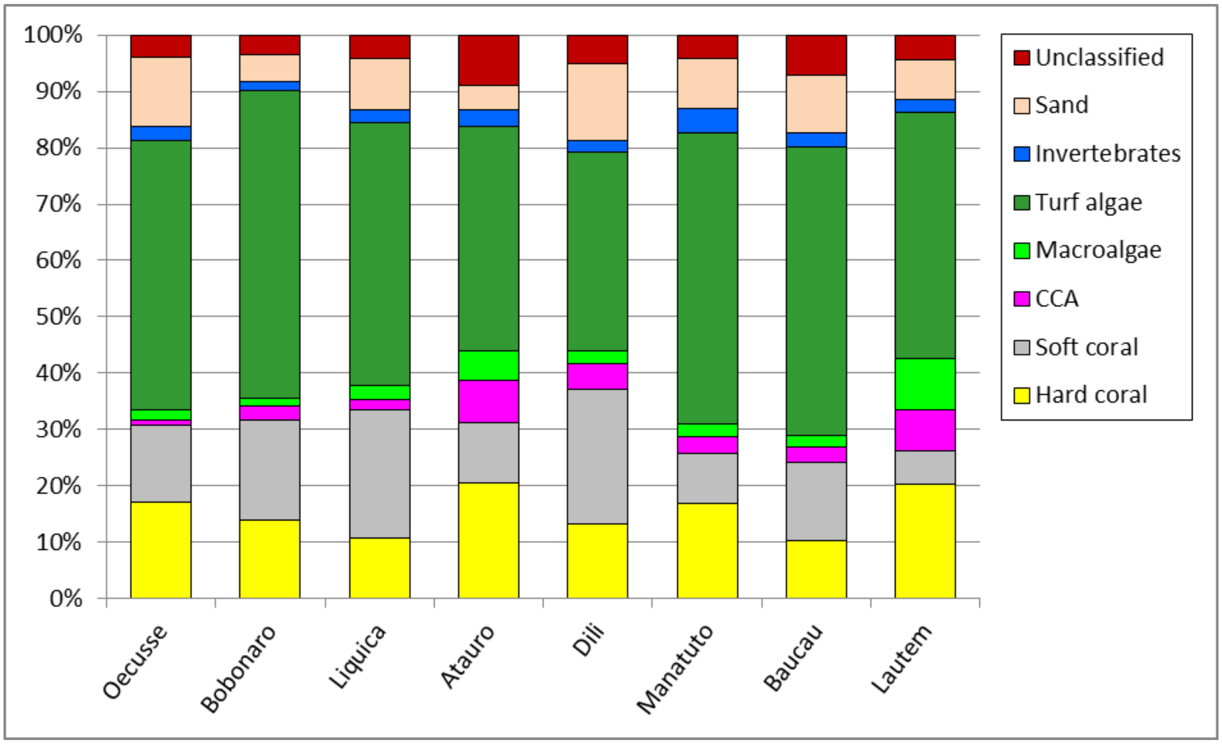

Figure 17. Spatial comparison of average benthic cover (%) for 8 districts along north coast of Timor-Leste, based on the analysis of benthic images collected at hard-bottom sites during surveys conducted by NOAA-CREP in 2013. District mean benthic compositions are spatially displayed from west to east. CCA: Crustose coralline algae.

Table 3. Average percent cover (standard error) of the reef benthos and benthic substrate ratio (hard and soft coral and CCA/turf and macroalgae) by district. Districts are sorted spatially from west to east. CCA: Crustose coralline algae.

District	Sites (#)	Hard coral % (SE)	Soft coral % (SE)	CCA % (SE)	Macroalgae % (SE)	Turf algae % (SE)	Sand % (SE)	Benthic Substrate Ratio
Oecusse	16	17.2 (3.0)	13.7 (3.9)	0.7 (0.3)	1.8 (0.5)	47.9 (4.6)	12.2 (2.5)	**0.9**
Bobonaro	16	14.0 (2.5)	17.8 (3.8)	2.4 (0.7)	1.5 (0.7)	54.5 (4.3)	4.7 (1.8)	**0.8**
Liquica	26	10.7 (1.6)	22.9 (3.6)	1.8 (0.7)	2.4 (0.6)	46.7 (4.7)	9.0 (1.6)	**1.4**
Atauro	22	20.5 (2.0)	10.7 (1.9)	7.7 (1.4)	5.2 (0.9)	39.8 (4.0)	4.4 (1.7)	**1.2**
Dili	14	13.2 (1.3)	24.0 (3.5)	4.6 (0.8)	2.1 (0.6)	35.4 (4.8)	13.6 (2.7)	**1.5**
Manatuto	13	17.0 (3.6)	8.9 (2.1)	2.9 (1.0)	2.2 (1.0)	51.8 (4.6)	8.7 (3.6)	**0.7**
Baucau	13	10.4 (1.8)	13.8 (4.4)	2.8 (0.7)	1.9 (0.6)	51.3 (5.0)	10.3 (3.9)	**0.7**
Lautem	19	20.3 (2.1)	6.0 (1.3)	7.2 (1.4)	9.2 (3.4)	43.7 (4.3)	7.1 (2.1)	**0.8**

Soft corals were another important reef benthic community component, ranging from 0.0 to 55.7% across sites, with an overall average of 14.9% (SE 1.2). The highest soft coral cover was observed in Dili (24.0% [SE 3.0]) followed closely by Liquica (22.9% [SE 3.6]), and while Lautem harbored one of the highest levels of coral cover, it exhibited the lowest levels of soft coral cover at 6.0% (SE 1.3; Figure 17 and Table 3). Macroalgae cover was highly variable among sites, ranging between 0.0 and 60.9%. However, the overall average percent cover among all districts was only 3.5% (SE 0.6). Lautem exhibited the highest levels of macroalgal cover at 9.2% (SE 3.4)—with sites LAU-63 and LAU-29 having significantly higher macroalgal cover compared with all other sites surveyed (60.9% and 34.1%, respectively). Bobonaro had the lowest macroalgal cover at 1.5% (SE 0.7). Turf algae dominated the benthic cover, averaging 46% among all districts. Finally, crustose coralline algae (CCA) cover was relatively low across all districts, but was twice as abundant in the eastern district of Lautem and Atauro Island compared to the other districts (7.2% [SE 1.4] and 7.7% [SE 1.4], respectively). In summary, turf algae, hard corals, and soft corals made up the majority of the benthos, representing >70% of the average benthic cover.

Benthic Substrate Ratio

Benthic substrate ratio, defined as the ratio of the sum of coral (hard and soft) and CCA divided by the sum of turf and fleshy macroalgae, is often used as a metric of reef condition (Houk et al. 2010). High benthic substrate ratios indicate reefs dominated by reef-building corals and calcium carbonate accreting CCA, whereas low benthic substrate ratios indicate reefs dominated by algal forms that do not contribute to reef structural growth (Figure 18). A ratio of 1 indicates a substrate equally covered by reef-building organisms (corals and CCA) and algae (turf and fleshy macroalgae). Dili, Liquica, and Atauro exhibited average benthic substrate ratios higher than 1, and the remaining districts had benthic substrate ratios less than 1 (Table 3).

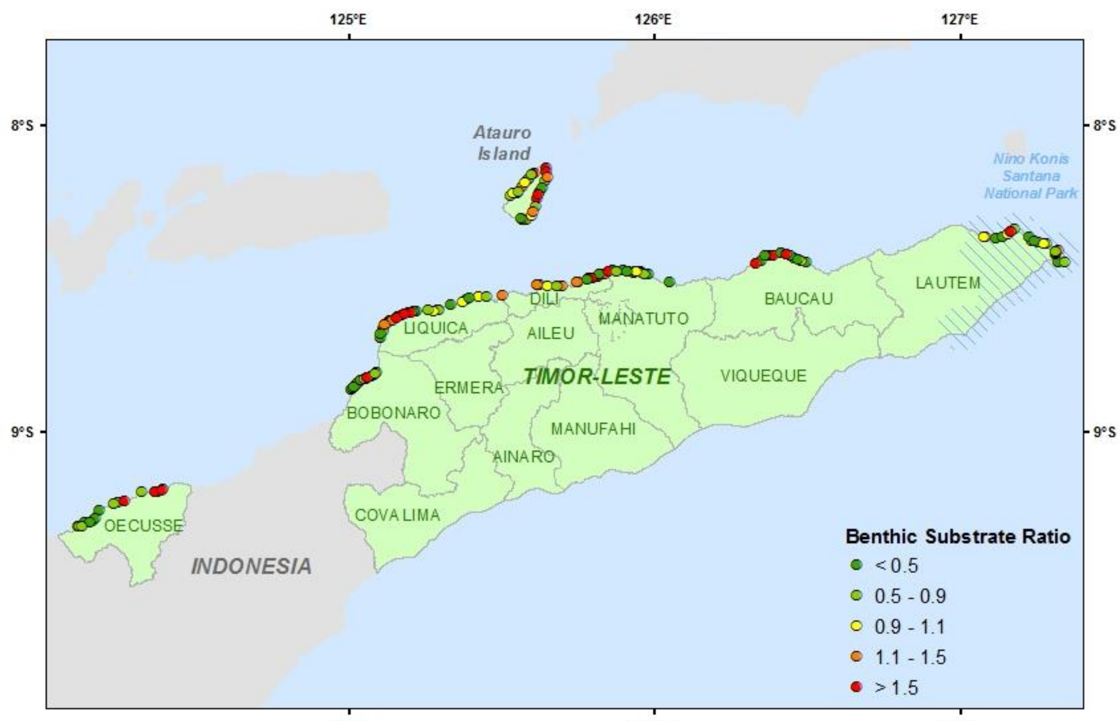

Figure 18. Benthic substrate ratio per site. Sites in green have low substrate ratios (algal dominated), sites in red have high ratios (coral dominated), and sites in yellow are generally balanced between reef builders (corals and CCA) and algae.