

# The composition and drivers of coral reef ecosystems in Timor-Leste

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## Introduction

Coral reefs are among the most diverse and threatened ecosystems on the planet. Hard corals provide the habitat structural complexity upon which other reef organisms rely on. We analyzed the impacts of natural and anthropogenic processes such as waves, sedimentation, and fishing in Timor-Leste by:

- 1) assessing the variability of benthic composition and;
- 2) testing relative wave exposure, distance from nearest river, and human population density of major components of benthic composition and the same drivers plus structural complexity on coral cover.

Timor-Leste is a small island nation in the southern edge of the Coral Triangle<sup>1</sup> (Fig. 1), the region of highest marine biodiversity globally.

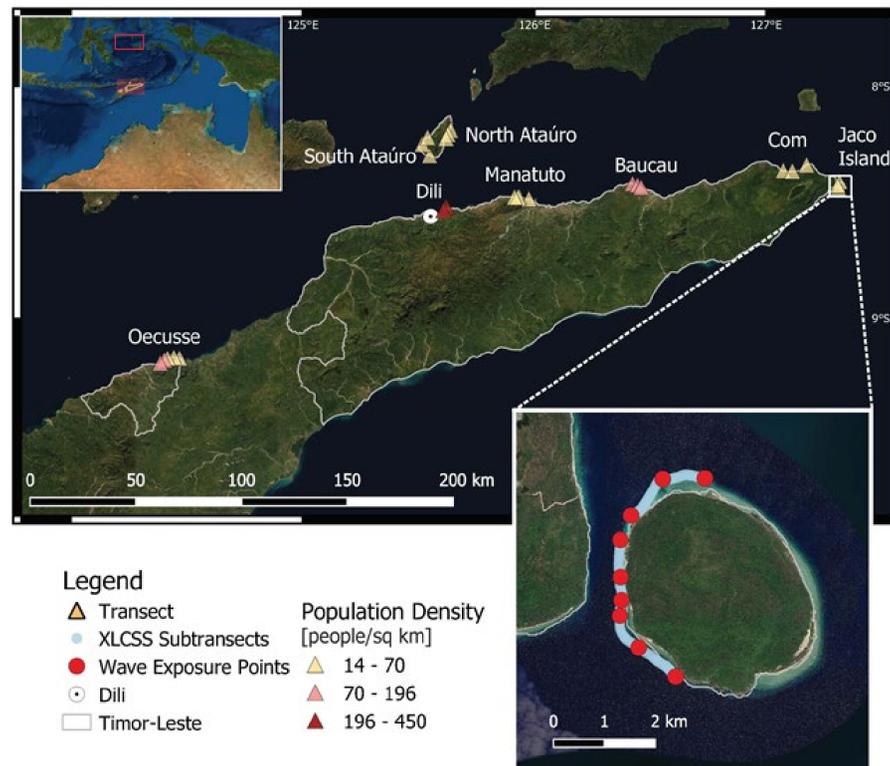


Figure 1: The 26 kilometer-scale phototransects collected by the XL Catlin Seaview Survey in 2014. Colored triangles indicates population density of adjacent *sucos*, or subdistrict. (Bottom Inset) Close-up with red dots indicates start, middle, and end GPS points of phototransects that were used for wave exposure points. Blue dots are subtransects.

## Methods

- Automated image analysis of over 20,000 coral reef 1 m<sup>2</sup> photos, from 26 kilometer-scale transects (Fig. 1) using machine learning<sup>2</sup>.
- Permutational analysis of variance (PERMANOVA) on major reef components including coral morphologies.
- Relative wave exposure from a GIS relative wave exposure model.
- Distance to river (sedimentation proxy) per subtransect calculated in GIS.
- Human population density of *sucos*, or subdistricts, from the 2015 census.
- Distance-based redundancy analysis (dbRDA) testing the effect of wave exposure, river distance, and human population on benthic composition.
- Linear mixed-effects model on coral cover testing the same drivers and the ratio of branching to massive corals (proxy for structural complexity).

## Results

### Variability of benthic composition:

- Benthic composition significantly different between transects (pseudo-F(25,1078) = 20.426, p(permut) < 0.001; Fig. 2).
- Turf on hard substrate* dominate benthic group ranging 26.3% (± 3.2 SE) to 64.8% (± 2.6) per subtransect.
- Coral cover highest at the east and west points of the country and Ataúro Island. Subtransect range from 5.4 (± 0.6%) to 33.0 ± 2.5%.

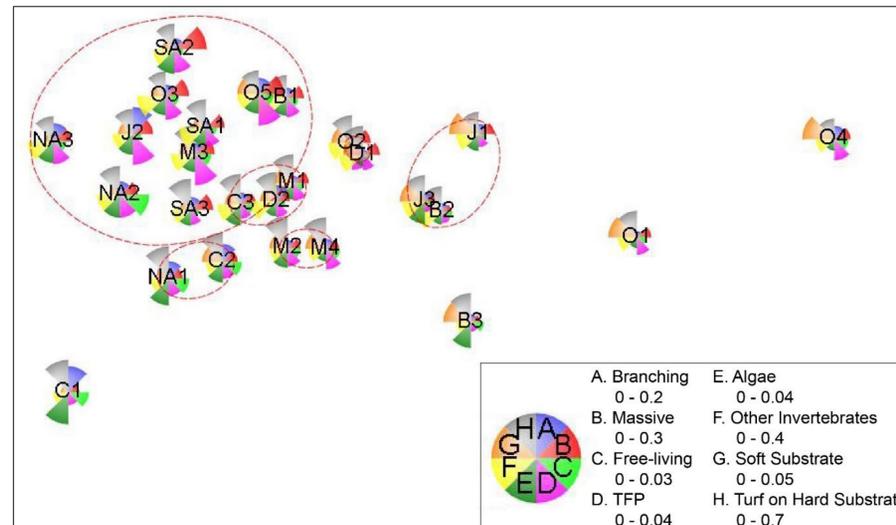


Figure 2: A nMDS plot of coral reef benthic composition from kilometer-scale phototransects in Timor-Leste—2D stress = 0.07. Bubbles represent benthic composition at centroids of each transect to aid visualization. Gray dashed lines represent groupings from similarity profile testing (SIMPREF). Letters and numbers on bubbles represent the region and transect number. Letters are as follows: O—Oecusse, SA—South Ataúro, NA—North Ataúro, D—Dili, M—Manatuto, B—Baucau, C—Com, J—Jaco Island. The pie chart represents benthic composition averaged by transect. TFP—thin/foliose/plating coral morphologies

### Drivers of benthic composition:

- The dbRDA explained 9.3% of the variation in benthic composition (Fig. 3).
- Branching coral*, *free-living coral*, and *macroalgae* positively associated with increasing distance from rivers. Soft substrate had inverse relationship.
- Massive* and *TFP (thin/foliose/plating)* coral increased with wave exposure.
- Turf on substrate* positively associated with human population.

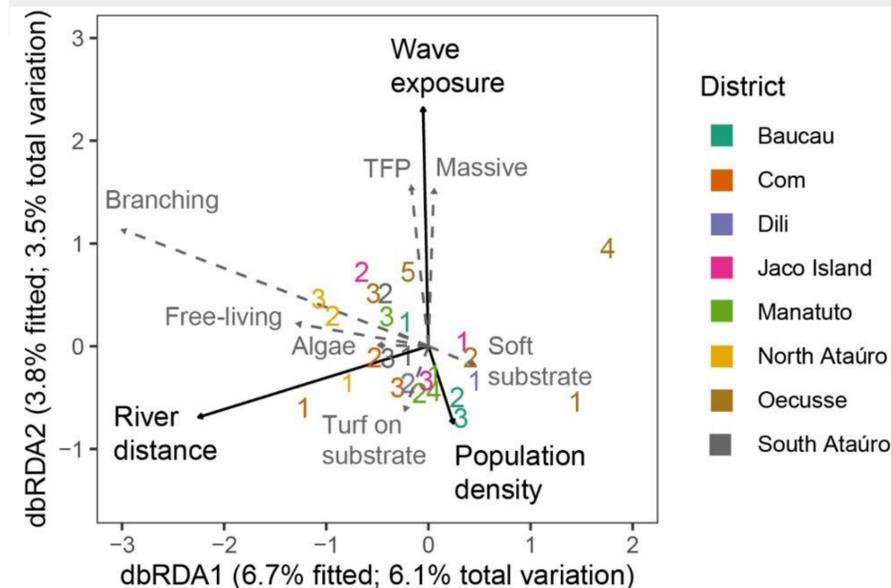


Figure 3: Ordination plot illustrating the relationship between three predictor variables and major benthic components. Massive, Branching, TFP (thin/foliose/plating), and Free-Living represent coral morphological groups and the following benthic groups are shown: Algae—macroalgae, Soft substrate, and Turf algae on hard substrate. Numbers are transect averages of dbRDA scores.

### Drivers of coral cover:

- Linear mixed-effect model explained 76.3% of coral cover variance.
- Significant, positive wave x ratio of branching to massive corals interaction in the model (Fig. 4).
- Effect greater with higher ratio of branching to massive coral morphologies (i.e., increased structural complexity).

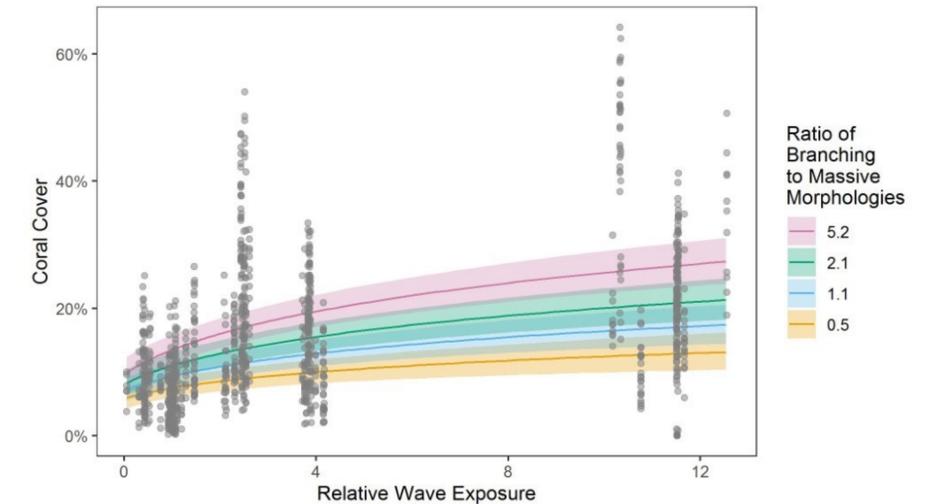


Figure 4: The partial effects plot of the significant, two-way interaction of wave exposure and the ratio of branching to massive morphologies. Covariates were adjusted from mean-centered and both parameters were back-transformed from a log transformation. The y-axis is square root back-transformed coral cover and colored bands represent 95% confidence intervals. Points represent raw data used in the model with transect as a random effect.

## Discussion and Conclusions

### Variability of coral reefs along the north coast of Timor-Leste:

- Coral reefs are highly heterogeneous.
- Coral cover low, but on par with Indo-Pacific meta-analyses of 19–22% coral cover<sup>2,3</sup>.
- Kilometer-scale transects reduce bias of conventional transect placement (10–100 m), but can include non-reef environments like sand.

### Drivers of benthic composition:

- Likely other factors not investigated such as upwelling, geology, or land-use would explain more of the variance in benthic composition.
- Tested variables were most associated with the coral morphologies versus other components like algae or soft substrate.

### Drivers of coral:

- Unexpectedly, maximum wave exposure in Timor-Leste was optimal for coral growth and more structurally complex reefs.
- At 8°S, the north coast is rarely affected by large storms and thus not a major threat to Timorese reefs unlikely other reef regions.
- Distance to river not significant in coral model, but with historical logging and steep terrain land to sea impacts should be monitored.

## References

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