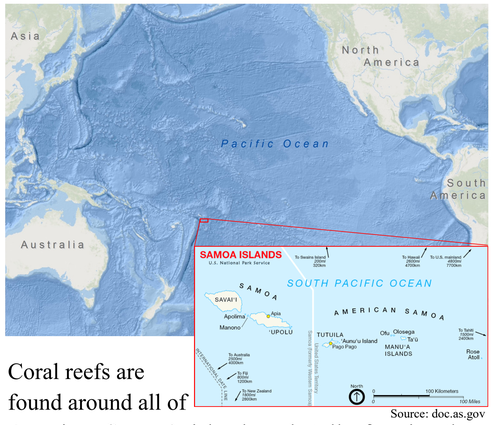
Fish diversity in American Samoa's Coral Reefs:

A richness and evenness analysis of Tutuila's reef fish in 2016 and 2018

Background

American Samoa is a U.S. territory made up of 5 islands and 2 atolls in the South Pacific. Most of the territory's population of 50,000 lives in or near Pago Pago, the capitol city that is located on the largest island, Tutuila. The territory's largest economic sectors are agriculture and fishing, making up 27% and 15% of the economy, respectively [2].



Source: doc.as.gov

Coral reefs are found around all of American Samoa's islands and atolls, forming the basis for the diverse marine life that supports local subsistence and commercial fishing [5]. American Samoa's coral reefs have proven resilient in recent decades [3] but climactic pressures continue to build. A worldwide bleaching event stretched from late 2014 into 2017, hitting American Samoa particularly hard in early 2015 and 2017(see Fig. 1).

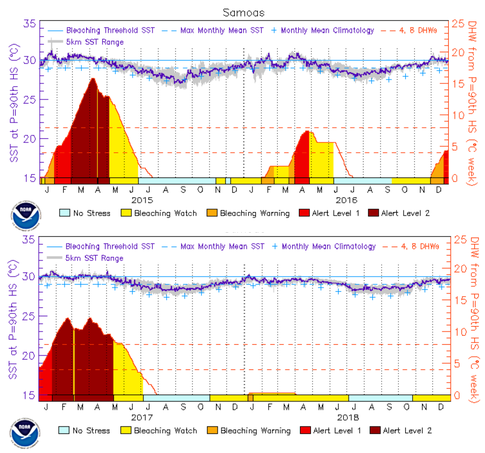


Figure 1. Graphs showing the bleaching alert level over time, starting in 2015 and ending in 2018. Note the extended high alert levels in 2015 and 2017. Source: coralreefwatch.noaa.gov

Understanding the changes in American Samoa's reef fish population has great cultural and economic importance. This analysis focuses on the ecological diversity of the reef fish surrounding Tutuila in 2016 and 2018.

Data Collection

The data used in this analysis were collected as part of the National Coral Reef Monitoring Program led by NOAA and the Coral Reef Ecosystem Program. Data come from conducted stationary point count surveys conducted by divers using stratified random sampling. For each survey, the number of individuals of each fish species was recorded along with estimates of benthic life (this analysis uses only data on fish). Two batches of surveys were used; the first were collected between 04/15/2016 and 05/05/2016 (n = 94) and the second was collected between 06/28/2018 and 07/18/2018 (n = 81). The earlier period occurs in the midst of a major, multi-year bleaching event, while the later period occurs several months after the event is over.

Methods

Species richness was calculated for each survey location using the Shannon-Wiener equation:

$$H' = \sum_{i=0}^{S} p_i \ln(p_i)$$

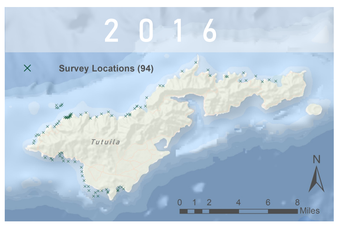
where S is the number of species and p_i is the relative abundance of species i, calculated as the number of individuals of species i over the total individuals of all species. Values for species richness generally vary between 1.5-3.5 but can be as high as 4 in some cases [4], with higher values indicating higher levels of richness.

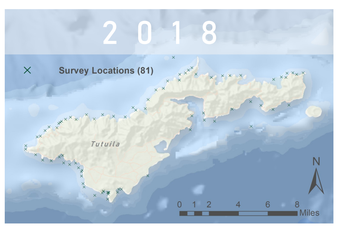
Species evenness was calculated for each survey location using the Shannon-Wiener evenness equation:

$$E' = \frac{H'}{\ln S}$$

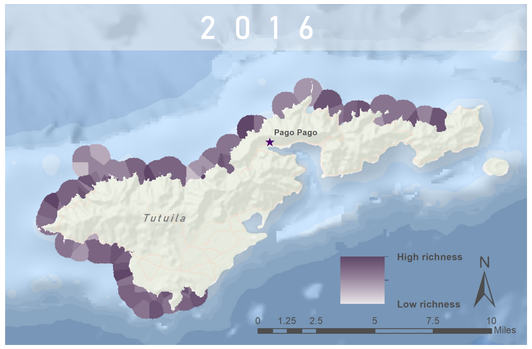
where H' comes from the previous equation and S is the number of species. The value for species evenness ranges from 0-1, with higher numbers indicating a more even distribution of individuals among species.

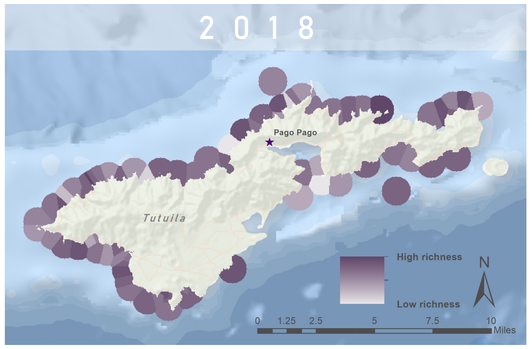
After calculating richness and evenness values for each survey location, raster datasets were created to better represent the information spatially. Each survey was assumed to be representative of the nearby area and each spot was assigned value based on the closest survey, with a maximum distance of 1,000 meters.



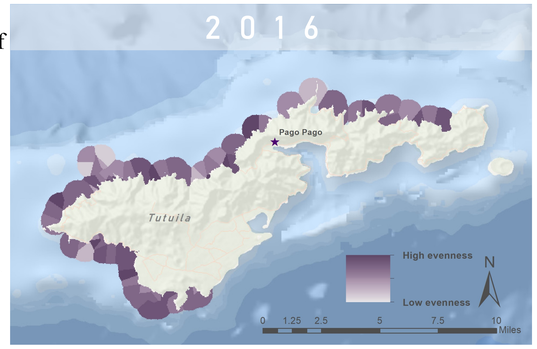


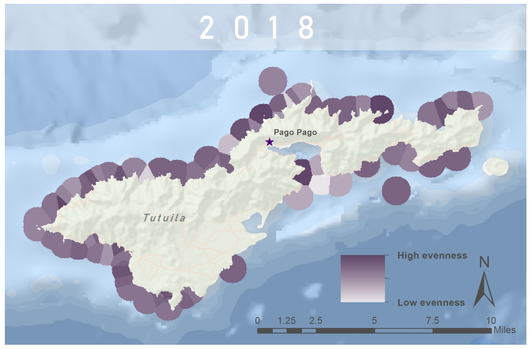
RICHNESS





EVENNESS





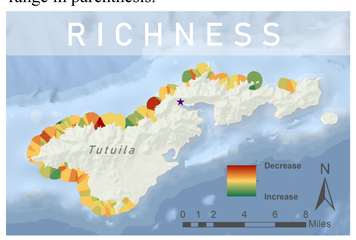
Results and Discussion

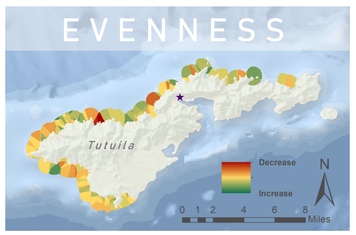
There was no substantial, large-scale difference in richness and evenness between the two survey periods. While the average richness in 2018 was slightly higher than the average richness in 2016 (see Table 1), further statistical analysis would be required to determine whether the result is significant. Average evenness values were very similar between 2016 and 2018.

While minimal overall change was observed, local changes can be observed in areas where data from both years was available. These results could be used to identify areas of particular concern, or assess the effectiveness of current intervention efforts. For example, the fish populations in areas due east of Pago Pago and near the eastern point of the island seem to have declined from 2016 to 2018.

	2016	2018
Richness (range)	2.98 (1.5-3.73)	3.07 (1.31-3.88)
Evenness (range)	0.73 (0.45- 0.89)	0.74 (0.40-0.89)

Table 1. Average values of richness and evenness values in 2016 and 2018, with range in parenthesis.





Limitations

There are several major limitations of this assessment of ecological diversity:

- The Shannon-Wiener equation does not take into account taxonomic distance between species (i.e. two different species within a family are treated the same as two different species in different families).
- These equations produce relative measures that do not incorporate absolute abundance.
- There is no guarantee that a survey is representative of the area in which it was conducted; chance and small-scale ecosystem differences could affect results.
- The surveys were conducted at different times of the year, so seasonality cannot be ruled out as a possible cause of the observed changes.

Recommendations

This analysis should be considered a starting point for future investigation and study of American Samoa's coral reefs.

- Extend this analysis by using broader timescale (limited by data availability), including a larger geographic study area, or incorporating benthic invertebrate and coral species data.
- Use diversity analyses results to focus and evaluate conservation efforts (e.g. restoring areas with low diversity indices, protecting areas with higher diversity indices).
- Continue regular surveys and monitoring to identify long-term trends in reef fish populations.

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Projection: WGS_1984_UTM_Zone_2S

Data Sources:

ESRI

NOAA Coral Reef Monitoring Program

ArcGIS Online

Literature Sources:

1. Bellwood, D. R., Hoey, A. S., Ackerman, J. L., & Depczynski, M. (2006). Coral bleaching, reef fish community phase shifts and the resilience of coral reefs. *Global Change Biology*, *12*(9), 1587–1594.
2. Central Intelligence Agency. (2019, May 1). Australia - Oceania :: American Samoa. Retrieved May 6, 2019, from The World Factbook website:
3. Craig, P., DiDonato, G., Fenner, D., & Hawkins, C. (n.d.). *The State of Coral Reef Ecosystems of American Samoa*. 27.
4. Liu, Y., De Boeck, H. J., Li, Z., & Nijs, I. (2019). Unimodal relationship between three-dimensional soil heterogeneity and plant species diversity in experimental mesocosms. *Plant and Soil*, *436*(1), 397–411.
5. Page, G., Nemerson, D., & Olsen, S. (2012). An Analysis of Issues Affecting the Management of Coral Reefs and the Associated Capacity Building Needs in American Samoa. *American Samoa Capacity Assessment*, 85.