

The Rufford Foundation

Final Report

Congratulations on the completion of your project that was supported by The Rufford Foundation.

We ask all grant recipients to complete a Final Report Form that helps us to gauge the success of our grant giving. The Final Report must be sent in **word format** and not PDF format or any other format. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please complete the form in English and be as clear and concise as you can. Please note that the information may be edited for clarity. We will ask for further information if required. If you have any other materials produced by the project, particularly a few relevant photographs, please send these to us separately.

Please submit your final report to jane@rufford.org.

Thank you for your help.

Josh Cole, Grants Director

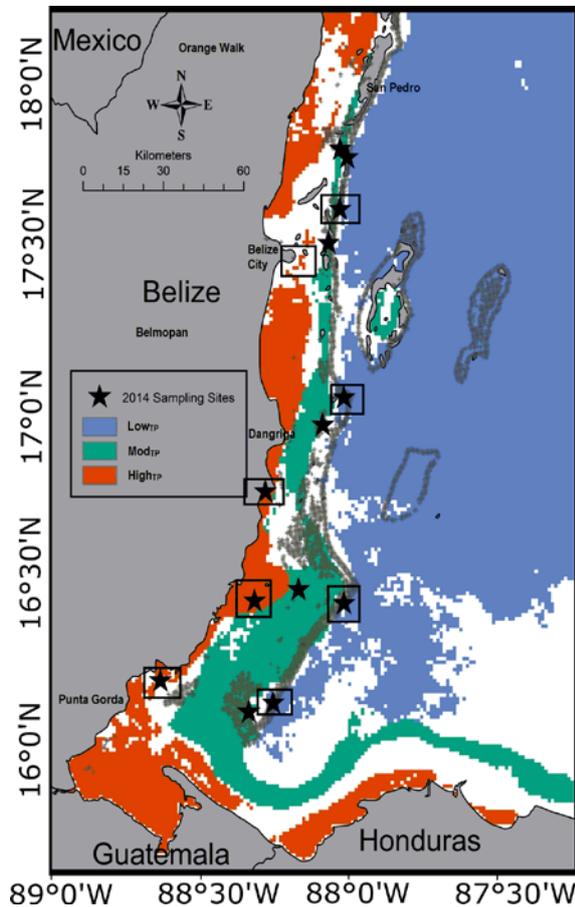
Grant Recipient Details	
Your name	Justin Baumann
Project title	Continuing research on coral acclimation on the Belize Barrier Reef System using thermal history and holobiont physiology
RSG reference	18264-2
Reporting period	9/8/2015-9/8/2016
Amount of grant	£5000
Your email address	j.baumann3@gmail.com
Date of this report	8/31/16

1. Please indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Core two species of coral at eight different sites in Belize			X	We planned to core up to five samples of each species at each site. We were not able to do this at every site but we were able to get at least three from all sites.
Analyse <i>Symbiodinium</i> communities in coral samples collected in 2014			X	We have sequenced DNA from three species of coral across six different sites to explore the diversity of <i>Symbiodinium</i> present in corals at these sites. An additional four sites are being analysed presently.
Analyse coral cores to determine growth and calcification rate		X		We are attempting to pioneer new methods to perform these core analyses and are a little bit behind our timeline as a result. Cores are currently still be analysed. We are unable to confidently determine trends yet but we hope to see some when all of the cores are analysed.
Correlate growth and calcification trends with temperature records and other stressors	X			When the core analyses are complete we will begin this process. Until then, it is temporarily on hold. We expect to being working on this in September or October.

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled (if relevant).

While in the field in Belize we suffered from some equipment failure. One of the drills we brought with us did not have the proper high pressure hoses on it and did not drill corals as a result. Luckily, we brought a backup system that ran on compressed air and were able to drill cores at all sites. This backup system was slower than anticipated which limited our sample size (three cores per species per site).



conducted in 2015.

3. Briefly describe the three most important outcomes of your project.

1.) Coral cores were collected at four backreef and four nearshore reef locations across Belize. These sites were paired by latitude (see map below).

Figure 1: Map of survey sites (stars) and coring sites (boxes) across the Belize Mesoamerican Barrier Reef System. Surveys were conducted in 2014 and coring was

We collected three to five cores of both *Siderastrea siderea* and *Pseudodiploria strigosa* when possible. Due to time restraints and equipment failure we collected only *S. siderea* at some sites. Either 1" or 2" diameter cores were collected. These cores date back to at least 2002. 2002 is the first year that high resolution satellite temperature data was recorded (NASA JPL MUR-SST). This temperature data was used to classify the Belize Mesoamerican Barrier Reef System (MBRS) into three distinct thermal regimes (seen above in red, green, and blue in Fig 1). These thermal regimes are distinct based not only on maximum temperature but also on the degree of temperature variability and number of days above the bleaching threshold seen at each site each year. We have already determined that the coral communities are different at these sites and we are currently analysing coral cores from low_{TIP} and High_{TIP} sites (backreef and nearshore reefs, respectively) to determine if corals at these sites show differences in growth and calcification rates.

Coral cores have been CT scanned at the University of North Carolina at Chapel Hill and growth and calcification records are currently being analysed. We hope these data will help us determine the impacts of temperature and local stressors on long term growth of corals across Belize.

2.) Temperature loggers that were placed at all of our sites during our 2014 surveys were recovered. These in-situ temperature loggers give us the ability to assess the accuracy of satellite temperature models and to see small scale variability at a specific site. Figure 2 shows a comparison of logger temperatures (HOBO pendant and HOBO Prov2) and three different satellite products. It is clear that the loggers and high resolution satellite temperature records (MUR SST and GHRSSST) are quite similar. This confirms our methods and allows us to continue using satellite products (coupled with in-situ logger data) to determine the impacts of temperature on coral growth and calcification.

Site Specific in-situ vs. satellite temperature comparison (Monthly Averages from Nov 2014- October 2015)

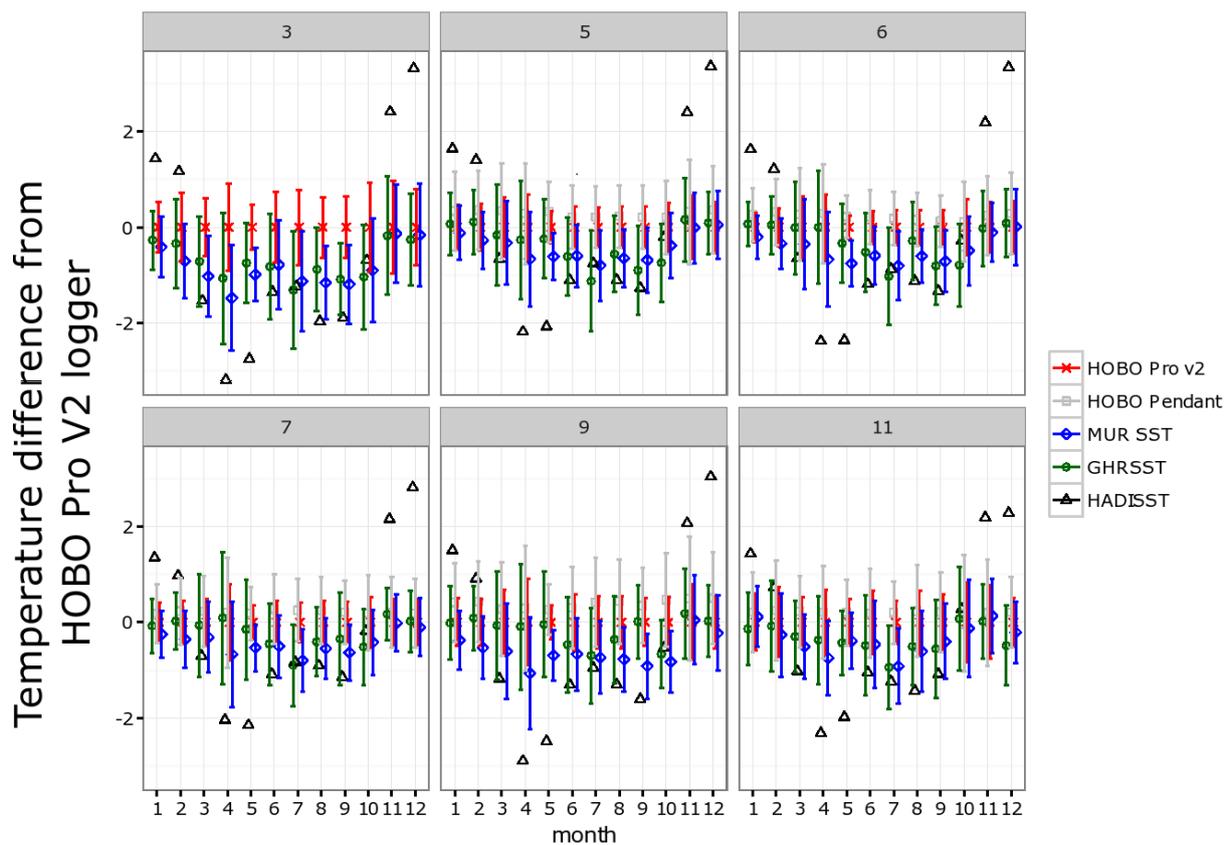


Figure 2: A comparison of in-situ temperature logger data and satellite SST records at 6 of our survey sites across Belize.

3.) We established a new collaboration with an NGO in Belize called the Toledo Institute for Development and the Environment (TIDE). TIDE manages a marine reserve that we do some of our research in and was interested in seeing our data and talking to us about our results. My lab has been working in this area for some time now so we agreed to give a seminar to local stakeholders and NGO employees at the TIDE office. In addition to the seminar we met with the staff biologist via Skype and discussed local scale issues (such as nutrients) specific to the marine reserve. TIDE trains Belizeans to become scientific divers and field researchers. We hired two such young scientists in training to help us with our work. They spent 2 weeks with us learning how to core corals and do field work. It was a great experience for both sides as we were able to learn more about the culture of Belize and the values of its citizens (especially in regards to the coral reefs).



Figure 3: TIDE community volunteer Curtis Hines cores a coral as part of our research team.

4. Briefly describe the involvement of local communities and how they have benefitted from the project (if relevant).

Local communities in Belize were actively involved in our work and we believe they will benefit from it as well. We contacted the Toledo Institute for Development and Environment (TIDE) before our field season in order to build a partnership with them. TIDE manages one of the marine reserves that we did some of our coring inside of and wanted to meet with us to discuss our plans and hear our ideas for targeted conservation efforts inside of their reserve. We also wanted to hire some of their trained local citizen diver/ scientists to help us do our work. These Belizean citizens are aspiring conservationists and marine scientists and we wanted to give them some real world experience working with a team of marine scientists from abroad and help them gain new skills. We had two such divers join us for the duration of our trip. Additionally, we gave a seminar at TIDE about our ongoing research into the impacts of humans, temperature, and nutrients on coral reef ecosystems in Belize. This talk was attended by members of the local community as well as conservationists from two local NGOs in Southern Belize. This seminar was great for us as well as we were given an opportunity to interact with local stakeholders and hear their concerns and values.

In addition to TIDE, we worked with local boating guides to secure dive boats and gear and we worked exclusively with small Belizean-owned business for lodging and food. Our goals on trips like these are not just to do our research and leave, but to also learn about the local community and provide them with economic support.

Our research aims to understand how coral reefs in Belize have changed in the recent past and how they may change in the future. Understanding future changes in reefs allows us to potentially predict how ecosystem services may change. We hope to share our work with the Belize Fisheries Department and their partners (such as TIDE) to inform policy on new management practices and protective status. Rufford funded research by our group has already determined that more inshore reefs in Belize may warrant further protection (currently they are not the focus of management efforts) and we hope to build on these findings in the future.

5. Are there any plans to continue this work?

There are plans to continue this work. Presently we are analysing coral cores in hopes of calculating growth and calcification records which we will then correlate to satellite temperature records to determine the impact of temperature on coral growth. Additionally, cores will be archived for future use in isotope studies. These isotope studies can reveal concentrations of pollutants and sediments in the skeletal

matrix which would allow us to assess the potential impacts of local stressors on coral growth.

Beyond the coring work, we hope to return to our study sites to continue our acclimatisation research. We now know that coral communities across Belize vary by thermal regime and we are currently looking into whether thermal regime impacts growth. We also want to understand how corals living in higher stress thermal regimes (nearshore reefs) are able to cope with these conditions. As such, we are planning to collect samples of four species of coral from each thermal regime and do a tank experiment with them. The corals will be exposed to varying degrees of daily thermal variation. If time and funding permit, we would also like to begin a reciprocal transplant experiment in which we move corals from each thermal regime to sites inside of the other thermal regimes and track their growth and health over the next 2-3 years. These two experiments combined with our previous work will allow us to make robust conclusions about how thermal regime and thermal stress can alter communities and coral physiology across Belize. Such knowledge could prove useful to NGOs and local managers who are looking to make informed policy decisions.

6. How do you plan to share the results of your work with others?

The results of the first Rufford Small Grant funded project have recently been published in the peer-reviewed journal PLOS ONE. Additionally, results from the continuing study have been presented at the International Coral Reef Symposium and the Ocean Sciences Meeting in 2016. A short documentary about this work has been produced by an undergraduate that I mentored and is available at my website (<https://jbaumann3.wordpress.com/research/>). Some results of this work have been shared with the Healthy Reefs Initiative. We hope that our data may be useful in improving their very valuable annual report titled "Healthy Reefs Report Card" that shows the current health status of coral reefs and fish populations across the western Caribbean. All of our major findings have been shared with the Belize Fisheries Department in the form of annual reports. New results will be published in various peer-reviewed articles and presented at academic conferences. They will also continue to be shared with TIDE and Belize Fisheries Department. In addition to these conventional means of communication, I have also posted several times on my blog (UNdertheCblog.org) about this project and other projects related to it and I plan to continue writing posts about this work as it progresses.

7. Timescale: Over what period was The Rufford Foundation grant used? How does this compare to the anticipated or actual length of the project?

The Rufford Foundation grant was used over the course of approximately 1 month (September-October 2015). The grant was used to cover some equipment and preparation costs as well as travel, gear, food, and accommodation costs of our research team in Belize. Our research trip was conducted in early to mid-October 2015. This timeline lines up exactly with the one we proposed. Although the grant was spent on the trip, invaluable samples collected are still being processed and likely will be utilized for multiple studies.

8. Budget: Please provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used.

Budget is in pounds sterling. Conversion rate is estimated rate between pound and USD (~\$1.3 per pound). Conversion rate between USD and Belize Dollar is 0.5 USD per 1 Belize Dollar. While Belize Dollar amounts are not included here they should be noted as some transactions occurred using Belize Dollars.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Travel to and from Belize (airfare for 6 people)	1750	1750	0.00	No difference as this was based on airline quotes. 50% of travel was paid by Rufford and 50% was paid by an NSF grant to my PI (Dr Castillo) as the trip was for his project and my project.
Boat Rental	1625	0	-1625	Due to difficulties getting cash advances from our university Dr Castillo used his grant to cover boat rental which was direct billed to the university. I made up the costs by covering additional lodging and tank rental.
Dive Gear	600	377	-223	Saved money on fins by buying used from Ebay and borrowed a few less essential items.
Lodging	925	1950	1025	Additional lodging was covered using Rufford Foundation grant money to

				make up for costs that were covered by Dr Castillo in other areas (boat rental and meals). We split the trip costs between our grants and I ended up covering lodging due to logistics.
Gas for drill compressor	100	0	-100	The gas powered drill was used for Dr Castillo's research only so he covered the cost of gas for it.
Meals	1000	500	-500	Most meals were covered by Dr Castillo. I used Rufford Foundation funds to cover additional lodging charges and to cover tank rental to make up for this as the two of us were splitting costs on the trip.
Tank Rental	0.00	425	425	We needed to rent dive tanks to power our compressed air drill. We planned to have these charges added to boat rental fees but we needed more tanks than the boat company had so we had to rent them separately. Since we needed these tanks to drill my corals I covered the cost.
Total	6000	5000	1000	

9. Looking ahead, what do you feel are the important next steps?

The most pressing next step is to finish analysing all of the coral cores. We are currently working diligently to finish analyses and expect to be finished in the next month or two. Over the fall and winter I plan to compare coral growth data to satellite temperature records in order to determine if temperature regime plays a role in altering coral growth rates in Belize.

After assessing coral community differences, coral symbiont community differences, and coral growth and calcification rates across thermal regimes, I would like to experimentally manipulate temperature conditions to assess the stress response of corals from each thermal regime to varying degrees of stress. I hope to do this with a future Rufford Foundation grant. Corals will be collected from each thermal regime

and exposed to varying degrees of daily temperature variability. We aim to test the impact of thermal variation on coral stress response, as it is not well documented, especially in the Caribbean. Are corals from more variable environments (inshore is more variable than offshore) better able to cope with stress? If so, they may warrant further protection. This research could prove very useful to local managers and NGOs who are looking to prioritise use of limited resources to protect the coral reefs of Belize.

10. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the RSGF receive any publicity during the course of your work?

The Rufford Foundation logo was used many times during this past funding year.

I used the Rufford Foundation logo for a research poster that I presented at the University of North Carolina at Chapel Hill annual Climate Change Symposium.

Additionally, the logo featured on two posters presented by Joe Townsend, an undergraduate who works with me, at the 2016 Ocean Sciences Meeting and the 13th International Coral Reef Symposium. Both conferences are major international conferences attracting 5-10 thousand participants. The logo was also used in the following academic talks:

- J Baumann et al – Ocean Sciences Meeting 2016
- J Baumann et al – 13th International Coral Reef Symposium
- L Speare – 2016 Celebration of undergraduate research at UNC Chapel Hill
- J Townsend – 2016 Celebration of undergraduate research at UNC Chapel Hill

The Rufford Foundation was also a monetary sponsor of the 13th International Coral Reef Symposium.

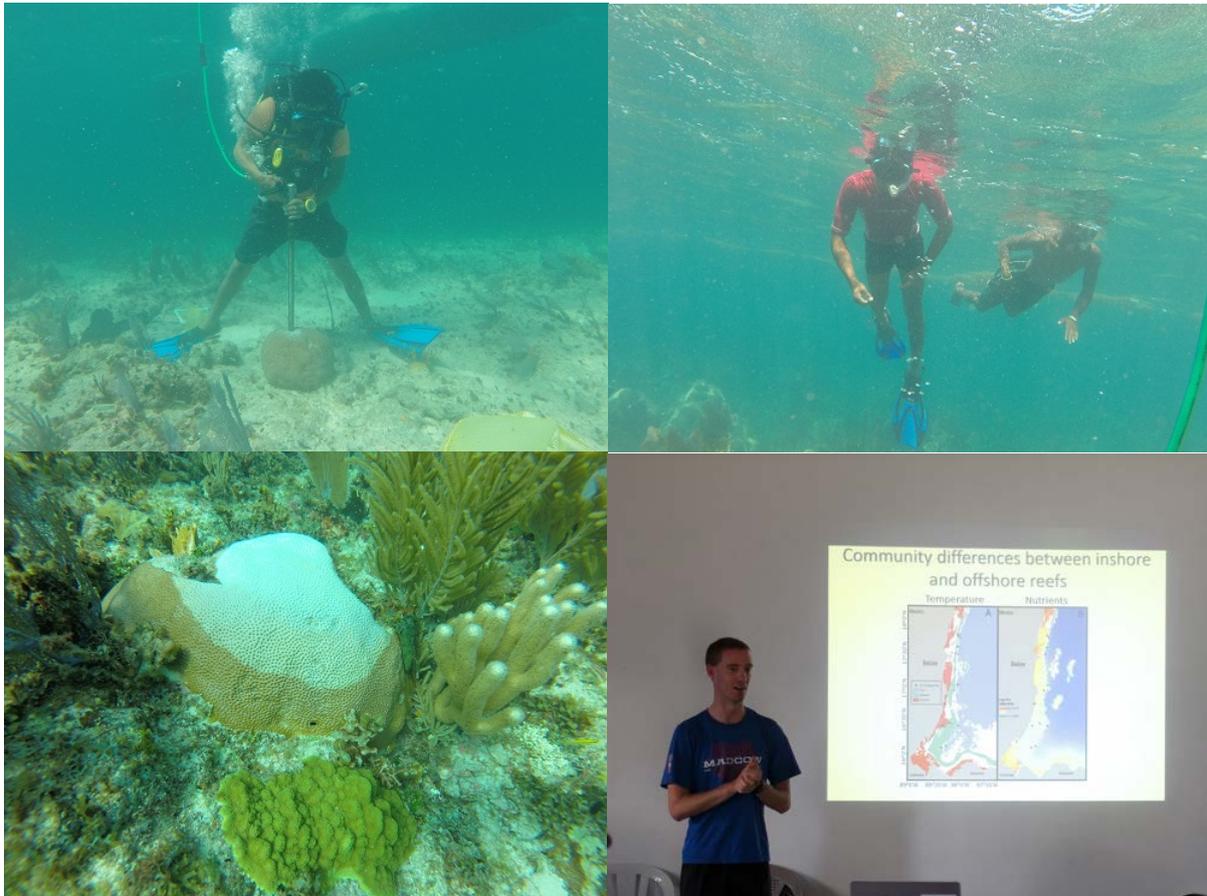
I also feature the logo on my personal research website (<https://jbaumann3.wordpress.com/research/>)

11. Any other comments?

The two Rufford Foundation small grants that I have received have been vital to my PhD dissertation research. Without them I would not have been able to do any of my proposed work. I am very grateful for your support!

Working in Belize has taught me a great deal about a culture that I was unfamiliar with. I have enjoyed my work there and feel a real connection to the people having interacted with many of them during my research trips. Locals in Belize care about their coral reefs, as they depend on them for food and to sustain eco-tourism, which

is a big portion of their economy. We received nothing but support from all of the local boat captains, field assistants, and business owners that we interacted with and we look forward to continuing to build these relationship and to helping them conserve their beautiful coral reefs for future generations.



Left to right: Belizean field assistant, Anthony, coring a small colony of *P. strigose*; Belizean field assistant, Curtis, and boat captain, Ray, help us locate corals; Photo of mild bleaching occurring in Oct 2015 in Belize & J. Baumann presenting RSG funded research at TIDE (Belize).