DPLR1\1021

Darwin Plus Local - Final Report (1)

Officer: Jessica Magnus

Section 1 - Darwin Plus Local Project Information (Essential)

Project Reference Number

DPL00004

Q1. Project Title

No Response

Overseas Territory(ies)

☑ Bermuda

Lead Organisation or Individual

Living Reefs Foundation

Partner Organisation(s)

Tritonia Scientific Limited

Value of Darwin Plus Local Grant Award

£49,997.00

Project Start Date

04 April 2023

Project End Date

31 March 2024

Project Leader Name

Samia Sarkis

Project Website/Twitter/Blog etc.

www.livingreefs.org/@bdalivingreefs

Report Author(s)

Samia Sarkis

Report Date

28 March 2024

Project Summary

No Response

Project Outcomes

Checked	**Biodiversity: improving and conserving biodiversity, and slowing or reversing biodiversity loss and degradation;**
Unchecked	**Climate Change: responding to, mitigating and adapting to climate change and its effects on the natural environment and local communities;**
Unchecked	**Environmental quality: improving the condition and protection of the natural environment;**
Checked	**Capability and capacity building: enhancing the capacity within OTs, including through community engagement and awareness, to support the environment in the short- and long-term.**

Section 2 - Project Outcomes (Essential)

On a scale of 1 (high – outcome substantially exceeded) to 5 (low – outcome substantially did not meet expectation), how successful do you think your project has been?

⦿ 1 - Outcome substantially exceeded

Project outcomes and justification for rating above

1. Biodiversity:
The project is a pilot study to demonstrate the strengthening and sustainability of a man-made boulder barrier using live corals and protect the shoreline from storm and hurricane waves. The goal was to not only strengthen shoreline protection using a nature-based solution involving live corals, but also simultaneously improve the biodiversity of corals in this area previously damaged by coastal development. The project was timely in that a source of large coral colonies, identified by the Department of Environment and Natural Resources (DENR), needed immediate translocation to avoid physical destruction due to the replacement of an oil dock. This source of 'rescue' corals supplemented the stock obtained by Living Reefs Foundation's coral culture programme. Coral colonies planted ranged from 10 cm to 1m in diameter, with homegrown colonies ranging between 10-30 cm, and rescued colonies greater than 30 cm. This source of corals resulted in the covering of a larger area of the boulder barrier, and exceeded the projected coral density within the time frame of the project, resulting in:
• Increased quantity of coral colonies planted from 100 to 170, and
• Increased coral cover on a total of 20 planting sections , coral cover was increased by 1.2% to 31.3% by the end

of the project.
A 99% survivorship was determined during the final survey (March 2024). This has exceeded our estimated outcome with respect to the impact on biodiversity in a 12 month period. A total of 4 non-branching reef-building coral species were planted as initially proposed; all colonies were genetically diverse and NOT obtained from fragmentation. This contributes to the resilience of the reef in the long term by maximising the genetic capacity of corals to adapt to environmental changes.
2. Capacity:
• A Puget computer equipped with Agisoft software to process 3D georeferenced maps of the seabed installed in Living Reefs Foundation's office. Resolution for extracting metrics from the 3D model enables accurate quantification of coral growth to ±1cm. This is made available to Bermuda government officers, namely the Curator of Shipwrecks who has been to date outsourcing the processing of 3D wreck models to a U.S. organisation.
• Training: Living Reefs staff (1 full-time, 2 part-time) in the surveying and processing of 3D models, and 1 Bermuda government officer. Two other Bermuda officers were interested, but unable to be trained during the timeframe of the project; however, they are updated on the methodology used. 15 Bermuda based students and community volunteers assisted in data collection and coral planting.
• A digital 3D model of the entire study site is available and shared with the Bermuda Government; in addition, to facilitate viewing by those who cannot access the programme, a video of the 3D map was produced.
• A digital 3D model of coral planting areas to monitor subsequent growth.
• Support from Ministry (Home Affairs) to scale up study to entire length of Causeway shoreline (>5,000 m2) by financing coral production infrastructure; this exceeded our expectations of the government's engagement.

Supporting Evidence - file(s) upload

Coral Planting Evidence Results Photos
30/04/2024
17:21:10
pdf 6.9 MB

Photogrammetry SOP PG004
30/04/2024
17:14:52
pdf 68.9 KB

Photogrammetry SOP PG003
30/04/2024
17:14:49
pdf 101.84 KB

Photogrammetry SOP PG002
30/04/2024
17:14:47
pdf 263.58 KB

Photogrammetry SOP PG001
30/04/2024
17:14:40
pdf 89.83 KB

Supporting Evidence - links to published document/online materials

1. Bermuda Royal Gazette Article and Living Reefs introducing nature-based coastal solution to Bermuda Climate Summit (June 2023): https://www.royalgazette.com/re-insurance/business/article/20230627/pioneering-coral-reef-project-can-have-wideranging-impact/
https://bda.bm/bermuda_climate_summit_agenda/

2. Bermuda Royal Gazette- print out of Biodiversity Challenge Fund newsletter (Feb 2024): https://www.royalgazette.com/opinion-writer/opinion/article/20240226/corals-the-nature-based-breakwater/

3. Video of 3D model generated from a photogrammetry survey by Agisoft model showing the man-made

boulder barrier with corals. Model processed by Living Reefs Foundation Bermuda; video processed by Tritonia Scientific, U.K. https://youtu.be/iN_E2dVtxeU

Project Challenges

The project encountered logistical and technical problems, but these were surmounted and did not hinder the final outcomes of the project. Of the risks anticipated, only the risk of failure to accurately measure changes in outplanted coral colonies was encountered and resolved through training and repeat models.
Unexpected challenges were:
• One month delay in building and custom clearing of the Puget Computer Work station extending the operating date to mid-June. This entrained further delays related to scheduling the training officer, and readiness to process coral reef photos was not complete until beginning of July. Progress was further slowed due to stormy weather conditions during July and August. To achieve all activities, field work was extended until December 2023; at this time, declining seawater temperatures called for shorter and more frequent SCUBA dives; in turn increasing boat rental expenses.
• Unexpected technical issues related to:
o the large size of the rescued coral colonies. We did not have the equipment to handle 70 cm to 1 m colonies, and called on more divers to retrieve them successfully.
o The LRF boat malfunctioned shortly after the start of the project, and we were forced to rely on the rental of a smaller boat.
o The study site proved to be difficult to survey due to its shallowness. This challenged the collection of clear photos using the stereoscopic Go Pro frame, and was surmounted by conducting multiple repeat surveys.

Lessons Learned

i) Project management effective by following established, clear tasks outlined in chronological order. Expenses were closely monitored to align with the projected costs for each sector, and remain within the grand total.
• Communication with Government departments followed the rigorous schedule, with each meeting providing a short presentation on progress and discussion of next steps
• Early communication with our partner Tritonia allowed order of equipment and materials prior to the arrival of training officer
• BCF newsletter was a huge boost in media awareness from Bermuda's Royal Gazette newspaper and UK The Telegraph.
• Technical: a GitHub with instruction notes was initially set-up by Tritonia and further developed by LRF is a great reference
• Training of several LRF staff was beneficial in establishing know-how on island and a 'think-tank' to improve techniques

ii)Timeframe allocated to training by Tritonia was not sufficiently flexible to allow for delays in shipping of computer workstation and poor weather. Thanks to the quality of Bermuda assistants, uptake of methodology was rapid;but,some government officers were unable to attend.
iii) Increase timeframe of the project to 2 years minimum; this would enable engagement of all government officers interested, and double the field season for planting and monitoring
iv) a. Do not underestimate the workload on a given day, and include sufficient human resource and equipment capacity in the proposal.
b. Meet with government departments regularly; this will enhance project longevity.
c. Make sure that all documentation, instructions are transferred from partners early on and throughout.

Section 3 - Project Finance (Essential)

Project Expenditure

Project Spend (indicative) since last Annual Report	2023/24 Grant (£)	2023/24 Total actual Darwin Plus Costs (£)	Variance %	Comments (please explain significant variances)
Staff Costs	[redacted]			
Consultancy Costs				
Overhead Costs				

Travel and Subsistence	[redacted]
Operating Costs	
Capital Items	

Others	[redacted]		
Total	49,977.00	49,975.22	-5.99

Please provide a short narrative summary on project finances.

The actual total expenses remained within budget, but some variation in the distribution of funds proved necessary. The re-allocation was made possible through the additional contribution of Dive Bermuda in supplying free tank refills mid-project, and the Glasgow-Bermuda flight charge covered by BIOS for P. Schulz, Tritonia consultant. Re-allocation was necessary due mainly to higher than expected costs in 1) overhead, related to shipping and duty, and 2) other expenses related to available internet and bandwidth capacity.
1) Shipping and duty costs were high and incurred by receiving equipment from different sources and disallowing for consolidated shipment. Duty for computers and parts in Bermuda amounts to 22%; shipping depends on weight and volume. A 30% estimate was included in the current budget for both shipping and duty; in fact this resulted in a 32.5% increase on the price of landed purchased goods.
2) Internet: Living Reefs Foundation's offices are located within the Marine Resources Division of the Department of Environment and Natural Resources. LRF has an independent internet source from that of Government because of its non-governmental status; its wifi capacity is sufficient for daily work, but proved insufficient to download new modelling software and GPS data. An additional local mobile device was purchased to install all necessary software and during the surveying period.

There was no co-financing for this project; all planned in-kind contributions were received, with the additional in-kind provision of SCUBA tanks fills by Dive Bermuda Ltd.

Section 4 - Contribution of Project to Darwin Plus Programme Objectives

Please select up to **one** indicator that applies within **each group/indicator list (A, B, C, D)** and report your results for that indicator in the text box underneath. If you do not have relevant results to report for any of the indicators in a particular group, you can leave them blank.

Please also submit some form of evidence (above) to demonstrate any results you list below, where possible.

Group A: Capability and Capacity - Core Darwin Plus Standard Indicators (select one)

Unchecked	**DPLUS-A01: Number of people from key national and local stakeholder groups completing structured and relevant training.**
Unchecked	**DPLUS-A02: Number of secondments or placements completed by individuals of key local and national stakeholders.**
Checked	**DPLUS-A03: Number of local/national organisations with improved capability and capacity as a result of project.**
Unchecked	**DPLUS-A04: Number of people reporting that they are applying new capabilities (skills and knowledge) 6 (or more) months after training.**
Unchecked	**DPLUS-A05: Number of trainers trained reporting to have delivered further training by the end of the project.**

Group A Indicator Results

3 staff from LRF and 1 from Bermuda Government

Group B: Policies, Practices and Management- Core Darwin Plus Standard Indicators (select one)

Unchecked	**DPLUS-B01: Number of new/improved habitat management plans available and endorsed.**
Unchecked	**DPLUS-B02: Number of new/improved species management plans available and endorsed.**
Unchecked	**DPLUS-B03: Number of new/improved community management plans available and endorsed.**
Unchecked	**DPLUS-B04: Number of new/improved sustainable enterprises/ community benefits management plans available and endorsed.**
Checked	**DPLUS-B05: Number of people with increased participation in local communities / local management organisations (i.e., participation in Governance/citizen engagement).**
Unchecked	**DPLUS-B06: Number of Local Stakeholders and Local Communities (people) with strengthened (recognised/clarified) tenure and/or rights.**

Group B Indicator Results

15 volunteers and students from the Bermuda Aquarium and Bermuda Institute of Ocean Sciences

Group C: Evidence and Best Practices - Core Darwin Plus Standard Indicators (select one)

Unchecked	**DPLUS-C01: Number of best practice guides and knowledge products published and endorsed.**
Unchecked	**DPLUS-C02: Number of new conservation or species stock assessments published.**
Unchecked	**DPLUS-C03: New assessments of habitat conservation action needs published.**
Unchecked	**DPLUS-C04: New assessments of community use of biodiversity resources published.**
Unchecked	**DPLUS-C05: Number of projects contributing data, insights, and case studies to national Multilateral Environmental Agreements (MEAs) related reporting processes and calls for evidence.**

Group C Indicator Results

N/A

Group D: Sustainable Benefits to People, Biodiversity and Climate - Core Darwin Plus Standard Indicators (select one)

Checked	**DPLUS-D01 Hectares of habitat under sustainable management practices.**
Unchecked	**DPLUS-D02: Number of people whose disaster/climate resilience has been improved.**
Unchecked	**DPLUS-D03: Number of policies with biodiversity provisions that have been enacted or amended.**

Group D Indicator Results

2,500 sq. metres of shoreline under sustainable nature-based coastal protection practice.

Section 5 - Project Partnerships, Wider Impacts and Contributions

Project Partnerships

i) Tritonia Scientific Ltd. (UK), technology partner. One training officer dedicated to this project to:1. Provide specifications for all photogrammetry equipment, 2. Consult with Puget Computers to custom build a workstation, 3. Preliminary test of equipment on site, 4. Train Bermuda-based staff in surveying and modelling, 5. Prepare photogrammetry instructions, 5.Assist remotely in transforming models to user friendly formats. The project lead, LRF responsible for: Project planning, coordination, government liaison, budget management, implementation and document preparation for reporting and communication.
ii) The Department of Environment and Natural Resources (DENR) and the Department of Works & Engineering (W&E) were involved. DENR provided input in defining the site boundary, granted permits for coral translocation,

and approved an additional source of coral colonies rescued from coastal development project. One officer joined training sessions. W&E approved coral planting on an underwater infrastructure (boulder barrier) and provided engineer expertise in building an efficient hybrid barrier.
iii) A Github with basic instructions was established by Tritonia prior to the site visit, which was very useful. Instead of remote assistance, a second site visit during the latter part of the project would have been more productive.
iv) Dive Bermuda SCUBA operator contributed in-kind to the project through partial free refill of tanks; 15 volunteers from the Bermuda Aquarium (BAMZ)and the Bermuda Institute of Ocean Sciences assisted in coral translocation. Engineers from Shell Oil facilitated the removal of corals earmarked for destruction with DENR. LRF raised awareness of residents and visitors through Coral Garden tours offered weekly.

Wider Impacts and Decision Making

A final meeting with the Minister and DENR concluded with the government's support to 1) expand this project to protect the Causeway bridge along its entire shoreline by upgrading the infrastructure for coral production and 2) update the Total Economic Valuation of Bermuda's Coral Reefs (2011) to better estimate the role of corals in coastal protection; this will serve to identify vulnerable areas and prioritise restoration efforts, and will update the estimated coastal protection value ($575 million per year for Bermuda's coral reefs; Sarkis et al., 2013) raising awareness and enhancing the engagement and support of the public and private sector. W&E is keen to 1) expand the existing man-made boulder barrier and support the integration of corals to produce a live sustainable nature-based breakwater, by budgeting for the purchase and installation of artificial substrates used as a base for corals, and 2) investigate this coral-based approach to other sites around Bermuda, namely that protecting one of the islands from cruise ship wake damage (St. George's Cut, East End). The Department of Marine & Ports joined later in the project and is keen to support further data collection related to wave impact. Finally, this project introduced a nature-based approach to coastal protection early in the project during the Bermuda Climate Summit (May 2023), attended by government officers, academics, NGO's, and the insurance industry; based on the feedback generated, it is hoped this will translate to a more tangible engagement by the reinsurance industry to develop an insurable coral product.

Sustainability and Legacy

In the short-term (May-October 2023), LRF plans to 1) continue monitoring of the corals planted, and 2) explore the extraction of metrics (additional to surface area) from the 3D Agisoft models produced to better quantify the restoration impact and biodiversity changes with increased coral cover. This will serve to inform future coral-based breakwater designs and the valuation of coral reef biodiversity, and potentially carbon credits, a potential source of continuous funding in the long-term. These activities will be made possible within the scope of LRF's partnership with the University of Oxford sponsoring two summer interns, assisted by Bermuda-based long term volunteers.

In the long-term, the project has generated much interest among Bermuda's community but also overseas. With the new Ministerial support, LRF is hopeful that potential funding opportunities from overseas agencies and Bermuda-based companies will prove fruitful and ultimately support a core permanent staff. LRF is exploring:
1) A Coral Risk Index study with the Ocean Risk and Resilience Alliance (ORRAA) answering an upcoming call from the Bermuda corporate sector
2) An improved high technology coral conditioning system with UK scientists from the Horniman Museum & Aquarium to increase coral production, and
3) The development of a multi-year, multi-disciplinary strategic grant to research and apply cost-effective techniques for the scaling up of the pilot study and implement the expansion of the Causeway coral-based coastal barrier for full protection. This will result in a model applicable beyond Bermuda.

Section 6 - Communications & Publicity

Exceptional Outcomes and Achievements

The Darwin Plus Local grant has been invaluable to increasing the Living Reefs Foundation's capacity to monitor and quantify its work in restoring damaged coral reefs. Through this grant, the Foundation has acquired a state-of-the-art custom built computer workstation and extensive training by its U.K. partner, Tritonia Scientific Ltd. (U.K.) to produce high resolution digital 3D marine maps. This provides the stepping stone to conduct high resolution image analyses and extract biodiversity metrics which will serve to inform future decision-making and implementation of a nature-based, or coral-based, approach to the protection of Bermuda's coastal infrastructures. This benefit is well recognized by Bermuda's Ministry of Home Affairs, who has granted LRF their support in expanding the 2023 Blue infrastructure pilot study to fully protect vulnerable and key infrastructure from storm and hurricane damage.

The project generated much traction both locally and overseas, thanks to a first article in the Biodiversity Challenge Funds (BCF) newsletter, and since several organisations from the Bermuda corporate sector have reached out unprompted to explore avenues for support. Living Reefs Foundation is already planning the next steps and seeking experts in the fields of artificial substrate design, coral production acceleration and biodiversity/carbon assessments to collaborate in the development of scalable, and cost-effective techniques applicable in a realistic time frame to nature-based solutions.

Photo, video or graphic to be used for publicity and communications.

Please upload at least one relevant and engaging image, video or graphic that you consent to be used alongside the above text in Defra, JNCC or NIRAS communications material.

DPL00004Translocating corals credit Y Hillier
30/04/2024
18:54:42
jpg 2.66 MB

DPL00004 Close up great star coral credit L Burgues
30/04/2024
18:54:35
jpg 2.54 MB

Photo, video, and/or graphic captions and credits.

1. Translocating corals. University of Oxford student intern (C. Hawley) assisting Bermuda's Living Reefs Foundation in translocating corals as part of a nature-based approach to protecting the coastline (DPL00004). Photo credit: Y. Hillier

2. Close up great star coral. A close up of a healthy Montastrea cavernosa, the great star coral, featuring its fluorescing polyps with extended tentacles, prior to planting on an artificial breakwater as part of a nature-based approach to coastal protection (DPL00004). Photo credit: L. Burgues

3. Note: Please see here a link to a 3D model of one coral, as an example of Agisoft product. This was generated from surveys conducted by LRF during this study and the model was transformed to a viewing file by Tritonia Scientific (our partner). https://sketchfab.com/3d-models/coral-c31c31954fc7444ab336b7f66ab04425.

I agree for the Biodiversity Challenge Funds Secretariat, Administrator, and/or JNCC to publish the content of this section.

⦿ Yes, I agree for the BCFs Secretariat and/or JNCC to publish the content of this section.

Please list any accounts that you would like tagged in online posts here. This can include project pages, partners' pages or individuals' accounts for any of the following platforms: LinkedIn, Facebook, Twitter, or Instagram.

Living Reefs Foundation:
Instagram- @bdalivingreefs
Linked in- https://www.linkedin.com/company/103416013/admin/feed/posts/

Section 7 - Darwin Plus Contacts

Please tick here to confirm that you have read and acknowledge the BCF's Privacy Notice on how contact details will be used and stored and that you have sought agreement from anyone that you are sharing personal details with us on their behalf.

⊙ I confirm I have read the Privacy Notice and have consent to share the following contact details

Project Contact Details

Project Contact Name	Samia Sarkis
Role within Darwin Plus Project	Project Leader
Email	[redacted]
Phone	
Do you need further sections to provide additional contact details?	⊙ No