DPLR2\1033

Darwin Plus Local - Final Report (1)

Officer: Jessica Magnus

Section 1 - Darwin Plus Local Project Information (Essential)

Project Reference Number

DPLR2\1033

Q1. Project Title

Cost-effective habitat monitoring to understand seagrass decline in Bermuda

Overseas Territory(ies)

☑ Bermuda

Lead Organisation or Individual

Station-B

Partner Organisation(s)

Arribada Initiative C.I.C

Value of Darwin Plus Local Grant Award

£48,429.61

Project Start Date

01 October 2023

Project End Date

31 March 2024

Project Leader Name

Jean-Pierre Rouja

Project Website/Twitter/Blog etc.

https://www.station-b.org/

Report Author(s)

Jean-Pierre Rouja (Station-B), Alasdair Davies (Arribada), Alex Bucknall (Arribada)

Report Date

30 April 2024

Project Summary

This project will establish a cost-effective sensor array to better monitor and understand seagrass decline in Bermuda, helping to inform management decisions by monitoring climatic conditions around seagrass habitats and the grazing behaviour of sea turtles and other species that rely on seagrass as a food source.

Furthermore, local Bermudian organizations will be trained to deploy, maintain and repair the sensor array through a series of capacity building workshops to enable long-term sustainability and monitoring to continue beyond project completion

Project Outcomes

Checked	**Biodiversity: improving and conserving biodiversity, and slowing or reversing biodiversity loss and degradation;**
Checked	**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?

⦿ 2 - Outcome moderately exceeded

Project outcomes and justification for rating above

We successfully designed, developed, tested and deployed the proposed low-cost oceanographic sensor within the designated timeframe (6 months) and were able to generate optical timelapse data during the trialling of the camera's hardware to support management decisions for the protection of Bermuda's unique biodiversity, helping to improve its resilience to climate change - our primary objective.

The overall goal of introducing the sensor array was to provide quantitative data to better understand the interaction between sea turtles and the seagrass beds, as well as other climatic factors that may be impacting

the propagation and succession of seagrass habitats. As documented in our Supporting Evidence, we believe the specification of the final prototype camera developed achieved our goal of enabling our local partners to begin to utilise the camera to generate both oceanographic water parameter data and optical data to monitor water quality and to observe and quantify the grazing time of green turtles consuming seagrass protected by seagrass cages.

The camera developed achieved our technical goal of capturing photographs incrementally every 30 seconds, with timelapse videos highlighting the output(s) available for viewing as Supporting Evidence. Importantly, the capability to measure water temperature, light/lux and Ph has been made possible through the inclusion of external low-cost Atlas sensors, allowing external cost-effective Ph probes to be attached to the camera through a standard SMA connector through the wall of the camera enclosure, ensuring that the cost of the camera remains affordable to local partners. To ensure that the camera can continue to benefit local partners technically, a development decision was made to design in and introduce an internal “quick-connect” modular system to support the introduction of future “plug-and-play” sensors, such as conductivity / salinity and dissolved oxygen, without requiring a hardware change. The quick-connect printed circuit board delivered currently supports the addition of two sensors at any time, with Ph and a supporting Ph probe currently supported as our default configuration.

As documented by reviewers on submission of the original project summary, we were asked to “consider if the video footage collected could have a beneficial secondary use in the form of a public outreach tool, to engage stakeholders in Bermuda's seagrass conservation efforts”. We agreed with the reviewer’s consideration and believe that the project merits outcomes were moderately exceeded, as professional video footage documenting both the testing, deployment, and use of the sensor array by local deployment partners (Waterstart) was successfully captured using drones and in-water footage to create awareness-raising content.

This footage has subsequently been edited for dissemination by Station-B, and their education and outreach partner the Nonsuch Expeditions, including schools and education institutes, including showcasing ongoing work by Waterstart.

Waterstart will continue to maintain the camera array beyond the completion of the Darwin Local project, achieving our project completion goal of enabling the lead applicant and local partners to independently deploy, maintain and scale the cost-effective system through successful knowledge transfer, achieved during delivery of the in-country technical knowledge exchange workshops.

Supporting Evidence - file(s) upload

Waterstart_Students_Deploying_Sensors_Station_B
30/04/2024
18:02:43
jpg 726.06 KB

external_camera_assembled
30/04/2024
11:50:51
jpg 489.91 KB

completed_PCB_front_side
30/04/2024
11:50:37
jpg 725.61 KB

completed_PCB_back_side
30/04/2024
11:50:35
jpg 909.36 KB

early_prototype_concept_sketches
30/04/2024
11:50:20
jpg 205.78 KB

timelapse_camera_sch_0304_v_0_0_1
30/04/2024
11:49:37
pdf 63 KB

example_photograph_frame
30/04/2024
11:48:33
jpg 908.92 KB

Supporting Evidence - links to published document/online materials

1) https://vimeo.com/940743226 - professional video produced by Station-B documenting the goals of the project via interviews with staff from Arribada and partner Waterstart

2) example_photograph_frame.jpg – this is a single frame captured by the prototype device during trial deployments, provided as an example to document the image quality, light level sensitivity and output of the optical sensor.

3) timelapse_camera_sch_0304_v_0_0_1.pdf – this document is the printed circuit board schematic file which will be published as an open source file under the GPLv3 licence publicly.

4) https://vimeo.com/941193781 – this video provides an example of the timelapse footage output from the sensor (30 second photos, accelerated to form a 20 second video). Environmental data (water parameters) will be saved as metadata on the camera's SD card together with footage for processing by local partners.

5) early_prototype_design_sketch.jpg – an early computer aided design (CAD) render of the camera's enclosure, mount and design produced in the first 3 months of the project (2023).

6) completed_PCB_front_side.jpg – the completed printed circuit board (front side) of the prototype camera.

7) completed_PCB_back_side.jpg – the completed printed circuit board (rear side) of the prototype camera.

8) external_camera_assembled.jpg – the completed prototype camera inside enclosure. This camera was the first to be deployed with partners and was moved from site to site to verify performance.

9) https://vimeo.com/941193605 – (short_assembly_process_local_partners.mp4) a short video for local partners show them how to charge the camera, remove / replace the SD card and assemble the enclosure.

10) Waterstart_Students_Deploying_Sensors_StationB.jpg - Waterstart students deploying sensor

Project Challenges

Developing and deploying new hardware within the 6-month development period (project duration) required vigilant attention to procurement deadlines, continuous assessment of manufacturing lead times (especially enclosure manufacturing) and ensuring there was sufficient time to work around any challenges encountered.

Electrically, we encountered an unexpected issue with the primary SD card slot during development of the sensor's printed circuit board (PCB). The camera struggled to initialise the card, suggesting there may be an issue with the prototype PCB or the microcontroller interface. With a limited development time and budget, we couldn't re-spin (manufacture) new PCBs as it would delay the at-sea deployment schedule, so instead we switched the microcontroller inside and introduced a backup SD card reader, visible in the short assembly_process_local_partners.mp4 video. This workaround ensured that we could meet with the project's at-sea deployment timeline.

Logistically, another challenge was verifying that the first prototype was ready to be duplicated, as the firm fixed budget dictated one production run to manufacture all 10 cameras, requiring us to first verify performance at-sea using the first prototype camera. We decided to continuously deploy and move the first prototype camera around to each site, re-risking the chance of producing all 10 cameras at once if there was a critical issue with the prototype design. Experimenting with deployments on shallow and deeper seagrass cages ultimately proved beneficial, as we discovered that mounting via simple zip ties was the preferred method on seagrass cages, vs our original concept to introduce stainless steel triaxial mounts.

Lessons Learned

Overall, we were able to deliver the project on time and to budget, but with very little margin for error due to the short development period designing and introducing new hardware. Ultimately, we would have liked to have had more time to see apparatus deployed across all sites and collecting data beyond the trial deployment of the prototype camera conducted during February and March, however, this was necessary to ensure we de-risked spending the available budget on a production run with a critical issue (as referenced in Project Challenges). Importantly, the local partner is now in a position to continue to manage the deployment of the full array of 10 cameras, which was our goal and objective.

Introducing the low-cost ph / lux / light sensors, necessary to record and monitor water quality parameters, did required extended technical work beyond our original predicted effort. We realised that we needed to ensure that other sensors could be integrated in the future (i.e. conductivity / salinity / dissolved oxygen) without having to redesign and remanufacture enclosures, as there was already interest and appetite from local partners regarding upgrades to the sensor in the future, especially to support any long term Darwin programmes and extend the scope of work. If we were to repeat this project again, or share our experiences with others, our recommendation would be to focus less on the quantity of sensors and more on the quality, focusing first on optimising one sensor at one initial deployment site.

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				
Operating Costs				
Capital Items				
Others				
Total	48,429.61	48,429.61	0%	

Please provide a short narrative summary on project finances.

The project budget remained within target with minimal variance, primarily due to partners understanding that costs needed to be kept within budget (or minimised), coupled with the relatively short project timeline, helping to minimise scope creep or other factors.

A cost saving of £[redacted] was achieved by not having to introduce marine stainless steel mounts to attach cameras to seagrass cages. Instead, simple zip tie mounts were found to be much more effective. The £[redacted] saving was instead utilised to cover expedited tooling and manufacturing of the enclosures. Expedited manufacturing of the tooling necessary to produce the enclosure for the sensor helped to increase the speed in which enclosure parts could be delivered, helping us to keep to the timeline. Faster turn around times demand higher tooling costs, and we couldn't wait for 6+ weeks to receive the enclosures as it was necessary to start in-water trials, hence £[redacted] was allocated to decrease the lead time by paying for expedited tool manufacturing via Protolabs in the United Kingdom.

Other costs, such as overheads, travel and operating costs all remained within budget and by project completion we achieved our combined target spend of £[redacted]

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

DPLUS-A03: 2 people from the WaterStart local stakeholder group completed relevant technical training in-country to deploy, operate and maintain the sensor array we developed and introduced and have the capacity to monitor local water parameters and seagrass consumption by green sea turtles.

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

DPLUS-B05: 964 people who participated in WaterStart activities (2022/23) now have access to help maintain and deploy the sensor array we introduced, and can participate in the processing and dissemination of data to better support local management decisions for the protection of Bermuda's unique biodiversity, and resilience to climate change.

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

DPLUS-D01 – Up to 10 seagrass cages monitored under sustainable management practices.

Section 5 - Project Partnerships, Wider Impacts and Contributions

Project Partnerships

Building strong local and international partnerships was essential to the successful delivery of the project, including enabling the long-term monitoring and maintenance of the sensor array. In preparation to submit the proposal, Arribada specifically travelled to Bermuda to meet with the Bermuda Government's Department of Conservation and local partners before submitting the Darwin Local proposal to better understand how we could deliver a unified programme of work.

Arribada's primary role was to transfer technical knowledge to Bermudian organisations, helping to build their capacity to deploy and maintain the sensor array. Arribada's secondary goal was to then assist Station-B in establishing a working environment with the physical tools, machines, skills and knowledge necessary to take ownership of the introduced sensors, be able to technically maintain them without additional third-party support, and to be able to teach other local partners how to deploy/recover the sensors to continue monitoring seagrass habitat. This was achieved by flying Arribada's lead Embedded Software Engineer to Bermuda to share technical knowledge locally.

Waterstart, a local partner and Charity who build self-confidence through practical skills training in the marine environment are now responsible for supporting the maintenance (i.e. cleaning lens and removing bio-foul, regularly checking moorings etc) of any deployed sensors and will assist with the downloading of data for review and analysis by Station B. Their involvement is incredibly important, as the long-term deployment of sensors can now cost-effectively be maintained.

Outreach partner the Nonsuch Expeditions are all ready and will continue to promote the project. www.nonsuchisland.com

Wider Impacts and Decision Making

We fully expect data and insights gathered through the deployment of the sensor array will lead to better decisions in time through the sharing of data with the Bermudan Government's Department of Conservation Services via their benthic mapping, monitoring and assessment program (BBMAP). Water quality data and verifiable optical data quantifying the presence and known grazing period of green sea turtles will help to better understand the relationship between seagrass decline, sea turtle grazing and climatic stresses and we expect monitoring to continue indefinitely if sensor hardware is well maintained, cleaned and cared for by the local partners.

Sustainability and Legacy

At project inception we factored in needing to plan for the delivery of legacy activities, as we are fully reliant on the involvement of local partners and stakeholders to continue to utilise, deploy, recover and maintain the sensor array we introduced with Darin Plus Local funding. By partnering with Waterstart, the local Bermudan Charity, we have benefitted from their ongoing activities creating opportunities for young local Bermudians to experience the marine environment, learning to scuba dive, and taking an active role in the conservation of Bermuda's coastline. The future maintenance of the sensors will be integrated into these activities, with Station-B supporting from a technical perspective and Waterstart helping to deploy and recover physical sensors installed at up to 10 seagrass cages (sites).

Outreach partner the Nonsuch Expeditions are all ready and will continue to promote the project. www.nonsuchisland.com

Section 6 - Communications & Publicity

Exceptional Outcomes and Achievements

We have had great outcomes!

Conservation managers from the Bermuda Department of the Environment and Natural Resources, researchers, citizen scientists, and students from Waterstart, and local schools, as well as Seagrass management programs, locally and internationally, will benefit greatly from the deployment and use of our platform.

This will be one of the first times that timelapse photography is combined with a suite of ocean sensors in a cost-effective, user-friendly, mass-deployable package.

Our tools and the resulting data will be shared widely and will arm all concerned with rich, hi-resolution datasets that will assist with the ongoing management and hopeful recovery of the much-needed seagrass meadows that are under threat worldwide, by highlighting and ground truthing many of the un-seen and otherwise un-confirmed factors that may be impacting them.

Our team would like to thank the Darwin Plus program for supporting this work and we look forward to sharing our platform with other British Overseas Territories and beyond.

Our local outreach and engagement partner the Nonsuch Expeditions will continue to create supporting videos and other media assets for this project.

Please contact J-P Rouja [redacted] if you would like anything specific produced for your purposes, or see this dropbox folder where we will add additional media assets when they become available:
[redacted]

Video: Bermuda Seagrass Camera Darwin Plus Introduction
https://vimeo.com/940743226/738eff4486 (can also be downloaded from this link)

Credit: Jean-Pierre Rouja, Station-B

Caption: Alex Bucknall, Arribada's Senior Embedded Engineer describes the goals of the Darwin Local seagrass monitoring programme in Bermuda, accompanied by Phoebe Barboza, Operations & Research Manager at Waterstart, who describes how Waterstart are teaching local students how to deploy, recover and maintain the sensor and camera array introduced.

Location: Blue Hole, Franks Bay, Burt Island, Bermuda

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.

Burt Island Waterstart Deployment 3
30/04/2024
20:28:14
jpg 6.61 MB

JP_Rouja Station-B1
30/04/2024
20:24:16
jpg 4.66 MB

JP_Rouja Station-B2
30/04/2024
20:24:14
jpg 5.79 MB

Burt Island Waterstart Base
30/04/2024
19:43:14
jpg 5.7 MB

Burt Island Waterstart Deployment 2
30/04/2024
19:42:46
jpg 6.94 MB

Frame_From_Timelapse_Capture
30/04/2024
12:13:27
jpg 158.39 KB

Alex_Bucknall_Deploying_Prototye_Camera_Arribada
30/04/2024
12:13:27
jpg 192.31 KB

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

Our local outreach and engagement partner the Nonsuch Expeditions will continue to create supporting media assets for this project.

Please contact J-P Rouja [redacted] if you would like anything specific produced for your purposes, or see this dropbox folder where we will add additional media assets when they become available:
[redacted]

Primary Video Asset: Bermuda Seagrass Camera Darwin Plus Introduction
https://vimeo.com/940743226/738eff4486 (can also be downloaded from this link)

Credit: Jean-Pierre Rouja, Station-B

Caption: Alex Bucknall, Arribada's Senior Embedded Engineer describes the goals of the Darwin Local seagrass monitoring programme in Bermuda, accompanied by Phoebe Barboza, Operations & Research Manager at Waterstart, who describes how Waterstart are teaching local students how to deploy, recover and maintain the sensor and camera array introduced.

Location: Franks Bay, Burt Island, Bermuda

Secondary Video Asset: Bermuda Seagrass Camera Darwin Plus Interview
https://vimeo.com/941387395/870a3dd19a (can also be downloaded from this link)

Credit: Jean-Pierre Rouja, Station-B

Caption: Alex Bucknall, Arribada's Senior Embedded Engineer describes the goals of the Darwin Local seagrass monitoring programme in Bermuda, accompanied by Jean-Pierre Rouja Seagrass Platform Project Lead / Station-B and Nonsuch Expeditions founder and conservation tech developer.

Location: Blue Hole, Bermuda

Photograph: Frame_From_Timelapse_Capture.jpg

Credit: Alex Bucknall, Arribada

Caption: The quality of the time-lapse camera footage was high enough that we were able to easily identify species of fish on/around the seagrass. The resolution and detail should generate a rich dataset for training future machine learning models to conduct the identification of local species, as the expectation is that we will be able to generate images from the numerous cameras/sensors placed around Bermuda's seagrass beds.

Location: Frank's Bay, Bermuda

-
Photograph: Alex_Bucknall_Deploying_Prototype_Camera_Arribada.jpg

Credit: Alex Bucknall, Arribada

Caption: The cameras were deployed to a number of different sites across Bermuda, allowing us to trial a number of lighting and sea state conditions. While the island is mostly protected from large offshore swells (due to the reef), we were able to capture the movement of the tide and the changing of night and day cycles.

Location: Frank's Bay, Bermuda

Photos: Burt Island Waterstart Deployment 2.jpg, Burt Island Waterstart Deployment 3.jpg, Burt Island Waterstart Base.jpg
Location: Burt Island, Bermuda
Credit: Jean-Pierre Rouja

Caption: Waterstart students at the Burt Island camp in Bermuda assist with the retrieval of a pilot seagrass monitoring device from a turtle exclusion cage.

Photos: JP_Rouja Station-B1.jpg JP_Rouja Station-B2.jpg
Credit: Station-B

Caption: J-P Rouja project lead and founder/conservation tech developer for Station-B & the Nonsuch Expeditions shows a timelapse video from the recently recovered Seagrass Monitoring camera to Waterstart students on Burt Island in Bermuda.

Location: Burt Island Bermuda

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.

Arribada Initiative - https://twitter.com/arribada_i
Station-B - https://twitter.com/Nonsuch_Bermuda
Nonsuch Expeditions - https://www.linkedin.com/company/51601119/
Nonsuch Expeditions - www.nonsuchisland.com/blog
Nonsuch Expeditions - https://www.instagram.com/nonsuchexpeditions/

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	Jean-Pierre Rouja
Role within Darwin Plus Project	Director of Station-B and Project Lead
Email	[redacted]
Phone	
Do you need further sections to provide additional contact details?	⊙ No