Darwin Plus: Final Report

To be completed with reference to the "Project Reporting Information Note":
(https://darwinplus.org.uk/resources/information-notes/).

It is expected that this report will be a **maximum of 20 pages** in length, excluding annexes.

Submission Deadline: no later than 3 months after agreed end date.

Submit to: BCF-Reports@niras.com including your project ref in the subject line.

Darwin Plus Project Information

Project reference	DPLUS145
Project title	Assessing the mobile fish biodiversity of Bermuda's deep seas
Territory(ies)	Bermuda
Lead Organisation	Bermuda Institute of Ocean Sciences
Project partner(s)	Beneath The Waves, Government of Bermuda, University of Rhode Island
Darwin Plus Grant value	£314,829
Start/end date of project	01/08/2021 - 31/08/2023
Project Leader name	Dr Austin [redacted]
Project website/Twitter/blog etc.	https://www.darwininitiative.org.uk/project/DPLUS145/ http://www.bios.edu/currents/bios-receives-u.k.-grant-to-study- deep-sea-marine-life/
Report author(s) and date	Dr Tim [redacted]

1 Project Summary

Though the use of innovative methodologies, the project was designed to fill critical knowledge gaps on Bermuda's mobile deep-sea biodiversity and support both the Bermuda and UK Government's strategic biodiversity conservation priorities. The complimentary use of environmental DNA metabarcoding and baited cameras were used to generate baseline biodiversity data of deep-sea fish and shark communities surrounding Bermuda. These data are to be utilised by the Government of Bermuda as it develops spatial protection measures under the Bermuda Ocean Prosperity Programme (BOPP). The project focused on habitats within the 250 – 1500 m depth range.

The biodiversity data generated by this project can contribute to the following local, regional and global biodiversity

Local
• Bermuda Biodiversity Action Plan objectives A (support of coordination, collaboration, communication of efficient biodiversity conservation), D (increase public awareness of biodiversity), I (re-designation of existing protected areas), J (support key species and habitat management plans) and K (increase research and monitoring of Bermuda's biodiversity)

• Bermuda Ocean Prosperity Programme (expanded on in Q12,13 and 22b).
• Outputs of this project will support the Bermuda Government's 2010 Strategy for the sustainable use of living marine resources and the implementation of the Shark Management Action Plan through the provision of elasmobranch biodiversity assessments.
• Biodiversity data collected by this project could provide baseline data to enable the ratification of territorial Key Biodiversity Areas (KBAs). At present the two KBAs focus on terrestrial areas.

Regional
• Sargasso Sea is designated an Ecologically or Biologically Significant Marine Area (EBSA), this project will give a greater understanding of the biodiversity founds within this EBSA.
• Hamilton Declaration on the Collaboration for the Conservation of the Sargasso Sea (2014). Whilst the Bermuda Exclusive Economic Zone is excluded from this declaration, these waters are physically part of the Sargasso Sea. This project supports the Commission's stewardship role to encourage and facilitate the conservation of the Sargasso Sea.

Global
• The project will directly support the Memorandum of Understanding on the Conservation of Migratory Sharks (UK signatory and extended to Bermuda) through identifying elasmobranch biodiversity found within Bermuda's EEZ.

• Bermuda is not a signatory to the Convention on Biological Diversity 2010, however, this project specifically contributes to Aichi Biodiversity Targets 10 (management of fish stocks), 11 (10% of oceans protected by marine protected areas), 19 (increasing biodiversity knowledge).

• United Nations Sustainable Development Goals: Goal 14: Conserve and sustainably use the oceans, seas and marine resources.

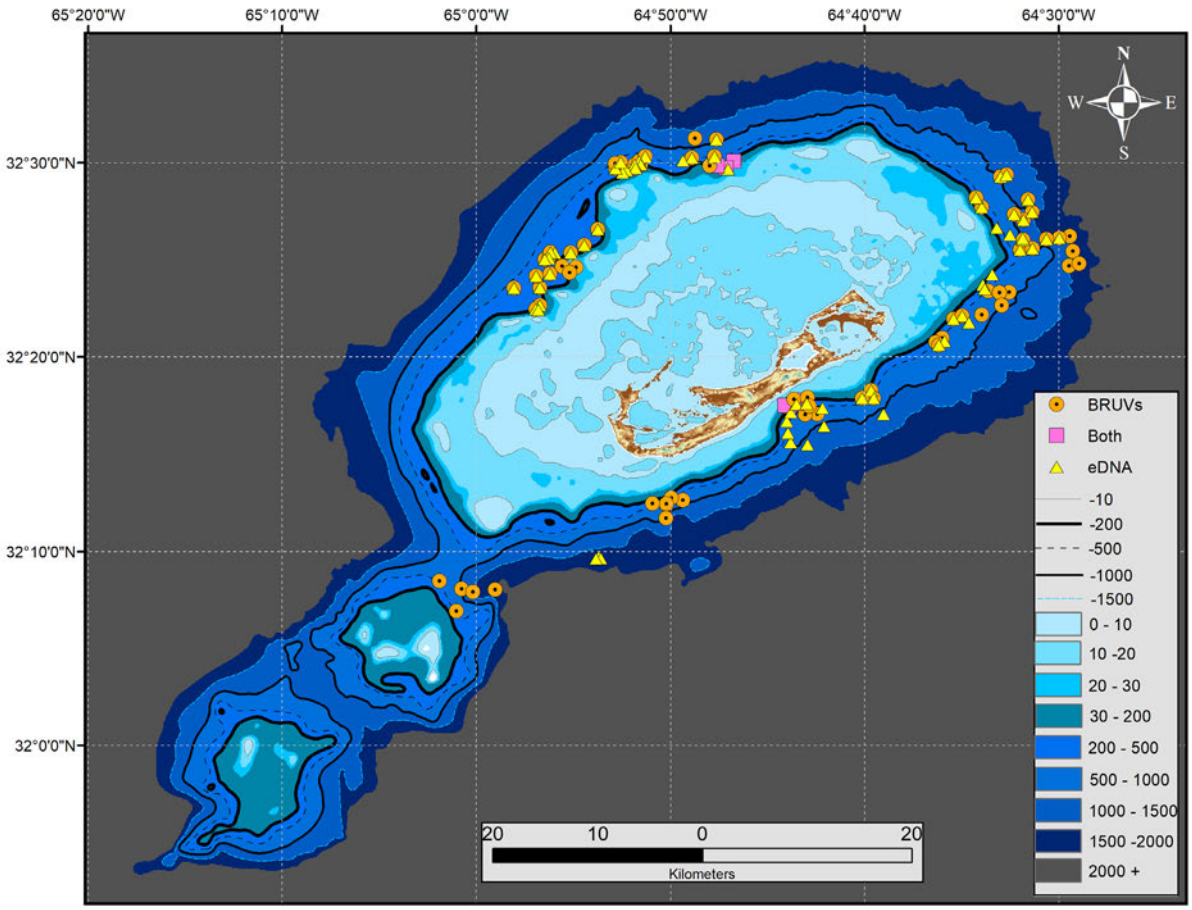

Figure 1. Bathymetric map of Bermuda illustrating the main study location with Baited Remote Underwater Video system (BRUVs; orange circle black dot), environmental DNA (eDNA; yellow triangle) and combined methods (pink square) survey sites. The deep sea is defined as beginning at the 200 m depth contour (thick black line).

2 Project Partnerships

The project partnerships were a combination of existing collaborations and the introduction of new partners with key skill sets required for undertaking deep-sea Baited Remote Underwater Video system (deep BRUVs) research. With the exception of the partner responsible for the final media product, all partners were involved at the planning stage of the project. The decision-making process was a collaborative effort initially which was essential as the project began during the COVID-19 pandemic. At the time, there was uncertainty of the proposed project timeline due to international travel restrictions and consumable supply chain delays. With the declining relationship of the two main project organisations, logistics and decision-making activities shifted from all project partner involvement to be lead by the primary project institution to allow completion of the project. As such, the preparation of this report has been completed by the primarily institution with input from Bermuda Government project partners.

The Government of Bermuda's Department of Environment and Natural Resources (DENR) are a formal partner of the project with personnel within the Marine Resources Section providing guidance on areas of interest under consideration by the BOPP initiative. Their key role within the project was to act as an advisory figure to the project and provide linkage between BOPP and other local stakeholders (e.g., Bermuda's Marine Resources Board, MRB) and the project activities. Additionally, those personnel provided valuable metadata on areas of interest for the project to target as identified by BOPP stakeholders and existing data on target species (i.e.,

sharks and deepwater snapper species). The relationship between BIOS ASU and the DENR remains in place and will continue post-project.

Despite the latter challenges of the project, the partnerships have allowed areas of the deep-sea environment around Bermuda to be seen for the very first time by people in addition to the completion of quantified scientific surveys. The initial partnerships were created to provide the required strength and resilience needed to conduct deep-sea research. Those strengths allowed the project to commence and successfully navigate a global pandemic. Examples of these achievements are the willingness of project partners to commit to international travel whilst COVID-19 restrictions were still in place. The initial procurement and building the specialised BRUVs equipment by the US based project partner who designed the deep BRUV systems, again when personnel movement was restriction by their institutions.

Two key lessons have been learned, all subsequent projects would be advised to incorporate additional time for administration of their project, particularly when the lead institution. Secondly, if partnerships are challenged to a point of negatively impacting the success of the project, then partners should not feel they should defer seeking advice and assistance from NIRAS/Darwin for fear of further damaging the relationship in question. The challenges experienced during this project were resolved to a degree that allowed the completion of the project albeit at a reduced level.

Irrespective of the technology available for deep-sea observations and science, the application of that technology remains extremely challenging regardless of the strengths of the personnel/partnerships undertaking the work.

There is an ongoing relationship between BIOS ASU and the Government of Bermuda's Department of Environment and Natural Resources (DENR) through both the collaboration on this project and those external to Darwin.

Preliminary discussions have begun regarding the development in implementation of deep-sea monitoring as part of the BOPP initiative. The capacity for this initiative has been greatly enhanced by both the equipment purchased and the experiences learned during this project. Noyes was recently invited to meet with the Environment Minister and stakeholders to discuss deep-sea communities.

The partnership with the University of Rhode Island will continue after the completion of this project. The PI's from BIOS and URI have been collaborating on the development and application of lower cost deep-sea research since 2018. Dr Phillips (URI) will be moving to BIOS for a 10-month sabbatical starting in September 2024. The arrival of Dr Phillips and members of his lab will allow for greater capacity building by allowing local stakeholders the opportunities to experience the steps marine engineers take to develop products through to application. For example, BIOS Bermuda Program Interns will be offered opportunities for working within the Phillips lab. Dr Phillips and K. Noyes (BIOS Director of Education and Community Engagement) are in discussions on K-12 educational level involvement during his sabbatical.

Whilst not a formal partner, the project has developed a relationship with the Government of Bermuda's television station, CITV to allow for greater local viewership of the findings of this and future marine focused projects.

3 Project Achievements

3.1 Outputs

The project was able to achieve the proposed six outputs with varying degrees of success.

Output 1. GIS database of deep-sea biodiversity combining BRUVs observations, eDNA species detections and environmental layers.

As a result of delays due to the pandemic, the project condensed deep BRUVs biodiversity surveys into 2022 resulting the loss of one field campaign and a reduction in the duration of the five conducted. During the course of 2022, the team successful deployed 59 deep BRUVs of 70 attempted (Figure 1; supplemental draft highlight video). Those that failed were primarily due to failures with the voltage regulators required to supply the cameras with extended battery life. A change in manufacturer resulted in increased reliability. We had originally proposed to conduct 96 deployments during six fieldwork campaigns between 2021 and 2022. The combination of a lack of existing data for deep-sea biodiversity and full field work schedule in 2022 meant the team prioritised deep-sea biodiversity surveys. As a result, no mesophotic BRUVs deployments were made. The project originally proposed to conduct 48 deployments. However, biodiversity data of Bermuda's mesophotic reefs does exist, although it was not collected concurrently with deep-sea observations.

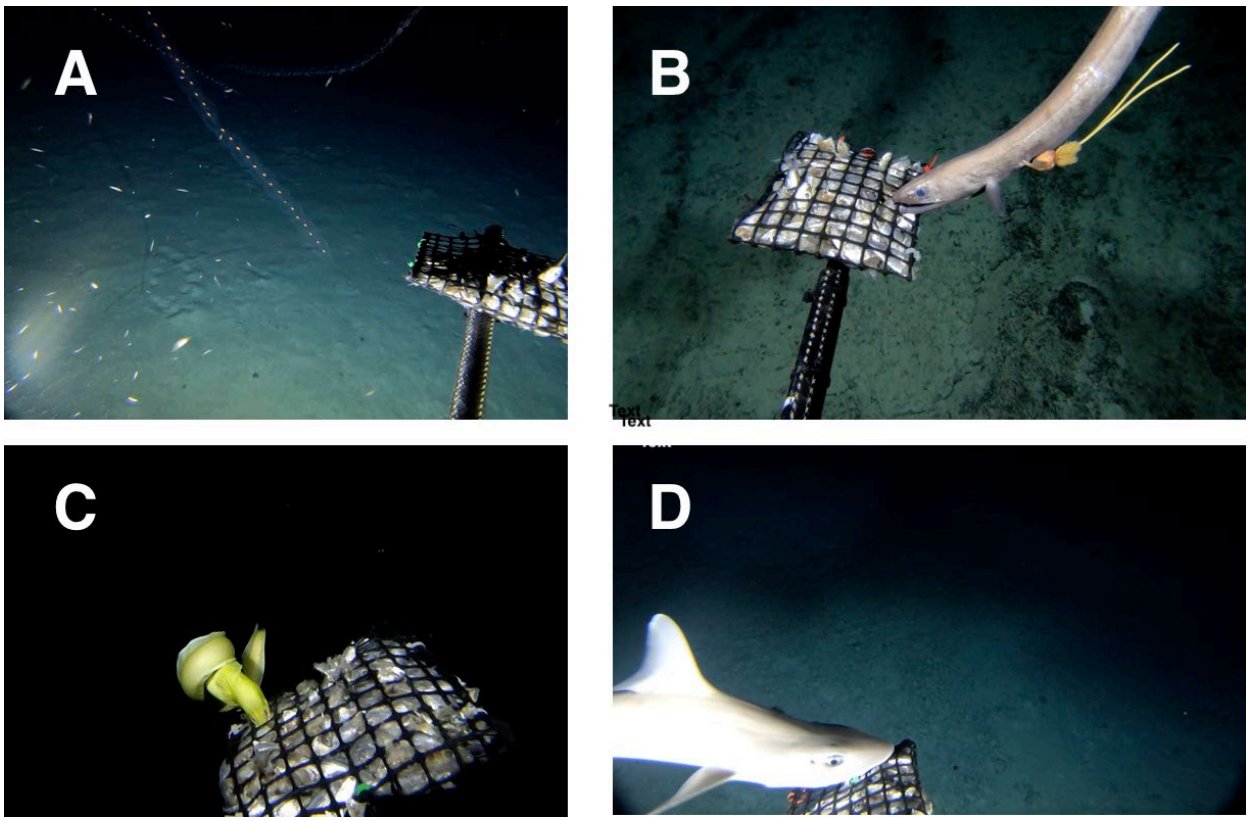

Figure 2. Example images from organisms filmed during deep BRUVs deployments. (**A**) an images of a chain of salps at 800 m depth. (**B**) Cutthroat eel Synaphobranchidae with a parasitic copepod attached to its side depth 950 m. (**C**), Sharktooth moray *Gymnothorax maderensis* depth 320 m. (**D**) Smooth dogfish eating bait *Mustelus canis* depth 580 m.

The project exceeded the proposed 120 deep-sea environmental DNA (eDNA) samples by collecting 160 samples (Figure 1) which were approximately spilt 50:50 and analysed for two independent 12S gene markers. The sample set were analysed for ray-finned fishes (Teleo02) and elasmobranchs (Elas02) using 12S universal markers.

Table 1. Primer pairs used for assessing fish and shark communities.

Name	Gene	Forward sequence (5'-3')	Reverse sequence (5'-3')	Sample numbers
Teleo02	12S	AAACTCGTGCCAGCCACC	GGGTATCTAATCCCAGTTTG	86
Elas02	12S	GTTGGTHAATCTCGTGCCAGC	CATAGTAGGGTATCTAATCCTAGTTTG	74

It was deemed necessary to adapt the planned sampling protocol (deep BRUVS combined with eDNA collections) to reduce the risk of contamination of the eDNA samples by the baited used for the camera systems. The original approach combined the two biodiversity assessment methodologies during fieldwork activities. During the first attempt at the combined procedure, it became apparent that there was a higher risk of sample contamination than originally considered resulting in the sample activities being separated. This mitigation action meant that non-Bermuda based project partners were primarily involved with deep BRUVs fieldwork as eDNA collections occurred in early 2023.

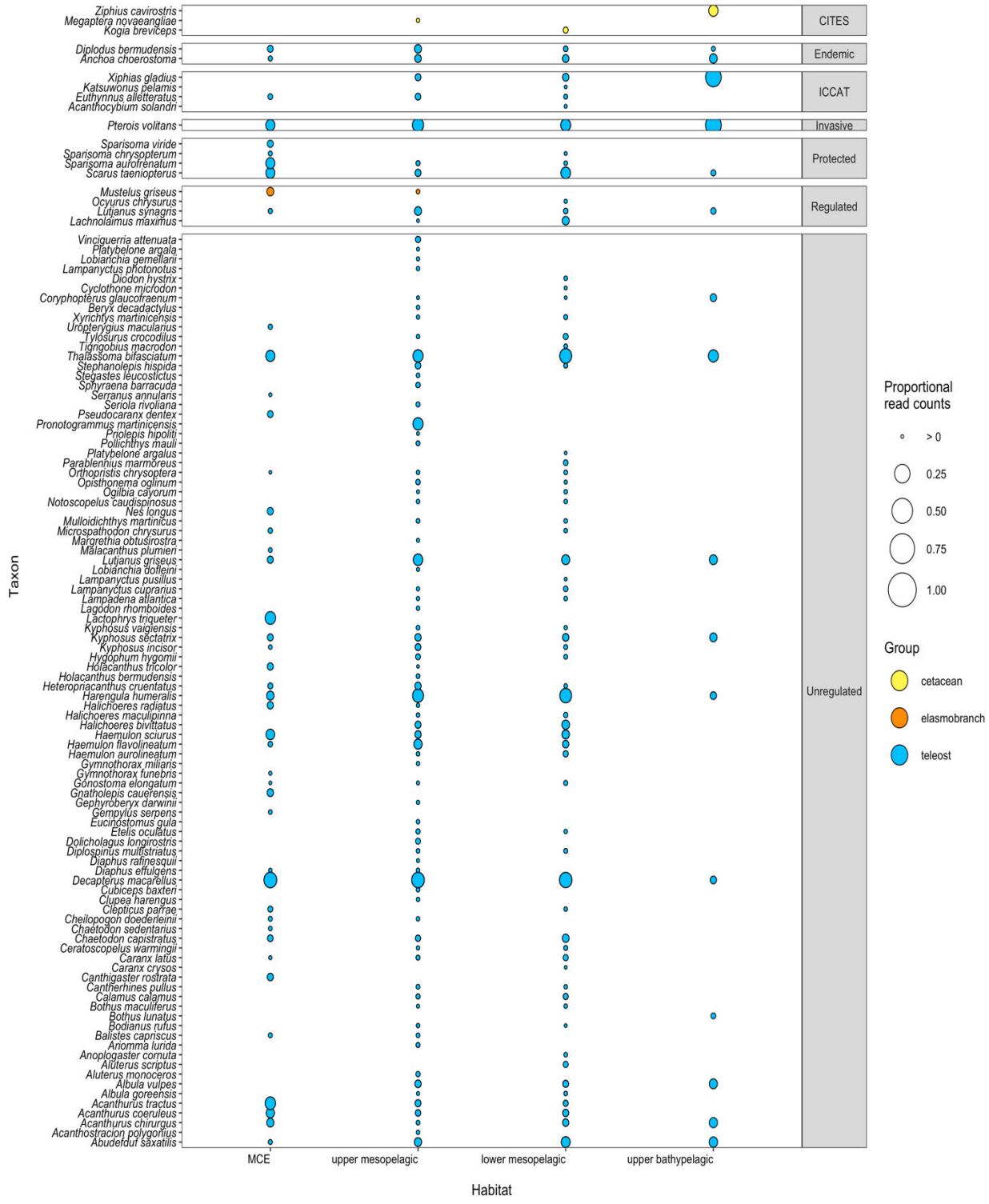

Figure 3. Bubble plot showing proportional read counts for taxa detections by eDNA and classified by management status pooled by deep-sea habitat. Taxa are identified according to order (yellow dots = cetaceans, orange dots = elasmobranchs, blue dots = teleosts). Habitats are defined as MCE (30 – 100 m depth), upper mesopelagic (200 – 500 m depth), lower mesopelagic (500 – 1000 m) and upper bathypelagic (1000 – 1750 m depth).

As noting in the HYR 1, the restrictions on personnel interactions during the COVID-19 pandemic led to a delay in determining which two Fisheries Wardens were able to participate on the project. Subsequently, the Wardens department experienced staff-storages meaning Fisheries Wardens were unable to dedicate time to the project.

2. Report describing the status of deep-sea biodiversity around Bermuda, with management recommendations.

The final reporting of the project has not been presented to any stakeholders. Project data will be shared with DENR project partners to aid future management decisions. A scientific publication is anticipated but due to the difficulties experienced due to the latter stages of the project, it is not an activity that has been started.

3. Report on elasmobranch biodiversity and distribution, with management recommendations.

The final reporting of the project has not been presented to any stakeholders. In March 2022, the Government of Bermuda amended the Fisheries (Protected Species) Order 1979 and Fisheries Regulations 2010 to increase protection to sharks (Annex 1.). Under the Order, only three species of sharks (Galapagos shark *Carcharhinus galapagensis*, Smooth dogfish *Mustelus canis* and Bluntnosed sixgill *Hexanchus griseus*) can be caught if in possession of a designated license.

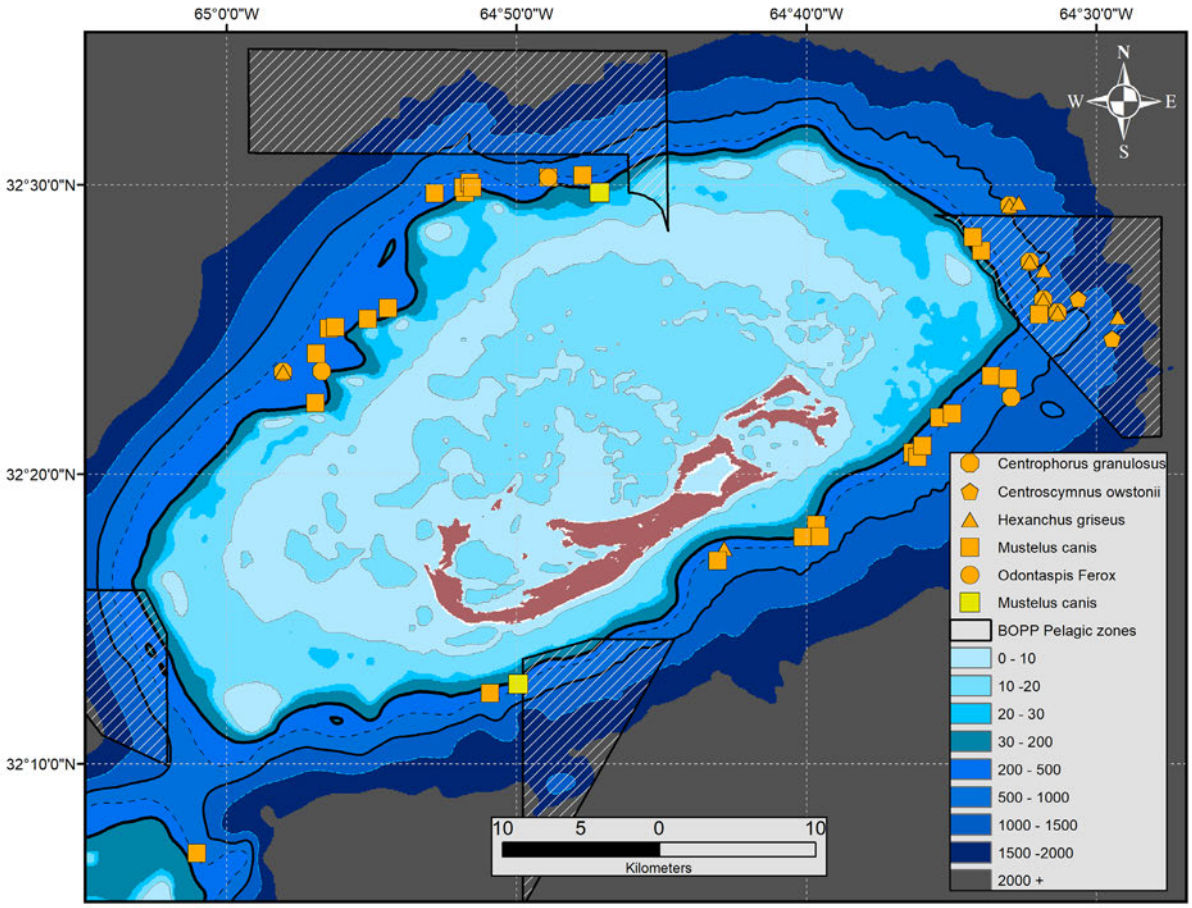

Figure 4. Bathymetric map of Bermuda illustrating all elasmobranch detections by both assessment methodologies (orange symbols = deep BRUVs observations, yellow symbols = eDNA detections). The hatches areas indicate the pelagic areas under consideration for alteration in management status by the Bermuda Ocean Prosperity Programme.

4. Management plan for Bermuda's deepwater vertical line fishery.

The output of this category was not met. Deepwater snappers were only detected at three locations throughout the combined dataset (one by deep BRUVs, two by eDNA). It was anticipated that this project would provide a great level of information on deepwater snapper distribution and abundance. Due to the lack of information at this time, it has not been possible

to develop a deepwater vertical line fishery management plan. It has been concluded that deepwater fishery resources are sparse and not evenly distributed, and that spatial protections for the shark areas may help to reduce bycatch.

5. Research and multimedia outputs developed and shared with target audiences (included local and international teachers' local government and BOPP) to promote conservation of Deep-sea biodiversity.

A draft outreach video presenting the overarching theme of the project and deep-sea investigations has been created and will be disseminated to all project partners and DEFRA for approval prior to dissemination to the wider pubic. This process has been delayed due to the challenges documented with NIRAS. The draft video has been included in the Annex section (Annex 2).

The ASU BIOS Education team designed, curated and honed a 2.5 hour eDNA lesson plan. At the close of 2021, the lesson had been curated and tested in ASU BIOS's summer Ocean Academy program and launched to teachers through a professional development workshop in February 2022. Details reporting the lesson plan and train materials are listed in the Annex section (Annex 4 – 5).

6. Local capacity enhanced via the training of two interns in project methodologies.

Three students were provided the opportunity for professional development through the ASU BIOS Bermuda Program Internship during the course of the project. A summary of each internship is provided in Annex section (Annex 3).

3.2 Outcome

The project was not able to fully meet the intended Outcome as defined in the logframe. The project was able to generate quantitative baseline data on deep-sea ichthyofauna surrounding the island of Bermuda. Additionally, it was able to target one of the pelagic Marine Protected Areas (MPAs) proposed under the Bermuda Ocean Prosperity Programme (area B9) therefore providing support on biodiversity conservation initiatives. The proposed extension would expand an existing seasonally protected area designated to safeguard the spawning aggregation sites of local grouper species. Due to a continued lack of data on deepwater snapper species, it has not been possible to contribute to the development of a deepwater vertical line fishery management plan. It has been concluded that deepwater fishery resources are sparse and not evenly distributed.

0.1 Baseline biodiversity maps

An example of maps generated by the detections of species have been include in this report (Figure 4). In addition to the geospatial representation of these data, eDNA species "relative abundance" has been displayed as Proportional Read Counts categorised by depth habitat and management status (Figure 3). It should be noted that the detection of multiple shallow water species at depth e.g., *Abudefduf saxatilis* is not an indication of individual fishes occupying those depths. It does however indicate a level of connectivity between shallow and deep-sea environments that have allowed the transfer of genetic material to depth. It is beyond the scope of this project to establish what the transport pathways are. When initially awarded the project, the inclusion of eDNA with BRUVs was questioned. Despite the aforementioned caveat, the complementary nature of assessment methodologies provide information on differing scales. Environmental DNA samples are from a fluid environment that contains a "soup" of eDNA material from the surrounding area whereas visual methodologies (i.e., deep BRUVs) are strictly linked to observations that in this case, would be biased towards benthic associated species. The project team were able to conduct biodiversity assessments to depths of 1750 m. Due to the

varying accuracy of local marine navigational charts it was not possible to accurately determine true depth prior to deployment of the BRUVs despite the use of vessel depth sounder.

To date, only maps (including shark species detections) have been provided to DENR project partners. I full list of species detections included relevant metadata (e.g. observation coordinates, depth, date) will be provided in due course.

0.2 Deep-sea biodiversity report.

The challenges faced by this project in the latter stages have meant that a formal biodiversity report has not been produced. ASU BIOS PI Noyes will continue to work with both DENR and BOPP representatives to aid the facilitation of an action plan development beyond the life of this project. Preliminary discussions have been had with BOPP regarding the continuation deep-sea assessments using the equipment purchased for the project.

0.3 Shark species listing

Figure 4 provides both a list and geospatial representation of shark species detections. A copy of this image has been sent to DENR project partners. Changes to shark management were enacted in 2022 prior to the generation of these date. However, the species detections serve as distribution data for these species.

0.4 Deepwater management plan

The data generated by the project on deepwater snapper species has not been succifient to create a draft management plan. The three detections of deepwater snapper indicate these species are not evenly distributed. Additional assessment efforts will be required to better understand the distribution patterns of these species.

0.5 Environmental DNA lesson material and outreach video

A supplemental report has been attached as Annex 3 - 4 that provides the lesson plan and outlines the development and use of the module. The draft outreach video (Annex 2) will be send to all project partners and DEFRA for approval prior to wider dissemination. The producer of the outreach video is an employee of the Government of Bermuda's local television channel (CITV). Once approval has been received, the video will be added to the media content. ASU BIOS are planning to release media content on the findings of the project in early September.

3.3 Monitoring of assumptions

The Logical Framework served as the road map for the project Outcome and Outputs. The stated assumptions still hold true for the project. Due to the protracted closure of the project and the reduction in deliverables some of the assumptions may no longer be applicable. For example, the assumption that the project recommendations and baseline biodiversity data will be incorporated into the marine spatial planning process and utilised to evaluate and enhance the nascent MPA network could not hold true. The BOPP Final Draft was released in April 2024. Continued dialog with DENR and BOPP personnel suggest that the project data will be valuable for future evaluation and monitoring efforts of any changes to Bermuda's surrounding pelagic environment.

The loss of eDNA sampling equipment (Niskin and messengers) during sampling activities was not originally included in the monitoring of assumptions. As a resulted of lost equipemnt an adaption of the sampling protocol was made. To obtain the required sample depths from small vessels (≤ 12 m), the team utilised a modified electric fishing reel to deploy the sampling Niskin attached to monofilament fishing line. However, on two separate occasions, the monofilament was cut resulting in the loss of equipment. The monofilament was replaced with spectra braided

fishing line terminated to a leader of coated stainless-steel cable. The was no further loss of equipment after this change.

4 Contribution to Darwin Plus Programme Objectives

4.1 Project support to environmental and/or climate outcomes in the UKOTs

The project has assisted with the delivery of long-term strategic outcomes through generating quantified biodiversity. Whether locally or international, there is a significant lack of knowledge about deep-sea communities. Importantly, the visual aspect (deep BRUVs footage) of the project will allow the entities responsible for long-term strategic outcomes a mechanism to demonstrate to the Bermuda populus what type of organisms inhabit these deep-sea environments and ultimately what will be protected through any legislative changes.

The lasting impact of the project will be the biodiversity data that will be incorporated into ongoing management strategies. This can be visualised (Figure 4) by the multiple shark detections within the proposed pelagic MPA. Additionally, these data serve as a baseline for which future assessments can be compared to. The project directly supports the Bermuda Biodiversity Action Plan objectives A (support of coordination, collaboration, communication of efficient biodiversity conservation), D (increase public awareness of biodiversity).

Whilst the Bermuda Shark Management plan was enacted before the completion of the project, these data confirm the presence of various elasmobranch species found within Bermuda's EEZ. Importantly they also report a geographical range extension for the Roughskin dogfish *Centroscymnus owstonii*, a species not documented in Bermuda prior to observations on deep BRUVs.

The generation of data on deep-sea communities has allowed members of BOPP Scientific Steering committee to more widely consider public acceptance of protection of these habitats.

4.2 Gender Equality and Social Inclusion (GESI)

Please quantify the proportion of women on the Project Board[1].	2 of 5 members
Please quantify the proportion of project partners that are led by women, or which have a senior leadership team consisting of at least 50% women[2].	To the best of my knowledge, none of the partner organisations have senior leadership teams consisting of at least 50%.

[1] A Project Board has overall authority for the project, is accountable for its success or failure, and supports the senior project manager to successfully deliver the project.

[2] Partners that have formal governance role in the project, and a formal relationship with the project that may involve staff costs and/or budget management responsibilities.

GESI Scale	Description	Put X where you think your project is on the scale
Not yet sensitive	The GESI context may have been considered but the project isn't quite meeting the requirements of a 'sensitive' approach	
Sensitive	The GESI context has been considered and project activities take this into account in their design and implementation. The project addresses basic needs and vulnerabilities of women and marginalised groups and the project will not contribute to or create further inequalities.	X
Empowering	The project has all the characteristics of a 'sensitive' approach whilst also increasing equal access to assets, resources and capabilities for women and marginalised groups	
Transformative	The project has all the characteristics of an 'empowering' approach whilst also addressing unequal power relationships and seeking institutional and societal change	

The project activities were considered solely on the basis of gathering quantifiable deep-sea biodiversity data whilst increasing local environmental monitoring capacity.

In the initial phases of the project all project parties participated in the decision-making process. Personnel involvement during the course of the project changed depending on the activities undertake during that period, i.e., project personnel were not full time on this award.

The project has neither activity encourage or discouraged the involvement of any sex. When BTW personnel were not available both a female and male graduate student provided fieldwork assistance. BTW personnel were a 50:50 mixture of men and women during fieldwork period.

The project team working with collaboration with Ocean Discovery League to provide capacity building opportunities for young scientists working in developing countries and as such partnered in training on deep-sea deployment methodologies with Veta Wade from the island of Monseratt. Veta spent the week with project scientists learning about operations for deep-sea deployments including planning, active fieldwork, deployments and recovery of instrumentation, Veta also participated in educational programming associated with ther Darwin 145 project.

5 Monitoring and evaluation

The only changes to the project design primarily concerned the scheduling of fieldwork activities and delivery dates of products as per the agreed changes.

The M&E system served a good reference point for the ASU BIOS PI to refer to and detemine the status of the project which of particular importance during the latter challenges the project faced. Attempts to share the work load where semi successful. As the project partners were geographically distant and depending on the activities, information was shared through a combination zoom/phone/WhatsApp calls or through email.

To date, the project has been independently reviewed at the YR1 Annual Report stage.

6 Lessons learnt

The key lesson learned by this project is to maintain clear communication channels with all project parties. Additionally, have background knowledge on project partners, especially those who have leadership roles. Second, have mitigation steps in place in the even lead personnel duties need to be assigned to alternative person(s).

I would add additional salary for administration of the project and increase the number of local ASU BIOS personnel by one or two at least for the fieldwork periods if still working with non-Bermuda based partners.

7 Actions taken in response to Annual Report reviews

N/A

8 Sustainability and Legacy

Assessment of deep-sea biodiversity surrounding Bermuda have continued past the duration of the project utilising resources procured during the project. Discussions are ongoing between project personnel (Noyes) and Bermuda Ocean Prosperity Programme (BOPP) personnel regarding the requirements for deep-sea biodiversity monitoring activities as part of the proposed nascent MPA network. As part of these preliminary discussions, Noyes has been invited to give a Q and A session with the Government of Bermuda's Environment Minister. The date is still to be confirmed.

The intended sustainable benefits are still relevant at the completion of the project. Whilst the project was able to complete ~ 60 deep BRUVs and 160 eDNA biodiversity assessments. Those assessments occurred within close proximity to the island of Bermuda. When taken into context, the majority of the UKOT's territory is deep-sea environment.

ASU BIOS, URI and the BTW project leader have all remained with respective institutions working on non Darwin funded projects. Both ASU BIOS and URI project partner continue to collaborate on Bermuda based deep-sea research.

The increase in deep-sea focused capacity afforded by the resources purchased through the 145 project have allowed the continuation of deep-sea biodiversity monitoring. The follow on project has concentrated on the eastern pelagic MPA proposed under the BOPP Draft Management Plan (Figure 5). Proposals are in preparation for a continuation of this project to allow future assessments at the southern boundary of the proposed MPA. An additional shark species has been observed and identifed as a range extension for Bermuda.

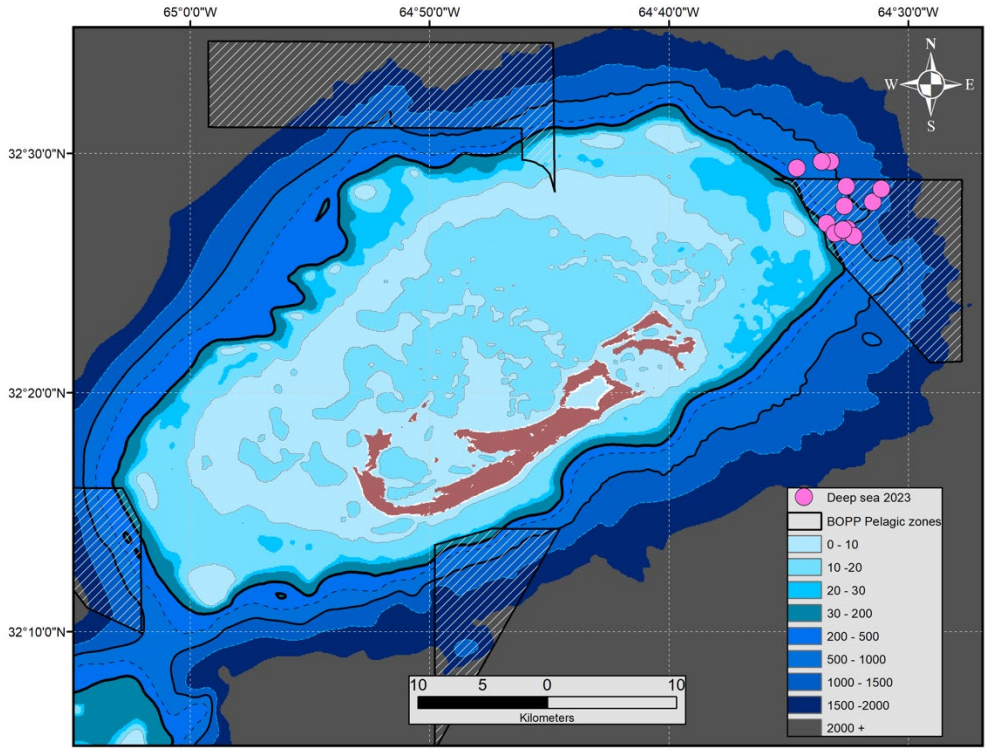

Figure 5. Deep-sea biodiversity monitoring of proposed pelagic Marine Protected Area (MPA) under the Bermuda Ocean Prosperity Programme. Deep BRUVs deployments are indicated by pink circles.

The continuation of essential work started by the 145 project allows marine spatial allows access to quantifiable deep-sea biodiversity data to enable informed management decisions.

In collaboration with the Government of Bermuda's Ministry of Education, two public school teacher professional development workshops were held during the February mid-term break for 39 educators. The workshops focused on the topic of 'Exploring Bermuda's Deep Sea: Where Do the Data Go?'. One virtual session saw 24 primary school teachers participate in a one and a half hour-long workshop, and an additional in-person session served 15 middle school teachers through the delivery of a three hour experiential workshop. An article showcasing the teacher workshops was published in the February edition of BIOS's newsletter, *Currents*, and can be found here: http://bios.edu/currents/bios-teacher-workshop-supports-ongoing-government-partnership

In collaboration with the Deep Ocean Strategy, this research was highlighted through a series of seven posts on Instagram (@deepoceanobs) for highlighting work in the deep sea throughout the Caribbean. Social media posts highlighted all partner institutions, associated project technology and included a species highlight reel. The associated posts have been viewed over 1,000 times.

Media produced:

1. **BIOS Receives Grant To Study Deep-Sea Life**
2. https://bernews.com/2021/06/bios-u-k-grant-study-deep-sea-marine-life/
3. Going to Great Depths
   http://www.bios.edu/currents/going-to-great-depths
4. Researchers hope deep sea creatures will take the bait
   https://www.royalgazette.com/environment/news/article/20220330/researchers-hope-deep-sea-creatures-will-take-the-bait/

Once the final outreach video produce had received approval form all project partners and DEFRA it will be disseminated through partner institutions, the Government of Bermuda CITV television network. The UK Government and Darwin Plus are recognised and acknowledged as the funders of the project with logo usage as per terms and conditions of the award letter.

9 Risk Management

The project did not foresee a breakdown in communication between the Project Leader and the Lead Organisation and was not accounted for within the original risk management strategy of the project. This has caused a significant delay to the completion of the project and jeopardised relationships between project partners and project partner relationships with NIRAS, Darwin Plus and DEFRA. NIRAS personnel have assisted with reestablishing communication pathways between the main partners to allow the closure of the project.

Has your Safeguarding Policy been updated in the past 12 months?	No
Have any concerns been investigated in the past 12 months	No
Does your project have a Safeguarding focal point?	No
Has the focal point attended any formal training in the last 12 months?	N/A
What proportion (and number) of project staff have received formal training on Safeguarding? BIOS ASU personnel are required to participates in annual Safeguarding training.	Proportion = 40% Number of personnel = 2
Has there been any lessons learnt or challenges on Safeguarding in the past 12 months? There have been no Safeguarding related issues in the past 12 months.	
Please describe any community sensitisation that has taken place over the lifetime of the project; include topics covered and number of participants. BIOS ASU personnel are required to participates in annual Safeguarding training on an individual basis.	

Have there been any concerns around Health, Safety and Security of your staff over the lifetime of the project? If yes, please outline how this was resolved. There have been no Health, Safety and Security concerns to any personnel during the project period.

10 Finance and administration

10.1 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]			N/A
Consultancy costs				N/A
Overhead Costs				Factor % to underspend
Travel and subsistence				Rescope of project fallout t performance constraints
Operating Costs				Rescope of project to performance constraints
Capital items				N/A
Others				Reasonable to project needs to procurement
TOTAL	314,829	272,484		

Staff employed (Name and position)	Cost (£)
Dr. Austin Gallagher – Project Leader	[redacted]
Dr. Timothy Noyes – BIOS Principal Investigator	
Christine de Silva – BTW Research Associate	
Claire Fox – BIOS Science Education Officer	
Dr. Oliver Shipley - BTW Director of Research (at project time)	
TOTAL	**103,577.18**

Consultancy – description and breakdown of costs	Other items – cost (£)
TOTAL	

Capital items – description	Capital items – cost (£)
Water Sampler (eDNA) BRUVs	[redacted]
TOTAL	48,116.81

Other items – description	Other items – cost (£)
eDNA sequencing Consumables Shipping and Postage	[redacted]
TOTAL	48,111.13

10.2 Additional funds or in-kind contributions secured

Matched funding leveraged by the partners to deliver the project	Total (£)
TOTAL	

Total additional finance mobilised for new activities occurring outside of the project, building on evidence, best practices and the project	Total (£)
TOTAL	

10.3 Value for Money

Project 145 represented good value for Money in terms of cost-effectiveness as it has generated critical base-line deep-sea biodiversity data. Data that did not exist prior to the project. The level of impact the project will have is still to be fully determined. However, the continued interest and engagement by the Government of Bermuda's DENR with ASU BIOS to continue work initiated under Project 145 suggest good Value for Money in terms of impact.
The geographical location of the Bermuda Islands (close proximity to deep-sea environments and access to suitable small vessels) allow such projects to implement lower cost approaches to deep-sea research. These approaches can then to taught to other Small Island Nations to aid in capacity building for example the training of Veta Wade (Section 4.2).

11 Other comments on progress not covered elsewhere

12 OPTIONAL: Outstanding achievements of your project (300-400 words maximum). This section may be used for publicity purposes.

In light of the recent challenges faced by the project, we have opted to not complete this section without first full cooperation and agreement from all project partners.

The project did document three new species for Bermuda (two sharks and one fish) that also represent range extensions for those species.

File Type (Image / Video / Graphic)	File Name or File Location	Caption, country and credit	Online accounts to be tagged (leave blank if none)	Consent of subjects received (delete as necessary)
				Yes / No
				Yes / No
				Yes / No
				Yes / No
				Yes / No

Annex 1 Report of progress and achievements against logframe for the life of the project

Project summary	Progress and achievements
Impact: Improved conservation and management of biodiversity, threatened species and fisheries resources in Bermuda's deep waters, and greater understanding of connectivity between these deep areas and shallow ecosystems. (Max 30 words)	Detection of three new species for Bermuda (2 sharks and one fish) highlighting the need for dep-sea biodiversity monitoring projects. All detections came from eastern pelagic MPA proposed under the draft BOPP Marine Spatial Plan.
Outcome: Marine conservation and management in Bermuda is enhanced by establishing quantitative baseline data for mobile deep-sea ichthyofauna, resulting in more comprehensive data-driven ecosystem management via a new fisheries management plan and a better informed marine spatial plan.	
0.1 Outcome indicator 0.1 Baseline biodiversity maps of mobile fishes and elasmobranchs, across 24 km^2 of mesophotic to deep-sea habitats (30 – 2000 m) provided to DENR and BOPP team by July May 2023.	The team successful deployed 59 deep BRUVs of 70 attempted. The team prioritised deep-sea biodiversity surveys as all BRUVs deployments were condensed into 2022 so no mesophotic BRUVs were conducted (Section 1, Figure 1). The project exceeded the proposed 120 deep-sea environmental DNA (eDNA) samples by collecting 160 samplesSection 3.1 Figure 2). Maps have been shared with DENR (Section 3.1 Figure 4), full GIS database of species detections is still pending to be transferred. See Section 3 Figures
Outcome indicator 0.2 The first extensive report on the status of Bermuda's deep-sea biodiversity provided to key stakeholders (DENR, BOPP, Marine Resources Board and Darwin) by July May 2023.	A final report has not been presented to any stakeholders due to efforts to overcome latter stage project challenges and complete the project.
Outcome indicator 0.3 A list of detected shark species presented to DENR and MRB at the end of year 1 and June 2023.	Section 3 Figure 4 details shark species detections and highlights geographical location of reprasentative detections which has been share with DENR project partner.

Outcome indicator 0.4 Draft management plan for deepwater fisheries presented to senior DENR managers by July May 2023.	The output of this category was not met. Deepwater snappers were only detected at three locations throughout the combined dataset (one by deep BRUVs, two by eDNA). It was concluded that deepwater fishery resources are sparse and not evenly distributed
Outcome indicator 0.5 eDNA based lesson plans and biodiversity outreach video	See Annex 3 – 4 for details on eDNA lesson plan. See Annex 2 for draft outreach video pending project partner /DEFRA approval.
Output 1. GIS database of deep-sea biodiversity combining BRUVs observations, eDNA species detections and environmental layers.	
Output indicator 1.1. Biodiversity surveys conducted in year 1 and year 2 (4 survey days per trip, 2 trips year 1, 4 trips year 2).	Biodiversity surveys were completed, survey sites illustrated in Figure 1, Section 1.
Output indicator 1.2. Data provided in GIS format e.g. shapefiles and maps provided to DENR and BOPP.	No GIS formated files have been provided to DENR or BOPP to date. Focus has been the closure of the project. Products will be provides post report submission.
Output indicator 1.3. A separate data layer per survey method and habitat (mesophotic and deep-sea)	No GIS formated files have been provided to DENR or BOPP to date. Focus has been the closure of the project. Products will be provides post report submission.
Output indicator 1.4. At least two additional DENR staff members participate in BRUVs and eDNA collection fieldwork to increase local survey knowledge and capacity.	Due to COVID-19 restrictions and staff shortages, no Fisheries Wardens were able to participate in the project. It is hoped the continuation of deep BRUVs deployments will enable this.
Output 2. Report describing the status of deep-sea biodiversity around Bermuda, with management recommendations.	
Output indicator 2.1. Report provided to DENR, BOPP, MRB and Darwin by July May 2023.	A final report has not been presented to any stakeholders due to efforts to overcome latter stage project challenges and complete the project.
Output indicator 2.2. Scientific publication in preparation by August May 2023	Scientific publication preparation has not begun due to efforts to overcome latter stage project challenges and complete the project.
Output 3. Report on elasmobranch biodiversity and distribution, with management recommendations.	

Output indicator 3.1. Year 1 findings and final report provided to DENR, MRB and BOPP by June 2022 and July 2023.	Overall all shark species detections have been provided to DENR in map form (Section 3, Figure 4)
Output 4. Management plan for Bermuda's deepwater vertical line fishery.	
Output indicator 4.1. Draft deepwater fishery management plan developed by July 2023.	The output of this category was not met. Deepwater snappers were only detected at three locations throughout the combined dataset.
Output 5. Research and multimedia outputs developed and shared with target audiences (included local and international teachers' local government and BOPP) to promote conservation of Deep-sea biodiversity.	
Output indicator 5.1 Outreach video produced and disseminated by June 2023.	Draft version will be shared with project partners and DEFRA for approval prior to final edit and dissimination.
Output indicator 5.2 Curated and simplified eDNA dataset for BIOS Databytes available and utilized at one educator workshop by July 2023.	At the close of 2021, the lesson had been curated and tested in ASU BIOS's summer Ocean Academy program and launched to teachers through a professional development workshop in February 2022.
Output indicator 5.3 Lesson plan developed for inquiry based eDNA lab by July 2023.	Lesson plan developed, see Annex 3.
Output indicator 5.4 Bioinformatic scripts published on www.github.com and included in stakeholder reports July 2023.	Bioinformatic scripts at not currently on Github, however are available for dissemination.
Output 6. Local capacity enhanced via the training of two interns in project methodologies.	
Output indicator 6.1 Two Bermuda Program interns trained by September 2022 – Extension of year 1 intern to align with field and lab work due to project delays	Two students were trained in field campaign deployments in 2021 and one student in 2022 (see Annex 3 section Capacity Building and Training for Young Professionals)

Annex 2 Project's full current logframe as presented in the application form (unless changes have been agreed)

Project summary	SMART Indicators	Means of verification	Important Assumptions
Impact: **Improved conservation and management of biodiversity, threatened species and fisheries resources in Bermuda's deep waters, and greater understanding of connectivity between these deep areas and shallow ecosystems.**			
Outcome: Marine conservation and management in Bermuda is enhanced by establishing quantitative baseline data for mobile deep-sea ichthyofauna, resulting in more comprehensive data-driven ecosystem management via a new fisheries management plan and a better informed marine spatial plan.	0.2 Baseline biodiversity maps of mobile fishes and elasmobranchs, across 24 km^2 of mesophotic to deep-sea habitats (30 – 2000 m) provided to DENR and BOPP team by July May 2023. 0.3 The first extensive report on the status of Bermuda's deep-sea biodiversity provided to key stakeholders (DENR, BOPP, Marine Resources Board and Darwin) by July May 2023. 0.4 A list of detected shark species presented to DENR and MRB at the end of year 1 and June 2023. 0.5 Draft management plan for deepwater fisheries presented to senior DENR managers by July May 2023. eDNA based lesson plans and biodiversity outreach video	0.1 Interim progress report (July 2022) and final biodiversity database and GIS layers presented to DENR and BOPP marine spatial planning steering committee (July May 2023). 0.2 Year 1 findings and final report given to key stakeholders by September 2022 and July May 2023 respectively to facilitate action plan development beyond the life of this project. 0.3 Draft revisions to the Bermuda shark management action plan, incorporating any additional species available by July May 2023 0.4 DENR management confirm receipt of the draft deepwater fisheries management plan and intention to present it to the MRB and CFC by July May 2023 0.5 Educational material use confirmed through educator workshops attendee lists and download of resources recorded by click count.	Target mobile fishes and elasmobranchs are detected by project methodologies. Assumption of species population connectivity. BOPP stakeholders continue willingness to cooperate on biodiversity conservation initiatives. Project recommendations and baseline biodiversity data will be incorporated into the marine spatial planning process and utilised to evaluate and enhance the nascent MPA network.

Output 1 GIS database of deep-sea biodiversity combining BRUVs observations, eDNA species detections and environmental layers.	1.1 Biodiversity surveys conducted in year 1 and year 2 (4 survey days per trip, 2 trips year 1, 4 trips year 2). 1.2 Data provided in GIS format e.g. shapefiles and maps provided to DENR and BOPP. 1.3 A separate data layer per survey method and habitat (mesophotic and deep-sea) At least two additional DENR staff members participate in BRUVs and eDNA collection fieldwork to increase local survey knowledge and capacity.	1.1 Meeting notes from consultation with BOPP MSP committee to identify areas of interest for surveys (October 2021). 1.2 Video foot age from mesophotic (n = 48) and deep BRUVs (n = 96) 1.3 Replicate eDNA sequencing results in the form of fasta files (mesophotic n =48, deep n = 120). 1.4 Biodiversity maps and GIS databases created. 1.5 Staff member timesheets report participation in fieldwork.	No failure of BRUVs equipment Bait will not contaminate eDNA samples Ichthyofauna will produce detectible levels of genetic material. Field activities can be re- scheduled if extreme weather events occur during grant period. Fisheries Warren will engage in professional development activities.
Output 2 Report describing the status of deep-sea biodiversity around Bermuda, with management recommendations.	2.1 Report provided to DENR, BOPP, MRB and Darwin by July May 2023. 2.2 Scientific publication in preparation by August May 2023	2.1 Stakeholder confirmation of the receipt of the Y1 project status report (July 2022) and final report (July 2023). 2.2 Draft publication appended to final project report	Inclement weather does not delay project timeframe. Publication schedule does not delay availability of scientific report.
Output 3 Report on elasmobranch biodiversity and distribution, with management recommendations.	3.1 Year 1 findings and final report provided to DENR, MRB and BOPP by June 2022 and July 2023.	3.1 Stakeholder confirmation of the receipt of the Y1 project status report (June 2022) and final report (July 2023). 3.2 Additional shark species added to shark management plan.	DENR and MRB continue willingness to cooperate on shark conservation initiatives.
Output 4. Management plan for Bermuda's deepwater vertical line fishery.	4.1 Draft deepwater fishery management plan developed by July 2023.	4.1 DENR management confirm receipt of the draft plan and intention to present it to the MRB and CFC by July 2023	Stakeholders are prepared to discuss management changes to the fishery. Distribution and relative abundance of deepwater snapper species can be determined from the video footage and eDNA

Output 5. Research and multimedia outputs developed and shared with target audiences (included local and international teachers' local government and BOPP) to promote conservation of Deep-sea biodiversity.	5.1 Outreach video produced and disseminated by June 2023. 5.2 Curated and simplified eDNA dataset for BIOS Databytes available and utilized at one educator workshop by July 2023. 5.3 Lesson plan developed for inquiry based eDNA lab by July 2023. 5.4 Bioinformatic scripts published on www.github.com and included in stakeholder reports July 2023.	5.1 The video link is available on stakeholder websites with usage recorded by click count. 5.2 The weblink is available through the BIOS website (www.bios.edu) and the download of resources recorded by click count. 5.3 The weblink is available through github and the BIOS website (www.bios.edu) with links to the material publicized in all reports and outreach material. Usage is recorded by click counts and citations through google scholar.	Users have access to online digital material. Users of bioinformatic materials have basic coding skills. Both national and international educators and students are permitted to travel to BIOS campus for in person workshops.
Output 6. Local capacity enhanced via the training of two interns in project methodologies.	6.1 Two Bermuda Program interns trained by September 2022 – Extension of year 1 intern to align with field and lab work due to project delays	6.1 BIOS Bermuda Intern application packet received by OA coordinator. 6.2 Intern reports appended to year 2 and final reports.	Assumption that Bermudian Students will apply to work on this project.

Activities (each activity is numbered according to the output that it will contribute towards, for example 1.1, 1.2 and 1.3 are contributing to Output 1)

1.1 Purchase and assemble equipment for deep BRUVs.
1.2 Purchase eDNA laboratory consumables, software licenses and electric reel for niskin retrieval.
1.3 Meet with BBOP MSP steering committee to identify high value survey areas.
1.4 Determine which 2 fisheries wardens will participate in sampling and discuss availability.
1.5 Acquire and map baseline data from historic initiatives and know fishing activities and overlay on sampling design (based on 1km^2 grid).
1.6 Deploy BRUVs (MCE) 6 times per trip (2 days), 2 trips in year 1, and 2 trips in year 2 (n = 48).
1.7 Deploy BRUVs (deep-sea) 16 times per trip (4 days), 2 trips in year 1, and 4 trips in year 2 (n = 48).
1.8 Analyze camera footage using EventMeasure software to generate relative abundance and biodiversity metrics.
1.9 Year 1, collect replicate seawater samples (8L) from BRUVs survey sites with the addition of a shallow water sample take from deep-sea sites to detect oceanic shark species. Repeat in year 2 (MCE n = 48, deep-sea n = 120).

1.10 Filter samples, extract DNA from filter using EZNA OMEGA DNA extraction kit, amplify mtDNA 12S region using MiFish primers (Miya et al. 2015) generating Illumina libraries in a two-step PCR approach. Additional sequencing required for negative and positive controls.
1.11 Libraries for all sampling trips sent for sequencing within a month of completing the final sample collection.
1.12 Assign Molecular Operational Taxonomic Units (MOTUs) to species using pipeline script developed by TN
1.13 Overlay BRUVs observational data and MOTU eDNA dataset in GIS to visualize species distribution patterns.
1.14 Create GIS database of biodiversity database and incorporate environmental data, provide to DENR and BOPP
2
2.1 Analyze and interpret species diversity patterns and identify areas of high biodiversity and provide progress report to stakeholders end of year 1.
2.2 Incorporate year 2 data, reanalyze full data set to determine distribution patterns and areas of high biodiversity. Compare species compositions across depth ranges as a proxy for corridors of connectivity (caveat, populations genetics is outside of the scope of this project).
2.3 Write up advisory report identifying areas of greatest biodiversity, species of commercial interest and highlighting vulnerable species.
3
3.1 Analyse and interpret elasmobranch diversity patterns and identify areas of high biodiversity and probable connectivity between MCE and deep-sea environments.
3.2 Provide DENR, MRB, and BOPP progress report in year 1, full analysis with management recommendations in year 3 and a scientific publication on the status of Bermuda's deep-sea biodiversity.

4.1 Collate landings and other data on deepwater snappers and other fishery target species over time by September 2021.

4.2 Interview current and past holders of deepwater vertical line licences to gather insights on distribution of fishing effort in space and time over the years, and how this may have changed. Use this information to help plan project surveys by January 2021.

4.3 Evaluate project data on distribution and relative abundance of deepwater fishery target species, fish species of conversation concern, and any supplemental data on deepwater macrobenthos of conservation interest by July 2023.

4.4 Utilise existing legislation and the ongoing marine spatial planning process to develop an ecosystem-based management plan for the deepwater fishery by July 2023.

5.1 Select video footage from year 1 and year 2 BRUVs for inclusion in outreach video.

5.2 Develop curated and simplified eDNA dataset for BIOS Databytes utilized at educator workshops.

5.3 Lesson plan development for inquiry based eDNA lab.

5.4 In conjunction with section 1.12, develop bioinformatic scripts for publication on www.github.com and inclusion in stakeholder reports at the end of year 2.

6.1 Review of Bermuda Program internship applications for local student placements (year 1 and year 2).

6.2 Review of final reports submitted to BIOS OA and DENR, January 2021 and December 2022

Annex 3 Standard Indicators

Table 1 Project Standard Indicators

DPLUS Indicator number	Name of indicator	Units	Disaggregation	Year 1 Total	Year 2 Total	Year 3 Total	Total achieved	Total planned
DPLUS-A01	Number of people in eligible countries who have completed structured and relevant training	People	Men	2	4			Not included in original proposal
E.g. DPLUS-A01	E.g. Number of people in eligible countries who have completed structured and relevant training	People	Women	0	1			Not included in original proposal
E.g. DPLUS-B01	E.g. Number of new or improved habitat management plans available and endorsed	Number	New	1	0		1	2
E.g. DPLUS-B01	E.g. Number of new or improved habitat management plans available and endorsed	Number	Improved	0	0		0	1

Table 2 Publications

Title	Type (e.g. journals, manual, CDs)	Detail (authors, year)	Gender of Lead Author	Nationality of Lead Author	Publishers (name, city)	Available from (e.g. weblink or publisher if not available online)

Annex 5 Supplementary material (optional but encouraged as evidence of project achievement)

Annex Supplementary material

1. Darwin 145 outreach video DRAFT not for dissemination
2. Darwin 145 Supplemental Report outlining all activities undertaken
3. Molecular Biology : Fishing for Fingerprints Lesson Plan & Worksheet
4. Molecular Biology : Fishing for Fingerprints Lesson Slides
5. DENR Shark Management and Protection Flier

Checklist for submission

	Check
Different reporting templates have different questions, and it is important you use the correct one. Have you checked you have used the **correct template** (checking fund, type of report (i.e. Annual or Final), and year) and **deleted the blue guidance text** before submission?	X
Is the report less than 10MB? If so, please email to BCF-Reports@niras.com putting the project number in the Subject line.	X
Is your report more than 10MB? If so, please discuss with BCF-Reports@niras.com about the best way to deliver the report, putting the project number in the Subject line. All supporting material should be submitted in a way that can be accessed and downloaded as one complete package.	X
If you are submitting photos for publicity purposes, **do these meet the outlined requirements (see section 14)?**	N/A
Have you included means of verification? You should not submit every project document, but the main outputs and a selection of the others would strengthen the report.	X
Have you involved your partners in preparation of the report and named the main contributors	No
Have you completed the Project Expenditure table fully?	Yes
Do not include claim forms or other communications with this report.	