Darwin Plus:
Overseas Territories Environment and Climate Fund

Final Report

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

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

Darwin Plus Project Information

Project reference	DPLUS122
Project title	Biodiversity discovery and the future of South Georgia's seaweed habitats
Territory(ies)	South Georgia and the South Sandwich Islands
Lead organisation	Natural History Museum (NHM)
Partner institution (s)	South Atlantic Environmental Research Institute (SAERI), Shallow Marine Surveys Group (SMSG), British Antarctic Survey (BAS), Tritonia Scientific Ltd.
Darwin Plus Grant value	£245,841
Start/end date of project	1st March 2021–31st March 2023
Project leader name	Juliet Brodie
Project website/Twitter/blog etc.	Field expedition blog: https://www.huntsmanmarine.ca/blog. Twitter: @Juliet_Seaweeds, @SAERI_FI, @Shallow_marine, @BAS_News, @TritoniaDiving.
Report author(s) and date	Juliet Brodie & Rob Mrowicki, 23rd June 2023

1 Project Summary

Seaweeds constitute a huge proportion of South Georgia's unique and charismatic marine biodiversity but they are highly vulnerable to environmental change. Although South Georgia is far from many human impacts (**Figure 1**), its marine biodiversity faces threats from rapid climate change (ocean warming and acidification), invasive species (including seaweeds), tourism and fishing activities (e.g. pollution). Seaweeds, many of which are on the edge of their distributional range in this region, are indicators of environmental change and their responses can resonate throughout entire ecosystems, with knock-on effects for fisheries and tourism. Despite the obvious ecological importance of seaweeds in South Georgia, very little is known about their biodiversity and distribution at this remote location, with implications for the conservation and management of the island's unique inshore marine environment.

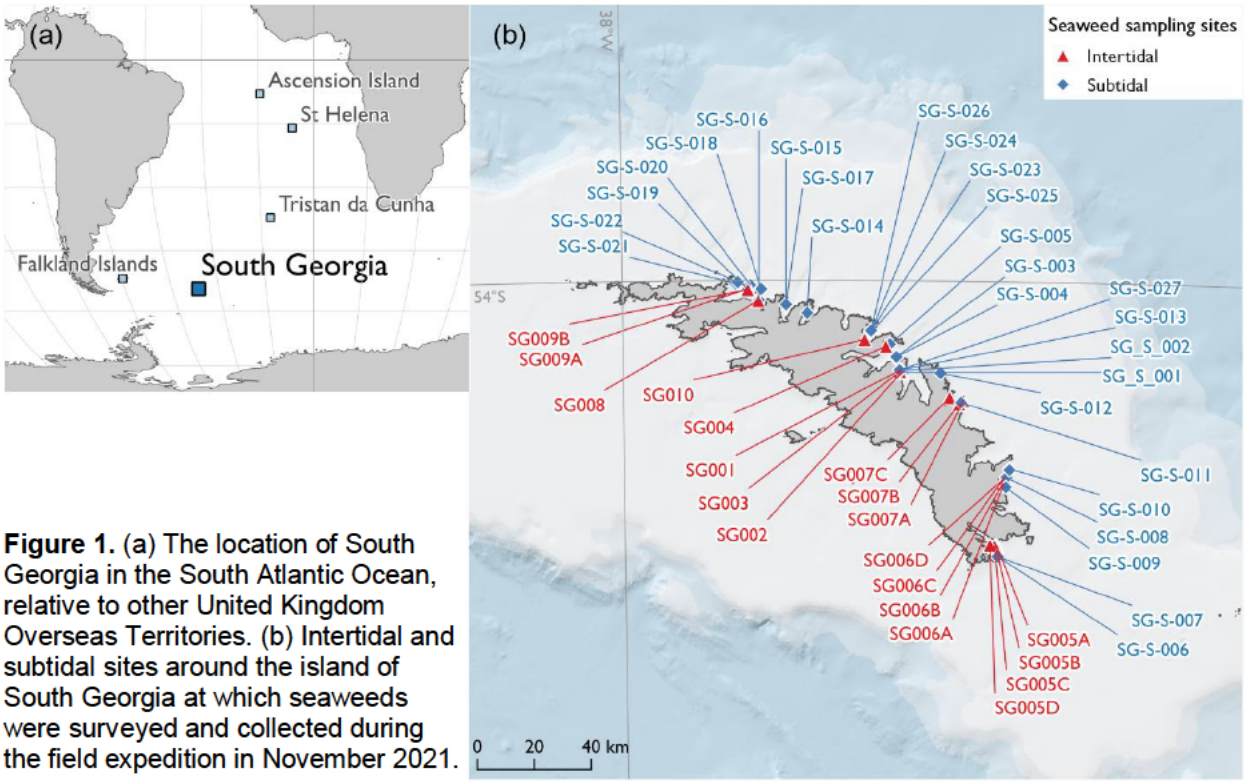

Figure 1. (a) The location of South Georgia in the South Atlantic Ocean, relative to other United Kingdom Overseas Territories. (b) Intertidal and subtidal sites around the island of South Georgia at which seaweeds were surveyed and collected during the field expedition in November 2021.

The primary aim of this project was to generate baseline seaweed diversity knowledge for South Georgia, filling critical gaps in knowledge of inshore seaweed-dominated habitats, enabling the development of new tools for marine environmental management. This is important because the South Georgia and South Sandwich Islands Marine Protected Area (SGSSI-MPA) is one of the world's largest MPAs. To achieve this aim, the project integrated innovative molecular techniques with historical specimen data and involved the first major field expedition to understand seaweed diversity and distribution around South Georgia. This wealth of knowledge provides a foundation for tools with which to build capacity for monitoring and decision-making in order to protect these vital marine habitats around the territory. This project has also facilitated knowledge transfer among stakeholders and raised public awareness of South Georgia's marine environmental importance, both within the region and internationally.

2 Project Stakeholders/Partners

All formal project partners, i.e. Juliet Brodie (Project Leader), Rob Mrowicki (Project Officer) and Jonathan Gabriel (NHM), Paul Brickle (SAERI), Paul Brewin (SMSG), Pete Convey (BAS) and Martin (or Jonathan) Sayer (Tritonia), were involved in the project conception and planning stages, including through a series of pre-project meetings held in May–June 2020 (see meeting notes – **Supplementary Document 1, Annex 6.2**). While the partners know each other and in various combinations have worked together on a number of projects, these early meetings were vital for building the team, putting a framework in place and iron out any logistical problems, particularly when dealing with the impact of COVID-19, which resulted in the project being delayed by approximately seven months. Partners also participated in ongoing decision-making throughout the project, particularly in advance of (and during) the main field expedition in November 2021 Regular contact among partners has been maintained through a series of 'steering group' meetings held approximately every four months, including project progress reports (largely from NHM partners) and development of new initiatives.

The field expedition itself involved all partner organisations; however, Pete Convey and Martin Sayer were unable to participate in the seven-week field expedition itself. This was due to (respectively) excessive quarantine requirements in between two Antarctic voyages and other professional commitments. Martin was replaced by dive supervisor Jonathan Sayer (Tritonia). The expedition team was also joined by three additional researchers: PhD student Joanna

Zanker (SAERI/BAS), Dr Karin Gérard (Universidad de Magallanes, Chile) and Dr Claire Goodwin (Huntsman Marine Science Centre, Canada), who participated in surveys and data/specimen collection, contributing directly to project scientific activities.

Although not a formal partner, the Government of South Georgia and the South Sandwich Islands (GSGSSI) has been fully engaged with the project and offered vital support. Prior to the start of the project, GSGSSI was in correspondence with the PL and wrote a letter of support. Importantly, GSGSSI enabled use of the fishery patrol vessel MV Pharos SG as our research vessel for the field expedition. During the field trip, we met with the GSGSSI Chief Executive (Laura Sinclair Willis) and Visitor Management and Biosecurity Officer (Ross James) at their offices in Stanley to report on the expedition and discuss future research in the context of marine environmental protection. Additionally, the Director of Operations (Steve Brown) was a key expedition participant, both acting as government representative and participating directly in scientific activities.

While in the Falkland Islands, we also took the opportunity to meet personally with other key project stakeholders: Director and Exhibitions Manager of the Falkland Islands Museum, Andrea Barlow and Tasmin Tyrrell, and curator of the South Georgia Museum (South Georgia Heritage Trust), Jayne Pierce, to arrange museum exhibits in Stanley and Grytviken (following which seaweed displays have been donated to both museums); and Falklands Conservation (FC) CEO and CO, Esther Bertram and Andy Stanworth, and Communications and Marketing Officer, Sorrel Pompert Robertson, to discuss policy-orientated research and run a seaweed-themed activity session with the 'Watch Group'.

Early meetings with Amanda Lynnes, Director of Environment and Science Coordination at the International Association of Antarctic Tour Operators (IAATO) ensured the support of this key stakeholder in establishing a citizen science programme, which has been achieved through collaboration with the Polar Citizen Science Collective (PCSC), overseen by the organisation's co-founder Annette Bombosch. This initiative is a key achievement of the project, and represents a valuable legacy in terms of a new partnership between NHM and PCSC and ongoing collection of biodiversity monitoring data.

A strategic framework workshop, led by the PI and bringing together GSGSSI plus other main stakeholders (FC, IAATO, South Georgia Heritage Trust [SGHT], BAS and SAERI), was held online in December 2022. Here, the main scientific results of the project were disseminated and the integration of seaweeds into marine environmental management in South Georgia was discussed.

3 Project Achievements

3.1 Outputs

Output 1. Enhanced baseline knowledge of seaweed diversity and distribution in South Georgia.

At the start of the project, seaweeds were poorly studied and inventoried in South Georgia, and represented a critical knowledge gap in terms of the current Biodiversity Action Plan and Research Monitoring Plan. This project has greatly enhanced baseline knowledge of seaweed biodiversity and distribution in South Georgia through cataloguing of existing museum specimens and molecular-assisted taxonomy of new specimens collected from around the island.

A total of 83 historical South Georgia seaweed specimens were located in the NHM algal herbarium, from which relevant information was extracted (including georeferencing according the NHM Georeferencing Guidelines) and formatted ready for addition to the NHM Data Portal. Only four of these specimens had previously been assigned barcode numbers, and were in the NHM Data Portal; the remaining 79 are currently being barcoded and databased by Senior Algal Curator Jo Wilbraham. A further 155 contemporary specimens collected during a 2010 expedition to South Georgia were also catalogued and imaged, resulting in a new total of 238 databased specimens (Activity 1.1 – database existing herbarium specimens; see herbarium specimen list – **Tables S1 & S2, Annex 6.1**).

Falkland Islands PhD student Amy Guest (University of Aberdeen/SAERI) joined the project for two months to undertake capacity building in DNA sequencing methods via training in the NHM molecular labs, and to perform molecular work on 42 of the 155 specimens from 2010 (Activity 1.2 – DNA analysis of recent specimens and produce initial species check-list). Despite using a range of different DNA extraction and amplification techniques, the success rate was very low (due to the general difficulties of conducting molecular work on seaweeds, combined with likely DNA degradation in decade-old specimens), with a total of eight sequences obtained from five specimens (**Table 1**). However, these data supported molecular work on new specimens collected during this project, ultimately resulting in the species identification of the remaining specimens within the same collection. Using these preliminary molecular results, combined with taxonomic data obtained from the historical herbarium specimens and existing species lists from other sources, a preliminary check-list of 76 South Georgia seaweed species was compiled prior to the field expedition.

Table 1. Summary of DNA sequences obtained from NHM South Georgia seaweed specimens collected during SMSG expedition in 2011 (preliminary names determined by Dr Emma Wells) and information relating to the best matching sequences in GenBank (obtained October 2021).

Specimen code	Preliminary species name	Genetic marker	Best matching GenBank sequence				
			Sequence code	Cover (%)	Identity (%)	Species name	Location
SG18b	*Gigartina skottsbergii*	COI	KY559908	93	100.00	*Microrhinus carnosus*	South Shetland Islands
SG42c	*Hymenocladiopsis pro*lifera	COI	KY559781	93	99.84	*Gymnogongrus antarcticus*	South Shetland Islands
SG4	*Cryptonemia* sp.	COI	KY559908	93	100.00	*Microrhinus carnosus*	South Shetland Islands
SG42c	*Hymenocladiopsis prolifera*	*rbcL*	AF388566	99	94.04	*Ahnfeltiopsis humilis*	New Zealand
SG20c	*Iridaea cordata*	*psbA*	MN967052	100	99.27	*Palmaria decipiens*	Antarctica
SG39a	*Scytothamnus fasciculatus*	*psbA*	GQ368347	94	99.78	*Desmarestia menziesii*	(Unknown)
SG42c	*Hymenocladiopsis prolifera*	*psbA*	KX525588	98	92.89	*Mastocarpus papillatus*	W. USA
SG4	*Cryptonemia* sp.	*psbA*	KY682936	100	94.92	*Hemineura frondosa*	Tasmania

The main field expedition took place between 10th October and 1st December 2021, beginning with approximately three weeks in the Falkland Islands, allowing for a mandatory COVID-19 quarantine period of five days, followed by project outreach activities (see Output 3 below) plus necessary preparations for South Georgia. The team departed for South Georgia aboard the GSGSSI fishery patrol vessel *MV Pharos SG* on 6th November, arriving on 8th November at King Edward Point (KEP) to begin fieldwork, which continued for 12 days, before departure on 20th November and arrival back in Stanley on 24th November (see expedition report – **Supplementary Document 2, Annex 6.2**). During the expedition, ecological surveys and specimen collections were undertaken at 19 intertidal and 29 subtidal sites around the northeast coast of South Georgia (Activity 1.3 – survey seaweed and faunal species; **Figure 1**; see survey site list – **Table S3, Annex 6.1**), enabling us to determine the distribution of key seaweed species (see Output 2) and to obtain a total of 729 seaweed 'specimens' (i.e. sheets comprising one to several individuals; Activity 1.4 – identify and database new specimens and establish reference collection; see specimen list – **Table S4, Annex 6.1**). The number of separate individuals is much greater than this (estimated >1,500), as often multiple individuals were preserved on a single sheet. This was in addition to 211 specimens (sheets) collected from seven intertidal sites in the Falkland Islands, which provided taxonomic and biogeographic context for determining the diversity of seaweeds in South Georgia.

Tissue subsamples for DNA were obtained from 475 representative seaweed specimens (see specimens used in molecular analyses – **Table S5, Annex 6.1**) in order to determine species identity, uncover cryptic diversity and resolve taxonomic issues through DNA barcoding (Activity 1.5 – inventory overall seaweed diversity and resolve taxonomy of problematic groups). Subsequent DNA extractions (conducted during December 2021–February 2022 in the NHM molecular labs) were successful for all samples, and PCR amplifications yielded 916 products of sufficient quality for sequencing, corresponding to 420 samples (1–3 products per sample, representing multiple genetic markers). From these products, 739 sequences of sufficient quality for DNA barcoding and phylogenetic tree reconstruction were obtained (see molecular analysis results – **Figure S1, Annex 6.1**). Through molecular-assisted taxonomy, a comprehensive check-list of 199 species was produced (**Supplementary Document 3, Annex 6.2**), representing a 162% increase relative to the initial list of 76 species. There still remains a great deal of

taxonomic uncertainty, highlighting the huge amount of remaining work to resolve seaweed taxonomy on a global scale, to which this project makes an important contribution.

Output 2. Tools for monitoring, managing and researching South Georgia's inshore marine environment, founded upon baseline biodiversity knowledge.

Knowledge of the biodiversity of South Georgia's shallow marine ecosystems, including species distributions and community composition, was very poor at the start of the project, particularly with regards to seaweeds. Thus, there were no environmental management tools based on synthesised biodiversity information available to stakeholders.

Using data from field surveys and specimens collected at 48 sites around the coast of South Georgia, together with updated taxonomic information, it was possible to determine areas with the highest taxonomic richness, highlighting habitats containing the largest proportion of rare species (Activity 2.1 – identify potential biodiversity hotspots and vulnerable habitats; see report on spatial and temporal trends in seaweed diversity – **Supplementary Document 4, Annex 6.2**). Giant kelp (*Macrocystis pyrifera*) densities and records of the presence of crustose coralline algae obtained from underwater surveys provided new data on the distribution of these important habitats in South Georgia, which could not be obtained from the analysis of remote sensing imagery (Activity 2.2 – develop maps of key seaweed-dominated habitats). It was not possible to conduct a full analysis involving ground-truthing of fine-scale coastal habitat maps, which would have required a more targeted approach focussing on areas with uncertain habitat classification, detracting from our main objective of gathering as much biodiversity data as possible. We also combined the contemporary (2021) and recent (2010) specimen data with the georeferenced historical records to investigate temporal and spatial trends in seaweed distribution in more detail (Activity 2.3 – analyse trends in seaweed diversity and distribution). Despite the limited amount of historical data, and remaining taxonomic inconsistencies, we have highlighted 22 potential new records (i.e. range expansions) and/or undescribed taxa, and three species that were recorded historically but which we did not encounter during the expedition (see report on spatial and temporal trends in seaweed diversity – **Supplementary Document 4, Annex 6.2**).

As an additional tool for stakeholders, including researchers, managers and visitors, a seaweed ID guide containing 75 species has been written (Activity 2.4 – publish seaweed species ID guide; **Supplementary Document 5, Annex 6.2**). This has been complemented by pictorial ID guides for nine key species, including four non-natives, involved in the South Georgia Big Seaweed Search citizen project (see Output 3). Given the extent of undescribed seaweed biodiversity, including the discovery of new species among what were thought to be well-known common and conspicuous seaweeds, it has not yet been possible to develop electronic identification keys for managers and citizen scientists (Activity 2.5). However, we would model such a key on the existing Seaweed Sorter app.

Synthesised specimen record data (from 2010 and 2021) were also used to conduct a species-orientated analysis to identify 27 'rare' taxa, including three potential introductions, based on Red List spatial distribution criteria. These were then fed into a site-orientated analysis, following 'Important Seaweed Area' criteria to determine sites of seaweed biodiversity importance in South Georgia (Activity 2.6 – Red Data list/Important Seaweed Area assessments; see report on spatial and temporal trends in seaweed diversity – **Supplementary Document 4, Annex 6.2**).

Data resulting from this project are being prepared for submission to open access databases (Activity 2.7 – make data and reports publicly available), but this is an ongoing process (see **Section 6** below). Metadata forms have been prepared for submission to the SAERI IMS-GIS Data Centre, encompassing specimen and molecular data (see metadata forms – **Supplementary Document 6, Annex 6.2**). Documents included with this Final Report will be publicly available via the Darwin Initiative; the expedition report (**Supplementary Document 2, Annex 6.2**) will also be available via the SMSG website.

Output 3. Strengthened capacity for marine environmental protection and research in South Georgia, through training, knowledge transfer and public awareness raising.

There was very little capacity for identifying and monitoring seaweed biodiversity in South Georgia prior to the project, including a lack of tools (even a basic, up-to-date species check-list) and training for stakeholders, and no seaweed citizen science programmes for members of the public. There was already some awareness of the ecological importance of seaweeds among stakeholders that we have worked with previously in the Falkland Islands, but this was specific to the Falklands as opposed to South Georgia. Even within the scientific community, there are extremely few data (almost none from recent decades) from South Georgia that would be pivotal in advancing our understanding of global seaweed biodiversity and distribution.

The PL and PO undertook a range of public outreach activities and stakeholder meetings in Stanley during the field expedition, including a seaweed ID workshop and public talk at the Falkland College (attended by 16 and 13 people, respectively), recording a feature with Falkland Islands TV, and recorded interviews at Falklands Radio both before and after visiting South Georgia. Additionally, the PL and PO gave a talk entitled 'Seaweed Explorers' to the Infant Junior School (total 60 students) in Stanley, conducted a lesson on seaweed biodiversity and conservation for Year 8 students (total 58) at Stanley secondary school, and ran a seaweed-themed activity session with the Falklands Conservation youth Watch Group (total 14 participants), led by Sorrel Pompert Robertson, at Falkland College. Museum exhibits featuring seaweed specimens collected during the field expedition were created for both the Falkland Islands museum in Stanley (currently on display) and South Georgia museum in Grytviken (made by the PL and PO), to be shipped in time for the 2023/24 season (Activity 3.1 – raise public awareness via public talk, TV/radio interviews and museum exhibit; see public event advertisements and photographs of museum exhibits – **Supplementary Document 7, Annex 6.2**).

Although the PL planned to establish a seaweed science working group at the 12th International Phycological Congress in March 2021, it was not possible to attend in person due to COVID-19 (**Section 9**); however, the PL and PO held a workshop at the 24th International Seaweed Symposium in Tasmania in February 2023, attended by 25 researchers (17 in person), to fulfil this objective (Activity 3.2 – establish seaweed science working group; see workshop report – **Supplementary Document 8, Annex 6.2**). There will be a follow-up workshop at the European Phycological Congress on 23rd August 2023.

In terms of dissemination of biodiversity information (Activity 3.3 – disseminate seaweed biodiversity information to stakeholders), a policy-orientated workshop was held for stakeholders from GSGSSI, BAS, IAATO, SAERI and SMSG online in December 2022, during which a summary of key scientific results from the project were presented (see workshop report – **Supplementary Document 9, Annex 6.2**). As well as the public seaweed ID workshop in Stanley, all participants of the field expedition, representing GSGSSI, SAERI, SMSG and BAS, received training from the PL and PO on seaweed collection, identification and preservation techniques (Activity 3.4 – conduct stakeholder ID training); in particular, the PL gave a talk to the team en route to South Georgia aboard the MV Pharos SG, focussing on the current state of knowledge on South Georgia's seaweed diversity and priorities for research.

Following the expedition, the PL has given three talks: two invited public lectures: 1) 'Operation *Himantothallus*: South Georgia seaweed diversity, environmental change and biogeographical considerations for the South Atlantic' at the British Phycological Society conference in January 2022, 2) 'The power of citizen science: developing a programme for seaweed aquaculture and conservation' at the University of Malaya in May 2023; 3) a presentation at the SGSSI MPA Symposium at the British Antarctic Survey Offices, Cambridge, on the 13th June 2023, entitled 'Biodiversity of South Georgia's seaweeds: unique, charismatic and essential'; and 4) will give a talk on the 23rd June 2023 at the annual Phycological Society of America meeting in Rhode Island, USA, entitled 'Biodiversity of South Atlantic and Southern Ocean seaweeds: rich, charismatic and undescribed island floras' (Activity 3.5 – disseminate scientific results via conference presentations and articles; see conference abstracts – **Supplementary Document 10, Annex 6.2**). Additionally, we have already published an open access scientific paper detailing the first record of a non-native seaweed in South Georgia, *Ulva fenestrata* (Mrowicki & Brodie, 2023, *Polar Biol.* 46:489–496), a key scientific finding from the project that has implications for biosecurity policy. We are also preparing a manuscript on the diversity of seaweeds in the order Bangiales in South Georgia and the Falkland Islands, including a number of new species

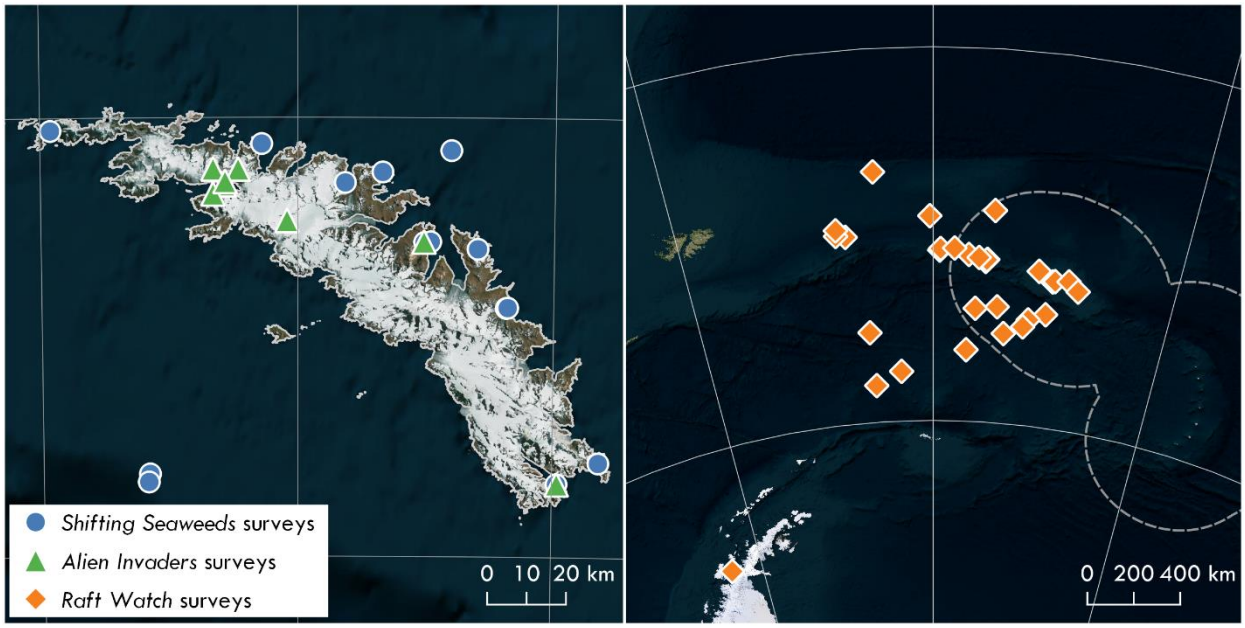

Figure 2. Locations of 'South Georgia Big Seaweed Search' citizen science surveys conducted by cruise ship passengers visiting South Georgia during October 2022–March 2023.

descriptions resulting directly from this project (see draft manuscript – **Supplementary Document 11, Annex 6.2**). This is a complex taxonomic manuscript and we also need to find names for a new genus and seven new species and plan to invite islanders from the Falkland Islands and staff from GSGSSI to work with us to come up with appropriate names. Another paper on South Atlantic seaweed taxonomy that we have co-authored this year (Kawai *et al.*, 2023, *Eur. J. Phycol.*) includes data from the Falkland Islands (acknowledgement of Darwin Plus funding for DPLUS068 'Falklands marine forests') that feed into the current project.

In partnership with IAATO and the Polar Citizen Science Collective (PCSC), we developed the 'South Georgia Big Seaweed Search' (SGBSS), a major new citizen science programme aimed at visitors on board cruise ships, for collecting long-term data on the distribution of key seaweed species and monitoring the health of seaweed-dominated ecosystems, as well as detecting the spread of non-native species (Activity 3.6 – develop citizen science programme; see SGBSS materials – **Supplementary Document 12, Annex 6.2**). This initiative is modelled on previous successful 'Big Seaweed Search' projects in the UK and Falkland Islands. Launched in November 2022, in time for the 2022/23 Antarctic cruise season, the SGBSS has so far been taken up by six cruise operators, with participants generating data from a total of 53 surveys across the three separate activities (**Figure 2**; see SGBSS end of season report – **Supplementary Document 13, Annex 6.2**). Given its popularity, we envisage the SGBSS engaging visitors and generating data for many future seasons. We will continue to provide participants with a report summarising results and feedback at the end of each season.

3.2 Outcome

The intended Outcome was: "Inshore marine biodiversity conservation is strengthened because environmental policymakers, managers and researchers are using previously unavailable tools and data generated through a major advance in seaweed diversity baseline knowledge."

As detailed above (**Section 3.1**), the project has achieved a major advance in seaweed diversity baseline knowledge through extensive field surveys and specimen collection, combined with molecular-assisted taxonomy and examination of existing specimens, filling a huge knowledge gap for South Georgia. Based on these data, new tools to enable future research and support conservation management were developed, including an annotated species check-list, specimen reference collection (with associated data/metadata) and DNA sequence data (Indicator 0.1), plus a report highlighting important taxa and sites and potential biodiversity hotspots, peer-reviewed publication confirming a non-native species, and lists of potential future introduced

species (Indicator 0.2). A comprehensive ID guide is in development, but pictorial ID guides for priority species (ecologically important, environmentally sensitive, and potentially invasive) produced as part of the citizen science programme are designed for use by anyone. The wealth of data generated by this project has exceeded expectations, and while the process of assimilating and preparing it for submission to local and global databases is ongoing (NHM Data Portal for specimen data, SAERI IMS-GIS Data Centre for survey data, GenBank for molecular data), this information will be made publicly available as additional evidence to support biodiversity action planning. We have transferred some of this new knowledge to stakeholders, by providing species ID training to local scientists and community members, establishing a citizen science programme for visitors (already generating new data records), and communicating key scientific results to environmental managers and policy makers through a strategic workshop, in addition to more informal updates (e.g. post-expedition debrief with GSGSSI). There was also a great deal of interest from members of the public in the various outreach and training activities undertaken in the Falkland Islands, in addition to international visitors to South Georgia participating in the citizen science programme, which have raised public awareness of the importance of seaweeds (Indicator 0.3).

Our scientific results indicate that there is still a huge amount of work to be done just in terms of resolving taxonomies, describing new species, etc., which is a notoriously long process and cannot be done in isolation from research in other parts of the world. The establishment of an international seaweed science working group (achieved at the International Seaweed Symposium in Feb 2023) is an essential part of advancing this work, and has already resulted in research collaborations focussing on key groups including our data from South Georgia (e.g. crustose coralline algae with Dr Paul Gabrielson, University of North Carolina; families Gigartinaceae and Kallymeniaceae with Prof. Wendy Nelson, University of Auckland). Together with the research community, we hope that new partnerships and continued engagement with environmental managers and policymakers beyond the life of the project (**Section 6**) will ensure that seaweeds remain an important part of marine biodiversity conservation in South Georgia.

3.3 Monitoring of assumptions

We carefully monitored Outcome and Output level assumptions throughout the course of the project – this was especially important when dealing with the impacts of COVID-19 (**Section 9**), but the fact that we were able to restructure the project and still deliver on its main objectives is a testament to careful planning and the resilience of the project team. Additionally, these impacts made us even more mindful of the risk of further disruption during the project.

A key assumption was that the NHM continued to manage the budget and ensure financial security for the duration of the project, while remaining a centre of excellence for organismal biology and environmental research. We considered that the NHM is a long-established, internationally recognised institution, with sound financial support systems in place, well-funded and maintained facilities, and highly competent operational and technical personnel. By partnering with other established institutions that are centres of excellence for South Atlantic environmental research (SAERI, BAS), the risk of project failure in the unlikely event that NHM could not meet its responsibilities was greatly reduced. Another key assumption was that key project personnel would remain in post, and that science staff were available to provide the required skills and expertise to deliver project outputs. As a consequence of delaying the start of the project due to COVID-19, and the PO initially being committed to other work, the decision to employ another researcher to fulfil the role ensured that the project could proceed. Following this initial phase, we determined that there was no evidence that key personnel would not be available for the remainder of the project; in particular, the PL and PO were committed to remain in post, and there was a pool of suitably-trained researchers who could participate in the field expedition.

Other critical risks and assumptions related to the field expedition (which was the foundation for most of the project outputs) – namely, that travel to South Georgia was not prevented by political/logistical issues or ongoing COVID-19 impacts, and field surveys were not restricted by weather conditions. We minimised these risks by allowing plenty of time for travel and quarantine, and aiming for the best time of year in terms of weather, while closely monitoring any developments in terms of international travel restrictions. Once the expedition was successfully

completed, we considered that the risks associated with COVID-19 for the remainder of the project were substantially lower, and focussed more on key assumptions relating to delivery of the more technical outputs (availability and quality of data, and sufficient interest/uptake among stakeholders for knowledge transfer).

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

The project addressed Objective 5 of the SGSSI Biodiversity Action Plan 2016–2020, i.e., "enhance knowledge of biodiversity and habitats" and "establishment of scientific baselines" and improving understanding of flora, as well as contributing to the SGSSI Environment Charter. This work aligns with the SGSSI MPA objectives and Research and Monitoring Plan (RMP; DPLUS069 workshop, 2018), particularly Research Themes 4 "Benthic Ecosystems - species and habitats" (including the High Priority objective "identification of existing samples to better taxonomic resolution"), 9 "Climate change and variability" and 10 "Other human impacts" (particularly relating to the introduction of non-native species). Project outputs support the UK Government's Blue Belt programme, through "improved understanding of the biodiversity of the marine environment", relevant to SGSSI's sustainable fisheries. At an international level, results also contributed to Aichi Biodiversity Targets 9 and 19 (https://www.cbd.int/sp/targets/), i.e., "invasive alien species and pathways are identified and prioritised" and "the science base and technologies relating to biodiversity, its values, functioning, status and trends […] are improved."

Our results have greatly enhanced taxonomic knowledge of an understudied group, namely seaweeds, as evidenced by relevant tools including an up-to-date species check-list (**Supplementary Document 3, Annex 6.2**) and identification guides for key species (**Supplementary Document 5, Annex 6.2**). Non-native species, including both confirmed and potential introductions, have been highlighted in citizen science materials (**Supplementary Document 12, Annex 6.2**), a published scientific paper and a synthesis report on the spatial and temporal distribution of seaweeds (**Supplementary Document 4, Annex 6.2**). The main relevant findings were presented at a policy-orientated workshop for stakeholders, including SGSSI representatives (**Supplementary Document 9, Annex 6.2**).

5 OPTIONAL: Gender equality

Throughout the project, we were mindful of gender equality and did everything possible not to increase inequality. Although the core project team consisted predominantly of men, the project was led by a woman. During year 1, we were able to employ another woman PhD student from the Falkland Islands. The international field expedition team comprised five men and four women, from the UK, Canada, France/Chile and the Falkland Islands (while the MV Pharos SG crew were from the UK, Chile, New Zealand and the Falkland Islands). Throughout the expedition, we did our best to include all members of the team in a range of activities, both scientific and social/developmental, and survey activities (diving or shore work) were deliberately not biased towards any gender.

For outreach and engagement activities in the Falkland Islands, the public talk was widely advertised and open to all members of the community, and during the school talks and conservation Watch Group session, we made sure that every attendee participated in seaweed pressing and breakout discussion groups (which were mixed in terms of gender). The South Georgia Big Seaweed Search citizen science project follows the same ethos of inclusivity, being open and accessible to any guides and tourists who are interested in participating.

6 Sustainability and Legacy

All outputs from this project are (or will be) publicly available long-term through open access data repositories maintained by the global scientific community. Data (and metadata) are currently being prepared for submission to the IMS-GIS Data Centre, SAERI's online public data repository for South Atlantic UKOTs. This includes species distributions and site occurrences, DNA

sequence data and corresponding specimen details. (This also fulfils a condition of the Falkland Islands Government research permit for survey work that was conducted in the Falklands during the field expedition, i.e., that all resulting data are deposited in the IMS-GIS Data Centre.)

Data from new South Georgia specimens in the NHM algal herbarium will be transferred into the NHM's Emu database, records within which are searchable via the online NHM Data Portal. For records to be added to the database, they must be assigned a unique 'BM' number and labelled with a corresponding barcode. Specimen labelling and mounting is an ongoing process, undertaken by dedicated plant mounters at the NHM (to illustrate how long this entire process can take: the Falkland Islands seaweed specimens from DPLUS068 "Falklands marine forests", collected during 2018–19, have recently all been barcoded and are only just at the stage of final mounting, at the start of 2023). While the incorporation of new material into the herbarium will continue beyond the end of the project, these specimens and their extracted DNA will be maintained in perpetuity at the NHM, whose core duty is to protect, develop and provide access to them. This reference collection constitutes an invaluable resource for temporal, spatial and genetic information for future biodiversity research.

Additionally, many of the new specimens from this project are still to be named and described, as the taxonomy of certain groups remains unresolved (in the field of phycology in general, as well as for this particular collection). This is another particularly long process – referring again to the DPLUS068 Falklands project, publication of just two new species of coralline algae (Brodie *et al.*, 2021, *Eur. J. Phycol.* 65:94-104) took nine months from submission to acceptance, not including the morphological and molecular analyses.

Molecular sequence data will be catalogued and deposited in GenBank (as for our recent publication on the non-native species *Ulva fenestrata*; Mrowicki & Brodie, 2023, *Polar Biol.* 46:489–496), a collection of all publicly available DNA sequences, and taxonomic and nomenclatural information will be available via AlgaeBase (already updated for Mrowicki & Brodie, 2023), a global species database for algae.

Importantly, the tools derived from our data, including the species check-list (and associated lists of priority species), ID guides and spatial/temporal analysis results, provide a framework for future environmental monitoring and research, in the form of a usable document for scientists and policymakers. Further scientific papers, publication of which will continue after the end of the project, will be made open access through funding obtained from the NHM or other sources. The global seaweed science working group, established through a workshop at the 24th International Seaweed Symposium (with follow-up workshop at the 8th European Phycological Congress in August 2023) will provide an excellent means advancing the project's scientific outputs. There is also much scope to develop postgraduate and postdoctoral research projects to follow up on specific areas of research identified during the course of the project, such as taxonomy and ecology of particular seaweed groups. In fact, the PL and PO have secured a MSc project (NHM and Imperial College London) on the coralline algal diversity of South Georgia and the Falkland Islands, based on specimens collected during this project.

An important legacy of the project is the citizen science programme, designed specifically to enable long-term data collection while maintaining public interest in seaweeds. The early success of this programme (and other established 'Big Seaweed Search' projects in the UK, Falkland Islands and Mexico) demonstrates that there is sufficient public interest to keep it going in future years. The seaweed exhibits created for both the Falkland Islands and South Georgia museums will continue to be displayed after the end of the project, with the aim of maintaining public interest in seaweeds.

Importantly, this project has also strengthened partnerships among individuals and organisations, well as fostering new ones, which will persist well beyond its lifetime, facilitating future collaborative work aimed at understanding and protecting biodiversity in South Georgia and other UKOTs.

7 Lessons learned

Despite the impact of COVID-19 (**Section 9**), we were able to restructure the project and reschedule fieldwork to ensure that objectives would still be met. Critically, the team came together before the start of the project and made sure that the project could go ahead as originally envisioned. There was also excellent cooperation from the Darwin team who helped us with this process, in addition to great support from the NHM with regards to project administration and recruitment changes.

Resulting from these changes, during the project itself we paid more attention to potential risks and contingencies, especially when planning our field expedition. The success of the expedition was largely a result of good communication and regular meetings among project partners and team members, who worked together extremely well and brought a huge amount of valuable expertise and local knowledge. We also included additional contingencies in our logistical planning, such as allowing for extra quarantine time in the Falkland Islands prior to departing for South Georgia.

If we had to do the project again, we would consider a greater range of risks that are out of our control (e.g. new pandemics, government cuts to research funding) and build in additional contingencies right from the initial planning stage, such as through brainstorming with the team as many eventualities as possible.

We would recommend that others doing similar projects do not get put off by obstacles in their way and that people keep the vision of their goals, to be ambitious with what they want to achieve but make sure there are tangible products that can stand as evidence for that. It is also important to not become too risk averse.

7.1 Monitoring and evaluation

While the design of the project was unchanged in terms of its outputs and indicators, the project start date and field expedition were delayed by six and 11 months, respectively, owing to the impact of COVID-19 (detailed in **Section 9**), including the temporary employment of an additional PhD researcher from the Falkland Islands. These changes were detailed in a Change Request submitted to Darwin in June 2020, and a further request resulting from the need to bring forward the field expedition and the start date of the PO was made in May 2021. There were additional small changes (December 2021, December 2022 and January 2023) involving the reallocation of operating costs (including surplus travel and accommodation expenses from fieldwork) to molecular lab consumables costs and an extension of the PO's employment, to make the most of the large number of samples and data resulting from the expedition – thus, rather than detracting from our objectives, these changes enhanced the project outputs (particularly Output 2, development of tools based on baseline biodiversity knowledge).

Monitoring and evaluation was achieved primarily through regular contact among project partners, using the log frame and project timetable as a basis for tracking progress. The PL (NHM) was responsible for overall monitoring and evaluation throughout the project. The project steering group (including the PL, PO and project partners) met every 3–4 months to evaluate progress and establish milestones and actions (**Supplementary Document 1, Annex 6.2**). The PL, PO and Paul Brickle (key project partner) met approximately monthly. The PL and PO had frequent meetings and informal discussions relating to the project, with the PO providing updates to the PL on progress with specific activities. The project finances were administered in-house through the NHM Research Coordination Office, with Grant Manager Jonny Gabriel working closely with the PL and PO – this approach was very effective in allowing to track the budget closely, particularly when adapting to changing circumstances as described above.

Aside from external reviews of annual reports (**Section 7.2**), there has been no formal evaluation of the work, but project progress and finances were tracked closely throughout by the team members, as explained above.

7.2 Actions taken in response to Annual Report reviews

We would like to address the following outstanding comments from the review of the previous Annual Report:

1. "*The Annex only includes the minutes of one steering group meeting, and the text earlier in the Report suggests that the group met on just one occasion. If this is the case, M&E could be improved through regular steering group meetings, involving a wide range of stakeholders, as originally planned.*"

    - Aside from regular in-person contact among all project partners during the South Georgia field expedition itself, the project steering group met on three further occasions spread throughout 2022–2023 (12th May and 7th September 2022, and 20th January 2023, i.e. slightly less than quarterly), the minutes of which are presented in **Supplementary Document 1, Annex 6.2**. An additional strategic research workshop and policy-orientated stakeholder workshop were held on 28th September and 6th December 2022, respectively (**Section 3.1, Output 3**).

2. "*The Application refers to an online management system (Box) to assist in achieving targets, but this is not mentioned in the Report.*"

    - This method of online document sharing was abandoned by NHM in favour of Microsoft SharePoint (which is less accessible to external collaborators) since the project proposal was written. We have therefore tended to use direct sharing of documents and files with project partners (e.g. reports, meeting notes), or resorted to other means (e.g. Dropbox or WeTransfer for materials associated with the citizen science programme, shared with participants and the PCSC). These methods have been sufficient for us to meet our objectives and remain engaged with partners and collaborators.

3. "*The project is measuring Output level indicators, and has provided some evidence in support, but future Reports would benefit from more details on training, and participant feedback. More information on the work with schools would also be useful.*"

    - Training given to the field expedition team involved a presentation on seaweed diversity in South Georgia and sampling methods (attended by all nine participants), plus practical training in seaweed sample sorting and specimen preservation (undertaken at various times during the expedition by at least four team members, including one in particular who was given some of the field equipment to continue with seaweed pressing in the Falkland Islands after the expedition finished). For the work with schools in the Falkland Islands, we conducted the following activities: (1) a presentation called 'Seaweed Explorers' given during assembly at the Stanley Infant Junior School on 18th October 2021, attended by ~120 children; (2) a lesson on seaweed diversity and conservation (including 'Operation *Himantothallus*') and discussion session, given to 58 year 8 students (and teachers) at the Falkland Islands Community School on 22nd October; and (3) an activity session focussing on seaweed identification, pressing and ecology at the Falklands Conservation 'Watch Group', involving 14 children aged 8–14 years. See also **Section 3.1, Output 3**.

4. "*The science working group has yet to be established and the citizen science project has yet to be finalised and launched. Is there any risk that these will not be in place by the project end? And if so, would this be detrimental to the citizen science project in particular.*"

    - The seaweed science working group was established during a special workshop led by the PL and PO at the 24th International Seaweed Symposium in February 2023, with confirmation of a follow-up workshop at the 8th European Phycological Congress in August 2023, after the end of the project (**Section 3.1, Output 3**). We also launched the South Georgia Big Seaweed Search in November 2022, and the programme has already been taken up by numerous tourist expeditions during its first season (**Section 3.1, Output 3**).

Also, the reviewer commented that "*The project could perhaps in future comment on how its outreach activities support gender equality.*" We have addressed this in **Section 5**.

8 Darwin Identity

Darwin Plus was publicised through acknowledgement of funding support (alongside support from project partners/collaborators and GSGSSI) and use of the logo during all public talks, workshops and interviews undertaken in the Falklands during the field expedition, in addition to the PL and PO's talks at the 12th International Phycological Congress (IPC12; March 2021), British Phycological Society annual meetings (January 2022 and 2023), 24th International Seaweed Symposium (ISS2023; February 2023) and GSGSSI MPA Science Symposium (June 2023).

GSGSSI and people associated with the territory (Falkland Islands in particular) are very familiar with the Darwin Initiative, owing to the large number of past Darwin-funded projects – this is true of both members of the public and across multiple stakeholder organisations. At the NHM (whose researchers have led numerous Darwin projects over the years), staff are also aware of Darwin funding opportunities, and the breadth of work supported by the scheme. This grant and the Darwin Initiative is listed on the PL's staff profile.

Project-related posts on social media from all partner organisations have included links to the Darwin Initiative Twitter account and Darwin project website. A news article by Paul Brewin was published on the SAERI website, highlighting the success of the field expedition. Claire Goodwin published a field expedition blog on the Huntsman Marine Science Centre website, and has produced an expedition video, both of which acknowledge Darwin Plus.

9 Impact of COVID-19 on project delivery

COVID-19 resulted in a delay in the fieldwork from December 2020 to November 2021, and a shift in the project start date from August 2020 to the end of the financial year in March 2021. In turn, this meant that the PO was unable to join the project until September 2021, and so PhD student Amy Guest was employed to cover some of his work for two months (working remotely from the Falkland Islands in March 2021, then in the NHM molecular labs during June–July). The NHM put in place a wide range of measures to ensure that staff working on the premises were as safe as possible during this time, and any staff working on the project were fully vaccinated against COVID-19.

More time was allocated to the field expedition to allow for mandatory quarantine for international staff in the Falkland Islands before travelling to South Georgia. A benefit of this extra contingency time in the Falklands was that much more could be achieved in terms of public outreach and engagement activities (**Section 3.1, Output 3**). The departure of the research vessel to South Georgia itself was then delayed by two days, following positive COVID tests from crew members about the join the ship. Although this shortened the fieldwork slightly, the expedition was successful in meeting its overall objectives. Also, molecular lab work at NHM at the beginning of 2022 was delayed by approximately two weeks, owing to the PO contracting COVID-19 – again, this did not impact the project outputs.

The PL originally planned to initiate a South Atlantic seaweed science working group via a workshop attended by expert phycologists at IPC12 in Chile during March 2021, but this conference was held virtually due to COVID-19 restrictions and so it was not possible to organise a workshop at the time; however, the PL and PO had the opportunity to run this workshop at ISS2023 in Tasmania during February 2023.

It is not foreseen that any of our project outcomes or impacts will assist with the response to COVID-19 or reduce the risk of future pandemics. We do anticipate discovering new seaweed species in this project and there is the possibility that they or their associated microbiome may contain useful properties against viruses.

Before the start of the project, we had always planned to have virtual meetings because the project partners cover such a wide geographical area (Falkland Islands to Scotland) and we had developed this way of working before for DPLUS068 "Building foundations to monitor and

conserve Falklands marine forest habitats". This also enabled Amy to be employed remotely, which presents the opportunity to use the same approach in future projects. Otherwise, the NHM (and most other organisations in the UK) have introduced flexible working arrangements since the onset of the pandemic, and conferences/meetings tend to include an online component as standard, meaning that in general there should be less need to travel for work and internationally.

10 Finance and administration

10.1 Project expenditure

Project spend (indicative since last Annual Report	2021/22 Grant (£)	2021/22 Total actual Darwin Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs	[redacted]			
Overhead Costs				
Travel and subsistence				
Operating Costs				
TOTAL	£90,776.39	£89,975.24	0.88	

[redacted]

10.3 Value for Money

[redacted] In addition to the use of the MV Pharos SG, in kind support was provided by NHM, SAERI, SMSG, BAS and GSGSSI and consisted of time dedicated by highly experienced researchers and technical staff with word-leading expertise in biodiversity science, specifically seaweed taxonomy and molecular biology and remote survey diving expeditions, laboratory costs (portacabin on ship provided by SAERI) and other expedition consumables. [redacted] The availability of the collections in the NHM algal herbarium, an unparalleled resource for studying past and present botanical diversity in the UKOTs, was key to development of a baseline for seaweed diversity. Having greatly enhanced the value of this resource for future research, the specimens collected during this project will now be preserved for perpetuity, in accordance with the core duty of the NHM (see also sustainability and legacy, **Section 6**).

Additional funding provided in kind during the course of the project held by the PL (Safe Seaweed Coalition, Horizon 2020 Research Framework ITN, British Academy grants) supported conference travel for her to establish a seaweed science working group with the PO (see Output 3), and to present the project at international conferences and public talks.

Kit, including underwater camera, compressor, Remotely Operated Vehicle and diving gear, bought for the UKOTs (FI and South Georgia) will support future research, particularly in relation to biodiversity discovery, monitoring in the Marine Protected Areas, including the new Falkland Islands Marine Management Areas. This project has also made the most of existing facilities and infrastructure for molecular biology (NHM) and data management (SAERI), and purchase of capital items was unnecessary for completing project outputs. The project also benefitted hugely from the NHM library facilities, particularly for the older literature that is essential for the taxonomic work.

The project was also able to provide considerable capacity building of both the project and field expedition teams and local population in FI and SGSSI in seaweed fieldwork and identification (see **Annex 3** for numbers of people trained).

The project set out to fill critical gaps in baseline knowledge of inshore seaweed-dominated habitats and to transform the knowledge into tools with which to build capacity for monitoring and protecting these habitats. As such, the project has succeeded. Overall, the project has yielded a large body of high quality data that will feed into conservation management in South Georgia (and the Falkland Islands), by addressing identified knowledge gaps and targeting specific environmental priorities.

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

Annex 1 Project's full current logframe as presented in the application form (unless changes have been agreed)

Please insert your project's logframe (if your project has a logframe), including indicators, means of verification and assumptions. N.B. if your application's logframe is presented in a different format in your application, please transpose into the below template. Please feel free to contact BCF-reports@niras.com if you have any questions regarding this.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
Impact: South Georgia is recognised globally as a model for large-scale marine management, with robust long-term strategies founded upon rigorous scientific evidence, protecting unique ecosystems while sustaining fisheries, tourism and research.			
Outcome: Inshore marine biodiversity conservation is strengthened because environmental policymakers, managers and researchers are using previously unavailable tools and data generated through a major advance in seaweed diversity baseline knowledge.	0.1. Major knowledge gaps filled for diversity and taxonomy of South Georgia seaweeds, with anticipated 100% increase in documented species, c. 500 historical and contemporary museum specimens databased, and reference collection of c. 1500 specimens established by end of project. 0.2 At least 6 tools to support long-term monitoring and management of South Georgia's inshore marine environment, founded upon baseline seaweed biodiversity knowledge, developed by end of project. 0.3 Management recommendations delivered to policymakers, scientists trained in seaweed identification, establishment of citizen science programme for visitors, increased public awareness of the importance of South Georgia's inshore marine biodiversity.	0.1 Specimen database records and photographs ('virtual herbarium' and DNA archive); comprehensive species checklists; new species descriptions in scientific literature. 0.2 Illustrated species ID guide; priority species keys and information pamphlet; seaweed habitat and biodiversity hotspot maps, ISA site descriptions, Red Data List and indicator/non-native species guide; open access data repository records. 0.3 Handbook for environmental managers and policymakers; knowledge transfer workshop proceedings; citizen science programme materials and data records; films, radio broadcasts and other media used for public outreach.	Project partner institutions remain centres of excellence for organismal biology and South Atlantic marine environmental research. Key project personnel remain in post for duration of project, and science and management staff are available. Travel and field-based activities are not restricted by weather, logistical issues, or ongoing impact of COVID-19, and relevant visiting and research permits are granted. Public engagement activities are taken up, and local capacity is maintained long-term via staff continuity and/or knowledge transfer. Online data repositories continue to be freely accessible.
Output 1. Enhanced baseline knowledge of seaweed diversity and distribution in South Georgia.	1.1 C. 200 historical and 300 contemporary NHM South Georgia	1.1 NHM Data Portal records and photographs.	DNA extraction and sequencing methods are successful for a representative range of novel taxa.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
	herbarium specimens digitised, georeferenced and imaged by Q2Y2. 1.2 Contemporary specimens (c. 160, collected 2011) identified through DNA sequencing to develop a taxonomic framework by Q3Y2. 1.3 Current distributions of at least 5 ecologically important seaweed species surveyed at >30 sites around South Georgia by Q3Y2. 1.4 Reference collection of South Georgia seaweeds (estimated 1500 specimens) established and databased by Q4Y2. 1.5 Overall seaweed diversity inventoried and taxonomy of problematic groups resolved, likely increasing the number of known species in South Georgia to c. 227 by Q4Y3.	1.2 Molecular analysis results; initial species checklist and identification guide based on current taxonomy. 1.3 Species distribution maps. 1.4 Labelled NHM herbarium specimens; NHM Data Portal records and photographs ('virtual herbarium'). 1.5 Report containing phylogenetic trees and DNA barcoding results; full species checklist highlighting previously undocumented taxa; scientific journal article containing descriptions of new species.	NHM herbarium and molecular lab technical support staff remain available and that there is sufficient lab time due to COVID-19 restrictions on access. Travel to South Georgia (via the Falklands) is not prevented by political, logistical issues or ongoing COVID-19 impacts. Access to field sites and completion of survey activities are not restricted by weather conditions or impact of COVID-19.
Output 2. Tools for monitoring, managing and researching South Georgia's inshore marine environment, founded upon baseline biodiversity knowledge.	2.1 Potential inshore biodiversity hotspots and vulnerable habitats are identified, based on surveys at >30 sites around South Georgia by Q2Y3. 2.2 Maps of key seaweed-dominated habitats (e.g. kelp forests and coralline reefs) developed via ground-truthing existing fine-scale coastal maps for South Georgia by Q3Y3. 2.3 Short- (10 yrs) and long-term (200 yrs) trends in seaweed diversity and distribution analysed to reveal species introductions, range	2.1 GIS consensus maps of seaweed and faunal diversity and community structure; field expedition report and survey data. 2.2 Refined habitat maps for kelp forests and coralline reefs; WebGIS spatial data layers (SAERI IMS-GIS Data Centre and BAS South Georgia GIS). 2.3 Contemporary and historical species distribution maps; report summarising indicator species. 2.4 Published ID guide.	Quantity and reliability of identity/locality data associated with historical specimens are sufficient for robust temporal and spatial analyses. Suitably-trained SMSG volunteers provide the required capacity for combining specimen collection with detailed quantitative surveys. Tools including printed and electronic seaweed identification guides, Red Data List, Important Seaweed Areas, non-native species list are all dependent on the checklist based on the most up to date taxonomy.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
	contractions/expansions and shifts in community structure by Q3Y3. 2.4 South Georgia seaweed species ID guide (including at least 150 key species) for researchers, managers and visitors, highlighting indicator and non-native species, published by Q4Y3. 2.5 Electronic identification keys to common and conspicuous seaweed species developed for managers and citizen scientists by Q4Y3. 2.6 Red Data List/Important Seaweed Area assessments and priority lists identifying potentially vulnerable and invasive species presented to managers and policy-makers by Q4Y3. 2.7 All data and reports made publicly available through open access repositories by end of project.	2.5 Electronic keys published via website and mobile app. 2.6 Management recommendations report with details of priority species and sites. 2.7 NHM Data Portal and SAERI IMS-GIS Data Centre uploads; BAS South Georgia GIS spatial data layers; GenBank accession numbers; data portal download requests.	
Output 3. Strengthened capacity for marine environmental protection and research in South Georgia, through training, knowledge transfer and public awareness raising.	3.1 Raised public awareness of the importance of seaweeds, via a public talk (>15 attendees), TV/radio interviews and museum exhibition in the Falklands during Q3Y2. 3.2 South Atlantic seaweed science working group established remotely during the course of the project via remote workshops commencing prior to start of project. 3.3 Seaweed biodiversity information synthesised and disseminated to stakeholders by Q3Y3. 3.4 GSGSSI, BAS and SMSG staff and other stakeholders trained in seaweed	3.1 Presentation slides; recorded FITV/Falklands Radio broadcasts; display specimens at Falkland Islands Museum. 3.2 Remote workshop attendance list; meeting minutes and proceedings; document outlining proposed work programmes. 3.3 Handbook for stakeholders, including biodiversity metrics (e.g. proportions of endemics vs. non-natives, species shared with other territories). 3.4 Presentation slides; course attendance list; participant feedback	There is sufficient interest among stakeholders (researchers, managers and visitors) for uptake of training activities and public engagement. International stakeholders and government representatives are available for a joint meeting. Information on biodiversity and status of seaweed habitats is recognised as an important contribution to future spatial management strategies. All stakeholders have long-term access to data repositories, which will be maintained into the future.

Project summary	Measurable Indicators	Means of verification	Important Assumptions
	ecology and identification coupled with policy-orientated workshop, attended by at least 10 government and non-government stakeholders, held in the UK during Q3Y3. 3.5 Scientific results disseminated via at least two open access peer-reviewed articles and presentations at one UK and one international phycology conference by Q3Y3. 3.6 Citizen science programme developed for visitors, delivered through tour operators and cruise companies, and taken up by at least one tour company by end of project.	forms; workshop meeting minutes and outcome report. 3.5 Submitted manuscript(s) for peer-reviewed articles; online article access/sharing metrics; presentation slides; conference proceedings and abstract booklets. 3.6 Letter of commitment by tour company; species ID leaflet and accompanying video; uploaded data records; blogs and social media posts.	

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. Database existing historical and contemporary herbarium specimens
1.2. DNA analysis of recent specimens; produce initial checklist and guide
1.3. Survey distribution and abundance of seaweed and faunal species
1.4. Identify, label and database new specimens; establish reference collection
1.5. Inventory seaweed diversity via molecular assisted taxonomy of new specimens

2.1. Identify inshore biodiversity hotspots and vulnerable habitats
2.2. Map seaweed-dominated habitats (kelp forests and coralline reefs)
2.3. Analyse temporal trends in seaweed diversity and distribution
2.4. Write and publish ID guide for South Georgia seaweeds
2.5. Develop electronic identification keys to common and conspicuous seaweeds
2.6. Conduct Red List and ISA assessments; produce species/site priority lists
2.7. Upload data and reports to open access repositories

3.1. Public talk and TV/radio interviews; set up museum exhibition
3.2. Establish South Atlantic seaweed science working group
3.3. Synthesise and disseminate biodiversity information to stakeholders

Project summary	Measurable Indicators	Means of verification	Important Assumptions
3.4. Conduct ID training and policy-orientated workshop with stakeholders 3.5. Disseminate scientific results via peer-reviewed articles and conference presentations 3.6. Develop and implement citizen science programme			

Annex 2 Report of progress and achievements against final project logframe for the life of the project (if your project has a logframe)

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
Impact: South Georgia is recognised globally as a model for large-scale marine management, with robust long-term strategies founded upon rigorous scientific evidence, protecting unique ecosystems while sustaining fisheries, tourism and research.		Through the new knowledge that this project has generated it has achieved the goal of putting South Georgia on the map. Through a wide range of activities, including a large body of scientific information and resources/tools for marine management, dissemination of information both locally and internationally, through publications and outreach, engagement via citizen science and by mobilising the global taxonomic seaweed community, the impact has been achieved. All of this knowledge will be incorporated into a review of conservation strategy for seaweeds for both SGSSI and FI, with the potential for use as a model for other UKOTs. Making the link between the importance of inshore biodiversity and offshore fisheries will contribute to sustaining fisheries, citizen science will engage with tourism, and the scientific results will feed into local and global research. Confirming and adding to the knowledge of previously recognised biodiversity, including mapping species' distributions, taxonomy, phylogenetics, biogeography, identifying endemics, detecting the presence of non-natives for the first time and documenting connectivity, will all be of value in marine management and conservation.
Outcome: Inshore marine biodiversity conservation is strengthened because environmental policymakers, managers and researchers are using previously unavailable tools and data generated through a major advance in seaweed diversity baseline knowledge.	0.1. Major knowledge gaps filled for diversity and taxonomy of South Georgia seaweeds, with anticipated 100% increase in documented species, c. 500 historical and contemporary museum specimens databased, and reference collection of c. 1500 specimens established by end of project. 0.2 At least 6 tools to support long-term monitoring and management of South Georgia's inshore marine environment, founded upon baseline	0.1 Existing museum specimens (238) databased, species check-lists written, field survey data collected, reference collection established (729 sheets =~1500 specimens), molecular taxonomic analyses completed – 162% increase in documented species relative to initial check-list. 0.2 Baseline biodiversity distribution data collected, spatial and temporal trends analysed, diversity hotspots, rare taxa and important habitats identified, initial results presented to stakeholders, species ID guide initiated, specimen databases formatted for public data portal – 4 tools completed (species check-list, biodiversity hotspots, temporal trends, species/site lists), 2 tools partially completed (ID guide, habitat maps). 0.3 Public outreach and engagement activities conducted, seaweed science working group established, ID workshops delivered to stakeholders, presentations given at phycological conferences and article published in

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
	seaweed biodiversity knowledge, developed by end of project. 0.3 Management recommendations delivered to policymakers, scientists trained in seaweed identification, establishment of citizen science programme for visitors, increased public awareness of the importance of South Georgia's inshore marine biodiversity.	scientific journal, citizen science programme implemented – increased awareness of South Georgia seaweeds in scientific and non-scientific communities, implications discussed with policymakers.
Output 1. Enhanced baseline knowledge of seaweed diversity and distribution in South Georgia.	1.1 C. 200 historical and 300 contemporary NHM South Georgia herbarium specimens digitised, georeferenced and imaged by Q2Y2. 1.2 Contemporary specimens (c. 160, collected 2010) identified through DNA sequencing to develop a taxonomic framework by Q3Y2. 1.3 Current distributions of at least 5 ecologically important seaweed species surveyed at >30 sites around South Georgia by Q3Y2. 1.4 Reference collection of South Georgia seaweeds (estimated 1500 specimens) established and databased by Q4Y2. 1.5 Overall seaweed diversity inventoried and taxonomy of problematic groups resolved, likely increasing the number of known	1.1 All existing NHM specimens (238) databased and georeferenced, with 155 contemporary specimens imaged (**Section 3.1**; **Tables S1 & S2, Annex 6.1**). 1.2 DNA sequences obtained from five specimens and compared against online databases, assisting with identification and contributing to taxonomic check-list (**Table 1**; **Section 3.1; Supplementary Document 3, Annex 6.2**). 1.3 Surveys conducted at 48 sites in South Georgia (**Figure 1**; **Section 3.1**; **Table S3, Annex 6.1**) and distribution maps of 105 seaweed species plotted based on data from 47 sites surveyed in 2010 and 2021 (**Supplementary Document 4, Annex 6.2**). 1.4 Approximately 1500 individual specimens (729 specimen sheets) collected, databased and imaged (**Section 3.1**; **Table S4, Annex 6.1**), with 149 awaiting imaging. NB – final identification and labelling (and incorporation into NHM Data Portal) depends on completed taxonomic analysis (Indicator 1.5). 1.5 Updated check-list includes 199 species (**Supplementary Document 3, Annex 6.2**); DNA extracted from 475 specimens, 420 of which yielded 916 high quality PCR products, 739 of which submitted for sequencing (**Section 3.1**; **Table S5, Annex 6.1**). NB – taxonomy of many groups remains

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
	species in South Georgia to c. 227 by Q4Y3.	unresolved, reflecting the current state of global seaweed taxonomy in general.
Activity 1.1. Database existing historical and contemporary herbarium specimens		Databasing of existing specimens completed, with 83 historical specimens awaiting imaging.
Activity 1.2. DNA analysis of recent specimens; produce initial checklist and guide		DNA analysis of recent specimens partially complete (but identification now complete following analysis of new specimens); initial check-list and ID guide completed.
Activity 1.3. Survey distribution and abundance of seaweed and faunal species		Species surveys completed.
Activity 1.4. Identify, label and database new specimens; establish reference collection		Identification and databasing of new specimens completed; establishment of reference collection completed.
Activity 1.5. Inventory seaweed diversity via molecular assisted taxonomy of new specimens		Molecular assisted taxonomy of new specimens completed.
Output 2. Tools for monitoring, managing and researching South Georgia's inshore marine environment, founded upon baseline biodiversity knowledge.	2.1 Potential inshore biodiversity hotspots and vulnerable habitats are identified, based on surveys at >30 sites around South Georgia by Q2Y3. 2.2 Maps of key seaweed-dominated habitats (e.g. kelp forests and coralline reefs) developed via ground-truthing existing fine-scale coastal maps for South Georgia by Q3Y3. 2.3 Short- (10 yrs) and long-term (200 yrs) trends in seaweed diversity and distribution analysed to reveal species introductions, range contractions/expansions and shifts in community structure by Q3Y3.	2.1 Biodiversity data collected from 48 sites in South Georgia (**Figure 1**; **Section 3.1**; **Table S3, Annex 6.1**), GIS consensus maps of species richness produced, highlighting sites with highest diversity and proportion of rare taxa (**Section 3.1**; **Supplementary Document 4, Annex 6.2**). 2.2 Giant kelp density and presence of crustose coralline algae recorded at all subtidal survey sites (**Supplementary Document 2, Annex 6.2**) which will allow comparison with existing habitat maps. 2.3 Multi-decadal trends in seaweed species distribution investigated, highlighting three potential introductions (one confirmed), three potential local extinctions and at least 22 potential new records/undescribed species (**Section 3.1; Supplementary Document 4, Annex 6.2**). 2.4 Detailed floral guide containing 75 species written (**Section 3.1**; **Supplementary Document 5, Annex 6.2**), complementing pictorial ID guides for citizen science project activities (**Section 3.1; Supplementary Document 12, Annex 6.2**).

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
	2.4 South Georgia seaweed species ID guide (including at least 150 key species) for researchers, managers and visitors, highlighting indicator and non-native species, published by Q4Y3. 2.5 Electronic identification keys to common and conspicuous seaweed species developed for managers and citizen scientists by Q4Y3. 2.6 Red Data List/Important Seaweed Area assessments and priority lists identifying potentially vulnerable and invasive species presented to managers and policy-makers by Q4Y3. 2.7 All data and reports made publicly available through open access repositories by end of project.	2.5 Electronic keys require input from the finalised species ID guide (2.4), but the existing 'Seaweed Sorter' app has been identified as a model. 2.6 Twenty-seven rare taxa identified using Red List local distribution criteria, including three potential non-natives, and used to determine 14 candidate Important Seaweed Sites (**Section 3.1; Supplementary Document 4, Annex 6.2**). 2.7 Database of c. 1500 specimens completed (see Output 1), formatted for NHM Data Portal (**Section 3.1**; **Table S4, Annex 6.1**). NB – data upload will take place alongside the mounting and incorporation of specimens into the NHM herbarium. Metadata formatted for submission to SAERI IMS-GIS Data Centre (**Section 3.1**; **Supplementary Document 6, Annex 6.2**). Molecular sequence data to be uploaded to GenBank upon publication (as per Mrowicki & Brodie paper on *Ulva fenestrata*).
Activity 2.1. Identify inshore biodiversity hotspots and vulnerable habitats		Identification of biodiversity hotspots and habitats containing rare species completed.
Activity 2.2. Map seaweed-dominated habitats (kelp forests and coralline reefs)		Habitat surveys completed; ground-truthing of maps partially complete (insufficient data to formally ground-truth fine-scale maps).
Activity 2.3. Analyse temporal trends in seaweed diversity and distribution		Analysis of temporal trends in seaweed distribution completed, within limitations of historical data.
Activity 2.4. Write and publish ID guide for South Georgia seaweeds		ID guide partially complete (detailed species descriptions ongoing).
Activity 2.5. Develop electronic identification keys to common and conspicuous seaweeds		Electronic keys not completed, but model app identified.

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
Activity 2.6. Conduct Red List and ISA assessments; produce species/site priority lists		Species/site priority lists completed, following Red List and ISA criteria.
Activity 2.7. Upload data and reports to open access repositories		Formatting of specimen data for NHM Data Portal completed, SAERI IMS-GIS metadata forms completed, GenBank sequence upload partially complete.
Output 3. Strengthened capacity for marine environmental protection and research in South Georgia, through training, knowledge transfer and public awareness raising.	3.1 Raised public awareness of the importance of seaweeds, via a public talk (>15 attendees), TV/radio interviews and museum exhibition in the Falklands during Q3Y2. 3.2 South Atlantic seaweed science working group established remotely during the course of the project via remote workshops commencing prior to start of project. 3.3 Seaweed biodiversity information synthesised and disseminated to stakeholders by Q3Y3. 3.4 GSGSSI, BAS and SMSG staff and other stakeholders trained in seaweed ecology and identification coupled with policy-orientated workshop, attended by at least 10 government and non-government stakeholders, held in the UK during Q3Y3. 3.5 Scientific results disseminated via at least two open access peer-reviewed articles and presentations	3.1 Public talk, ID workshop, TV/radio interviews, school lessons, Watch Group activity session, expedition participant training and stakeholder meetings conducted in the Falkland Islands (total >150 attendees); South Georgia seaweeds displayed in Falkland Islands museum, and exhibit produced for Grytviken museum (**Section 3.1**; **Supplementary Document 7, Annex 6.2**). 3.2 Global seaweed taxonomy group (focussing on Southern Hemisphere diversity) founded during workshop at 24th International Seaweed Symposium attended by 25 experts (**Section 3.1**; **Supplementary Document 8, Annex 6.2**). 3.3 Scientific results disseminated to stakeholders at strategic framework workshop (**Section 3.1**; **Supplementary Document 9, Annex 6.2**). 3.4 Stakeholder workshop (16 attendees from GSGSSI, BAS, SMSG, SAERI, FC and Georgia Seafoods Ltd., plus members of the public) held in the Falkland Islands; field expedition participants trained in seaweed ecology and identification (**Section 3.1**; **Supplementary Document 7, Annex 6.2**). Strategic framework (i.e. policy-orientated) workshop held online, with 10 attendees from GSGSSI, FC, SGHT, SAERI and BAS (**Supplementary Document 9, Annex 6.2**). 3.5 Presentation given by PL at 70th British Phycological Society meeting and overview of scientific results presented by PO at workshop during 24th International Seaweed Symposium (**Section 3.1**; **Supplementary Document 10, Annex 6.2**). Open access peer-reviewed article on non-native seaweed published (**Section 3.1**) and manuscript on the order Bangiales in preparation (**Supplementary Document 11, Annex 6.2**).

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
	at one UK and one international phycology conference by Q3Y3. 3.6 Citizen science programme developed for visitors, delivered through tour operators and cruise companies, and taken up by at least one tour company by end of project.	3.6 South Georgia Big Seaweed Search citizen science project established in partnership with IAATO and PCSC, with 54 surveys conducted by visitors aboard six cruise operators (**Section 3.1**; **Supplementary Documents 12 & 13, Annex 6.2**).
Activity 3.1. Public talk and TV/radio interviews; set up museum exhibition		Public talk and TV/radio interviews completed; museum exhibition completed in Falkland Islands, with a second developed for South Georgia.
Activity 3.2. Establish South Atlantic seaweed science working group		Establishment of seaweed science group completed.
Activity 3.3. Synthesise and disseminate biodiversity information to stakeholders		Synthesis of biodiversity information completed; dissemination to stakeholders partially complete (presented at stakeholder workshop, report on spatial and temporal trends to be disseminated with this final report).
Activity 3.4. Conduct ID training and policy-orientated workshop with stakeholders		ID training and policy-orientated workshops completed.
Activity 3.5. Disseminate scientific results via peer-reviewed articles and conference presentations		One peer-reviewed article published, conference presentations given at UK and international conferences.
Activity 3.6. Develop and implement citizen science programme		Implementation of citizen science programme completed.

Annex 3 Standard Measures

Code	Description	Totals (plus additional detail as required)
Training Measures		
1	Number of (i) students from the UKOTs; and (ii) other students to receive training (including PhD, masters and other training and receiving a qualification or certificate)	
2	Number of (i) people in UKOTs; and (ii) other people receiving other forms of long-term (>1yr) training not leading to formal qualification	(i) N/A (ii) **1** – further training in taxonomy, molecular biology and bioinformatics for PO
3a	Number of (i) people in UKOTs; and (ii) other people receiving other forms of short-term education/training (i.e. not categories 1-5 above)	(i) **152** – 1 Falkland Islands PhD student, 3 field expedition UKOT participants, 16 ID workshop delegates, 60 pupils at Stanley IJS, 58 Year 8 students at Stanley secondary school, 14 FC Watch Group members (ii) **77** – 4 field expedition international participants, 1 ICL Master's student training in molecular biology with PO, >72 citizen science expedition guides (>22) and guests (~50)
3b	Number of training weeks (i) in UKOTs; (ii) outside UKOTs not leading to formal qualification	(i) **1** – 1.5 hrs FC watch group session, 1 hr ID workshop, >1 hr expedition training, ~5 days PhD student laboratory training (ii) **1** – 2 hrs citizen science training, ~5 days Master's student laboratory training
4	Number of types of training materials produced. Were these materials made available for use by UKOTs?	**7** – ID guides, online training platform (citizen science), presentation slides + video (citizen science), citizen science activity guides, herbarium specimens
5	Number of UKOT citizens who have increased capacity to manage natural resources as a result of the project	Difficult to quantify; 1 GSGSSI executive directly involved in natural resource management; SAERI, SMSG and BAS scientists conducting monitoring surveys; members of the public involved in decision-making processes
Research Measures		

Code	Description	Totals (plus additional detail as required)
9	Number of species/habitat management plans/ strategies (or action plans) produced for/by Governments, public authorities or other implementing agencies in the UKOTs	**1** – Red List/Important Plant Area assessment
10	Number of formal documents produced to assist work in UKOTs related to species identification, classification and recording.	**5** – species check-list, ID guide, citizen science activity guides (3)
11a	Number of papers published or accepted for publication in peer reviewed journals written by (i) UKOT authors; and (ii) other authors	(i) N/A (ii) **2** (+1 in preparation)
11b	Number of papers published or accepted for publication elsewhere written by (i) UKOT authors; and (ii) other authors	
12b	Number of computer-based databases enhanced (containing species/genetic information). Were these databases made available for use by UKOTs?	**4** (open access for UKOTs) – NHM KEmu/Data Portal, SAERI IMS-GIS Data Centre, NCBI GenBank, AlgaeBase
13a	Number of species reference collections established. Were these collections handed over to UKOTs?	**3** – 1 maintained at NHM, 2 UKOT museum exhibits (Falkland Islands and South Georgia)
13b	Number of species reference collections enhanced. Were these collections handed over to UKOTs?	**1** (NHM algal collections)
Dissemination Measures		
14a	Number of conferences/seminars/workshops/stakeholder meetings organised to present/disseminate findings from UKOT's Darwin project work	**11** – 4 steering group meetings, 1 Falklands public talk, 2 school lessons, 1 FC Watch Group session, 2 Falklands Radio interviews, 1 FITV interview
14b	Number of conferences/seminars/ workshops/stakeholder meetings attended at which findings from the Darwin Plus project work will be presented/ disseminated	**7** – 3 UK conferences, 3 international conferences/workshops, 1 stakeholder workshop
Physical Measures		
20	Estimated value (£s) of physical assets handed over to UKOT(s)	[redacted]
21	Number of permanent educational/training/research facilities or organisation established in UKOTs	**1** – citizen science programme
22	Number of permanent field plots established in UKOTs	**50** new field sites
23	Value of resources raised from other sources (e.g., in addition to Darwin funding) for project work	[redacted]

Checklist for submission

	Check
Is the report less than 10MB? If so, please email to BCF-reports@niras.com putting the project number in the Subject line.	-
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.	✓
If you are submitting photos for publicity purposes, **do these meet the outlined requirements (see section 11)?**	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.	✓
Do you have hard copies of material you need to submit with the report? If so, please make this clear in the covering email and ensure all material is marked with the project number. However, we would expect that most material will now be electronic.	N/A
Have you involved your partners in preparation of the report and named the main contributors	✓
Have you completed the Project Expenditure table fully?	✓
Do not include claim forms or other communications with this report.	