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	DPLUS132
Project title	Monitoring albatrosses using Very High Resolution Satellites and citizen science
Territory(ies)	South Georgia and the South Sandwich Islands, Tristan da Cunha
Lead Partner	British Antarctic Survey (BAS)
Project partner(s)	The Royal Society for the Protection of Birds (RSPB)
Darwin Plus Grant value	£87,246
Start/end date of project	1st December 2021 - 30th November 2023
Project Leader name	Dr Peter [redacted]
Project website/Twitter/blog etc.	Website: Albatrosses from Space - British Antarctic Survey (bas.ac.uk) Twitter: @AlbatrossBAS
Report author(s) and date	Peter [redacted], Marie [redacted] & Richard [redacted], 3rd April 2024

1 Project Summary

Monitoring the world's threatened albatross species is challenging because of their remote nesting locations, making ground or aerial surveys expensive, infrequent and often incomplete. With rapid advancement of geospatial remote-sensing technologies, citizen science can contribute accurate and reliable georeferenced wildlife data. Here, we (1) implement the first citizen science campaign to count wandering albatrosses *Diomedea exulans* in South Georgia using 31 cm resolution satellite imagery (**Figure 1**), and (2) assessed the feasibility of using 31 cm resolution satellite imagery to count Tristan albatrosses *Diomedea dabbenena*, which are listed as Vulnerable or Critically Endangered, respectively, by the International Union for the Conservation of Nature. The Tristan albatross breeds almost exclusively on Gough Island (**Figure 2**) where incidental mortality (bycatch) in fisheries and chick predation by invasive house mice *Mus musculus* have led to an ongoing population decline. Regular on-the-ground monitoring of Tristan albatross populations may be reduced or discontinued in the future due to financial and logistical constraints, and therefore alternative methods would be required for determining long-term population trends. Counts of wandering albatrosses (and Tristan albatrosses if feasible) during the breeding season will be used to develop standardised and efficient monitoring protocols for future satellite surveys, greatly improving our understanding of archipelago-wide population dynamics.

2 Project Partnerships

Our project is led by British Antarctic Survey, with RSPB as a project partner and the governments of Tristan da Cunha, and South Georgia and the South Sandwich Islands (GSGSSI) as stakeholders. All project investigators from BAS, i.e., Peter Fretwell (Project Leader), Professor Richard Phillips (co-investigator), Marie Attard (co-investigator) and Ellen bowler (co-investigator) were involved in all project planning, data collection, analysis, and write-up stages. BAS investigators met regularly in person or online to discuss project progress (e.g., data collection/analysis and dissemination of findings) to meet each Outcome.

Stakeholder meetings were held every ~2-4 months (22nd February 2022, 13th May 2022, 13th June 2022 and 8th December 2023; see **Annex 5.1-5.8**), providing an opportunity for GSGSSI, RSPB and Tristan da Cunha government representatives (**Table 1**) to provide feedback at each stage of the project. No stakeholder meetings were held while Marie Attard was on maternity leave (August 2022-August 2023). The early meetings were vital for putting a framework in place and iron out any logistical problems, particularly for recruiting volunteers for the Albatrosses from Space crowdsourcing campaign (**Annex 5.1-5.4**). The wealth of knowledge provided by partners throughout the project allowed us to improve our methods and interpretation of the data collected. The meetings also resulted in useful discussions on potential future applications and limitations of satellite technology to detect and count each albatross species (**Annex 5.7**).

Table 1. Mailing list for stakeholder meetings and distribution of results at each project stage.

Name	Role	Institution/Organisation
[redacted]	Senior UK Overseas Territories Officer	RSPB
	Marine conservationist	RSPB
	Researcher in Machine Learning within Artificial Intelligence lab	BAS
	Head of UK Overseas Territories, RSPB & Strategy Advisor	RSPB
	Researcher	South Georgia Surveys
	Albatross Image Project Analyst	BAS
	Marine Ecologist/Science Manager	South Georgia Fisheries (CCAMLR) at BAS
	South Georgia Science Manager	BAS
	Geographic Information Officer	BAS
	Fisheries Ecologist	BAS
	Leader of the Higher Predators and Conservation group within the Ecosystems team	BAS
	Atlantic Guardians Project Manager	RSPB Overseas Territories Team
	Conservation Scientist	RSPB Centre for Conservation Science
	Researcher	South Georgia Surveys
	UK based Environment and Conservation Officer	Tristan da Cunha Government
	Conservation Officer for Tristan da Cunha	Tristan Conservation

Analysis of crowdsourced data and age/sex information of nesting Tristan albatrosses in satellite imagery began in mid-August 2023 when M. Attard returned from maternity leave. All results from this project were presented at the final stakeholder meeting on 8th December 2023. As many individuals could not attend, the minutes and presentation from this meeting were distributed via email (**Annex 5.7-5.8**).

Stakeholder personnel that contributed significantly to the project are listed as co-authors in upcoming peer-reviewed publications. Sally Poncet from GSGSSI provided regular feedback on the analysis and results from the wandering albatross crowdsourcing project via email and stakeholder meetings and is a co-author on this manuscript. Sally Poncet and Ken Passfield provided nest GPS locations from the 2023/24 census to refine the breeding boundaries to improve the accuracy of counts. Shapefiles for these breeding boundaries (**Annex 5 Supplementary Material Figure S1a, S2a, S3a, S4a, S5a, S6a, S7a**) will be published with the manuscript and can be reused for any future wandering albatross campaigns at South Georgia.

Dr Steffen Oppel (Project Partner), formally based at RSPB, has provided extensive assistance on the Tristan albatross project, including interpretation of results and manuscript write-up, and is a co-author on the paper (currently being prepared for submission to *Ibis*). The Conservation Data Management Unit at RSPB are acknowledged in the manuscript for providing digital elevation models and geographic information on the Gough Island surveys (**Figure S8**). The ground count data was gathered by the RSPB field team on Gough Island in 2018, who are acknowledged in the manuscript (see **Annex 3 Table 2** for private link to manuscript).

3 Project Achievements

3.1 Outputs

The outputs set out in the Log frame have been closely followed and have been addressed individually. We have (1) completed the first archipelago-wide satellite survey of wandering albatrosses on South Georgia (**Figure S1-S7**), (2) determined that satellite imagery can be used to assess presence-absence of Tristan albatrosses on Gough Island (**Figure S9-S10, Table S1-S9**), but is not suitable for obtaining population estimates due to limited detectability (**Figure 2 in Section 1, and Table S1**) and persistent cloud cover, (3) verified the accuracy of wandering albatross satellite counts using ground-truthing data from several sites (**Table S10**) and implemented a private campaign for experts to count wandering albatrosses (**Annex 5.9**), and (4) published one paper (Attard *et al.* 2024) and drafted two manuscripts that we plan to submit for publication in peer-reviewed journals (**Annex 3 Table 2**).

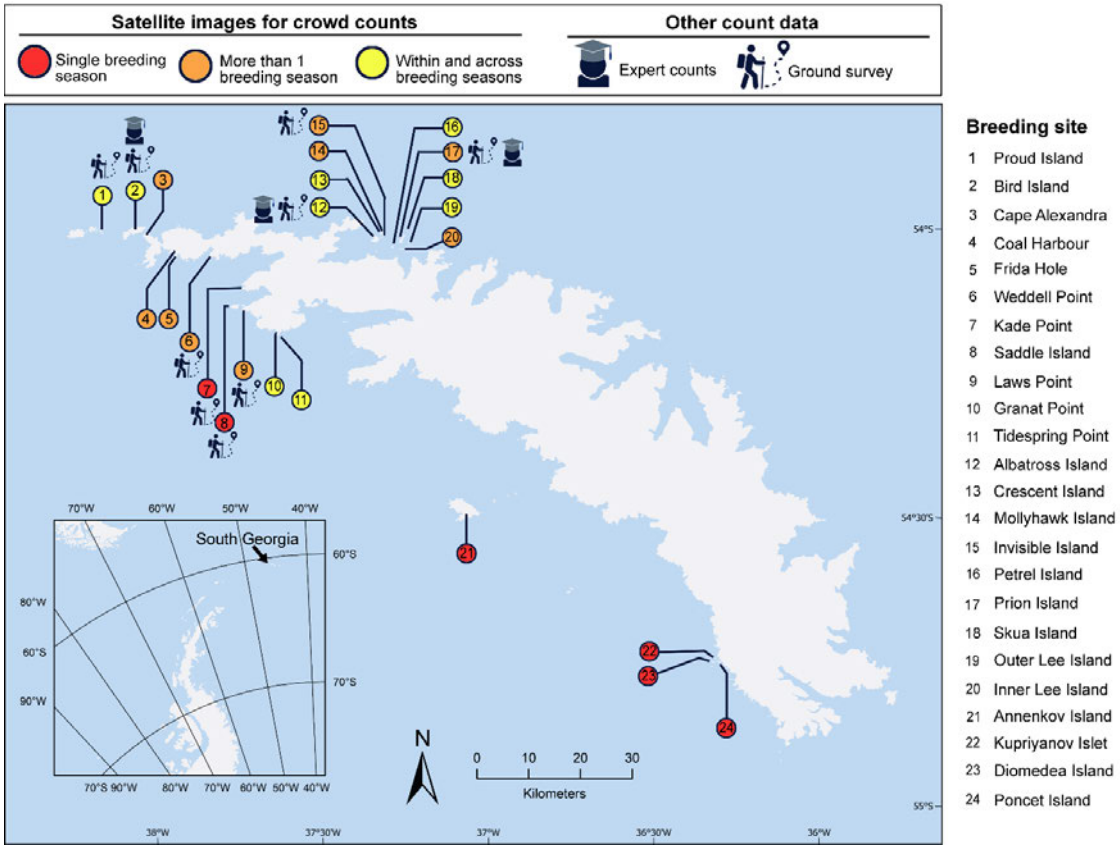

Figure 1. Locations of the breeding sites across South Georgia where satellite images from 2015 to 2022 were obtained for the Albatrosses from Space crowd campaign. Breeding sites are categorised based on the availability of cloud-free satellite imagery (red circle = captured from single breeding season, orange = captured over more than one breeding season, yellow = captured more than once within and across breeding seasons) and whether there was ground-truthed data available (ground survey symbol). A private campaign was conducted by experts (expert symbol) for satellite images from three intensely studied breeding sites where ground surveys were conducted.

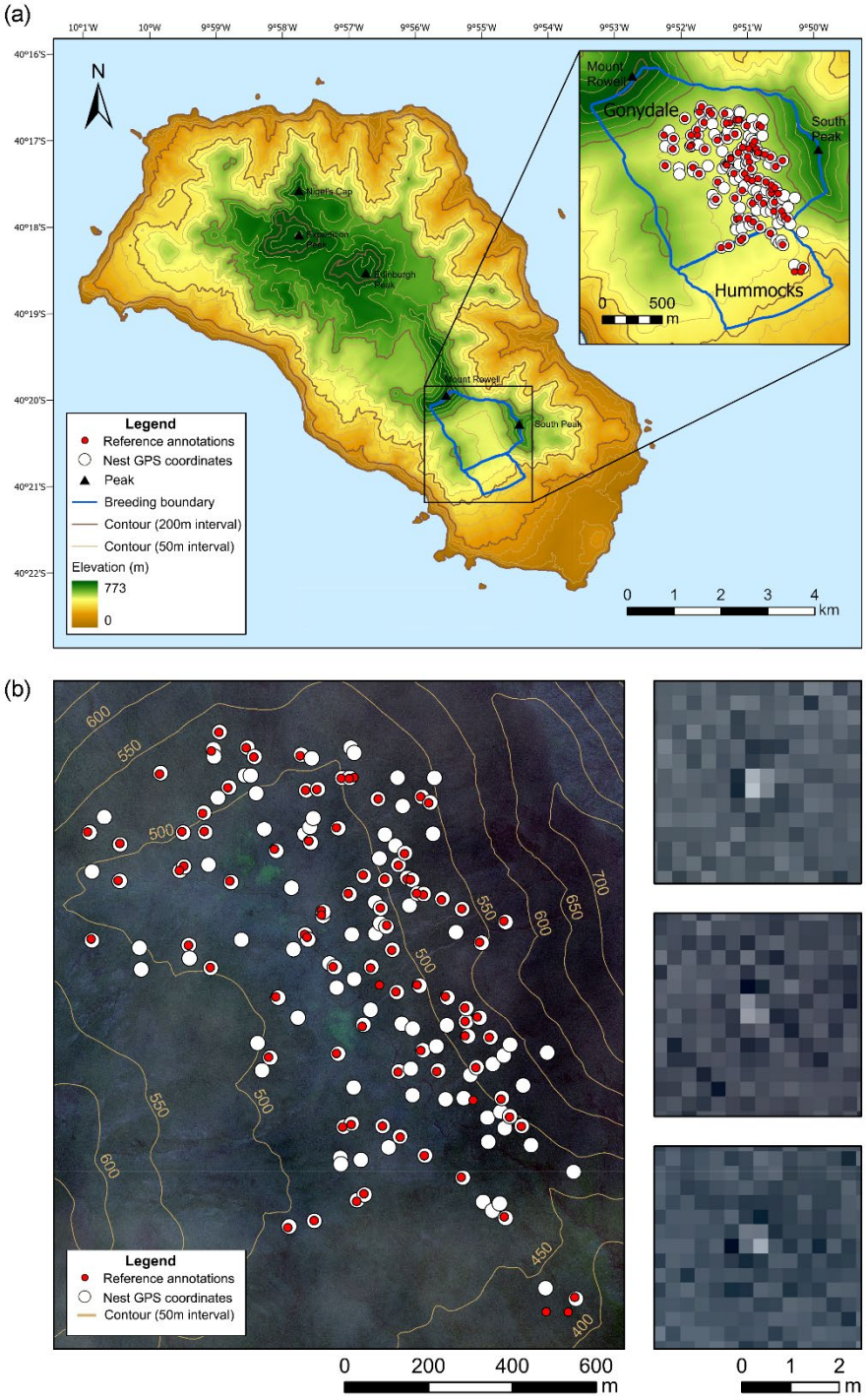

Figure 2. (a) Map of Gough Island and relevant features, with an inset map of the only two study areas (Gonydale and Hummocks) that were cloud-free in the satellite image. (b) Satellite image (31 cm resolution) showing GPS coordinates of Tristan albatross nests from ground surveys in 2018, and nests and presumed non-breeders detected in imagery. Three random examples from the satellite image shows an individual nesting Tristan albatross as light pixels in the centre of the panel. Credit for satellite images © 2024 Maxar Technologies.

Results from each output is described below:

Output 1. A satellite survey protocol for wandering albatrosses across the South Georgia archipelago, which could easily be applied to other locations across the globe.

1. The citizen science campaign for wandering albatrosses covered 24 breeding areas using imagery captured from 2015 to 2022 (**Figure 1**). Citizen scientists were asked to label presumed albatrosses in tiles (150 m x 150 m, with 5 m overlap), each viewed by at least 7 unique users. A total of 11,839 tiles covering 154 km^2 were classified by 639 citizen scientists in 107 days (**Annex 5.10**).
2. Ground counts and crowd counted satellite data were plotted for the 24 breeding sites included in the crowd campaign (**Figure S1-S7**). Only labels within each breeding boundary were included in the crowd counts. The raw labelled features from the campaign were filtered based on agreement of a feature between observers to produce the final dataset. Two surveyors agree on a feature if their labels are placed within 2 m of each other. Using ground survey data to compare with the satellite counts we found that bird counts based on labels agreed by at least 3 observers were the closest to adjusted bird counts based on ground surveys conducted in the same breeding season (**Figure S11 and S12**). This filtered dataset was used in all subsequent analysis. The estimated number of adult wandering albatrosses from ground surveys and satellite imagery were plotted each year (2015-2022) for each breeding location, where available (**Figure S1-S7**).

3. Satellite counts reflect the total number of adult birds present at the colony, whereas ground surveys are of the number of nests where an egg is present, and are usually corrected for previous breeding failures (based on the rate in a study plot that is visited more frequently) to estimate the original number of breeding pairs. This would reflect an imbalance in the relative numbers of birds in the two surveys and make comparisons unequal. To correct for this, we increased the number of breeding pairs in the ground surveys by 26.7% for small colonies (≤40 breeding pairs; see **Figure S13**) and 11.1% for large colonies (>40 breeding pairs; Fretwell *et al.* 2017) to obtain an estimated total bird count to compare with satellite counts. Different correction factors were applied because smaller colonies tend to have a higher proportion of non-breeding birds (failed breeders, pre-breeders or deferring breeders) in the colony than larger colonies.

4. Satellite-based counts from the crowdsourced campaign were compared to ground counts from the same breeding season to assess their accuracy. There was a strong, positive correlation ($r=0.98$, $df=16$, $P<0.001$) between adjusted ground and satellite-based bird counts, with 4.5 to 30.9% percent deviation for colonies with over 100 breeding pairs (**Table S8**).

5. No counts of wandering albatrosses from Annenkov Island, which is the second largest population of wandering albatrosses at South Georgia, had been collected since 2004. We calculated breeding pairs based on crowd counts from a 2017 satellite image. All nest GPS co-ordinates from the last census (2003/04) and satellite annotations were plotted on a map of Annenkov Island (**Figure S7a**). These were compared to expert counts from the same satellite image published by Bowler *et al.* 2020. The results suggest that the number of breeding pairs on Annenkov Islad was in line with the average annual decline of wandering albatrosses among large colonies elsewhere at South Georgia (**Figure S7b**).

6. We completed a private campaign on the GeoHIVE citizen science platform to count wandering albatrosses in satellite images of Prion Island, Albatross Island and Bird Island by 7 experts (i.e., individuals with expertise in counting wildlife in satellite imagery). The campaign consists of 542 image chips (**Annex 5.9**). Expert counts were compared to counts from the crowd and ground surveys (**Table S9**). Crowd and expert counts for Albatross Island and Prion Island were very similar, while satellite counts by the crowd and experts overestimated ground truthed counts by 10.48% and 15.56%, respectively (**Table S9**).

7. Although three presumed wandering albatrosses were tagged on Hall Island in the crowdsourced campaign, their presence would need to be confirmed in a ground survey.
8. A manuscript is being drafted, titled "Crowdsourcing satellite imagery to count breeding wandering albatrosses". Analysis of bird counts from the crowd are being assessed and compared to updated colony extents using nest GPS data gathered during the 2023/24 census. All sections of the manuscript are complete and will be updated with new results using revised breeding boundaries.

9. A new project has been planned to compare wandering albatross counts from unoccupied aircraft systems (UAS), satellite, and ground surveys. We have satellite and UAS imagery of Prion Island from 2022 to compare count accuracy with corresponding ground counts. The 2022 satellite imagery has been counted by the crowd and one expert (Marie Attard). Counts will be completed by 4 additional experts with prior experience of counting birds in satellite imagery (Peter Fretwell, Ellen Bowler, Richard Phillips, and Nathan Fenny). The intention is to provide an evaluation of different methods to obtain population estimates of wandering albatross, including pros and cons of each, and will be submitted to a peer-reviewed journal.

Output 2. First VHR satellite survey of Tristan albatrosses on Gough Island.
We completed the first assessment of whether Tristan albatrosses on Gough Island can be detected and counted accurately in 31 cm resolution WorldView-4 imagery. We examine this both in terms of presence/absence surveys (detecting whether albatrosses are present regardless of number) and for population censuses (accurately counting all nesting individuals). First, we compared the location of manually annotated Tristan albatrosses in an orthorectified 31 cm resolution satellite image (captured during the 2018 incubation period; see **Table S10** for details) with concurrent nest GPS coordinates from ground surveys. Secondly, we evaluated if nest location attributes (slope and aspect) and plumage hue or value (assumed from the sex and minimum age of the incubating bird) influenced the detectability of individuals in satellite imagery. Finally, we summarise the current and future potential of using VHR satellite imagery as a tool for long-term monitoring of the population. Our findings are described in a draft manuscript titled "Feasibility of using very high-resolution satellite imagery to monitor Tristan albatrosses *Diomedea dabbenena* on Gough Island" that will be submitted to the journal *Ibis* in April. A summary of our findings is below:

1. Expert counts of Tristan albatrosses were completed for a 31-cm satellite image showing a cloud-free region of their breeding area on Gough Island. GPS coordinates of active nests from the ground survey were superimposed over the satellite image to use as a guide to mark the locations of breeding albatrosses and obtain a 'true reference' distribution which was used to calculate the proportion of nests that were detected in the satellite image (**Figure 2a-b**). Reference annotations within 10 m of a nest GPS coordinate were classified as the same individual. Ground surveys indicate 152 nesting birds in the area overlapping with the satellite image. Only 84 nesting birds (55.3%) were visible in the satellite image, in addition to 4 presumed non-breeders. Orthorectification slightly improved the number of birds detectable in the satellite image because pixel smearing resulting from the orthorectification process made some of the nesting birds appear larger, and therefore more obvious.

2. Independent observers with varying levels of experience each detected 57% - 71% of the nests annotated by the reference observer. Aggregating detections of independent observers (based on labels agreed by at least 4 observers) resulted in a nest detection probability of 67.9% across a subset of images (**Figure S9**). The aggregated detections (**Figure S10**) included 9 labels that did not coincide with nest coordinates and were not identified by the reference observer. These labels represent false positives or potential non-breeders that were missed by the reference annotator.

3. We tested whether detectability of nesting Tristan albatrosses in 31 cm satellite imagery was influenced by characteristics of the incubating parent and nest. The factors that were considered were sex and minimum age of the incubating bird, and slope and aspect of the nest. To assess which factors may explain the detection probability of Tristan albatrosses in satellite imagery, we used a generalized linear model (GLM) with a logit link function for the binomial dependent variable (undetected/detected albatross in satellite image). We first fitted the full GLM model containing all potential predictor variables (i.e., slope, aspect, sex and minimum age), and then reduced the number of explanatory variables by fitting all possible model subsets. Slope and aspect were available for 152 nests, while the sex and age of the incubating bird was known for 50 nests. Therefore, our main GLM was limited to 50 nests for which complete information was available. To validate the importance of slope and aspect, we also fitted a separate GLM with only those two predictor variables but a larger sample of nests (n=152). In addition, differences in detectability based on minimum age were analysed separately for males and females using a one-way ANOVA.

   Minimum age of incubating males or females had no effect on detectability of nesting albatrosses in the satellite image (estimate= -0.01, CI = -0.13-0.10 for males and estimate = -0.01 , CI = -0.15-0.14 for females). In total, 69% (n=18) of females and 58% (n=11) of males were detected by the reference observer, but this difference was not statistically significant (chi-square test: X^2=0.33, df=1, p=0.56). The two top-ranked models (δAICc<2) explained only 9-11% of the variance in detectability (**Table S11**). Nest aspect was a useful predictor in the two most parsimonious GLM models for the 50 nests where bird age and sex were also known, with higher detection probability for more westerly facing nests (estimate = 0.01, 95% CI = 0.001-0.02). However, this effect was not evident in the analysis of all 152 nests of known aspect (estimate = 0.01, 95% CI = -0.02-0.02). Sex of the incubating parent was retained in one of the two top-ranked models but the effect was weak (estimate=0.01, 95% CI = -1.84-0.60; **Table S11**).

4. We found that acquisition of suitable imagery is a major challenge for Tristan albatrosses because its upland nesting sites are prone to low-lying orographic cloud, and only one cloud-free image could be obtained over eight seasons. Incomplete detection because of persistent cloud on the island is such that the Tristan albatross cannot be counted reliably using 31 cm resolution satellite imagery.

Output 3. Raised public awareness of albatross conservation and biodiversity on the UKOTs through engagement with the crowdsourcing campaign.

The campaign went live on 4th September 2022 to coincide with National Wildlife Day. Through close communications with Emily Neville (BAS Communications and Engagement Manager) and Ness Amaral-Rogers (RSPB Senior Science Communications Executive), we were able to achieve extensive media coverage to BAS staff, and RSPB staff and members. This included:

- Social media posts on Twitter (@BAS_News, @RSPBScience, @AlbatrossSpace, @PeterTFretwell), Facebook and Instagram (@rspb). See **Annex 5.11** for media post examples.
- An article in BAS news stories (published 4th September) and website (updated throughout the project). The news story included a link to sign up to the campaign.
- A feature article on the RSPB website and Wingbeat, the RSPB's magazine directed at 13-18 years olds to encourage younger people to get involved. The article was also included in RSPB's science external enewsletter on 24th September, which goes out to 1,000 recipients.

- RSPB Internal communications to get staff involved, including posts on yammer, intranet article and internal enewsletter.
- BAS Internal communications to get staff involved.
- Advertising at RSPB local group talks.

Output 4. Research outputs developed and shared with target audiences, local government and stakeholders.

The minutes summarising results of the crowd counts were disseminated in a stakeholder meeting on 8 December 2023 (see **Annex 5.7 and 5.8** for meeting minutes and presentation). The results have been presented at several conferences (**Annex 2 Activity 4.5 and Annex 5.12)**, including two conferences later this year **(Annex 5.13**).

Two articles on Tristan albatross and wandering albatross satellite survey to be submitted to open access journals between April-June 2024 (manuscript accessible via private links in **Annex 3 Table 2**). The protocol for repeating satellite and crowd survey methods have been written within the manuscript methods and can be adapted for future surveys. Automated methods were not developed, as we determined that counts from crowdsourcing offered an accurate and more cost-effective option.

An additional project comparing UAV, satellite and ground count data of wandering albatrosses at Prion Island is also planned, with the intention to submit findings as a separate peer-reviewed publication.

References

Bowler, E., Fretwell, P.T., French, G., Mackiewicz, M. 2020 Using deep learning to count albatrosses from space: Assessing results in light of ground truth uncertainty. *Remote Sensing*. **12**: 10099–10102. https://doi.org/10.3390/rs12122026

Fretwell, P.T., Scofield, P. and Phillips, R.A. 2017 Using super-high resolution satellite imagery to census threatened albatrosses. *Ibis*, **159**: 481-490. https://doi.org/10.1111/ibi.12482

3.2 Outcome

The intended Outcome was “Improved archipelago-wide monitoring of wandering albatrosses on South Georgia, and Tristan albatrosses on Gough Island, will enhance our understanding of population trends and inform targeted conservation efforts.”

As detailed above (**Section 3.1**), the project has achieved a major advance in remote monitoring of wandering albatrosses through our crowdsourcing campaign, filling a huge gap for wandering albatross population trends throughout South Georgia (**Output 1**). Crowdsourcing provided accurate data on population sizes for wandering albatrosses, highlighting the utility of this approach as a long-term monitoring tool with great potential for expansion to other breeding locations and seabird species. Based on these data, new tools to enable future research and support were developed, including protocols for delivering and analysing crowd-based satellite counts of this species. Our peer-reviewed publication provides guidelines for designing satellite or drone projects for wildlife on land, which can be downloaded from the online ACAP conservation guidelines (https://www.acap.aq/resources/acap-conservation-guidelines) (**Output 1**). Public awareness of albatross conservation and biodiversity on the UKOTs was achieve through multiple sources of engagement with the crowdsourcing campaign (**Output 3**), including media posts (twitter, facebook, Instagram; **Annex 5.11**), online feature articles and TV interviews (**Annex 3 Table 2**).

This study is the first to assess the feasibility of detecting Tristan albatrosses in satellite imagery (**Output 2**). Counts of Tristan albatrosses in satellite images by a wildlife remote-sensing specialist were compared to GPS coordinates of active nests recorded in the field. In total, birds were visible at only 84 (55.3%) of the 152 active nests in the cloud-free regions of the satellite image captured in February 2018. Acquisition of suitable imagery is a major challenge for this species because its upland nesting sites are prone to low-lying orographic cloud, and only one cloud-free image could be obtained over eight seasons. Incomplete detection because of persistent cloud on the island is such that the Tristan albatross cannot be

counted reliably using 31 cm resolution satellite imagery. The addition of more commercial satellites in orbit may increase the chance of obtaining cloud-free imagery across the island in the future, but until then on-the-ground monitoring must continue to obtain accurate population counts and for the UK to meet its commitments to monitor this critically endangered species.

Wandering albatross crowdsourcing and Tristan albatross detectability results were shared with stakeholders (**Section 2**) and will be disseminated to the public and scientific community through conferences and two manuscripts (including data and R scripts) currently being prepared for submission to peer-reviewed journals (see **Annex 2, Output 4** for details).

3.3 Monitoring of assumptions

We carefully monitored Outcome and Output level assumptions throughout the course of the project – this was especially important when adjusting plans around Marie Attard's maternity leave. The Albatrosses from Space campaign was prepared for release before Marie went on maternity leave, allowing data to be collected through the online GeoHIVE platform during her absence (**Annex 5.10**), which was analysed upon her return (**Section 3.1**).

A key assumption was that cloud-free imagery would be obtained at appropriate times during the nesting season. We incorporated multiple images of different colonies at South Georgia in the campaign (including darker and partially cloudy imagery) (See **Table S12** for full list), but only included counts from clear, cloud-free imagery in our analysis. Acquisition of suitable imagery was a major challenge for Tristan albatrosses because its upland nesting sites are prone to low-lying orographic cloud, and only one cloud-free image around the Gonydale GPS survey area could be obtained over eight seasons. Due to the rarity of cloud-free imagery at Gough Island, we used a single archived image from 2018 (**Table S10**).

The second key assumption was that 'enough volunteers will be recruited to process the image efficiently'. Prior to the campaign going live, we had predicted that at least 1,000 volunteers would be required to complete the campaign. We worked closely with BAS and RSPB communications and engagement offices to develop an article/blog and media posts to recruit volunteers from the public and within these organisations (see **Section 3.1, Output 3**). The campaign was completed quicker than we expected and were able to publicly recruit enough volunteers to label albatrosses in all satellite images of South Georgia breeding sites.

The last key assumptions were that we 'can organise meetings to discuss outputs and stakeholder meetings' and that 'manuscripts would be accepted'. We have published 1 manuscript (Attard *et al.* 2024) and have two manuscripts drafted for this project (**Annex 3 Table 2**). Details on stakeholder and internal meetings are provided in **Section 2**.

4 Contribution to Darwin Plus Programme Objectives

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

This project is making an important contribution to the Conservation Action Plan for wandering Albatrosses at South Georgia: (https://www.gov.gs/docsarchive/Environment/Birds/SG_Wandering%20Albatross%20Conservation%20Action%20Plan_Final.pdf), especially component 1 – assessing populations. Satellite imagery has been used to complete the first island-wide remote survey of wandering albatrosses at South Georgia. The combination of very high-resolution satellite imagery, which is safe, relatively cheap, low carbon and disturbance free, with citizen science which provides multiple counts freely at each location, is a powerful tool for future monitoring of the species and an excellent tool for outreach and engaging the public on the vital conservation of this iconic bird. The data that we have generated on trends in population size across years and breeding sites will facilitate analyses of effects of annual and spatial variation in climate and other environmental drivers.

The data will be useful to IUCN for assessing Red List status, and for the Agreement on the Conservation of Albatrosses and Petrels. Overall, the project benefits the UK Government by contributing to the Blue Belt initiative for protection of the marine environment, supporting vital conservation objectives whilst demonstrating the commitment of the UK to protecting the global

marine environment. The crowd sourcing app has raised public awareness both of the plight of albatrosses at South Georgia.

The project has also informed RSPB and the Government of Tristan da Cunha of the limitations of using satellite imagery for monitoring long-term changes in numbers of Tristan albatrosses. Currently, it is not feasible to use satellite imagery to conduct population estimates of Tristan albatrosses, mainly owing to the persistent cloud-cover over Gough Island.

4.2 Gender equality and social inclusion

Throughout the project, we were mindful of gender equality and did everything possible to maintain equality. The core project team consisted of two women, Marie Attard and Ellen Bowler. Marie Attard was hired as the postdoctoral researcher on the team when the project commenced. Dr Sally Poncet from South Georgia Surveys was a key contact for acquiring ground GPS nest locations of wandering albatrosses from past censuses. The field expedition team on Gough Island comprised of two men (Roelf Daling, Fabrice LeBouard) and four women (Vonica Perold, Jamie Cleeland, Kim Stevens, Kate Lawrence), which carried out the work in 2018.

The Albatrosses from Space citizen science project follows the same ethos of inclusivity, being widely advertised and open to all members of BAS, RSPB and the general public worldwide. Participation in the campaign was open to anyone with access to a laptop or desktop computer (recommended minimum age of participants is 10 years old).

Please quantify the proportion of women on the Project Board[1].	50% project board (Attard+ Bowler)
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].	Of the stakeholder group 31% are women

5 Monitoring and evaluation

There were no major changes to the project design, other than the project being paused for a year while Marie Attard was on maternity leave from mid-August 2022.

As stated in the DPLUS132 application, the project leader and lead analyst were responsible for project M&E. The log frame was referred to during regular project meetings held every ~1-2 weeks with the Project Leader and Lead analyst to keep track of the timeline and ensure that all outputs were addressed. Formal monthly meetings were organised by the Lead analyst for all BAS personnel on the project where overall progress was assessed; outputs, short and long term objectives, challenges and budgeting were reviewed. Formal half annual meetings were arranged with all project partners and stakeholders, which were written up and reported (**Annex 5.1-5.8**). The M&E system was helpful in communicating key questions and findings during stakeholder meetings. Additionally, Sally Poncet and Steffen Oppel were kept updated with new results as soon as they were available by email or zoom, and their feedback was incorporated into the analysis required.

All scientific outputs of the project are being formalised as manuscript submitted to scientific journals. These results will be communicated to the wider network of overseas groups and NGOs through email and attendance of international meetings (**Annex 2 Activity 4.5**). Social

[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.

media engagement were monitored by assessing the success of publicity posted, for example on BAS/RSPB twitter, facebook and Instagram pages (**Annex 5.11**).

Financial monitoring of the project was carried out by the BAS Financial Office. Since all project personnel are based at BAS, and the project partners are also based in Cambridge, costs of M&E were low.

6 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. *"In the last reporting period, the logframe register informed that all ground survey data for Bird and Prion Island had been received. Ground counts were discontinued on Albatross Island from 2020, but earlier data is pending. This also depends on the conclusion of the orthorectifying of the purchased satellite images of Bird, Albatross and Prion Islands using DEMs provided by RSPB and BAS. Year 2 reports that imagery acquisition was completed in Year 1 (Section 3 Project Progress) but it is unclear to the reviewer if all the initially planned areas were covered and compared with ground survey data." (see Output 1.2)*
   A private campaign was launched on 6 October 2023, consisting 543 tiles covering Bird, Albatross and Prion Island (**Table S9**). We recruited seven satellite image experts to complete the counts. All counts were completed by 15 January 2024 (evidence in **Annex 5.9**) and were compared to crowd and ground survey counts (**Table S9**).

2. *"The logframe in the Year 2 report informs that the results have been stored and will be analysed in the remaining months of the project." (see Output 1.4)*
   All crowd-sourced counts have been compared to ground counts (**Table S8**) for all breeding sites where satellite imagery was available from the same breeding season as ground surveys. Crowd counts have also been compared to expert counts at Prion Island, Albatross Island and Bird Island (**Table S9**).

3. *"The logframe informs that the protocol document has been written and will be published. Although the written information in the logframe is not very clear, the reviewer infers that the automated detection algorithm will be completed in the later part of the project, after the inclusion of manually collected counts." (see Output 1.5).*
   We did not train automated detection algorithms using the crowd annotations (Output 1.5) as we determined that counts form crowdsourcing offered an accurate and more cost-effective option for studies involving large areas over multiple years. The campaign also provides an excellent opportunity for community involvement and could be carried on for long-term monitoring of wandering albatross.

   The satellite images are incorporated into the GeoHIVE platform without needing to be purchased, and tiles from the campaign are provided by Maxar as jpegs if requested (this is useful to check for any errors in annotations, such as misidentification of rocks for albatross). These tiles could be used as test datasets to improve existing automated detection protocols (Bowler *et al.* 2019) if required in the future. However, this would mean that imagery would need to be purchased for future counts. Images purchased directly from Maxar cost £17.78/km^2 for 30 cm archived imagery (3-4 band) costs per with a minimum order of 25 km^2 per satellite image and £25.69/km^2 for 30 cm tasked imagery (3-4 band) with a minimum order of 100 km^2 per satellite image (Supplementary Table S4 in Attard *et al.* 2024).

4. *"The Year 2 report informs that Initial results show that, unlike wandering albatross, only a percentage of the Tristan albatrosses were accurately identified and concluded that Tristan albatross are less suitable for counting from satellite. As there is no evidence of these results illustrated in the report, it is unclear for the reviewer if all the initially planned assessments of the results have been conducted." (see Output 2.4)*
   There was only one partially cloud-free image available over Gonydale and the Hummocks areas at Gough Island over the past 8 breeding seasons (**Table S10**). As this was the only suitable satellite image, we decided to purchase the archived image and complete expert

and crowd counts in a private campaign using freeware VGG image annotator (VIA). This was a more cost-effective solution, and allowed us to gather information on the level of experience of each person annotating the images. The draft manuscript, R scripts and data can be downloaded using the private links available in **Annex 3 Table 2**.

5. *"The Year 2 report does not update on this activity neither informs about any scheduled meetings." (see Output 2.5)*
   The initial results from the Tristan albatross study were communicated at the Tristan da Cunha Projects Update Meeting on 13th June 2022 (see **Annex 5.5** for program and **Annex 5.6** for presentation). By this time, we had purchased satellite imagery of Gough Island, obtained Nest GPS coordinates, orthorectified the image and completed a preliminary blind count from the satellite imagery. Updated results on detectability of Tristan albatrosses in satellite imagery were communicated at the final stakeholder meeting on 8th December 2023 (**Annex 5.7 and 5.8**). Steffen Oppel from RSPB and all project investigators from BAS assisted with interpretation of findings and manuscript write-up, to be submitted to the journal *Ibis*.

6. *"The Year 2 report does not update on the development of this activity." (see Output 3.5)*
   Evidence of success of the crowdsourced campaign in terms of engagement can be found under Section **Annex 3 Table 1 & 2.** This included online feature articles and news stories, social media posts and TV interviews. Richard Phillips discussed the success of the campaign on the Polar diaries podcast after the campaign was completed. Participants were not individually contacted after the campaign with key results, as the findings of this study are currently being prepared for publication.

7. *"The logframe informs that results will be showcased at ACAP and South Georgia Science Symposium in May and June 2023."* (see Output 4.1)
   Results were not showcased at the ACAP and South Georgia Science Symposium or at the ACAP Advisory Committee meeting as Marie Attard was on maternity leave from August 2022 to August 2023.

   However, Marie Attard submitted her pre-recorded oral presentation (**Annex 5.12**) to the BOU Citizen Science and Birds (#BOUasm22) conference (held in October 2022) before going on maternity leave. Since her return, Marie Attard and Peter Fretwell have submitted abstracts to present the wandering albatross and Tristan albatross results at the Ecological Society of America (ESA) conference (see **Annex 5.13** for abstract) and SCAR conference in August 2024. Draft manuscripts and published papers reporting the results of the project will be submitted as information papers to the meeting of the Populations and Conservation Status Working Group of ACAP in Peru in August 2024.

8. *"The log frame informs that the reports will continue when project re-starts in August 2023." (Output 4.2)*
   Analysis for all projects was completed when the project re-started in August 2023, and results were communicated to stakeholders during the final meeting on 8th December (**Annex 5.7** and **5.8**). Results from both studies are being prepared as separate manuscripts to peer-reviewed journals.

9. *"The log frame informs that two draft manuscripts have been written for the project." (see Output 4.3)*
   This is correct. Two draft manuscripts have been written on the Tristan albatross and wandering albatross results. A review paper was also published in *Remote Sensing* in January 2024.

10. *"The log frame informs Code and protocols for analysing crowdsourced data have not commenced" (see Output 4.4)*
    The R script and protocols for the crowdsourced data have been developed and will be made available in an online data repository with the manuscript upon acceptance.

11. *"Y2 report informs that results will be showcased at ACAP and South Georgia Science Symposium in May and June 2023" (see Output 4.5)*
    See response under point 7.

12. "*Although the project reports that the Darwin logo was incorporated into the crowdsourcing application, and used in publicity and publications no evidence was presented." ('Darwin Plus Identity' subheading of Annual Report Review)*
    The Darwin plus logo is on the right panel of the Albatrosses from Space webpage (https://www.bas.ac.uk/project/wildlife-from-space/albatrosses-from-space/) and was included in the 'Help and Information' section of the GeoHive platform for this campaign (**Annex 5.14**).

7 Lessons learnt

1. Our results show that wandering albatrosses can be accurately counted by the public from satellite imagery.
2. With only one 31-cm resolution satellite in orbit at the time of the data acquisition, collection of suitable imagery is still challenging in cloudy areas. This should become easier as more satellites are launched over the next ~5 years. For example, the Albedo Space Corporation (Albedo) aims to complete a constellation of 24 satellites with a 10 cm image resolution by 2027. This increase in capacity should greatly improve the chance of obtaining cloud-free imagery in areas with few time windows without cloud cover.
3. Despite our rapid responses to their correspondence, it will take longer for the provider to develop and launch a fully functional crowdsourcing app than we anticipated. For future platforms, the financial budget will need to be larger, and timeframe longer.
4. Regular meetings and collaboration across projects can benefit all stakeholders.
5. Correction factors to convert from birds counted in satellite imagery to estimate breeding pairs must consider colony size. Different correction factors have been recommended for small (≤40 breeding pairs) and large (>40 breeding pairs) colonies.
6. Pervasive cloud-cover remains a major limitation in using satellite technology to count Tristan albatrosses on Gough Island. Tasked and archived imagery of Gough Island were considered for this study, but only a small portion of the target area was cloud-free in a handful of images, making it impossible to conduct an island-wide remote census.
7. We recommend that current on-the-ground monitoring of the Tristan albatross population continues until suitable and reliable alternatives become available. While currently available satellite imagery is insufficient to obtain accurate and reliable population size estimates for Tristan albatrosses, future developments may improve the temporal and spatial resolution of satellite imagery and therefore warrant a re-evaluation of remote monitoring opportunities in the 2030s.

8 Risk Management

There are no new risks arising in the last 12 months that were not previously accounted for, therefore no adaptations to the project design was required.

9 Sustainability and Legacy

With the success of the citizen science app to reliably detect and count wandering albatrosses at numerous breeding sites at South Georgia, we will start the process of working towards a further and larger project, possibly of all albatross colonies in the Southern Ocean. This would require collaboration with overseas research and management bodies, both government and NGOs. Ssome have been already been contacted by Dr Fretwell to discuss options. The Darwin Plus project has been a great start to further such opportunities for larger-scale

crowdsourcing projects. Given the challenges of developing efficient AI approaches for counting wandering albatrosses at large spatial scales, crowdsourcing campaigns are likely to be remain more cost-effective for some years to come .

The BAS project investigators for DPLUS132 were awarded a 3-year Darwin Plus grant (DPLUS187). The new project commenced on 1 December 2023 just after the DPLUS132 project had ended. The new project will be utilising some of the protocols and R scripts developed in DPLUS132 to assess the feasibility of monitoring other seabird species (mollymawks, burrowing petrels and shags) across South Georgia using satellite imagery. Some of the satellite images purchased for DPLUS132 will be reused to detect other seabird species for DPLUS187.

10 Darwin Plus Identity

The Darwin plus logo is on the right panel of the Albatrosses from Space webpage (https://www.bas.ac.uk/project/wildlife-from-space/albatrosses-from-space/) and was included in the 'Help and Information' section of the GeoHive platform for this campaign (**Annex 5.14**). The Darwin Plus logo has also been included in stakeholder and conference presentations (see **Annex 5.2, 5.4, 5.8** and **5.12** for examples). The funding source was included in Attard *et al.* 2024 and in upcoming publications. The Darwin Plus funding was recognised as a distinct project with a clear identify. The Twitter account for the project (@AlbatrossSpace) posted information on the project progress, including the release of the campaign. Future posts will link back to the Darwin Plus Funds social media accounts to acknowledge the source of funding.

11 Safeguarding

Has your Safeguarding Policy been updated in the past 12 months?	Yes
Have any concerns been investigated in the past 12 months	No
Does your project have a Safeguarding focal point?	Yes, at BAS.
Has the focal point attended any formal training in the last 12 months?	?
What proportion (and number) of project staff have received formal training on Safeguarding?	25% of BAS staff have been trained. They are primarily staff living and working on a research vessel. More training is planned this year.
Has there been any lessons learnt or challenges on Safeguarding in the past 12 months? Please ensure no sensitive data is included within responses. The most challenging issue for BAS was to engage staff who had an inaccurate idea of what safeguarding was and who it affected. BAS do not employ staff working with children; however many of the staff live and work in isolated environments and under challenging conditions, which may make them more vulnerable.	

12 Finance and administration

12.1 Project expenditure

Project spend (indicative) since last Annual Report	2022/23 Grant (£)	2022/23 Total actual Darwin Plus Costs (£)	Variance %	Comments (please explain significant variances)
Staff costs	[redacted]	[redacted]		

Project spend (indicative) since last Annual Report	2022/23 Grant (£)	2022/23 Total actual Darwin Plus Costs (£)	Variance %	Comments (please explain significant variances)
Consultancy costs	[redacted]			
Overhead Costs				Due to an Additiona[redacted] for FY 23/24 not being awarded for overheads
Travel and subsistence				
Operating Costs				
Capital items				
Others				The Customized GeoHive Crowdsourcing Campaign – Albatrosses were budgeted this FY but claimed for last FY when it was missing from the budget
TOTAL	30,910.27	22,291.07	**-28%**	**See above**

Staff employed (Name and position)	Cost (£)
Marie Attard	[redacted]
Peter Fretwell	
Richard Phillips	
TOTAL	**13691.86**

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

Capital items – description	Capital items – cost (£)
TOTAL	

Other items – description	Other items – cost (£)
Satellite imagery and citizen science app costs	[redacted]

TOTAL		[redacted]	

12.2 Additional funds or in-kind contributions secured

Source of funding for project lifetime	Total (£)
TOTAL	**0**

Source of funding for additional work after project lifetime	Total (£)
TOTAL	**0**

12.3 Value for Money

We have considered value for money throughout the design of the project. We will benefit from analysis which has been developed in previous studies (Fretwell *et al.* 2017; Bowler *et al.* 2020), which will avoid considerable development costs and associated risks. The engagement of citizen scientists has ensured excellent value for money for the analysis of imagery. Importantly the campaign has promoted a conservation message for albatrosses at the UKOTs, and addresses key public engagement targets in the NBAPs and other action plans of the OTs. This in itself has significant value. The campaign gained widespread attention through promotion via the established media networks of BAS and RSPB. This promotion and advertisement had no cost other than modest staff time but high value in terms of raising public awareness.

For the satellite imagery, the majority of purchased imagery were taken from Maxar's existing archive, which has a lower associated cost than tasking new imagery. The satellite campaign using the GeoHIVE platform cost [redacted], charged by Maxar, which included all suitable 31-cm satellite imagery from South Georgia breeding sites with >5 breeding pairs captured between August 2014 to March 2022. This option was less expensive than purchasing these images directly and using a free crowdsourcing platform (e.g., Zooniverse or VGG). Maxar staff were responsible for creating the tiles from each satellite image, processing the crowd data (e.g., removing outliers and creating the clustered datasets), customising their platform for this campaign and included a static tutorial showing how to use their interface to locate and annotate albatrosses in a tile (**Annex 5.15**). See **Annex 5.16** for a screen recording of presumed albatrosses being labelled on the GeoHIVE platform. Upon our request, Maxar also provided jpegs of every image chip, and the grid used to create the tiles, which can be used by BAS according to the licence agreement. The methods used for the campaign and subsequent data analysis will be made available in a peer-reviewed journal article. The same protocols can be adapted to any future projects to estimate populations of wandering albatrosses using satellite imagery.

Staff costs are based on standard organisational pay scales, and BAS will complement support with waived overheads and resources necessary for the project.

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

I agree for the Biodiversity Challenge Funds Secretariat to publish the content of this section (please leave this line in to indicate your agreement to use any material you provide here).

Satellite imagery was used to complete the first island-wide remote survey of wandering albatrosses at South Georgia. The combination of very high-resolution satellite imagery, which is safe, relatively cheap, low carbon and disturbance free, with citizen science which provides multiple counts freely at each location, is a powerful tool for future monitoring of the species and an excellent tool for outreach and engaging the public on the vital conservation of this iconic bird.

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)
Image	Image 1_Wandering albatross	Wandering albatrosses breeding on Bird Island. Credit Richard Phillips.		NA
Image	Image 2_Wandering albatross	Wandering albatrosses breeding on Bird Island. Credit Richard Phillips.		NA
Image	Image 3_Wandering albatross	Wandering albatrosses breeding on Bird Island. Credit Richard Phillips.		NA
Image	Image 4_Wandering albatross	Wandering albatrosses breeding on Bird Island. Credit Richard Phillips.		NA
Image	Image 5_Wandering albatross	Wandering albatrosses breeding on Bird Island. Credit Richard Phillips.		NA
Image	Image 6_Wandering albatross	Wandering albatrosses breeding on Bird Island. Credit Richard Phillips.		NA

Image	Image 7_Tristan albatross	Photograph showing breeding habitat of Tristan albatrosses on Gough Island and difference in plumage colour and patterns between the partners. Males (left bird) tend to be overall lighter in colour than females (right bird). The area around their nests is mostly trampled, with vegetation consisting of moss and grass-like species. Photos are courtesy of Steffen Oppel and Peter Ryan.		
Image	Image 8_Tristan albatross	Photograph showing breeding habitat of Tristan albatrosses on Gough Island and difference in plumage colour and patterns between the partners. Males (left bird) tend to be overall lighter in colour than females (right bird). The area around their nests is mostly trampled, with vegetation consisting of moss and grasses. Photos are courtesy of Steffen Oppel and Peter Ryan.		NA
Graphic	Graphic 1_Albatrosses from space logo	Logo for Albatrosses from Space project, led by the British Antarctic Survey. Credit Marie Attard.		

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: An efficient and repeatable method for conducting VHR satellite surveys of albatrosses is in place, allowing for more frequent and wide-ranging monitoring, including colonies beyond UKOT's.			
Outcome: Improved archipelago-wide monitoring of wandering albatrosses on South Georgia, and Tristan albatrosses on Gough Island, will enhance our understanding of population trends and inform targeted conservation efforts.	0.1 Monitoring of wandering albatrosses on SG will be possible across the entire archipelago when required by the end of Y2Q3, in comparison to the current baseline of annual ground surveys on Bird, Albatross and Prion islands 0.2 The first VHR satellite survey of Tristan albatrosses will be conducted, and evaluated by comparing with ground based counts by Y2Q3 0.3 Thousands of volunteers will engage with the crowdsourcing campaign launched in Y2Q1, increasing exposure of UKOT biodiversity and albatross conservation	0.1 Results will be communicated to stakeholders via email, conferences, and attendance at meetings (e.g RSPB, ACAP, GSGSSI annual working group meetings) 0.2 Publish results of study and consult expert opinion and peer review 0.3 Assess volunteer numbers via GeoHive platform, monitor engagement with social media campaigns	Assume that cloud free imagery will be obtained, at appropriate times during the nesting season (in the December-April nesting period). We will use existing archival imagery which has been collected by the WV-3 satellite since 2015. These cover various colonies across the archipelagos, and we have confirmed that a sufficient number of clear images exist. For future surveys greater coverage will be given by the Maxar Legion, due to be launched Sept 2021, making it more likely cloud-free images will be collected in the future.
Outputs: **1**. A satellite survey protocol for wandering albatrosses across the South Georgia archipelago, which	1.1 All images capturing the 34 known wandering albatross colonies across SG collated from the existing archive (from the	1.1 List of archival images compiled in correspondence with Maxar 1.2 Downloaded images; image quality verified by experts;	Image quality will be high enough to see albatrosses, taking into account factors such as cloud-cover. We have verified that such

Project summary	Measurable Indicators	Means of verification	Important Assumptions
could easily be applied to other locations across the globe	31cm resolution WV-3 satellite) by Y1Q4. 1.2 Images of Bird, Albatross and Prion island analysed by experts, and compared to ground survey data, by end of Y1Q4. 1.3 100% of archival images annotated by citizen scientists on GeoHive by end of Y2Q2. 1.4 Satellite survey protocol and automated detection algorithm developed throughout, and finalised by end of Y2Q3.	statistics showing comparison to ground survey 1.3 GeoHive tracking statistics 1.4 Algorithm results assessed using test images; consult expert opinion and peer review process; publication of manuscript.	images exist in the archival dataset. Enough volunteers will be recruited to process the imagery efficiently. Given the relatively small area to survey, and the large amount of engagement in similar projects (e.g over 325,000 volunteers for 'seals over space' project [7]), we are confident that this will be the case.
2. First VHR satellite survey of Tristan albatrosses on Gough Island	2.1 31-cm resolution images of Tristan albatrosses on Gough Island obtained by Y1Q4. 2.2 Images analysed by experts, and counts validated against ground survey data collected at Gonydale site on Gough by Y2Q1.	2.1 Image downloaded from Maxar; image quality verified by experts 2.2 Scientists receive image to analyse; ground truth data from Gonydale received; analysis showing comparison	Images will be cloud free and albatrosses visible Cloud free images roughly coinciding with the Gonydale GPS survey
3. Raised public awareness of albatross conservation and biodiversity on the UKOTs through engagement with the crowdsourcing campaign	3.1 Communications and media campaign plan developed by the end of Y1Q4. 3.2 Website links and extra material developed in conjunction with UKOT and parters, ready for campaign launch in Y2Q1	3.1 Communication emails between partners; correspondence with BAS media office; report summarising plan 3.2 Communication emails; web pages; front end of GeoHive host page	Publicity will recruit enough volunteers

Project summary	Measurable Indicators	Means of verification	Important Assumptions
	3.3 At least 5000 citizen scientists engage with the image counting campaign by end of Y2Q2 3.4 Follow up material reporting results relayed to all volunteers and on all social media platforms by end of Y2Q3	3.3 GeoHive statistics showing the number of volunteers engaged with the project 3.4 Email follow ups if opted in; social media posts; social media analytics	
4. Research outputs developed and shared with target audiences, local government and stakeholders	4.1 Report summarising results of crowd counts disseminated among stakeholders by end of Y2Q3 4.2 Clear protocol for repeating satellite & crowdsourcing methods for future surveys presented at workshop Y2Q3. 4.3 Journal article on the satellite survey and automated methods submitted to open access journal by Y2Q3	4.1 Final report; email communications; meeting proceedings 4.2 Workshop proceedings; attendance records; presentation slides and recordings 4.3 Journal confirmation email; draft article	Can organise meetings to discuss outputs and stakeholder meetings. Manuscripts will be accepted.
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 In consultation with Maxar, collate all archival WV-3 imagery which captures known wandering albatross nesting sites, across the SG archipelago. 1.2 Conduct expert analysis of Bird, Prion and Albatross Island imagery, and compare to ground survey data collected by field researchers. 1.3 Make all archive images available on GeoHive for crowd-sourced counts 1.4 Analyse results of crowd-sourced counts, assess variance, agreement, deviation from expert labels. Conduct analysis into uncertainty of the methods. 1.5 Train automated detection algorithms using the crowd annotations. Assess the performance of the automated methods using train and test datasets 2.1 In consultation with Maxar, collate all existing archival WV-3 imagery of Gough Island.			

Project summary	Measurable Indicators	Means of verification	Important Assumptions
2.2 Using expert analysis, conduct counts of Tristan albatrosses on Gough. Compare satellite counts to GPS ground survey data at Gonydale to verify detectability. 2.3 Make Gough images available on GeoHive for crowd counting. 2.4 Assess results of crowd counts, compare variance, agreement and consistency. 2.5 Prepare report assessing viability of using satellite imagery to monitor Tristan albatrosses, to be submitted to stakeholder meetings (for example Tristan Da Cunha government, RSPB for monitoring of mice eradication scheme). 3.1 Develop relevant materials to be linked on GeoHive campaign site with UKOT's and RSPB 3.2 Develop front end of the GeoHive campaign site, in consultation with GeoHive. 3.3 Plan publicity campaign to launch crowd-counting website (for example name for campaign, twitter hashtag). Contact key stakeholders and groups who could advertise. 3.4 Launch campaign, in collaboration with the BAS and RSPB media offices. Press release. 3.5 Assess the success of the campaign in terms of engagement. Follow up materials with key results and update emails for volunteers if opted in 4.1 Prepare reports for meetings with stakeholders. 4.2 Share results with all stakeholders via email, conferences, and at meetings (e.g ACAP, GSGSSI annual stakeholder/ working group meeting) 4.3 Prepare and submit manuscript for peer reviewed, open source, journal 4.4 Make code and protocol for satellite monitoring publicly available. 4.5 Attend national/international conference to present results.			

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: An efficient and repeatable method for conducting VHR satellite surveys of albatrosses is in place, allowing for more frequent and wide-ranging monitoring, including colonies beyond UKOT's.		
Outcome Improved archipelago-wide monitoring of wandering albatrosses on South Georgia, and Tristan albatrosses on Gough Island, will enhance our understanding of population trends and inform targeted conservation efforts.	0.1 Monitoring of wandering albatrosses on SG will be possible across the entire archipelago when required by the end of Y2Q3, in comparison to the current baseline of annual ground surveys on Bird, Albatross and Prion islands 0.2 The first VHR satellite survey of Tristan albatrosses will be conducted, and evaluated by comparing with ground based counts by Y2Q3 0.3 Thousands of volunteers will engage with the crowdsourcing campaign launched in Y2Q1, increasing exposure of UKOT biodiversity and albatross conservation	0.1 The crowd counts are completed and analysed. All areas of South Georgia where successfully captured with imagery. Imagery was made available and successfully counted on a bespoke citizen science platform made for the project. Results compared to ground counts from Bird Island and Albatross Islands showed that ground counts were showed that satellite counts were useful and accurate metrics of population after a conversion for the number of none-breeders had been applied. 0.2 The satellite survey of Tristan albatrosses was completed by one expert (Marie Attard) and nine additional observers of varying experience. Data have been analysed and a draft manuscript prepared. Ground surveys indicate 152 nesting birds in the area overlapping with the satellite image. Only 84 nesting birds (55.3%) were visible in the satellite image by the expert, in addition to 4 presumed non-breeders (**Figure 2** in section 1). The non-orthorectified image of Gough Island was annotated to determine if slight blurring of orthorectified image has negatively impacted detection. Orthorectification improved nest detectability by 3.3% because pixel smearing resulting from this process made some of the nesting birds appear larger, and therefore more obvious. The nine observers detected only a proportion of the nests annotated by the expert and flagged up many additional labels >10 m from known nests (**Table S1**). These labels represent false positives or potential non-breeders that were missed by the reference observer. Hence although aggregating

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
		the detections of several observers approached the detection probability of the expert (**Figure S10**), it did not overcome the fundamental limitation that many nesting Tristan albatrosses were not detectable in the available imagery. We found no evidence that nest slope or aspect, or the sex or age of Tristan albatrosses on nests influenced detection in satellite imagery (Evidence in **Section 3.1, Output 2**). Instead, we suspect that surrounding vegetation or other aspects of the terrain that obscure incubating birds are more important in determining detection probability. The effect may depend on the angle from which a satellite image is taken, but whatever the reason, it is likely to make long-term remote monitoring extremely challenging. 0.3 The crowd campaign consisting of 11,839 tiles was launched on 4th September to coincide with World Wildlife Day. The campaign was completed by the public in 107 days. A total of 96,499 labels were marked by 639 participants over the course of the campaign. Evidence is provided in **Annex 5.10**. Less people were required to complete the campaign than originally estimated and was completed in a relative short timeframe.
Output 1. A satellite survey protocol for wandering albatrosses across the South Georgia archipelago, which could easily be applied to other locations across the globe	1.1 All images capturing the 34 known wandering albatross colonies across SG collated from the existing archive (from the 31cm resolution WV-3 satellite) by Y1Q4. 1.2 Images of Bird, Albatross and Prion island analysed by experts, and compared to ground survey data, by end of Y1Q4. 1.3 100% of archival images annotated by citizen scientists on GeoHive by end of Y2Q2.	1.1 All WV-3 imagery of SG has been acquired and all imagery has been assessed and counted using the MAXAR GeoHIVE app using 7 unique observers per image chip. We included locations where at least 5 breeding pairs have been previously recorded. Labels were filtered based cluster distance (2 m) and number of observers that agree there is an albatross present (3 or more observers) to achieve the most accurate counts (**Figure S11 and S12**). These protocols can be easily applied to other locations around the globe. 1.2 A private campaign was launched in October 2023, consisting of 543 tiles covering Bird, Albatross and Prion Island (see **Table S9** for list of images and counts). We recruited seven satellite image experts to complete the counts. All counts were completed by 15 January 2024 (evidence in **Annex 5.9**). Crowd and expert counts for Albatross Island and Prion Island were very similar, while satellite counts by the crowd and experts

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
	1.4 Satellite survey protocol and automated detection algorithm developed throughout, and finalised by end of Y2Q3.	overestimated ground truthed counts by 10.48% and 15.56%, respectively (**Table S9**). Specific images of Bird, Albatross and Prion Island were acquired. UAV imagery has been obtained for Prion Island, and will be compared to 5 expert counts and crowd counts from the satellite imagery using zooniverse. 1.3 All archival images have been annotated by citizen scientists and analysed (**Figure S1-S7**). These results are being prepared for publication. 1.4 Satellite survey protocols for wandering albatrosses has been written in the manuscript. The automated detection algorithm will not be needed for this project, as we have determined that crowdsourced information is preferable for future projects as it is less-expensive, accurate and quicker to complete.
Activity 1.1 In consultation with Maxar, collate all archival WV-3 imagery which captures known wandering albatross nesting sites, across the SG archipelago		All suitable archival WV-3 imagery of known wandering albatross nesting sites across SG were collated and included in the Albatrosses from Space GeoHIVE campaign. See **Table S12** for a full list of images.
Activity 1.2 Conduct expert analysis of Bird, Prion and Albatross Island imagery, and compare to ground survey data collected by field researchers.		Expert counts of Prion Island, Albatross Island and Bird Island were completed in a private GeoHIVE campaign by seven people with extensive experience in wildlife counts using satellite imagery. This was compared to crowd counts and ground survey data collected by field researchers (**Table S9**).
Activity 1.3 Make all archive images available on GeoHive for crowd-sourced counts		All archived images of wandering albatross colonies from South Georgia (**Table S12**) were included in the GeoHIVE campaign, which included areas that were cropped and under partial cloud cover. After the campaign, we selected cloud-free images of the entire breeding site for the crowdsourced counts (**Figure S1-S7**).
Activity 1.4 Analyse results of crowd-sourced counts, assess variance, agreement, deviation from expert labels. Conduct analysis into uncertainty of the methods.		The crowd-sourced counts were compared to ground-truthed data and expert satellite counts from the same breeding season (**Table S9**).

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
1.5 Train automated detection algorithms using the crowd annotations. Assess the performance of the automated methods using train and test datasets		Automated methods were not developed, as we determined that counts from crowdsourcing offered an accurate and more cost-effective option.
Output 2. First VHR satellite survey of Tristan albatrosses on Gough Island	2.1 31-cm resolution images of Tristan albatrosses on Gough Island obtained by Y1Q4. 2.2 Images analysed by experts, and counts validated against ground survey data collected at Gonydale site on Gough by Y2Q1.	2.1 The only cloud-free satellite image of Gough Island was acquired, and birds counted. Only a small area of Gough was suitable due to persistent cloud cover. However, this area was large enough to compare with ground data provided by RSPB. 2.2 After orthorectification and pan sharpening, the images were counted by one expert and six additional observers of varying experience and matched to geolocated nest coordinates (see **Section 3.1 Output 2** for result summary). The manuscript has been drafted, with intention to submit to *Ibis* in April.
Activity 2.1 In consultation with Maxar, collate all existing archival WV-3 imagery of Gough Island.		WV-3 imagery of Gough Island was tasked in 2022, however all images had cloud obscuring the survey area. As such, the online Maxar archive was searched for cloud-free imagery. The only cloud-free imagery over the past 8 seasons was purchased for this study.
Activity 2.2 Using expert analysis, conduct counts of Tristan albatrosses on Gough. Compare satellite counts to GPS ground survey data at Gonydale to verify detectability.		Counts of Tristan albatrosses from the expert were compared to counts of known nests in the cloud-free area of the image to verify detectability (**Figure 2**). Annotations from nine other observers, taken from a subset of images, were combined and compared to counts from GPS ground survey data at Gonydale and the Hummocks (**Figure S10**).
Activity 2.3 Make Gough images available on GeoHive for crowd counting.		There was insufficient imagery of Gough Island available for crowd counting, therefore, the only partially cloud-free image available was annotated by an image analyst expert (reference observer) in addition to nine observers of varying experience. The counts from the nine observers and reference were compared to each other and the nest GPS co-ordinates from the ground survey (**Table S1-S7**) to assess the feasibility us using satellite imagery to obtain accurate population estimates.
Activity 2.4 Assess results of crowd counts, compare variance, agreement and consistency.		We compared crowd counts filtered based on different threshold agreement scores (**Table S11-S12**) and plotted variance in counts based on different agreement values (**Figure S1-S7**). Reliability of labels were reported by Maxar using CrowdRank scores (**Annex 5.10**), which partially depends on

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
		the observer accuracy. We determined that filtering labels based on label agreement scores provided more accurate population estimates across the breeding sites than filtering labels by CrowdRank.
Activity 2.5 Prepare report assessing viability of using satellite imagery to monitor Tristan albatrosses, to be submitted to stakeholder meetings (for example Tristan Da Cunha government, RSPB for monitoring of mice eradication scheme).		Final results from the Tristan albatross study were disseminated at the stakeholder meeting held on 8th December (**Annex 5.7-5.8**).
Output 3. Raised public awareness of albatross conservation and biodiversity on the UKOTs through engagement with the crowdsourcing campaign	3.1 Communications and media campaign plan developed by the end of Y1Q4. 3.2 Website links and extra material developed in conjunction with UKOT and partners, ready for campaign launch in Y2Q1 3.3 At least 5000 citizen scientists engage with the image counting campaign by end of Y2Q2 3.4 Follow up material reporting results relayed to all volunteers and on all social media platforms by end of Y2Q3	3.1 The media campaign was developed months prior to the campaign release (see section 2 for details) to attract participants and increase public awareness of albatross conservation issues. 3.2 The website links (**section 2 and Annex 3 Table 2**) and extra material (e.g., annotation tutorial and FAQs embedded within the campaign platform – see **Annex 5.14**) were developed by BAS and RSBP, ready for campaign launch. 3.3 Only 639 participants were required to complete the campaign. This has helped us quantify how many participants would be required for future campaigns of SG and other breeding areas in the Southern Hemisphere. 3.4 Completion of the campaign was relayed on social media posts (e.g., **Annex 5.11**). Richard Phillips discussed results of the wandering albatross campaign and Tristan albatross project in the podcast Polar Diaries (**Annex 3 Table 2**). Results from this project are being prepared for submission to peer-reviewed journals (see **Annex 3 Table 2** for link to manuscript drafts) and will be included in a BAS media release upon publication.
Activity 3.1 Develop relevant materials to be linked on GeoHive campaign site with UKOT's and RSPB		Relevant materials were developed and integrated within GeoHIVE campaign site (**Annex 5.14**). The funding body, stakeholders and partners were acknowledged in the materials.
Activity 3.2 Develop front end of the GeoHive campaign site, in consultation with GeoHive.		Completed front end development of GeoHIVE campaign site in consultation with GeoHIVE.

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
Activity 3.3 Plan publicity campaign to launch crowd-counting website (for example name for campaign, twitter hashtag). Contact key stakeholders and groups who could advertise.		Planned publicity campaign coinciding with release of GeoHIVE campaign release and contacted RSPB and BAS media teams to help promote and advertise (**section 2**).
Activity 3.4 Launch campaign, in collaboration with the BAS and RSPB media offices. Press release.		The campaign was launched on 4th September (National Wildlife Day). Online news stories, feature articles and media posts were released by BAS and RSPB to coincide with the campaign launch date (**Annex 3 Table 2**).
Activity 3.5 Assess the success of the campaign in terms of engagement. Follow up materials with key results and update emails for volunteers if opted in		The campaign was completed within a relatively short period of time by the public, reflecting the success of online materials developed by BAS and RSPB media offices to increase engagement. The volunteers that opted in were not informed of the results, as data analysis was postponed until Marie Attard returned from maternity leave. The overall success of the campaign has been communicated via podcast interviews, stakeholder meetings and conference presentations.
Output 4. Research outputs developed and shared with target audiences, local government and stakeholders	4.1 Report summarising results of crowd counts disseminated among stakeholders by end of Y2Q3 4.2 Clear protocol for repeating satellite & crowdsourcing methods for future surveys presented at workshop Y2Q3. 4.3 Journal article on the satellite survey and automated methods submitted to open access journal by Y2Q3	4.1 The minutes summarising results of the crowd counts were disseminated in a stakeholder meeting on 8 December 2023 (**Annex 5.7-5.8**). 4.2 The protocol for repeating satellite and crowd survey methods have been written within the methods section of the prepared manuscripts. These can be adapted for future satellite remote sensing surveys. 4.3 Two journal articles on Tristan albatross and wandering Albatross satellite survey to be submitted to open access journals between April-June 2024 (see **Annex 3 Table 2** for link to manuscript drafts). An additional project comparing UAV, satellite and ground count data of wandering albatrosses at Prion Island is also planned, with the intention to submit findings as a separate peer-reviewed publication. Automated methods were not developed, as we determined that counts from crowdsourcing offered an accurate and more cost-effective option.
4.1 Prepare reports for meetings with stakeholders.		Meetings minutes were completed for all stakeholder meetings (**Annex 5.1, 5.3 and 5.7**).

Project summary	Measurable Indicators	Progress and Achievements for the life of the project
4.2 Share results with all stakeholders via email, conferences, and at meetings (e.g ACAP, GSGSSI annual stakeholder/ working group meeting)		Results were shared with all stakeholders via email and stakeholder meetings at each stage of the project (**Annex 5.1-5.8**).
4.3 Prepare and submit manuscript for peer reviewed, open source, journal		Review paper has been published (Attard *et al*. 2024), and two manuscripts have been prepared for submission to peer-reviewed journals.
4.4 Make code and protocol for satellite monitoring publicly available.		All R scripts for processing crowd and expert annotations and counts have been uploaded to an online repository (figshare) and will be made publicly available upon manuscript publication. All protocols for the wandering albatross and Tristan albatross studies will be in the methods section.
4.5 Attend national/international conference to present results.		Marie Attard presented this study at the BOU Citizen science and birds (#BOUasm22) online conference in October 2022, and has submitted an abstract for a presentation at the Ecological Society of America conference in California, August 2024 (**Annex 5.13**).

Annex 3 Standard Indicators

Table 1 Project Standard Indicators

DPLUS Indicator number	Name of indicator using original wording	Name of Indicator after adjusting wording to align with DPLUS Standard Indicators	Units	Disaggregation	Year 1 Total	Year 2 Total	Year 3 Total	Total to date	Total planned during the project
DPLUS-A01	Number of people from key national and local stakeholders completing structured and relevant training.	Number of people from BAS, RSPB and GSGSSI who attended stakeholder meetings	People	Men and women; public sector	Between 6-16 per meeting			16	16
DPLUS-A03	Number of local/national organisations with improved capability and capacity as a result of the project.	Number of local/national organisations with improved capacity and capability to perform remote sensing counts of albatrosses as a result of the project.	Number	South Georgia Surveys	1			1	1
DPLUS-B05	Number of people with increased participation in local communities / local management organisations (i.e., participation in Governance/citizen engagement).	Number of people with increased participation in citizen engagement	Number	Public (Men and Women); age 10 years +	639 +			639 +	639 +
DPLUS-C01	Number of best practice guides and knowledge products published and endorsed	Number of best practice wildlife census guides published and endorsed.	Number	Wildlife remote census guides published in *Remote Sensing*	1			1	1
DPLUS-C06	Number of downloads of new peer reviewed publications	Number of views of new peer reviewed publication	Number	1114 views of Attard *et al.* 2024 since 8 February 2024.	1114				1114
DPLUS-C11	Average monthly number of Website Visitors.	Average monthly number of Website Visitors on BAS Albatrosses from Space webpage	Number	Viewed by 15 people per month on average. Total 165 views by 113 users between 11 May 2023 to 7 April 2024. Average engagement	15/month				15/month

DPLUS Indicator number	Name of indicator using original wording	Name of Indicator after adjusting wording to align with DPLUS Standard Indicators	Units	Disaggregation	Year 1 Total	Year 2 Total	Year 3 Total	Total to date	Total planned during the project
				time: 49.61 seconds					
DPLUS-C15	Number of Media related activities	Number of specific online media stories	Number	https://community.rspb.org.uk/wildlife/f/latest-research-and-conservation-news/281474/surveying-albatrosses-from-space https://fitv.co.fk/news-and-events/counting-albatross-from-space/ https://polarjournal.ch/en/2022/09/12/albatross-detectives-wanted/	3				
DPLUS-C17	Number of unique papers submitted to peer reviewed journals	Number of unique papers submitted to peer reviewed journals	Number	Journals: *Remote Sensing* (published) and *Ibis* (in review)	2				
DPLUS-C18	Number of papers published in peer reviewed journals	Number of papers published in peer reviewed journals	Number	Annual downloads: 1111; Journal: Remote Sensing	1				

In addition to reporting any information on publications under relevant standard indicators, in Table 2, provide full details of all publications and material produced over the last year that can be publicly accessed, e.g. title, name of publisher, contact details, cost. Mark with an asterisk (*) all publications and other material that you have included with this report.

Please do not disseminate the private link for the journal article to the public, as this manuscript will be submitted for peer-review shortly.

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)
Review of Satellite Remote Sensing and Unoccupied Aircraft Systems for Counting Wildlife on Land	Journal	Marie R.G. Attard, Richard A. Phillips, Ellen Bowler, Penny J Clarke, Hannah Cubaynes, David W. Johnston, Peter T. Fretwell, 2024	Female	British/Australian/Maltese	Remote Sensing	https://doi.org/10.3390/rs16040627
Feasibility of using very high-resolution satellite imagery to monitor Tristan albatrosses *Diomedea dabbenena* on Gough Island	Journal	Marie R.G. Attard, Richard A. Phillips, Steffen Oppel, Ellen Bowler, Peter T. Fretwell, In preparation	Female	British/Australian/Maltese	In preparation - Planned submission to Ibis, UK	Private link to download the draft manuscript is here: https://figshare.com/s/1a9b1180acfc2db937cd Private link to Tristan albatross R scripts and data to be submitted for peer-review are here: https://figshare.com/s/bcd818eca54e662abf81
Crowdsourcing satellite imagery to count breeding wandering albatrosses	Journal	Marie R.G. Attard, Richard A. Phillips, Sally Poncet, Ellen Bowler, Peter T. Fretwell	Female	British/Australian/Maltese	Manuscript in preparation	Private link to download the draft manuscript is here: https://figshare.com/s/53ad706c67a7a32092e6

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)
Albatrosses from space: monitoring albatrosses using very high-resolution satellites and citizen science	Webpage	Marie R.G. Attard, 2022	Female	British/Australian/Maltese	BAS, Cambridge	https://www.bas.ac.uk/project/wildlife-from-space/albatrosses-from-space/#about
Counting Albatross from Space	TV interview	Darnell Christie, Kathryn Daniels and Ellen Bowler, Broadcast 6 September 2022	Male	Unknown	Falkland Islands TV, Fauklands	https://fitv.co.fk/news-and-events/counting-albatross-from-space/
Albatrosses from space: wildlife detectives needed!	Online news story	Emily Neville, 2022	Female	Unknown	BAS, Cambridge	https://www.bas.ac.uk/media-post/albatrosses-from-space-wildlife-detectives-needed/
Watch birds from space	Feature article	Ness Amaral-Rogers, 2022	Female	Unknown	RSPB, UK	https://www.rspb.org.uk/helping-nature/so-many-ways/explore/watch-birds-from-space
Polar Diaries. Episode 3 Albatrosses from space with Professor Richard Phillips.	Podcast	Octavia Brayley and Richard A. Phillips, Broadcast 13th March 2024	Female	Unknown	BAS, Cambridge	Available from Spotify (https://spotifyanchor-web.app.link/e/Lf3JPWZDVHb), Apple Podcasts (https://podcasts.apple.com/us/podcast/polar-diaries/id1732990061) and Instagram page (https://www.instagram.com/polardiariespodcast/).

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 10)?**	
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.	
If you are submitting photos for publicity purposes, do these meet the outlined requirements (see section 13)?	
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.	