# ALBATROSS POPULATION MONITORING USING SATELLITE IMAGERY, A CASE STUDY: SHORT-TAILED ALBATROSS *PHOEBASTRIA ALBATRUS* AT THE SENKAKU ISLANDS

NIGEL BROTHERS[1*], CATHERINE BONE[1] & ALEXIA WELLBELOVE[2]

[1]*Marine Ecology & Technology, 178 South Arm Drive, Wonga Beach, Queensland 4873, Australia* [*]*(brothersbone1@gmail.com)*
[2]*Humane Society International, P.O Box 439, Avalon, New South Wales 2107, Australia*

*Submitted 21 May 2021, accepted 29 November 2021*

## ABSTRACT

BROTHERS, N., BONE, C. & WELLBELOVE, A. 2022. Albatross population monitoring using satellite imagery, a case study: Short-tailed Albatross *Phoebastria albatrus* at the Senkaku Islands. *Marine Ornithology* 50: 7–12.

Accurate monitoring of vulnerable albatross populations is essential to their conservation. Herein, we explore the prospect of monitoring one particular remote albatross population with a view to promoting accurate worldwide monitoring of vulnerable albatross populations. We used very high-resolution (VHR) satellite images to count nesting Short-tailed Albatrosses *Phoebastria albatrus* on two islands of the Senkaku group, western North Pacific Ocean, where conventional monitoring has not occurred for 19 years due to a geopolitical territory dispute. Despite count uncertainties across rocky terrain, many birds were clearly discernible using the highest resolution image available of Minami-kojima. The result was a count of 132 (109–162) nesting pairs in the 2020/21 breeding season (the timing of the count indicates the presence of nesting birds); this compares to a count of 52 when the population was last surveyed in 2002. On Kita-kojima, no birds were counted in images available for the 2019/20 and 2020/21 breeding seasons; one bird (a chick) was counted in 2002. If accurate, these counts are inconsistent with existing projections of increasing abundance of this species at the Senkakus (190 breeding pairs by 2018/19). Based on our findings, we suggest that reliable satellite image-based counts, independent of ground verification, is an achievable goal for albatrosses. Images must be of the highest possible resolution, with angle and timing optimized appropriately for the breeding site. There is a need for standardization of specific procedures and methodologies, a task that is well-suited to The Working Group of the Agreement on the Conservation of Albatrosses and Petrels.

**Key words:** Short-tailed albatross, Senkaku Islands, satellite image count, census methodology, population monitoring, albatross conservation

## INTRODUCTION

Albatrosses are a globally threatened avian group, more so than all other avian groups of similar numbers of species (Anderson *et al*. 2011, Croxall *et al*. 2012, ACAP 2019). The conservation of albatrosses, owing to their wide-ranging habitats, is dependent on substantial international cooperation, with accurate and current population trends being a cornerstone of such conservation efforts, facilitated by The Agreement on the Conservation of Albatrosses and Petrels (ACAP). To date, albatross population monitoring has been largely reliant on opportunistic or routine conventional ground census, although aerial photography counts have recently contributed to monitoring efforts (Rexer-Huber *et al*. 2020).

The propensity of albatrosses to nest in rugged, often inaccessible terrain on small, remote islands compounds the difficulty and cost of maintaining regular census data using conventional methods. This is further complicated by the fact that certain species or breeding populations can be distributed over vast distances, which causes problems for counting, and also for detection of incidental mortality by fisheries (ACAP 2019b), which varies unevenly across the range of a population. Effective albatross conservation strategy depends on the regular monitoring of most colonies of every albatross species. Small annual population changes, if sustained, can have conservation status implications for albatrosses (Croxall *et al*. 1990, Gales & Robertson 1998), making count accuracy and regular monitoring essential to adjusting conservation status and efforts. Although ACAP population monitoring and species conservation status data are generally comprehensive, data on the Short-tailed Albatross (STA) *Phoebastria albatrus* remains an exception.

Fretwell *et al*. (2017) provided evidence that albatrosses can be counted with reasonable accuracy using very high-resolution (VHR) (30 cm) satellite imagery and considered this to be "a step change in ability without disturbance and potentially lower cost and minimal logistic effort." Since then, Dolliver (2019) and Bowler *et al*. (2020) have aimed to further demonstrate the potential of this method, proposing it for situations where there are obstacles to a conventional census. STA is a case in point in which a territorial dispute is responsible for the inability to conduct censuses more accurately (USFWS 2020, Kyodo News 2020, Manyin 2021).

The STA is currently classified as vulnerable (IUCN, 2021) or endangered (USFWS 2020). During the 2018/19 breeding season, 84% of the population (1011 breeding pairs) occurred in the Torishima Islands, where the species has been undergoing population growth near to its maximum potential (USFWS 2020); 16% (190 breeding pairs) are at Senkaku (western North Pacific, 25.43°N, 123.33°E). However, reliable count data for the latter population has been unattainable since 2002 when a count of 52 pairs was estimated (ACAP 2019). Within the Senkaku group, STA nest on two small islands (approx. 0.4 ha each). In 2002, one chick was recorded at Kita-kojima and 33 chicks were recorded at Minami-kojima.

According to USFWS (2020), "surveys of the Senkaku Islands population are critical to determining the worldwide population of the STA and remains one of the highest priority recovery actions for this species" (noting that the US Endangered Species Act requires knowledge of the population size and growth rate on the Senkaku Islands [USFWS 2008]). Because of the ongoing nature of obstacles to a conventional count in the Senkaku Islands, alternatives are required, with counts of VHR satellite imagery being the only potential option. The only previous satellite count attempt in 2015 (Dolliver 2019) was constrained by low-quality imagery.

Down-listing the STA from "Endangered" to "Threatened", according to USFWS (2020), may occur by 2028 (the next STA Recovery review is due in 2025), but this is contingent on verification of the Senkaku population, for which ground counts have been deemed essential. Satellite imagery, however, appears to be the only option to satisfy this requirement. Herein, we report counts derived from review of images from February and November 2020. It should be noted that, during the course of our study, Japan's Ministry of Environment (MoE 2021) was using the 27 November 2020 satellite image of the Senkaku Islands to independently attempt an updated STA population estimate.

## MATERIAL AND METHODS

Geoimage initially offered an archived image taken on 02 February 2020 (the 2019/2020 nesting season), late in the most suitable stage of nesting and with partial cloud cover. This image was taken by the GeoEye-1 satellite, which has a maximum resolution of 40 cm; it was taken 21° off nadir, which is below the maximum recommended capture angle limit of 25° (for minimising pixel distortion), after which smearing can occur in the image in the orthorectification process (Wahballah *et al*. 2016). Due to this combination of factors, this archived image was deemed sub-optimal for counting, so it was not purchased at this time.

In June 2020, a satellite tasking request was made to Geoimage for a WorldView-3 30-cm resolution image to be captured between mid-November 2020 and late January 2021. This period covers most of the recommended survey period, including incubation and chick brooding for this population (USFWS 2008, 2020; ACAP 2019a). The intention was to apply census methodology similar to the successful first demonstration of satellite image count viability by Fretwell *et al*. 2017.

On 16 December 2020, Geoimage advised of a partial image capture success. Capture angle was below the 25° maximum recommended capture angle, but the timing coincided well with the presumed egg-laying interval at this breeding site (USFWS 2008, 2020); a low-resolution sample of the image indicated that previously documented albatross occupation areas (Dolliver 2019) were cloud-free. Because the minimum image quality specification had not been met (the image was rated below the specified 15% maximum allowable cloud obscurity within the entire 25 $km^2$ designated area), purchase of this image was delayed for the chance of a better image. However, there was no other image captured during the designated time window ending on 20 January 2021.

After purchase of the November 2020 image, close examination revealed thin cloud cover obscuring a critical count area at the southwest edge of Kita-kojima, where a chick had been seen in 2001 (USFWS 2008). A decision was made to purchase the less desirable but archived February 2020 image to count any birds in this particular area. The orthorectified, pansharpened, and colour balanced images in natural colour (NC), false colour (FC), and enhanced natural colour (ENC) were made available for download by Geoimage from Maxar Technologies (see Table 1 for details). Geoimage provided the images as jpegs which were viewed without any satellite imagery analysis software.

Using the November 2020 image, and the three colour presentations (NC, FC, ENC), all objects believed to be albatrosses were counted by whiteboard pen, marking each on a 140-cm monitor with the magnified image mirrored from a desktop computer. Each image was counted three times across the three image contrast presentations in random order, by two individuals (Table 2). The nesting slope on Minami-kojima was divided into two areas (Fig. 1) in an attempt to differentiate the primary colony of highest bird density and regular spacing (area P) from a secondary area (area S) of confusing habitat (more rock, and in shadow) of scattered nests where counts seemed less reliable. Both counters had extensive experience and familiarity with albatross nesting behaviour, including aerial counting, although not with STA specifically (STA possess nesting and behavioural traits typical of many albatross species familiar

**TABLE 1**

**Details of the two satellite images of Minami-kojima and Kita-kojima islands, Senkaku group, western North Pacific Ocean, from which counts of nesting Short-tailed Albatross *Phoebastria albatrus* were attempted during the 2019–2020 and 2020–2021 breeding seasons**

| Image Details | February 2020 image | November 2020 image |
|---|---|---|
| Date | 02 February 2020 | 27 November 2020 |
| Time (local) | 11:31 am | 11:52 am |
| Satellite type | GeoEye-1 | WorldView-3 |
| Off-nadir angle | 22.5° | 19.4° |
| Effective ground resolution | 0.47 m | 0.34 m |
| Panchromatic resolution | 0.40 m | 0.30 m |
| Multi-spectral resolution | 1.6 m | 1.2 m |
| Image ID | 105001001B24F000 | 1040010063074B00 |

**TABLE 2**
**Numbers of nesting Short-tailed Albatross *Phoebastria albatrus* in two areas, primary (P) and secondary (S), of Minami-kojima Island on 27 November 2020[a]**

| Count repeat | Counter ID | Image Presentation | | | | | |
|---|---|---|---|---|---|---|---|
| | | ENC | | NC | | FC | |
| | | Area P | Area S | Area P | Area S | Area P | Area S |
| 1 | A | 77 | 48 | 86 | 30 | 84 | 39 |
| | B | 107 | 38 | 132 | 30 | 111 | 42 |
| 2 | A | 84 | 35 | 89 | 25 | 84 | 34 |
| | B | 116 | 21 | 123 | 16 | 115 | 36 |
| 3 | A | 79 | 30 | 83 | 27 | 89 | 42 |
| | B | 122 | 24 | 121 | 24 | 104 | 36 |
| Area mean | | 98 | 33 | 106 | 25 | 98 | 38 |
| Mean island total (P + S) | | 130 | | 131 | | 136 | |

[a] Results were obtained using two counters (A & B) conducting repeated counts of a single satellite image formatted to three image presentations differing in contrast: enhanced natural colour (ENC), natural colour (NC), and false colour (FC).

to the counters), nor with satellite image-based counting, nor any familiarity with this site.

## RESULTS

### Minami-Kojima population counts

The number of nesting birds counted on Minami-kojima ranged from 109 to 162 (Table 2) with the majority (77–132) concentrated in one primary nesting area (Fig. 1) and with additional but fewer birds (16–48) in the secondary area. Count numbers could not be compared between satellite images because the February 2020 image lacked definition and had a semi-transparent veil of cloud cover over the area of highest bird density. Most of the information learned about the Senkaku Islands population in this study, therefore, comes from the November 2020 image (2020–2021 breeding season).

Repeats of the count resulted in reasonably consistent numbers from both counters (109–131, compared to 137–162), but the difference between the individuals counting remained consistent (counter B always had the higher count; Table 2). The average count range was 98–106 in the primary nesting area P and 25–38 in area S. There was a similar count range in image FC (35) and ENC (37), whereas image NC had a greater range (52; Table 2). Counts for each image presentation did vary between counters—the overall average was 118 for counter A and 146 for counter B.

### Kita-Kojima population counts

Both observers determined STA to be clearly evident on Minami-kojima but absent from Kita-kojima. Zero nesting albatrosses were detected across 90% or more of cloud-free Kita-kojima in the November 2020 image, and zero birds were detected in the February 2020 image (which had inadequate clarity for a reliable count). The 5% of Kita-kojima that was cloud-covered in the November 2020 image was not clear enough to conclusively state that no birds inhabited this area. However, despite the February 2020 image being less sharp and having light cloud over the primary nesting area of Minami-kojima (Fig. 1), birds were still discernible. We suggest that, had birds been present on Kita-kojima at the particular cloud-impacted area of interest (AOI), they would have been visible.

## DISCUSSION

The STA Recovery Plan (USFWS 2020) currently requires a ground count to verify the Senkaku population size before considering any change to species conservation status. This requirement may require review in light of the ongoing unavailability of ground counts, the lower-than-forecast population size indicated by the 2020 satellite imagery, and the fact that satellite imagery is rapidly improving. Until adequate ground count and satellite image-derived count comparisons have been made for various colony locations, satellite-derived count reliability will likely remain in doubt.

The presence of STA was clearly evident to both observers when viewing satellite images of Minami-kojima, but on Kita-kojima, STA were deemed absent or of uncertain status. Two observers counted 109 and 162 nests of presumed STA from the November 2020 image, indicating that with advanced techniques, ground validation, and spatial analysis, future population trends and population estimates may be possible. From this study, we can only provide a limited perspective on STA nesting presence and perhaps an index of abundance that can inform future endeavours.

In this study, one challenge was in differentiating birds from inanimate objects across vegetated terrain with abundant scattered boulders, stones, and bare rock outcrops on Minami-kojima (area S). Thus, an accurate count is likely only achievable in the primary colony area (area P, Fig. 1), and this may provide the best sub-sample for population trend monitoring in the future.

If the population trend measured elsewhere for this species is applied to the last reliable Senkaku Islands count, which was 32 nests on Minami-kojima (and one on Kita-kojima) 19 years ago (USFWS 2020, T. Mizuta pers. comm.), the population could have reached 217 pairs by the 2020/21 season. However, if the 2020/21 nesting season satellite count by this study and by Japan's Ministry of the Environment (MoE 2021) is properly indicative of breeding pairs, the presumed magnitude of population increase (USFWS 2020), also supported by Dolliver (2019), has not occurred. No adjustment has been made to the 2020 count for non-breeding birds present (Dolliver 2019) or annual breeding birds known to be absent (USFWS 2014) because these adjustments negate one another.

At 30-cm resolution, one STA is only around two pixels in size. Due to the resulting lack of definition and shape, albatrosses are best identified by habitat type combined with spacing that is indicative of nesting behaviour, which helps the counter to distinguish between albatrosses and other albatross-sized objects of similar colour. However, without ground truthing or site familiarity, some incorrect assignation to albatross-sized objects or non-breeding individuals is likely to occur. Indeed, this is believed to be responsible for the considerable difference between the November 2015 image count by Dolliver 2019 and the recent counts from both 2020 images. In 2015, there were about 42 birds counted, not only near the single verified nest site of 2002, but—uncharacteristically for the species—sparsely and widely scattered over much of Kita-kojima. No birds were seen anywhere on this island in the 2020 images, but thin cloud in the immediate vicinity of the 2002 nest makes it impossible to rule out birds in that specific area. On Minami-kojima in 2015, there were nine birds counted in the small part of the island captured by this image, whereas in the November 2020 image, no birds were detected at that location and the habitat was considered unsuited to occupancy.

The albatross counts of 2015 and 2020 cannot be compared, as none of the nests counted in this study were counted in Dolliver's study. This major discrepancy is unlikely to have arisen from differences in image clarity. Although both the 2015 and February 2020 images are 40-cm resolution, the capture angle of 25.6° in the 2015 image is known to reduce clarity (data supplied by Geoimage). While it is true that the WorldView-3 (2015 image) is apparently capable

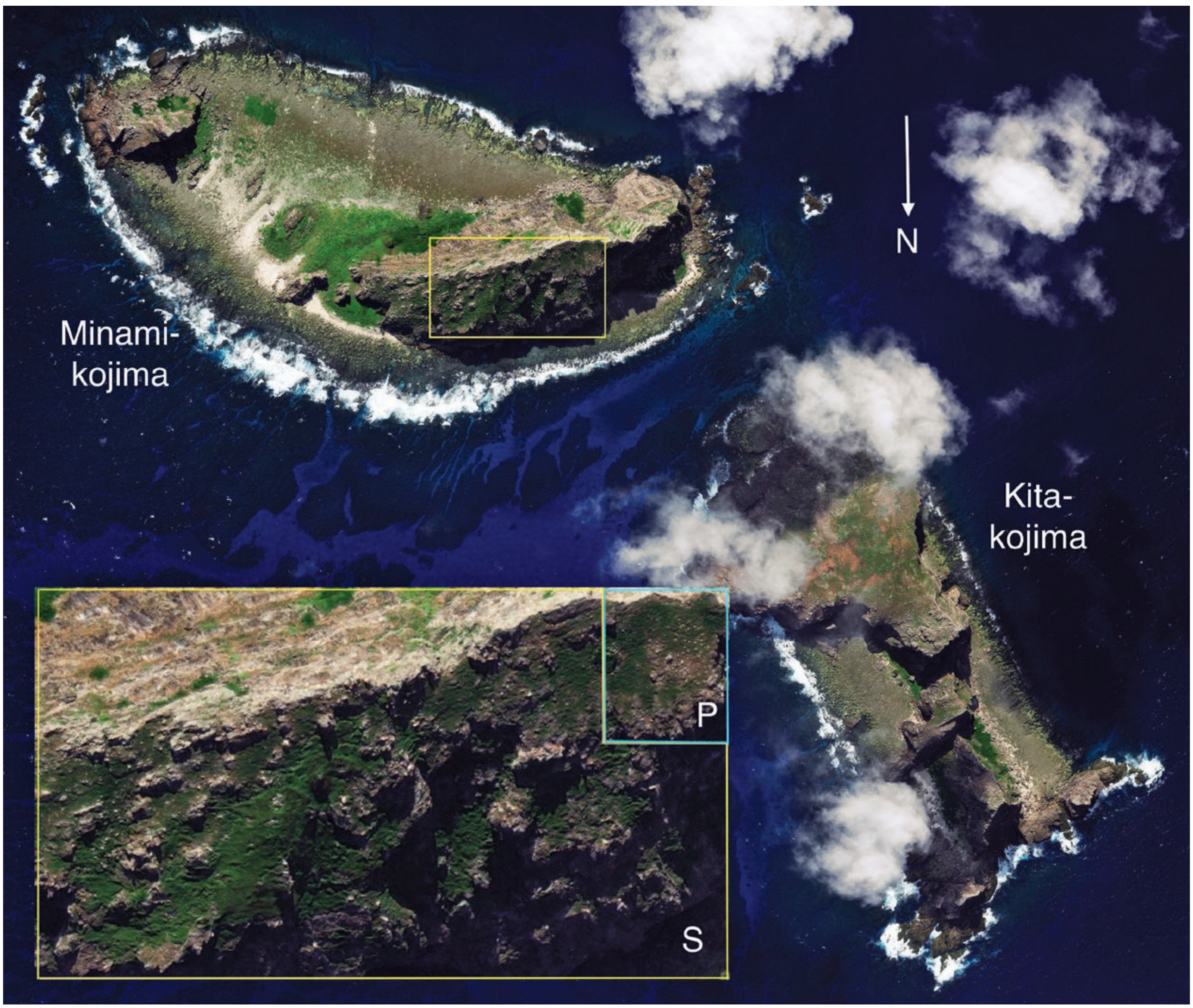


**Fig. 1.** WorldView-3 30-cm resolution satellite image of Minami-kojima and Kita-kojima, Senkaku Islands, western North Pacific Ocean on 27 November 2020, with inset showing primary (P) and secondary (S) nest count areas of Short-tailed Albatrosses *Phoebastria albatrus* (©2020 Maxar Technologies).

of providing a less ‘fuzzy’ image than GeoEye-1 (February 2020 image), perhaps this did not compensate for the larger capture angle and lower resolution. The birds counted in the November 2020 image (greatest resolution, best capture angle, WorldView-3, not GeoEye-1) were also discernible in the February 2020 image, yet this image did not show any birds on Kita-kojima. Successive image-based counts should be comparable, and the fact that, in this case, they are not highlights the importance of maintaining best image-capture specifications.

Although there was minimal difference in counts across the three colour presentations of the same image, the most between-counter consistency was derived from the FC image. Surprisingly, the visually preferred ENC images did not reduce the count variation by, or between, observers. Reasonable count consistency by observers across image colour presentations was considered a promising outcome, suggesting that just one image colour presentation may be adequate, although the best image presentation may be site-specific.

Using satellite imagery to count nesting albatrosses at this locality, particularly on Minami-kojima, may be not as straightforward as reported for other albatross species elsewhere (Fretwell *et al*. 2017, Dolliver 2019), but the November 2020 image count suggests that this approach is feasible. With improved understanding of site-specific requirements, satellite tasking could be refined to acquire images that enable monitoring of the population trend—even across terrain that is difficult to interpret—provided that better count methodology is applied, including georeferenced nest locations and comparisons of breeding and non-breeding season images.

In order to optimize the prospects of accurately counting albatrosses from satellite images, at the Senkaku Islands in particular, we recommend the following image capture parameters:

*Type of satellite:* A satellite with 30-cm resolution or higher and equivalent or better than WorldView-3 (not Geo-Eye-1) currently provides the best albatross counting image. In this study, the effective ground resolution of even the highest resolution image used for counting was a little less than the optimal 30 cm possible resolution, which was further impacted (to an unknown degree) by a sub-optimal image capture angle.

*Position of satellite:* The position of the satellite relative to the specific AOI needs to be carefully considered. A site-specific capture angle may prove critical with respect to ground slope. At the Senkaku Islands, the best satellite position is likely to be NW, with the image taken toward the SE (the February 2020 image was taken with the satellite NW of the island facing SW at a bearing of 232° to true North, whereas the November 2020 image was taken with the satellite in the SW facing NW, with a bearing of 304° to true North; Geoimage pers. comm.). This recommended positioning would only apply as long as birds do not occupy south facing slopes.

*Off-nadir angle:* The off-nadir angle should be no greater than 19° for the Senkaku Islands, although less angle is desirable. The angle of the camera affects the spatial resolution and physical distortion of the image. Image capture angle must take into account the ground-slope of the target area; otherwise, some steep terrain may be excluded from view. This occurs on Minami-kojima, where the ideal image capture direction need not include the south-facing aspect (extensively sheer, bare, and providing the least nesting habitat).

*Timing:* With a reasonable image existing within the optimal timeframe, a similar image capture date (27 November) should be the aim. The obstacles to obtaining time-specific images of specific localities like the Senkaku Islands include regional and seasonal weather-related constraints, but also heavy tasking demand by others with higher priority missions of national and international interest (Dolliver 2019). Competition for satellites will likely become less of an issue as greater numbers of suitably capable satellites become available (Geoimage pers. comm.). This should help to increase image capture success and will potentially reduce image acquisition costs. Dolliver 2019, for example, described two unsuccessful tasked image capture attempts, one of around 60 d (2017) and another of 180 d (2018). Although it took only 12 d for the November 2020 tasking to succeed, it was the only image to be captured from the entire tasking interval of 66 d. This is a consequence of the typical cloudy weather during the nesting season.

The importance of cooperative satellite image tasking and acquisition became apparent during this study. During this study’s tasking period, another image capture request was received by the provider for the same AOI in the same time period for an undisclosed purpose (50 cm, not 30 cm image resolution). Then, in Japan on 05 November 2020, submissions were invited for a satellite survey of the Senkaku Islands, and the outcome of this request became apparent only after this manuscript went to review. It was then that MoE 2021 became available online (a translated version was obtained separately), highlighting the need for coordination of conservation efforts and resources. It is important to note that images from successful tasking are all later available as archived images at a lower cost.

In conclusion, the conservation status of STA has yet to be resolved, and currently the Species Recovery Plan (USFWS 2020) states that an island visit is necessary. Ideally, greater confidence in satellite census of albatrosses can be established so that this significant population monitoring gap can be addressed in accordance with MoE 2021 intentions.

## ACKNOWLEDGMENTS

This study was carried out with the support of Humane Society International (Australia) in the interests of addressing a deficiency in monitoring of one particular albatross species population and to help expand the accurate worldwide monitoring of vulnerable albatross populations, in order to illuminate threats to albatrosses and petrels globally. For contributions to the various stages of this study, we sincerely thank Takashi Hiraoka, Callum Bryant, Taku Mizuta, Aya Inoue, and in particular Haruko Hatta. Many thanks to Michelle LaRue for her review suggestions that greatly improved the manuscript, and to our anonymous reviewer for fine tuning. Lee Anderson and Diana Herrmann (Geoimage) provided invaluable and generous advice on satellite imagery and guidance with tasking procedures.

## REFERENCES

ACAP (Agreement on the Conservation of Albatrosses and Petrels). 2019. *Population and Conservation Status Working Group*. AC11 Doc 09. ACAP: Florianópolis, Brazil.

ACAP (Agreement on the Conservation of Albatrosses and Petrels). 2019a. *Species assessments. Agreement on the Conservation of Albatrosses and Petrels*. Florianópolis, Brazil: ACAP. [Accessed at https://www.acap.aq/acap-species on 12 March 2020.]

ACAP (Agreement on the Conservation of Albatrosses and Petrels). 2019b. *Drivers and barriers in the uptake of seabird bycatch mitigation measures and related conservation actions.* SBWG9 Doc 10. Florianópolis, Brazil: ACAP.

ANDERSON, O.R.J., SMALL, C.J., CROXALL, J.P. ET AL. 2011. Global seabird bycatch in longline fisheries. *Endangered Species Research* 14: 91–106. doi:10.3354/esr00347

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: 2026. doi:10.3390/rs12122026

GALES, R. & ROBERTSON, G. 1998. *Albatross: biology and conservation*. New South Wales, Australia: Surrey Beatty & Sons Chipping Norton.

CROXALL, J., BUTCHART, S. LASCELLES, B. ET AL. 2012. Seabird conservation status, threats and priority actions: A global assessment. *Bird Conservation International* 22: 1–34. doi:10.1017/S095270912000020

CROXALL, J.P., ROTHERY, P., PICKERING, S.P.C. & PRINCE, P.A. 1990. Reproductive performance, recruitment and survival of wandering albatrosses *Diomedea exulans* at Bird Island, South Georgia. *The Journal of Animal Ecology* 59: 775–796. doi:10.2307/4895

DOLLIVER, J.E. 2019. *Using Satellite Imagery to Count Nesting Albatross from Space*. MSc thesis. Corvallis, USA: Oregon State University.

FRETWELL, P., SCOFIELD, R. & PHILLIPS, R. 2017. Using super-high resolution satellite imagery to census threatened albatrosses. *Ibis* 159: 481–490. doi:10.1111/ibi.12482

IUCN (International Union for the Conservation of Nature). 2021. *The IUCN Red List of Threatened Species. Version 2021-1.* [Accessed at https://www.iucn.org/resources/conservation-tools/iucn-red-list-threatened-species on 15 March 2021.]

KYODO NEWS. 2020, Oct 15. Japan eyes survey of disputed Senkaku Islands using satellite images. *Kyodo News. [Accessed online at https://english.kyodonews.net/news/2020/10/f55993c01af6-japan-eyes-survey-of-disputed-senkaku-islands-using-satellite-images.html* on 06 December 2021.]

MANYIN, M.E. 2021. *The Senkakus (Diaoyu/Diauyutai) dispute: U.S. Treaty obligations*. CRS Report R42761, Version 22. Washington, USA: Congressional Research Service. [Accessed online at https://sgp.fas.org/crs/row/R42761.pdf on 09 August 2021.]

MoA (MINISTRY OF ENVIRONMENT, JAPAN). 2021. *Review on survey method for albatross counting using satellite images*. Tokyo, Japan: Ministry of Environment, Japan. [Accessed online at https://www.env.go.jp/nature/kisho/hogozoushoku/ahoudori_chuukannhoukoku.pdf on 20 May 2021.]

REXER-HUBER, K., WALKER, K., ELLIOT, G. ET AL. 2020. Population trends of light-mantled sooty albatross (*Phoebetria palpebrata*) at Adams Island and trials of ground, boat, and aerial methods for population estimates. *Notornis* 6: 341–355

US FISH AND WILDLIFE SERVICE. 2008. *Short-tailed Albatross Recovery Plan*. Anchorage, USA: US Fish and Wildlife Service.

US FISH AND WILDLIFE SERVICE. 2014. *Five-Year review-summary and evaluation Short-tailed albatross*. Anchorage, USA: US Fish and Wildlife Service Field Office.

US FISH AND WILDLIFE SERVICE. 2020. *Short-tailed Albatross (Phoebastria albatrus) 5-Year Review: Summary and Evaluation*. Anchorage, USA: US Fish and Wildlife Service Field Office.

WAHBALLAH, W.A., BAZAN, T.M., El-TOHAMY, F. & FATHY, M. 2016. Analysis of smear in high-resolution remote sensing satellites. *Sensors, Systems, and Next-Generation Satellites XX* 10000: 100001J. doi:10.1117/12.2241634