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SHORT NOTE

The use of an Unmanned Aerial Vehicle to census large breeding colonies of black-billed gull (*Larus bulleri*) and white-fronted tern (*Sterna striata*) at the Ashburton River/Hakatere River mouth

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Aerial photography has been used to count a range of colonial nesting seabirds in New Zealand; including gulls (Frost & Taylor 2018; Mischler 2018), shags (Schuckard *et al.* 2015, 2018), gannets (Stephenson 2005), and albatross species (Frost *et al.* 2018). Recent innovations in Unmanned Aerial Vehicle (UAV) platforms with improvements and miniaturisation of navigation tools and cameras has revolutionised ecological studies (Anderson & Gaston 2013). However, the use of UAV's to census colonial breeding seabirds has not been reported from New Zealand. Here we test the use of a UAV to census two large colonies of a gull and tern species.

In mid-October 2017 a large colony of black-billed gull (*Larus bulleri*) established on the true left bank of the Ashburton River/Hakatere River mouth, directly below the bluffs adjacent to the Hakatere Huts, Canterbury, New Zealand (44.051986°S, 171.805860°E). Concurrently, a similarly large colony of white-fronted tern (*Sterna striata*) was established on the true right bank, at the base of the gravel spit that encloses the lagoon. To measure the size of these colonies two independent methods were employed: extrapolation from nest plots, and counts from aerial photos recorded from an Unmanned Aerial Vehicle.

The perimeter of each colony was measured using a handheld Garmin Map64St GPS by walking around the edge of the colony holding the GPS over the outermost nests on 12 November 2017. These data were uploaded to ArcView to create a polygon used to calculate colony size. To determine nest density, a series of non-overlapping 0.375 m radius circular plots (each 0.45 m²) were carried out along a transect running through the centre of the colony, and the number of nests counted in each. Mean nest density was calculated, and the number of breeding pairs in the two colonies estimated by extrapolating this density across the area of each colony.

For comparison, an aerial survey of each colony was carried out by a UAV (DJI Phantom 3), also on 12 November, and 2 hours after the completion of nest plot counts. The UAV flew 5–7 transects over each colony at a height of approximately 100m. Neither the black-billed gulls nor the white-fronted terns reacted to the UAV. The resulting images were digitally stitched together using Adobe Photoshop to provide a photomosaic of the entire colony. These aerial photographs were counted using ImageJ, an open source image processing program designed for scientific images. Each image was worked through systematically, during which all Apparently Occupied Nests (AON), and additional birds within and outside the nesting area, were counted.

The area of the black-billed gull colony was calculated to be 1,555 m². From 50 nest plots laid out through the colony, we calculated a mean nest density of 5.02 nests/m² (SD 1.668). Extrapolating from this the black-billed gull colony is estimated to be 7,807 nests (95% confidence interval 7,088–8,526).

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In comparison, a total of 7,485 Apparently Occupied Nests were counted on the aerial photograph of the black-billed gull colony. An additional 1,305 birds were counted within the nesting area, and a further 646 birds were recorded outside the nesting area. Assuming this count, like aerial counts of other species (Baker *et al.* 2014), is consistent with a Poisson model, a property of which is that the variance and mean are the same, the standard deviation of the count can be estimated as its square root. In the case of a single count, the standard deviation and standard error are the same, so the 95% confidence interval can therefore be estimated as 1.96*√[count]. For the black-billed gull colony, the 95% confidence interval is 7,315–7,655. Mischler (2018) estimated the National population of black-billed gull to be 60,000 breeding pairs, and highlighted that since the mid 1990's the Ashburton River has supported a significant breeding population. This colony appears to be the single largest black-billed gull colony recorded in New Zealand since the mid 1990's.

The size of the white-fronted tern colony was calculated to be 1,651 m². From 40 nest plots taken through the colony mean nest density of 3.72 nests/m² (SD 1.457) was recorded. Again, extrapolating from this the white-fronted tern colony was estimated to be 6,145 nests (95% confidence interval 5,400–6,891). By comparison, a total of 5,746 Apparently Occupied Nests were counted from the aerial photograph of the white-fronted tern colony. Another 334 birds were recorded within the nesting area, and none outside. The 95% confidence interval of this count is 5,597–5,895 using the methods described for black-billed gulls above. White-fronted tern is the commonest tern in New Zealand; colonies of several thousand birds have been recorded, but most colonies are 50–200 pairs (Heather & Robertson 2005). This colony of 6,000 breeding pairs is likely to be the largest colony of this species recorded.

The results of aerial photography and nest plots gave similar results and show that both methods are suitable for determining the colony size of these species (Table 1). Counts from aerial photos were 94–96% of colony size estimates from ground counts. Chabot *et al.* (2015) found that aerial photo counts from UAV yielded population estimates within 93–96% ground counts of common tern (*Sterna hirundo*) in New Burnswick. Similarly, our results highlight the potential value of UAV for surveying and counting large groups of colonial nesting seabirds.

The flight of a UAV over the breeding colony caused no disturbance to the breeding birds, whereas counting the nest-density plots created short-term disturbance because of the need to enter the colonies to measure nest densities. Borrelle & Fletcher (2017) highlight that UAV's can reduce disturbance impacts on surface nesting seabirds, and our study confirms the UAV's value for producing accurate counts while having little impact on densely nesting colonial seabirds.

Chabot & Francis (2016) point out that with the continued advances in camera and drone technology, in combination with increasingly sophisticated image analysis software, it is now possible for investigators involved in monitoring bird populations to save time and resources by increasing their use of computer-automated bird detection and counts from digital aerial images. These methods have not been tested in braided river systems, and would be a useful area of further research.

Table 1. Comparison of colony size estimates from ground counts (nest density plots) and counts from aerial photos of black-billed gull (*Larus bulleri*) and white-fronted tern (*Sterna striata*) breeding at the Ashburton River/Hakatere River mouth, November 2017.

Species	Ground count	Aerial count	Aerial/Ground ratio
Black-billed gull	7,807	7,485	95.9%
White-fronted tern	6,145	5,746	93.5%

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