

Breeding population assessment of kawau pāteketeke/New Zealand King Shag in the Marlborough Sounds: 2021 breeding season.



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Executive Summary

During the 2021 kawau pāteketeke/New Zealand King Shag breeding season breeding at two colonies was asynchronous. In order to estimate the breeding population, we combined data from aerial surveys, boat-based observations and a drone survey, assessed by three independent assessors, to estimate the total breeding population for kawau pāteketeke/ New Zealand King Shag in 2021 as 253 pairs. Aerial surveys continue to be a cost-effective tool for monitoring the numbers of kawau pāteketeke/ New Zealand King Shag. Although surveys must account for variation in the time of breeding between colonies. The quality of aerial images significantly affects the results and is one source of variation among assessors. Further refinements to the methodology, execution and supply of aerial images are warranted, including the possibility of using drones to acquire the necessary imagery. Variation in counts among assessors could perhaps be reduced by refining and standardising the criteria on which birds in the colonies are classified when aerial images are analysed.

Introduction

Regular aerial surveys of kawau pāteketeke/ New Zealand King Shag (*Leucocarbo carunculatus*) have been undertaken since 2015 to determine population numbers during the non-breeding period and the number of breeding pairs during the wintertime. Aerial survey methods have proven to be practical, rapid and cost-effective for surveying this species across its entire range in a few hours with minimal evidence of disturbance (Schuckard *et al.* 2015, Schuckard *et al.* 2018).

Following guidelines developed during earlier surveys, the plan was to estimate the 2021 breeding population using aerial surveys. However, the timing of breeding at two colonies during 2021 was found to be variable. A fixed wing survey was carried out in late May 2021 to capture “peak” breeding at most colonies, with a follow-up survey planned for 4-6 weeks later. But a significant adverse weather event in July caused widespread colony failure. As a result, no follow-up aerial surveys of the colonies were carried out, except for the colony at Kuru Pongi, which was surveyed by drone as the birds here bred exceptionally late.

This report presents the results of the analyses of the aerial and drone photographs, undertaken by three independent assessors, to determine the 2021 breeding population of kawau pāteketeke/ New Zealand King Shag.

Methods

Survey design and timing

The stage of breeding at kawau pāteketeke/ New Zealand King Shag breeding sites can vary markedly among colonies. Consequently, the timing of the aerial survey was determined by first making at-sea observations of the state of breeding at the colonies during related research to re-sight banded shags, carried out as part of a project funded by the Marine Farming Association Seafood Innovation Limited. This involved regular visits to breeding colonies, during which breeding activity was also noted.

Early in the 2021 breeding season, it was clear that breeding at two of the colonies was going to be asynchronous, with birds nesting unusually early at Tawhitinui, whereas breeding at Kuru Pongi was late. Breeding activity at the other colonies was more closely aligned. The first aerial survey was therefore timed for late-May 2021, to capture the peak of activity at the active colonies. A planned second flight was then intended to capture better the late breeding at Kuru Pongi.

On 17 July 2021, after the first aerial survey, the Marlborough Sounds and surrounding land experienced a significant adverse weather event (<https://www.stuff.co.nz/national/300360148/900-people-evacuated-in-worst-marlborough-flood-on-record>). Excessive rainfall and high wind caused widespread landslips, erosion and considerable sediment-rich runoff entering the region's coastal waters. This caused the near total failure of the Duffer's Reef colony, and significant breeding failure at Rahuinui, The Haystack, Hunia Rock and White Rocks. Breeding had not yet started at Kuru Pongi colony, so it avoided a similar fate.

At-sea observations of these failed colonies showed that no re-nesting occurred at any of them. Breeding commenced later at Kuru Pongi and continued successfully for the rest of the season. This colony was therefore surveyed in mid-October 2021 by drone when breeding was considered to be at its peak.

Aerial survey

The aerial survey was undertaken by Canterbury Aviation flying a Cessna 180 on 26 May 2021. Canterbury Aviation had new cameras mounted on the underside of the aircraft used in previous king shag aerial surveys. The resulting high-definition, vertical aerial images of the colonies and adjacent areas were stitched together to produce single large images of each colony and their wider surroundings. These composite images were huge, ranging from just under 160 Mpx (White Rocks) to over 2,878 Mpx (Duffers Reef). In some of them there was poor control during stitching, with smearing along the stitched boundaries. Fortunately, the nesting areas were unaffected, so this problem did not adversely impact subsequent counting. Canterbury Aviation are sensitive about the IP of their technology, and so have been unwilling to provide further details of the camera, flight path and stitching methodology used.

Kuru Pongi was surveyed on 15 October 2021 using a DJI FC3170 camera mounted on a DJI Mavic Air 2 drone to obtain images of the colony around the time of peak breeding. Four 9-

Mpx images were selected from among those taken to provide both vertical and oblique views of the colony.

Photograph assessment

Significant problems were experienced with the largest images provided by Canterbury Aviation. These could not be easily handled with commonly used image-processing software (*e.g.*, Photoshop Elements, Paint.net, GIMP, IrfanView, ImageJ). Eventually, the two largest images were displayed in QGIS and smaller areas of interest extracted for detailed analysis. Despite the large file sizes, however, birds in the colonies were poorly resolved, making it challenging sometimes to determine the stage of breeding of individual birds.

As in previous surveys all birds seen on the images were counted and allocated to one of several behavioural- or breeding-stage categories (Schuckard and Frost 2020). One assessor used the programme DotDotGoose [v 1.5.0] (<http://cbc.amnh.org>; Ersts 2019), another used ImageJ (<https://imagej.nih.gov/ij/>), whereas the third marked nesting birds manually and in colour on a printed enlargement of the original image. At each colony, birds were categorized into the following classes, with a tally kept of the number of individuals in each:

- (1) one or two adults sitting horizontally on nest (thought to be either incubating eggs or brooding small chicks)
- (2) nests with one or more chicks clearly visible with one adult, two adults or a chick alone
- (3) one or two birds standing upright by an empty nest or loosely gathered nesting material, not incubating, and
- (4) one or two birds together roosting on the fringes of the nesting area.

Nests with two birds close together (one apparently incubating or attending chicks and the other standing) were counted as a single occupied nest. The total of all birds present at a colony (excluding the number of chicks), or dispersed over same island group was also calculated. In this report, the sum of classes 1 and 2 represents the number of 'active nests', whereas class 3 is the number of additional occupied sites. As in previous years, the 2021 results are given as the total number of nesting pairs, derived from the sum of the average number of active nests counted by the observers at each colony.

Results and discussion

Overall, from the aerial surveys, 239 breeding pairs of kawau pāteketeke/ New Zealand King Shag were estimated to be present at eight sites throughout the Marlborough Sounds (Table 1). This comprised 169 nesting pairs at seven colonies estimated from the late-May aircraft survey, plus 70 nesting pairs on Kuru Pongi in mid-October, counted from the drone imagery. In addition, 27 active nests were recorded at Tawhitinui in April 2021 from a boat-based count. Combining this count with those from the two aerial surveys gives an estimated total breeding population for kawau pāteketeke/ New Zealand King Shag in 2021 of 253 pairs (Table 2).

*Table 1. Number of active kawau pāteketeke/ New Zealand King Shag nests, standard deviation and coefficient of variation (CV), at each colony where breeding was recorded during the aerial survey on 26 May 2021 as assessed by three independent assessors (A1–3) * was surveyed by drone at 1 October 2021.*

	A1	A2	A3	Average	SD	CV
The Twins	2	4	4	3	1.2	34.6
White Rocks	26	29	28	28	1.5	5.5
Hunia	15	19	18	17	2.1	12.0
Duffer's Reef	62	70	74	69	6.1	8.9
Moturaka/ The Haystack	16	19	19	18	1.7	9.6
Tawhitinui	16	8	16	13	4.6	34.6
Kuru Pongi/ North Trio*	71	70	70	70	0.6	0.8
Rahuinui	19	21	22	21	1.5	7.4
Total	227	240	251	239	12.0	5.0

There was some variation among the assessors in the number of active nests counted on the aerial images of individual colonies. The coefficient of variation (CV) of these counts, a measure of the variability among individual assessments, was 5.5 – 34.6% (Table 1). This variation is likely a consequence of the lack of definition of the birds, leading to difficulties and differences among the assessors in their interpretation of the behavioural or breeding status of certain birds, even in magnified images. In contrast, minimal difference was recorded in the counts made by the three assessors of the birds nesting on Kuru Pongi (71, 70 and 70 active nests, SD = 0.6; CV = 0.8%), using higher quality images taken by drone. Some of the difference in interpretation could also stem from the fact that two of the assessors are familiar with the birds and the colonies, while the third is not. Moreover, one of the assessors, through regular boat-based observations of the colonies carried out for a different purpose, had more knowledge of how breeding was progressing in 2021. This could have unwittingly influenced what was seen and interpreted on the aerial photographs.

Table 2. Number of active kawau pāteketeke/ New Zealand King Shag nests each year over the past seven breeding seasons (Schuckard and Frost 2020 and this study).

	2015	2016	2017	2018	2019	2020	2021
The Twins	0	0	5	25	15	13	3
White Rocks	24	23	36	27	28	24	28
Hunia Rock	13	1	1	18	17	16	17
Sentinel Rock	14	5	5	0	0	0	0
Moturaka/ The Haystack	nc	nc	nc	nc	16	20	18
Duffer's Reef	43	42	74	73	82	83	69
Tawhitinui	14	14	12	22	28	29	27
Kuru Pongi/North Trio	66	29	0	13	43	44	70
Kuru Pongi/South Trio	nc	nc	nc	nc	37	27	0
Tekuru Kuru/ Stewart Island	5	0	1	0	0	0	0
Rahuinui	22	4	21	23	33	22	21
Total	201	118	155	201	299	278	253

The 2021 estimate of 239 breeding pairs of kawau pāteketeke/ New Zealand King Shag is slightly lower than that recorded in both 2019 and 2020, but higher than for 2015–2018 (Table 2). It is possible that some colonies were overlooked during these surveys. For example, the lack of breeding recorded in the Kuru Pongi group in 2017 could have been when the birds were shifting between the North and South Islets and may have been missed in the aerial surveys. Likewise, the low counts at Hunia in 2016 and 2017 may have missed peak breeding at this colony in these years.

Gummer (2022) found that replacement clutches are scarce for this species. It is therefore unlikely that the birds breeding late at Kuru Pongi were ones that had moved there from the colonies that failed during or immediately after the 17 July 2021 storm. This justifies the decision to combine the early, mid, and late counts to estimate the total breeding population in 2021, but it shows the risks of tacitly assuming that breeding in this species is always reasonably synchronous. Several counts per season are strongly recommended for future monitoring of the kawau pāteketeke/ New Zealand King Shag (and other cormorant species) breeding population.

Aerial surveys continue to be a cost-effective tool for monitoring the numbers of kawau pāteketeke/ New Zealand King Shag. The quality of aerial images significantly affects the results and is one source of variation among assessors. Further refinements to the methodology, execution and supply of aerial images are warranted, including the possibility of using drones to acquire the necessary imagery. Variation in counts among assessors could perhaps be reduced by refining and standardising the criteria on which birds in the colonies are classified when aerial images are analysed.

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