Chatham Island Shag tracking, and testing Bluetooth downloadable GPS devices

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Introduction

The study of seabird foraging ecology has gained increasing prominence in recent years, driven by technological advancements that have enabled the monitoring of seabird movements with greater precision, minimal disturbance and less cost. The progressive miniaturisation of GPS tracking devices has facilitated the tracking of a broader range of species, including smaller-bodied seabirds that were previously inaccessible to such methods. These tools provide critical insights into spatial ecology, foraging strategies and habitat use, which are essential for understanding species ecological roles and informing conservation management.

A diverse array of tracking technologies is currently available, each with distinct advantages and limitations regarding data acquisition and retrieval. While satellite-based systems offer global coverage and real-time data transmission, they are often prohibitively expensive and require ongoing subscription fees. In contrast, Bluetooth-enabled GPS devices present a cost-effective alternative, particularly for species that return regularly to breeding colonies or roost sites, where data can be downloaded remotely without the need for recapture.

This project was supported and approved by the Department of Conservation as part of a broader initiative to evaluate the efficacy of remote-downloadable GPS tags for inshore foraging seabirds. The Chatham Island Shag (*Leucocarbo onslowi*), a threatened island endemic with no prior tracking data and limited knowledge of its foraging ecology, was selected as a focal species. In addition to assessing the performance and practicality of Bluetooth GPS devices in the field, the study aimed to generate baseline ecological data on this understudied species, contributing to the broader understanding of its spatial behaviours and informing future conservation strategies.

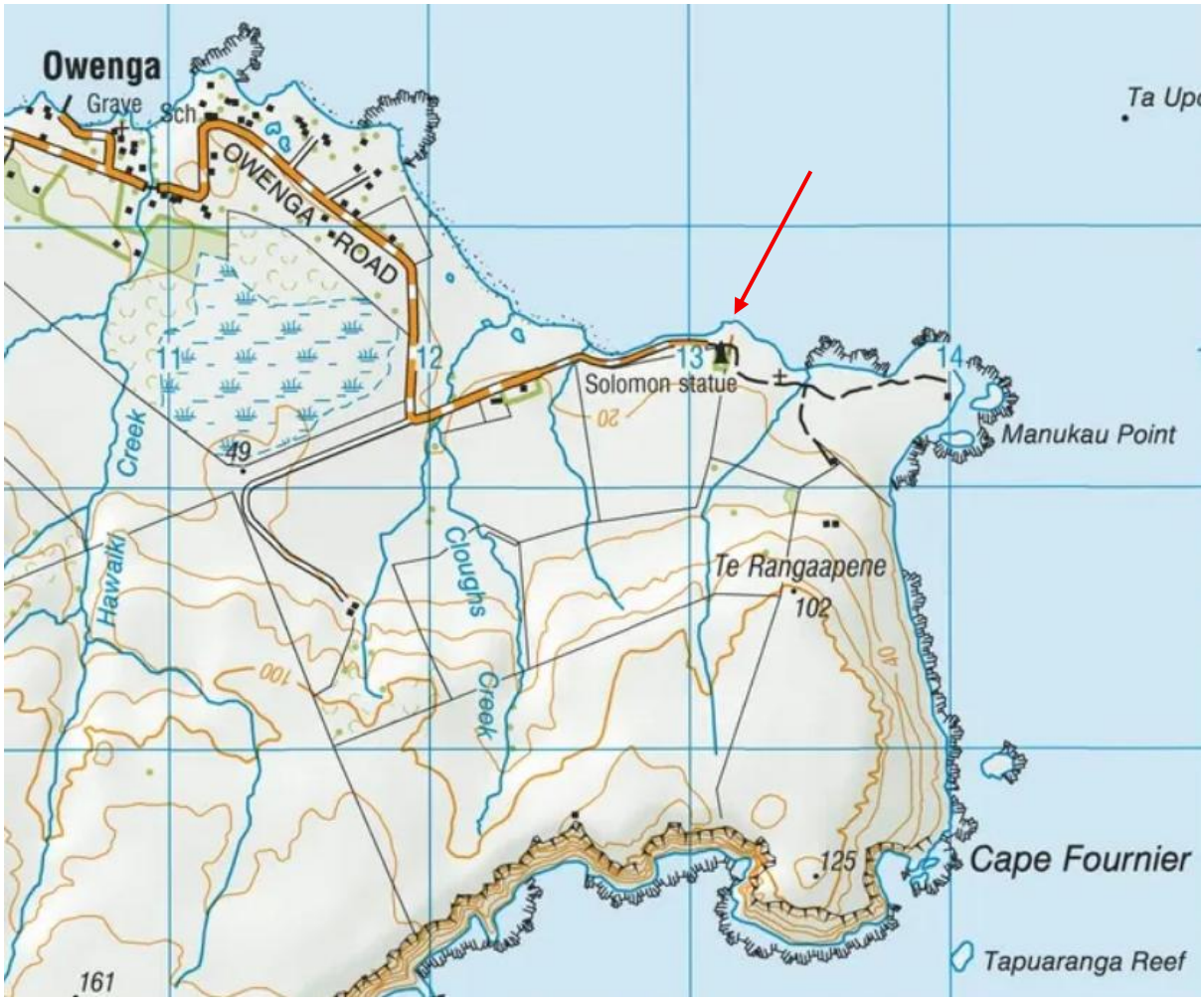
Study site

The breeding colony at Manukau, located on the south-east corner of Rēkohu/Wharekauri/Chatham Island, was the selected study site for this trial (Figure 1). This site was chosen primarily for its accessibility, with a public road extending to within 80 metres of the

colony, facilitating easy access for repeat visits for data collection. The colony is situated on private land, and permission to access and conduct research was granted by the landowner.

The Manukau colony currently supports approximately 25 breeding pairs of Chatham Island Shags. Although the colony is relatively new in its current form, the site has a documented history of intermittent use by breeding Chatham Island Shags dating back to the 1960s (Bell and Bell 2000). No breeding activity was recorded at the site in 2016; however, breeding activity was first confirmed in October 2020 based on eBird records. It is possible that recolonisation occurred sometime between 2017 and 2019, although the precise time remains uncertain.

Figure 1. Location of the Manukau Chatham Island Shag colony (Red arrow indicates colony location).



Methods

Device details

Five GPS devices were deployed during this trial, all of which were Druid YAWL C2 Max S from wildlife GPS tracking company Druid Technology (Shenzhen, China). These devices were operated using the company's custom-built Ecotopia mobile application. Each tag measured

61mm x 28mm x 15mm and weighed 25.2g, making them suitable for deployment on medium-sized seabirds such as the Chatham Island Shag.

The devices had an internal memory capable of storing up to 400 days of location data and included integrated solar panels to support long-term battery maintenance. Data retrieval was conducted via Bluetooth connection using a mobile phone running the Ecotopia App, allowing for remote download without the need to physically recapture a bird to retrieve the device.

Shag capture and device attachment methods

At the time of capture, Chatham Island Shags were actively nest building, but the birds had not yet laid eggs. During this pre-laying period, individuals were observed actively guarding nests, with only one bird of each pair foraging at a time. The strong nest-site fidelity facilitated capture, as researchers were able to approach the colony slowly and selectively target individuals without causing widespread disturbance.

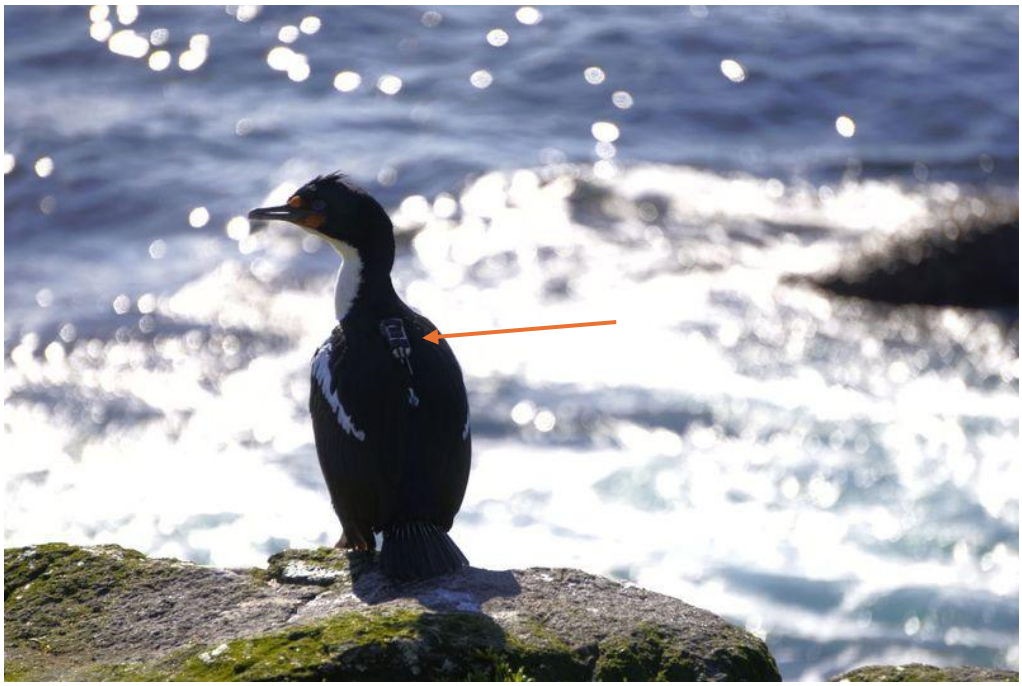
Birds were captured from the periphery of the colony using a neck crook. Once hooked, individuals were gently drawn toward the observer, placed into a holding bag and relocated away from the colony area for processing. Chatham Island Shags were readily approachable, generally quiet and exhibited low levels of agitation during handling. Their reluctance to abandon nest sites further assisted with capture efforts. During processing, the bird's head was kept within the holding bag, which likely contributed to reduced stress and calmer behaviour.

Each bird was weighed, wing length measured, banded with both metal and engraved Darvic bands, and fitted with a GPS tracking device (see below – Figure 2). Wing length and body mass were used in the field to estimate sex, allowing for an approximately balanced sex ratio among tracked individuals. In addition, several feathers were plucked for subsequent genetic sexing to confirm gender. Feather plucking was carried out following device attachment just prior to release. Sex was correctly assigned on 4 of 5 birds; however, the incorrect bird was a suspected female which meant that the tracked birds were heavily male biased, 4 males only 1 female.

Tracking devices were attached to the feathers of the upper back, between the wings, using 5-6 strips of Tessa tape. As the devices lacked a base plate, tape was applied directly to the device. To preserve solar panel functionality, only the upper most and lower most strips of tape were wrapped fully around the device, while intermediate strips were trimmed short of the solar panel. An additional strip of tape was applied along the side of the device to secure the ends of the shorter strips. A structural "fin", located at the lower end of the device, required careful taping to ensure secure adhesion. The ends of each tape strip were reinforced with superglue to prevent lifting during deployment.

Processing time per bird averaged approximately 15 minutes. Following processing, birds were released adjacent to the colony. All but one individual, went directly to sea following release.

Figure 2. Chatham Island Shag with attached GPS tracking device.



Device deployment and connecting to the device in the field

GPS devices were deployed on Saturday 16th August, with the first data check on Monday 18th August. Following that, the colony was visited every 1-3 days to check for birds and download data. On some occasions, individual birds were not present at the colony during the observation period. Tracking data revealed that several of these birds spent nights at alternative breeding sites, including Motuhinahina in Te Whanga Lagoon and Cape Fournier further around the South Coast.

In general, the GPS devices connected reliably to a mobile phone via Bluetooth, and data downloads were straightforward using the Ecotopia application. However, Manukau is on the edge of mobile phone coverage, which posed challenges for the app functionality and connectivity. When coverage was lost, the Ecotopia app failed to operate effectively. Device caching was not supported, meaning the list of previously connected devices was unavailable. If coverage dropped out after caching the Terminal Information tab – used to manage the Intelink connection to each device - would not load, requiring relocation to an area with restored signal. These limitations highlight the importance of considering mobile coverage when selecting sites for deploying this type of GPS device.

Connectivity tests indicated a maximum Bluetooth range of approximately 80m. However, this likely represents a conservative estimate, as connectivity at Manukau was constrained by line of sight. Even in close range, devices failed to connect the moment a bird dropped down lower in the colony, just out of view. Line of sight proved critical for maintaining a stable connection and should be a key consideration when selecting both deployment species and location.

Two of the dropped devices were successfully recovered within the colony. The Ecotopia app includes a useful feature that displays the user's position (based on mobile phone GPS) relative to the device location (Figure 3). This function assisted in locating the tag on the ground after

observing banded birds without devices, but detecting a Bluetooth signal from the GPS device, confirming the device was nearby.

Figure 3. Mobile phone screen shot of the Ecotopia app, showing a GPS device track (red lines) and positions (green circles and bends in tracks) in relation to my position (blue dot). This feature assisted in locating dropped tags both within and near the colony.

Two GPS devices were recovered either within or near the colony. Both units exhibited similar patterns of detachment. All tape strips remained affixed to the device, suggesting that detachment occurred either through the gradual separation of tape separated from the feathers, or as a result of active preening by the birds to remove the device (Figure 4).

Figure 4. Recovered device found on the edge of breeding colony. Showing the underside of the device, and how the tape has remained attached to the device, but some feathers have become unstuck, and others preened out by the bird.

Chatham Island Shag tracking results

Five Chatham Island Shags were GPS tracked during the study period (Table 1). Throughout the tracking period, none of the pairs associated with tagged individuals proceed to lay an egg, and only three other pairs within the colony laid during this time. All tracked birds were observed actively guarding nest sites, consistent with pre-laying behaviour. A follow-up survey conducted one month after the conclusion of tracking confirmed that all tagged birds were observed incubating eggs, indicating that they were breeding birds captured just prior to egg laying.

Behaviour during this period is similar to that observed during incubation, with one member of each pair remaining at the nest site guarding it – likely to deter other birds from stealing nesting material. This strong nest-site fidelity supports the suitability of this species and timing for GPS deployment, as it facilitates repeated observations and data collection.

GPS devices remained attached for between 12 and 17 days generating between 8 and 22 individual locations per bird. This data provided extensive coverage of the at sea movements and colony attendance of these shags.

Table 1. Details of GPS tracked Chatham Island Shag, August 2025.

Colour band	Device	Gender*	N foraging tracks	Days tracked	Mean foraging trip 9(h)	Mean foraging distance (km)	Average depth of foraging Area (m)
Blue 26	060b	Male	15	8	4.3	27.1	48.5
Blue 27	607	Male*	17	22	3.7	34.2	58.7
Blue 28	606	Female	12	8	9.8	19.5	5.2
Blue 30	060a	Male	13	10	5.2	22.7	41.1
Blue 31	608	Male	16	19	5.56	18.2	45.4

*gender confirmed by DNA testing; bird Blue 27 was thought to be female based on morphometrics at time of capture, but DNA testing confirm it was female, leaving a heavily male biased sample

Chatham Island shags showed high foraging site fidelity, with birds consistently returning to the same general area to forage throughout the tracking period. Each of the five tagged individuals utilised distinct, non-overlapping foraging areas (Figure 5a and 5b), suggesting spatial segregation in foraging activity among colony members. Foraging trips typically ranged between 5 and 15 km from the colony, with most birds undertaking a single foraging excursion each day. This pattern of behaviour is consistent with observations from other closely related blue-eyed *Leucocarbo* shag species, which also demonstrate strong site fidelity and limited foraging range during the breeding season (Bell 2022, Camprasse *et al*. 2017).

Figure 5a. GPS tracks of five Chatham Island Shag tracked from Manukau Point, Chatham Island August 2025.

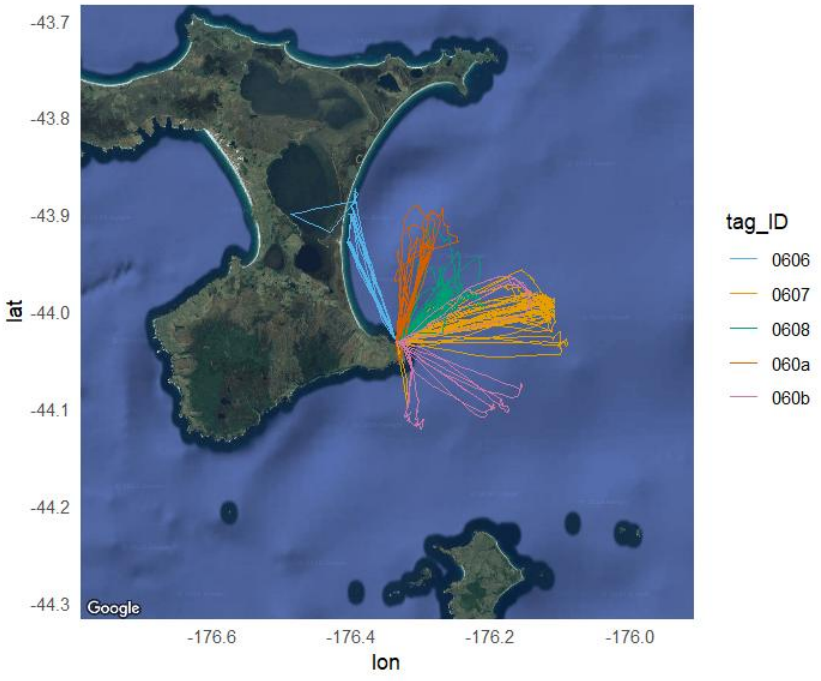
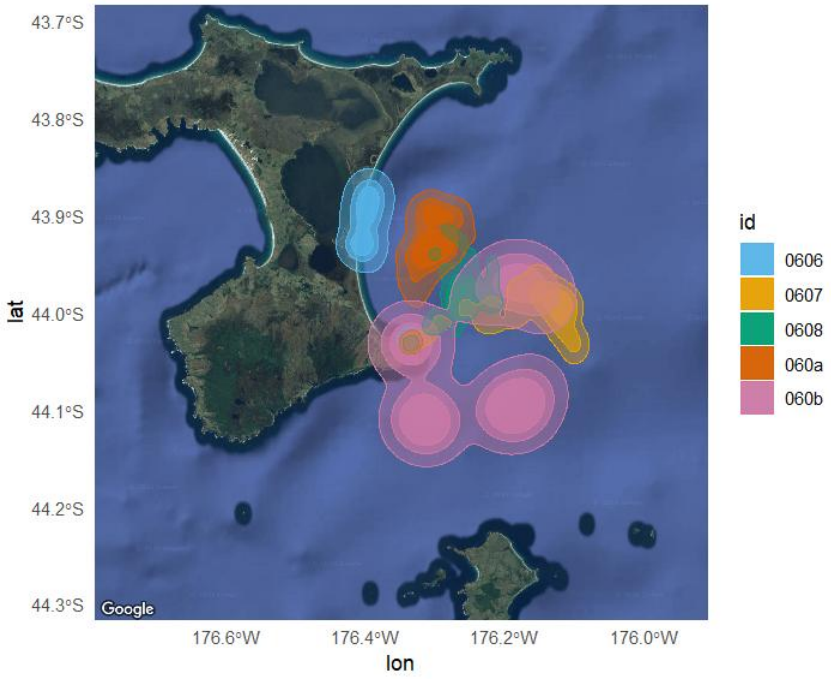


Figure 5b. Kernel density of foraging GPS points of five Chatham Island Shag tracked from Manukau Point, Chatham Island August 2025. Outer ring 95%, then 75% and inner area 50% utilisation density.



Conclusions

The Druid YAWL C2 Max S GPS devices performed reliably when deployed on Chatham Island Shags and are likely to be suitable for other seabird species that return regularly to a breeding colony or roost sites. Species that exhibit consistent nightly roosting behaviour are particularly well-suited for this technology, as their predictable presence facilitates regular data collection.

Field data was successfully downloaded via Bluetooth connection using the Ecotopia App at distances of up to 80 metres, although connectivity was strongly influenced by line-of sight. Birds that moved out of visual range, even at close proximity, could not be connected to, underscoring the importance of colony topography and nest placement when selecting deployment sites. Additionally, the apps reliance on mobile network coverage presents a limitation in remote areas, as offline functionality is currently unsupported

As such, given these constraints, this type of GPS device is best suited for above ground breeding seabirds such as gannets, boobies, gulls, terns and shags, particularly in colonies with open visibility and reliable mobile coverage.

Chatham Island Shags demonstrated foraging behaviour consistent with other blue-eyed shags – including limited foraging range (5 to 15 km), high foraging site fidelity, and likely estimated dive depth (Bell 2022, Camprasse *et al* 2017). However, the observation of breeding individuals roosting at alternative breeding colonies is novel and has not previously been documented in this group.

This behaviour, combined with the distances travelled during foraging, suggest the potential for inter-colony overlap in foraging areas. Previous tracking of other blue-eyed shags has reported strict segregation between colonies with no inter-colony foraging overlap (Wanless and Harris 1993 and see review in Bolton *et al.* 2019). Further tracking of Chatham Island Shags from additional colonies – such as Okawa, Motuhinahina Island and Cape Fournier - would help determine whether this represents a species-specific or context-dependent deviation from previously observed patterns.

Acknowledgements

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