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Population trends, breeding distribution and habitat use of black petrels (*Procellaria parkinsoni*) – 2016/2017 operational report.

New Zealand Aquatic Environment and Biodiversity Report No. 198

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During the 2016/17 breeding season a total of 448 black petrel study burrows were followed within the Mt Hobson study area on Great Barrier Island. Of these 285 (65%) were occupied by breeding pairs, and 93 (21%) by non-breeding birds. Overall breeding success was 68%, slightly down on the 20 year average (74%). Annually adult survival was 95%, which has been relatively stable for the past 20 years. Work on both Great Barrier Island and Little Barrier Island has showed that passive acoustic monitoring to be an effective tool for detecting black petrels. Spatial patterns in black petrel detections and call rates confirm our understanding that black petrels are concentrated within the two existing study areas: the summit ridges on Little Barrier Island and the Mt Hobson area of Great Barrier Island. Call rates were substantially lower on Little Barrier Island, which also supports our understanding that the breeding population on Great Barrier Island is substantially larger. A trail using Satellite GPS devices to track fledging black petrel chicks proved successful, with three birds tracked on their departure from Great Barrier Island. Due to the low sample size no conclusions can be drawn on how these three birds are representative of the movements of juvenile black petrels. However, it is clear that these three birds have followed a similar eastward migration route to that used by adult black petrels tracked in previous years. Wildlife Management International continued to undertake a range of advocacy work on black petrel on Great Barrier Island, including local schools, iwi representatives, fishing industry and training of international seabird conservation managers.

1. POPULATION VITAL RATES OF BLACK PETRELS ON GREAT BARRIER ISLAND

1.1 Introduction

Black petrels (*Procellaria parkinsoni*) are a medium–sized endemic seabird that only breeds on Little Barrier Island (Te Hauturu–o–Toi) and Great Barrier Island (Aotea) in the Hauraki Gulf of New Zealand. Black petrels are known by the name of Takoketai by the tangata whenua and mana whenua of Great Barrier Island (Aotea), Ngāti Rehua Ngātiwai ki Aotea. Black petrels are ranked as Nationally Vulnerable under the New Zealand Threat Classification System and Vulnerable on the IUCN Red List of Threatened Species (Robertson et al. 2017; BirdLife International, 2017). They are recognised as the seabird species at greatest risk from commercial fishing activity within New Zealand's Exclusive Economic Zone (Richard & Abraham 2013), and most reported bycatch of black petrels (96.2% of 78 birds caught between 2002 and 2013) were birds caught by longline fishing vessels (Abraham et al. 2015). Black petrels are also exposed to threats on land, including habitat loss and depredation by cats (*Felis catus*), rats (*Rattus sp.*) and pigs (*Sus scrofa*) (Bell 2013).

To monitor the ongoing population impacts of fisheries bycatch and other threats to black petrels, it's necessary to quantify population parameters such as adult and juvenile survival rates, and adult reproductive success, in order to create accurate assessments of population trends. To this end, a long–term research project aimed at quantifying these population parameters was initiated in 1995–96 (Bell & Sim 1998). During this first season, three 40 m x 40 m census grids were set up within the known breeding colony on Mt Hobson/Hirakimata, and all burrows within the grids were marked and monitored. Additional burrows located within 10 m of the public walking tracks were also monitored. In 1998–1999, the number of census grids was increased to six, and then to nine in 1999–00 (Bell & Sim 2000a; Bell & Sim 2000b). Over the years, additional burrows situated near the public walking tracks have continued to be added, so that by the 2016–17 season a total of 448 study burrows were being monitored.

Monitoring of these study burrows continued during the 2016–17 season, and in this first section of the report we provide an update on several population vital rates, based on the data that we've collected.

1.2 Methods

1.2.1 Field methods

A network of 448 study burrows have been established within a 35 ha study area in the vicinity of Mt Hobson/Hirakimata on Great Barrier Island (Figure 1.1). These burrows have been progressively established over the past 21 years, and include 172 burrows located within nine 40 m x 40 m census grids, plus a further 269 arbitrarily selected burrows situated within 10 m of public walking tracks. To facilitate accurate monitoring, many of these study burrows have had study hatches installed, providing easier access to one or more chambers within the burrow.

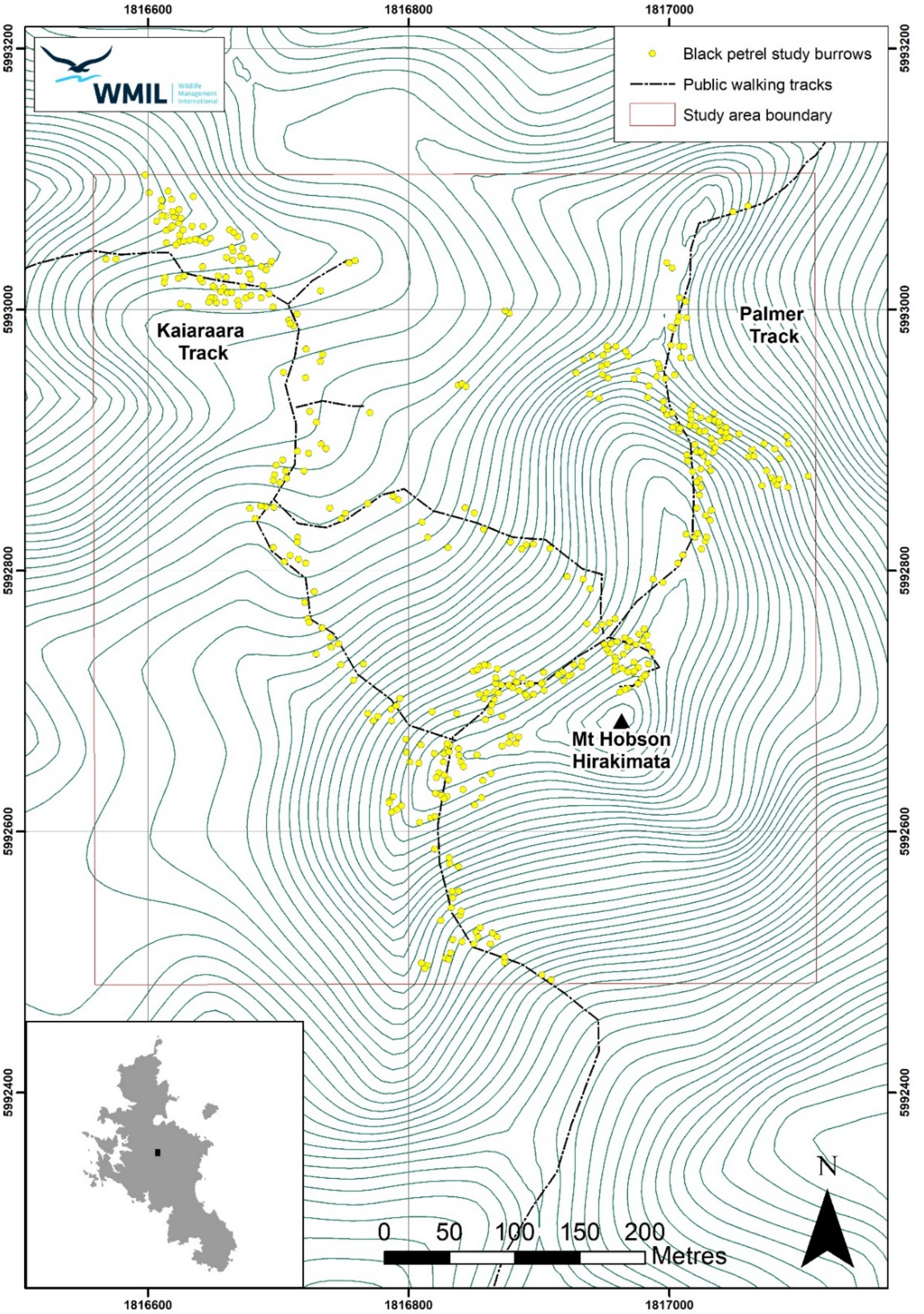

Figure 1.1: Map of the 448 black petrel study burrows that have been established in the vicinity of Mt Hobson/Hirakimata.

During the 2016–17 field season, study burrows were monitored during three visits to the Mt Hobson/Hirakimata study area, in November 2016 and in February and May 2017. These visits roughly coincided with the early incubation, late incubation/early chick rearing and late chick rearing phases of the black petrel breeding season. During each visit, each study burrow was visited between one and three times in order to determine the breeding status and outcome for each burrow, and to record the adult occupants of each burrow.

During each burrow check, any resident adults were removed from the burrow, and checked for bands. If banded, the band number of each bird was recorded, otherwise the bird was banded with a size H stainless steel bird band. Before being returned to the burrow, a small mark was made on each bird's forehead using white correction fluid to provide a means of visually checking whether the same bird is still occupying the burrow during subsequent checks, without having to remove the bird to read its band. The presence of an egg or chick was also recorded. After each check, a palisade of twigs was erected over the burrow entrance to provide a quick means of checking for recent activity during subsequent checks of the same burrow. During the May 2017 fieldtrip, all fledgling chicks found in the study burrows were extracted and banded.

During each trip, observers spent several nights walking the public track system within the 35 ha study area, capturing any black petrels found on the ground. These birds were checked for bands, and any band numbers were recorded. If unbanded, a size H stainless steel band was applied to the bird's leg, before being subsequently released. Before release, a small mark was made on each bird's forehead using white correction fluid to provide a means of visually checking whether a bird had already been captured, if encountered again on the same or another subsequent night.

Additional mark–recapture data were also collected during the transect surveys carried out in February and May 2017, the results of which are described in Section 3 of this report. Additional data were also collected during surveys carried out by a seabird detection dog.

1.2.2 Data entry and analysis

All mark–recapture and breeding status data were entered into a Microsoft Access™ database at the completion of each trip, and data analysis and visualisation has been performed using Microsoft Excel™.

Adult survival rates were analysed from black petrel mark–recapture data using the Cormack–Jolly–Seber (Live/Dead) model in the software package MARK™ (Lebreton et al. 1992; Cooch & White 2001). Candidate models were constructed and fitted to the mark–recapture data, and the most parsimonious model was selected using Akaike's Information Criterion (Burnham & Anderson 2002). The most parsimonious model for adult survival was the model that assumed that both adult survival and recapture probability varied according to the age of the bird.

1.3 Results

1.3.1 Burrow occupancy and breeding success

Of the 448 study burrows monitored during the 2016–17 breeding season, 437 were accessible via either the entrance or a study hatch, allowing burrow occupancy and the breeding status of any occupants to be determined. Among these 437 burrows, 285 (65%) were occupied by breeding birds, 93 (21%) were occupied by non–breeding birds and 61 (14%) were unoccupied.

The proportion of study burrows occupied by both breeding and non–breeding black petrels has been relatively stable over the past 19 breeding seasons, despite some year–to–year fluctuations in occupancy (Figure 1.2). The proportion of burrows occupied by breeding birds during the 2016–17 season (65%) is very close to the 19–year average of 67%.

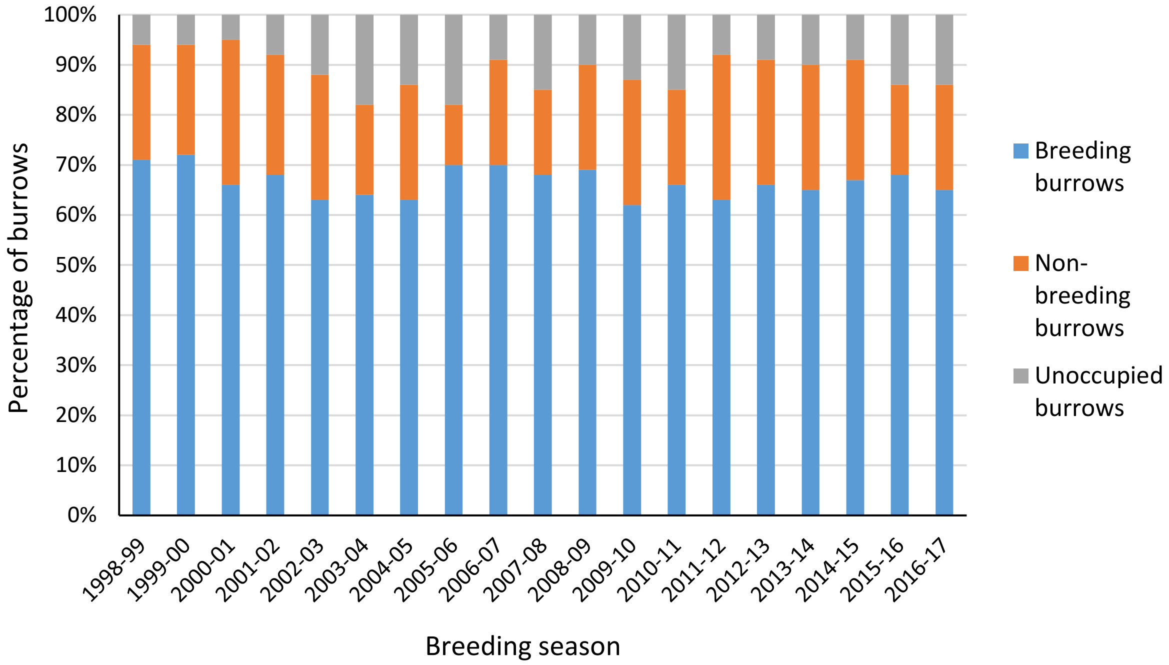

Figure 1.2: **Percentage of breeding, non–breeding and unoccupied black petrel study burrows at Mt Hobson/Hirakimata on Great Barrier Island between 1998 and 2017.**

In contrast, it's possible that there has been a small, gradual decline in burrow occupancy rates within the nine census grids that have been monitored since 1995–99 (Figure 1.3). This decline is not statistically significant, however (one–way ANOVA, F = 0.63; $P = 0.86$).

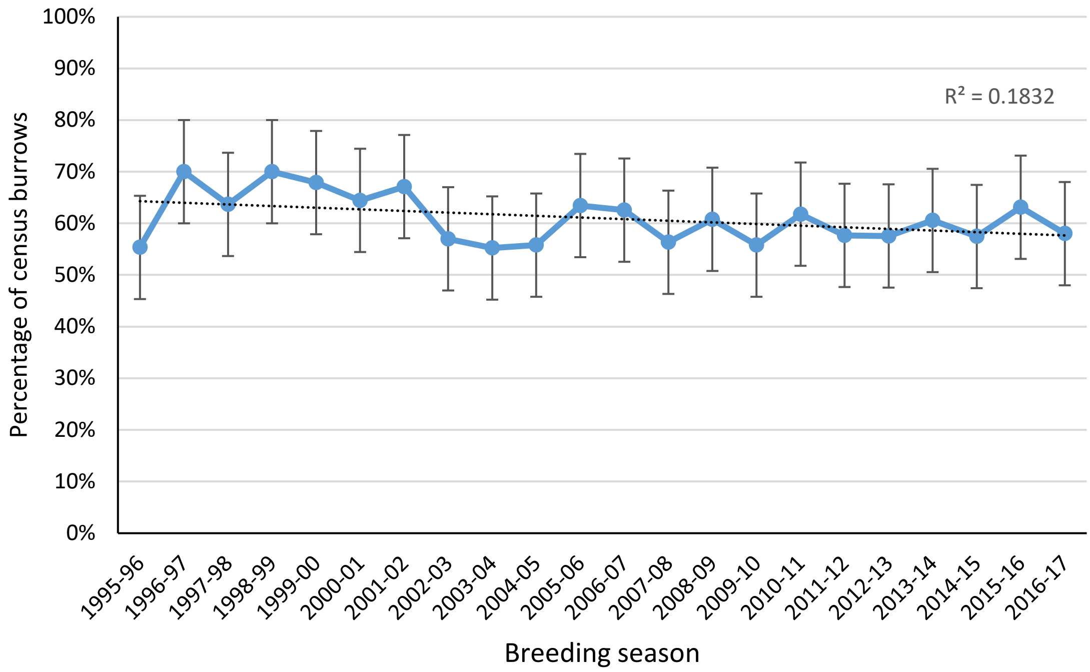

Figure 1.3: **Mean percentage of census grid burrows occupied by breeding black petrels at Mt Hobson/Hirakimata on Great Barrier Island between 1995 and 2017 (error bars represent 95% confidence intervals (c.i.)).**

Of the 285 burrows that were occupied by breeding birds during the 2016–17 breeding season, a total of 194 chicks were produced, representing a 68% breeding success rate. Although there was a range of ages, sizes and stages of feather development in chicks, the peak fledging period this season appeared to have occurred between the 5 and 15 May. Among the 285 breeding burrows, there were 91 breeding failures representing a failure rate of 32%. Causes of breeding failure included eggs or chicks that disappeared from burrows (possible evidence of rat or cat predation, or disturbance by visiting non–breeding black petrels), infertile eggs, abandoned eggs, embryonic deaths and chick deaths.

Over the past 19 breeding seasons, there has been a slight downward trend in breeding success over time, however this trend is rather weak (R = 0.0287), so it's ambiguous whether this reflects a true decline in breeding success. (Figure 1.4). Breeding success during the 2016–17 season (68%) is slightly below the 19–year average of 74%.

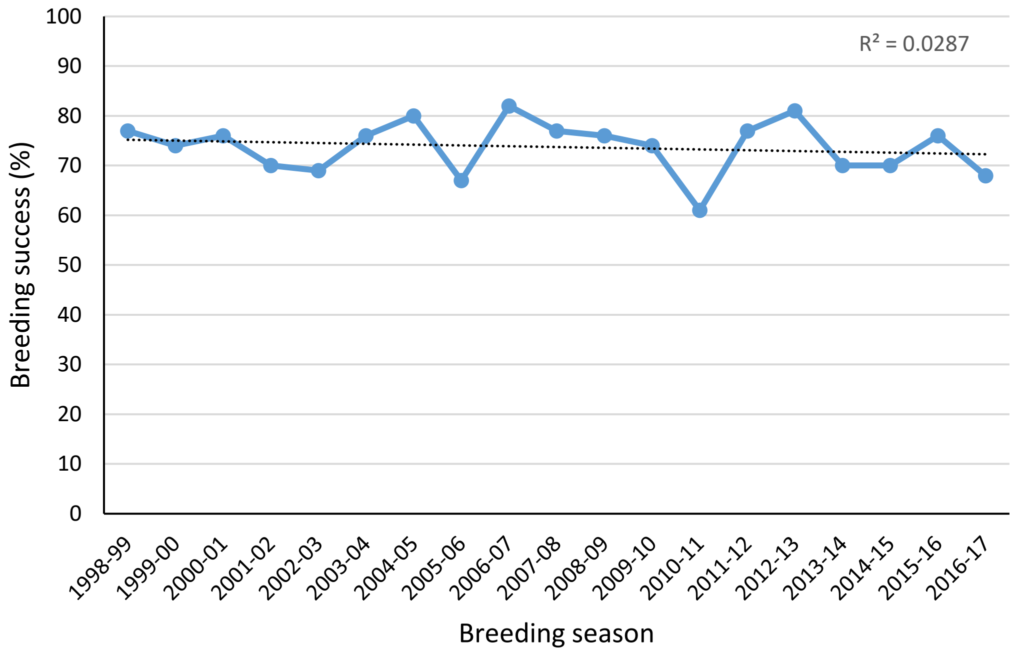

Figure 1.4: **Trend in breeding success (percentage of breeding burrows that fledge a chick) among black petrel study burrows at Mt Hobson/Hirakimata on Great Barrier Island between 1998 and 2017.**

1.3.2 Adult survival rates

During the 2016–17 breeding season, a total of 499 recaptures were recorded, including 196 returned chicks, of which 25 were chicks that had been caught for the first time since being banded as fledglings. A total of 274 returned chicks have now been recaptured at the Mt Hobson/Hirakimata colony. A further 189 adults and 289 chicks were banded during the 2016–17 field season, and bands were also recovered from three dead adults found hung up in trees.

Annual adult survival remained high for the 2016–2017 season with an estimated 95% survival rate of adult birds. Annual adult survival continues to be high, and relatively stable over time (Figure 1.5).

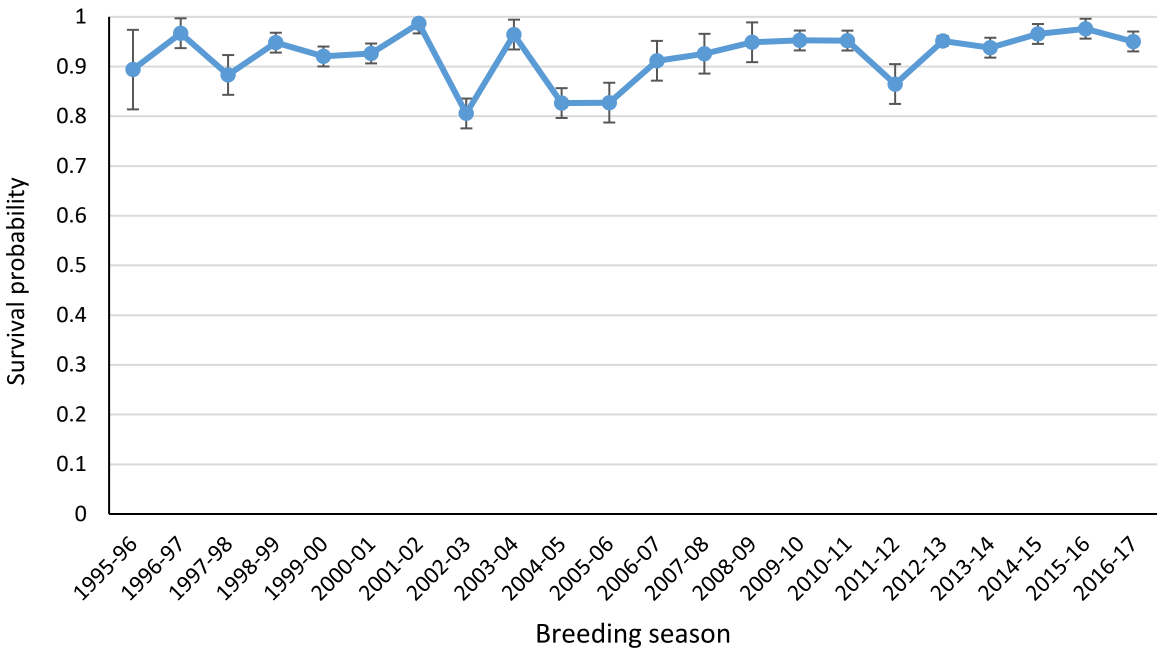

Figure 1.5: Trend in annual adult survival among black petrels banded at the Mt Hobson/Hirakimata colony between 1995 and 2017 (error bars represent the standard error of the mean).

Feral cat trapping at the Mt Hobson/Hirakimata black petrel colony was resumed by the Department of Conservation during the 2016–17 breeding season. During two pulses of trapping carried out in Nov/Dec 2016 and April/May 2017, eight feral cats were caught. Despite these trapping efforts, evidence of cat predation on adult black petrels was observed again this season, indicating that cats are continuing to causes some losses of adults, and likely chicks, at the colony (Louise Mack, DOC, pers. Comm.).

1.3 Discussion

It is possible that the observed burrow occupancy across all Great Barrier Island study burrows may be biased upwards in relation to the true trend in burrow occupancy. The reason for this is that the ongoing addition of arbitrarily selected burrows to the study burrow network outside the nine census grids usually involves the preferential selection of burrows containing breeding birds. This ongoing preferential addition of breeding verse non–breeding or unoccupied burrows to the study burrow network may therefore be masking any potential decline in true burrow occupancy that is occurring over time, if observed burrow occupancy rates alone are reported. To overcome this bias, trends in burrow occupancy rates should perhaps be reported separately for separate ‘cohorts’ of burrows. In other words, burrows should be grouped into annual ‘cohorts’ according to the year during which they were added to the study, and subsequent trends in occupancy rates be reported separately for each burrow ‘cohort’. Such an analysis may be performed by constructing encounter (= occupancy) histories for each burrow, and building burrow occupancy models incorporating a cohort structure reflecting the length of time that each burrow has been monitored. Other options for eliminating this possible upward bias in burrow occupancy is to use a strictly random criteria for selecting burrows for addition to the study burrow network, reporting burrow occupancy rates for census grid burrows alone, or to cease adding any further study burrows to the network.

1.4 Recommendations

Based on the result of this season’s study burrow monitoring work, we recommend that the issue of a potential upward bias in observed burrow occupancy rates be investigated, and a statistical technique be developed to overcome, or account for, this upward bias. We also recommend that no further study burrows be added to the study burrow network outside of the census grids, or if further study burrows need to be added, that they be selected on a strictly random basis without bias towards burrows occupied by breeding birds.

Based on the observation that adult black petrels continue to be preyed upon by feral cats, we support the recommendation by local Department of Conservation staff that cat trapping be continued at the Mt Hobson/Hirakimata black petrel colony during subsequent breeding seasons.

2. AN ACOUSTIC SURVEY OF THE DISTRIBUTION AND RELATIVE DENSITY OF BLACK PETRELS ON GREAT BARRIER AND LITTLE BARRIER ISLANDS

2.1 Introduction

Although we now have a good understanding of the population vital rates of black petrels, our estimates of the current population size, breeding distribution and population density of this species is still somewhat imperfect. The reason for this is that it's technically very difficult to accurately census a nocturnal burrow–nesting seabird that breeds on two such large, rugged and densely forested islands. To further improve the conservation management of black petrel, the National Plan of Action 2013 has highlighted a need to carry out a more accurate estimate of the total population size of black petrels (Minstry for Primary Industries 2013). Devising accurate and regularly updated estimates of population size is also crucial for assigning an appropriate conservation threat ranking under the New Zealand Threat Classification System (Townsend et al. 2008; Robertson et al. 2017).

Since 2014, Wildlife Management International Ltd have been working to improve our understanding of the current distribution of black petrels on both Great Barrier and Little Barrier Islands, as a precursor to carrying out an accurate assessment of population size. One method that has been employed to map black petrel distribution is the detection of black petrel vocalisations using passive acoustic sensors.

Passive acoustic sensors combined with automated acoustic classification techniques have increasingly been used to search for rare and elusive bird species, including many seabirds (Buxton & Jones 2012, Oppel et al. 2014, Borker et al. 2015, Dufour et al. 2016). This method takes advantage of the social behaviour that occurs in and around breeding colonies, namely the frequent vocalizations the birds make when flying overhead of colonies, when communicating with partners or chicks at burrows, or when attracting potential mates. Automated acoustic sensors and automated acoustic classification techniques now make it possible to efficiently detect and quantify vocalisations in large acoustic monitoring datasets. This survey technique improves our ability to identify and delimit previously unknown, or poorly known breeding sites and to quantify population change at known breeding sites. Automated data collection and analysis greatly increases the spatial and temporal scale of seabird monitoring that can be achieved by producing better quality data at a lower cost (e.g., Sherley et al. 2010). Increased survey effort also improves the statistical power of long–term monitoring projects, enabling more accurate estimation of population trends and more strategic allocation of funds toward data–driven conservation actions (MacKenzie et al. 2002, 2005, McDonald–Madden et al. 2011).

2.2 Methods

2.2.1 Passive acoustic monitoring

Passive acoustic devices were deployed on Little Barrier Island over three consecutive breeding seasons (2014–15, 2015–16 and 2016–17) and on Great Barrier Island over two consecutive breeding seasons (2015–16 and 2016–17). Between 18 and 31 acoustic devices were deployed on each island during each season (Figures 2.1 and 2.2). Two models of devices were used: DOC ARU acoustic sensors, produced by the Department of Conservation, and Song Meter 2+ devices produced by Wildlife Acoustics Inc. DOC ARU sensors were attached to the trunks of small trees (ca. 3–10 cm DBH), approximately 1.5m from the ground, with either cable ties or electrical tape. Song Meter 2+ devices were deployed at ground level, usually cable–tied to the base of small trees (Figure 2.3). Survey locations on Little Barrier Island during the 2014–2015 and 2016/2017 seasons were chosen to survey a range of altitudes on the island in an attempt to delimit the existing limits of black petrel distribution on the island (black petrels are thought to be largely restricted to ridges above 500m altitude). During the 2015–2016 season however, recorders were placed within the black petrel study area on Little Barrier Island, in an attempt to calibrate recorded vocalisation rates with known local burrow densities (Figure 2.1). On Great Barrier Island, most acoustic devices were deployed within the existing black petrel study area on Hirakimata/Mt Hobson, in an attempt to calibrate recorded vocalisation rates with known local burrow densities. However, several recorders deployed during the 2015–2016 season were deployed at other locations on Great Barrier Island, to confirm the presence and approximate densities of black petrels in other areas of suitable habitat on the island (Figure 2.2).

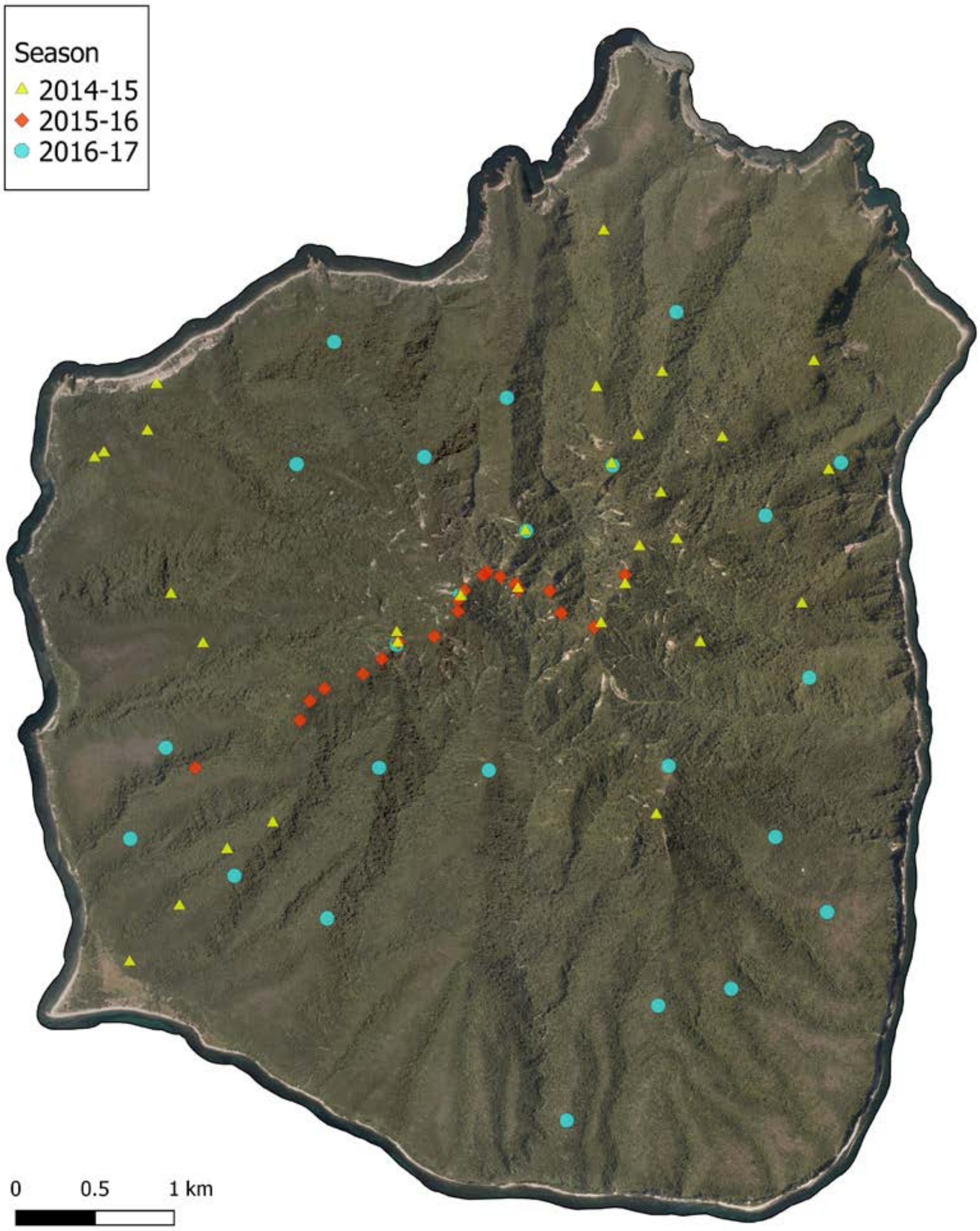

Figure 2.1: Locations of acoustic monitoring devices deployed on Little Barrier Island between 2014 and 2017.

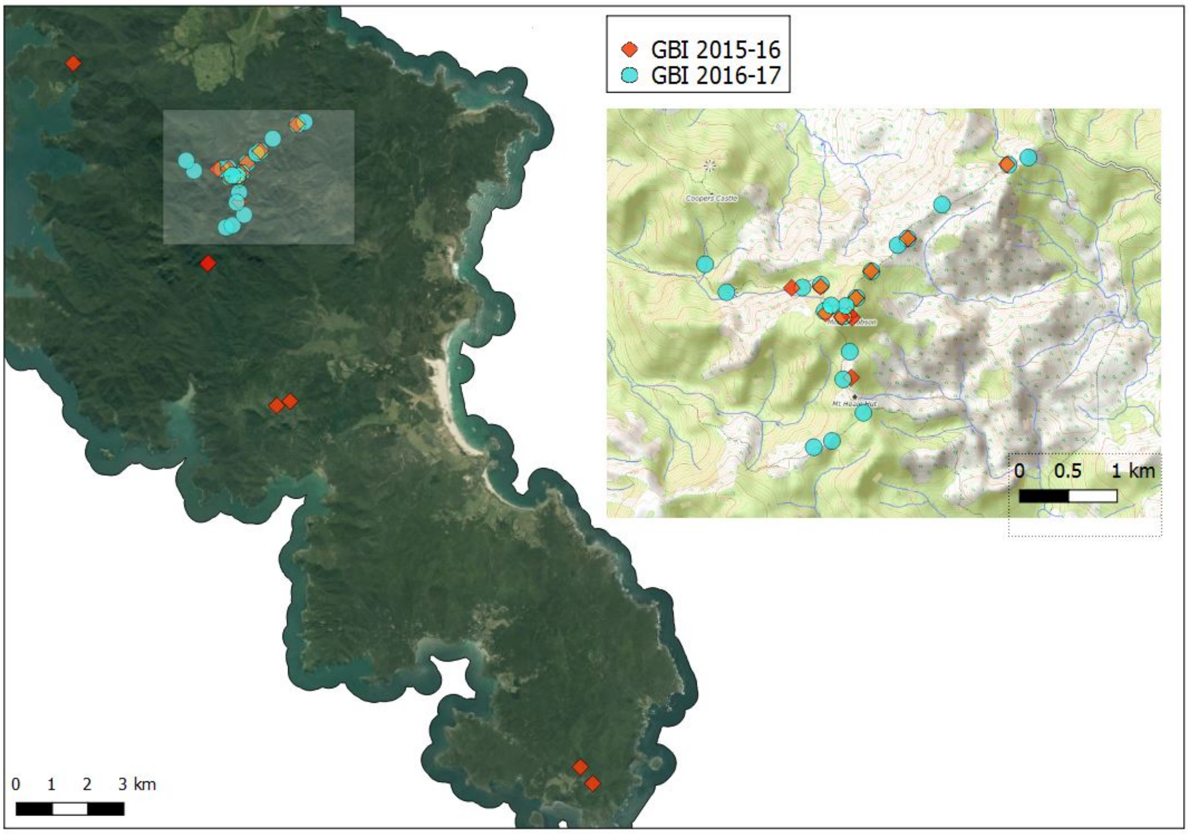

Figure 2.2: **Locations of acoustic monitoring devices deployed on Great Barrier Island between 2015 and 2017.**

Figure 2.3: **Representative examples of the field deployment of DOC ARU (left–hand image) and Song Meter 2+ (right–hand image) passive acoustic devices on Little Barrier and Great Barrier Islands.**

All acoustic device clocks were set to GMT+12 hrs, but recording schedules varied from year to year. Most sensors deployed on Little Barrier Island during the 2014–15 season were programmed to record continuously for 2 hours each night from 21:30 to 23:30. Most sensors deployed on Little Barrier Island during the 2015–16 season were programmed to record continuously for 1 hour and 15 minutes each night, from 21:30 to 22:45. During the 2016–17 season, most of the Little Barrier Island recorders were programmed to record continuously for 2 hours and 15 minutes, from 21:45 to 24:00 each night. On Great Barrier Island, all of the acoustic devices deployed in the 2015–16 season were programmed to record continuously for 2 hours each night from 21:00 to 23:00, and all devices deployed in the 2016–17 season were programmed to record continuously for 9 hours from 21:00 each night. The recording settings used also varied from season to season, and according to the devices used. The DOC ARU recorders record in mono, for instance, whereas the Song Meter 2+ devices can record in both mono and stereo. To improve consistency, any stereo recordings obtained from the Song Meter 2+ devices were split into two single–channel files, and only the left channel was analysed.

Automated analysis of these acoustic field recordings was carried out by Conservation Metrics Inc, using proprietary detection and classification software. The technique employs Deep Neural Network (DNN) classification models, a machine learning technique that trains models to detect sounds on field recordings that match features found in sounds produced by target species. Deep Neural Networks are a powerful classification tool used in many fields to perform speech recognition, image recognition and computer vision tasks (Deng et al. 2013; Schmidhuber 2015; Cichy et al. 2016; Min et al. 2016).

Field recordings were split into 2–second clips, and measurements were calculated for 10 spectro–temporal features typically found in animal sounds. Training and cross–validation datasets were then created that contained examples of black petrel vocalisations from both Little Barrier and Great Barrier Islands, together with a representative sample of other sounds from the local soundscape that didn't contain black petrel vocalisations. Two common black petrel vocalisations were targeted during this analysis: the 'gump' call made primarily by females, and the male 'clack' call (Figures 2.4 and 2.5). Due to the abundance of clack calls on some recordings, it was suspected that the soundscape could become saturated at sites with high black petrel burrow densities. Therefore, the detector was optimised to detect the 'gump' call, which was generally less common. DNN classification models were then trained to learn unique combinations of spectro–temporal features that best differentiate target sounds from other sounds in the environment. Classification models return the probability that any 2–second window contains the target sound, and model performance is described with Receiver Operator Curves. ROC's of multiple model iterations were assessed to determine the best performing model, and the probability threshold of that model was used to provide the desired sensitivity (i.e., the proportion of black petrel vocalisations that are actually detected) and accuracy (the proportion of false detections that are above a given classification probability). In total, 16 candidate models were created and evaluated for detection sensitivity, with the goal of achieving greater than 50% detection of the 'gump' call on a control dataset consisting of a uniform sample from all field recordings (0.1%; ca. 47.25 hours of recordings). The model selected for use in the analyses presented here is a two–class model, classifying both the 'gump' and 'clack' calls that achieved 51% sensitivity and 23% accuracy. This chosen model was then applied to new acoustic data to detect black petrel vocalisations. All detections above the predetermined model classification threshold were flagged and reviewed by an analyst to confirm that those clips contained true black petrel calls, and to remove any clips misidentified by the classification model. All of the recordings from all three seasons on Little Barrier Island and from the 2015–16 season on Great Barrier Island were analysed, but only the recordings that were collected between 21:00 and 23:00 on Great Barrier Island during the 2016–17 season were analysed. It was found that this analysis window greatly reduced the manual review workload, while still facilitating accurate comparisons with other seasons' data.

For these 2016–17 data, these raw unreviewed data for the entire recording window (9 hours each night) were analysed to look at nightly phenology in black petrel vocalisations, and for seasonal patterns in vocal activity. These raw, un–reviewed data may contain some false positives, however it was assumed that the false positive rate is too small to influence the underlying seasonal and daily patterns in vocal activity.

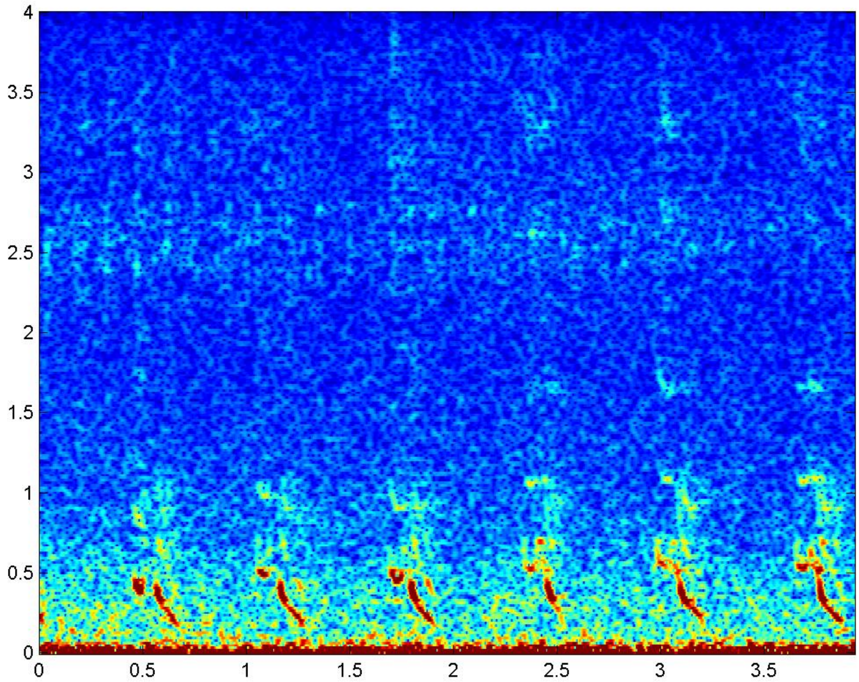

Figure 2.4: Spectrogram of a black petrel 'gump' call. The x–axis represents time in seconds, and the y–axis represents the frequency in kilohertz.

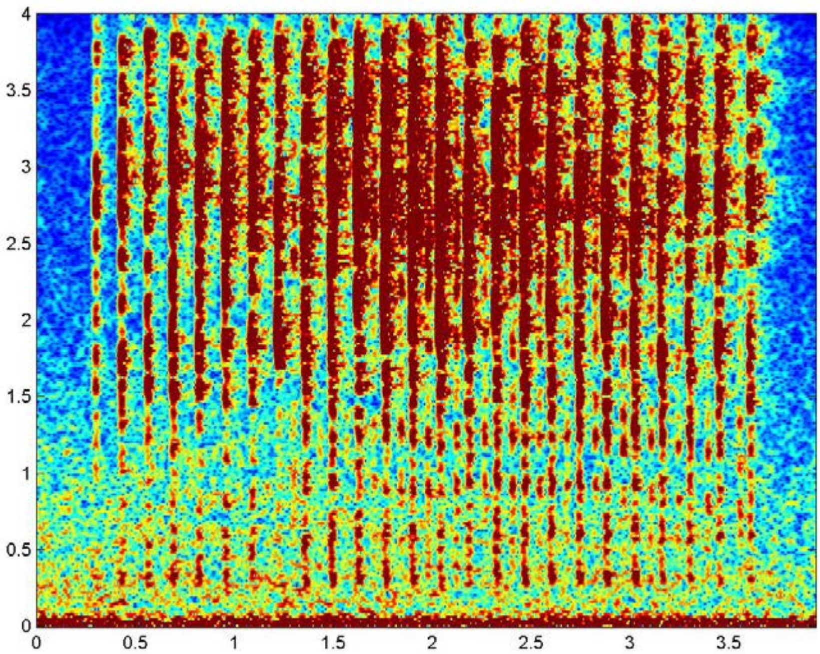

Figure 2.4: Spectrogram of a black petrel 'clack' call. The x–axis represents time in seconds, and the y–axis represents the frequency in kilohertz.

Over the course of an acoustic sensor deployment, exposure to the elements can degrade the sensitivity of microphones. To normalise survey effort between units of varying sensitivities, the recording quality of each minute of acoustic data were evaluated. Poor quality data were included in the initial analysis of black petrel vocalisations, but were removed for call rate calculations to minimise bias due to varying microphone sensitivity.

Call rates are reported here as an index of black petrel activity. To facilitate accurate comparisons of call rates at different locations and in different years, the number of data used to calculate rates, and the time period from which those data were selected, were both standardised. An inter–annual comparison and survey duration threshold of 15 days was set to ensure that the call rates reported here are comparable between survey sites and breeding seasons. To ensure comparability, a one month comparison period from 10 December to 10 January was chosen, which allowed the inclusion of the greatest number of sensors from all seasons. This one–month period also represented a complete lunar cycle in all years, ensuring that inter–annual call rate comparisons were not biased by the effect of the lunar phase on black petrel vocal activity. To standardise rate calculations between sensors with different nightly recording schedules, a peak hour of 150–210 minutes after sunset was chosen. This period included the greatest number of survey sites, based on the overlap of the various recording schedules used, while not artificially drawing down activity rates by including data from lower activity times that only occurred at some site/year combinations.

2.3 Results

2.3.1 Passive acoustic monitoring

Great Barrier Island

A total of 17 302 hours of acoustic recordings from 6 931 survey nights at 113 locations on both Little Barrier and Great Barrier Islands were analysed (Table 2.1). Microphone quality was poor on some nights (based on measurements of the spectral energy on recordings), likely due to wet or windy weather conditions. Several sites lost more than 15% of recorded minutes, and several recorders appear to have malfunctioned as they didn't record at all during the entire deployment period. The reason for these device failures isn't clear from the acoustic data, however, batteries dying prematurely or SD cards not fully inserted into the devices are two possible reasons. Once poor quality data were removed, the analysis included 16 291 hours of data from a total of 6 872 survey nights from 113 survey sites on the islands (Table 2.1).

Table 2.1: A summary of acoustic monitoring survey effort on Little Barrier and Great Barrier Islands between 2014 and 2017. Nights lost and hours lost represent data that were removed due to poor microphone quality. Corrected nights and hours are the data that were included in the analyses reported below.

Season	Total Nights	Total Hours	Corrected Nights	Corrected Hours	Nights Lost	Hours Lost	% Nights Lost	% Hours Lost
GBI 2015–16	1 175	2 345.11	1 175	2 345.11	0	0.00	0%	0%
GBI 2016–17	878	7 465.60	878	7 465.60	0	0.00	0%	0%
LBI 2014–15	2 774	4 329.41	2 715	3 422.86	59	906.55	2%	21%
LBI 2015–16	1 289	1 339.50	1 289	1 306.26	0	33.24	0%	2%
LBI 2016–17	815	1 822.73	815	1 752.12	0	70.61	0%	4%
Total	6 931	17 302.35	6 872	16 291.95	59	1 010.40	0.8%	6%

Black petrels were detected at all locations surveyed on Great Barrier Island. Vocal activity was present throughout the night for both call types (Figures 2.6 and 2.7). ‘Gump’ calls peaked at 130–190 minutes after sunset (Figure 2.6), whereas ‘clack’ calls peaked 180–240 minutes after sunset (Figure 2.7). A slight increase in calls per minute after sunrise is due to false positives caused by the calls of diurnal forest birds that don’t call during night–time hours. Therefore, these obvious false positive events are unlikely to influence the night–time call rates reported below.

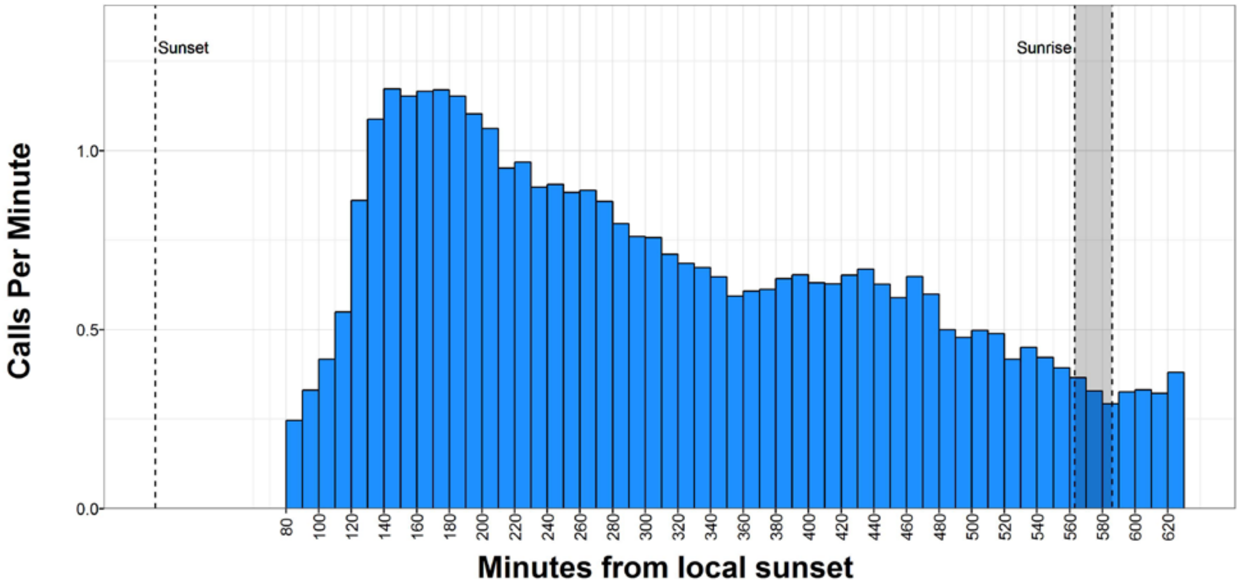

Figure 2.6: ‘Gump’ call rates as a function of time from sunset averaged in 10–minute bins across the entire night for Great Barrier Island in 2016–17. Note that this is the raw unreviewed data. The slight increase in calls per minute after sunrise is likely due to false positives (e.g., forest birds) that do not occur during the night–time hours.

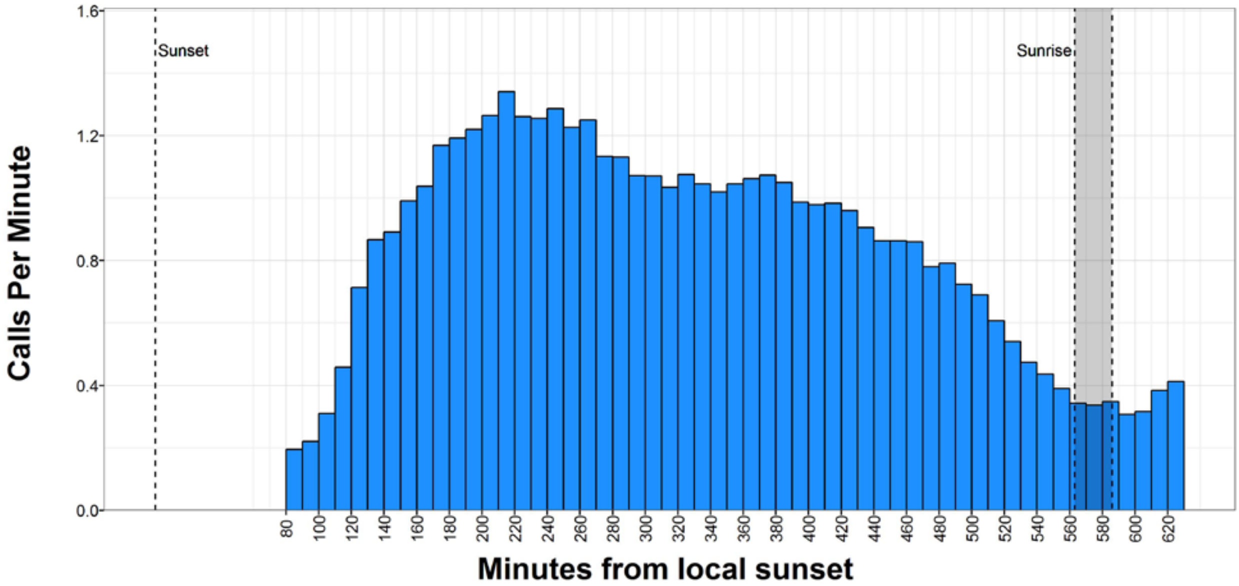

Figure 2.7: ‘Clack’ call rates as a function of time from sunset averaged in 10–minute bins across the entire night for Great Barrier Island in 2016–17. Note that this is the raw unreviewed data. The slight increase in calls per minute after sunrise is likely due to false positives (e.g., forest birds) that do not occur during the night–time hours.

Call activity was sporadic throughout the survey period, with no clear seasonal pattern of activity (Figures 2.8 and 2.9). This may be attributed to the relatively short survey period, with factors such as microphone quality, differences in recording schedules and differences in sensor locations between years combining to mask potential seasonal patterns.

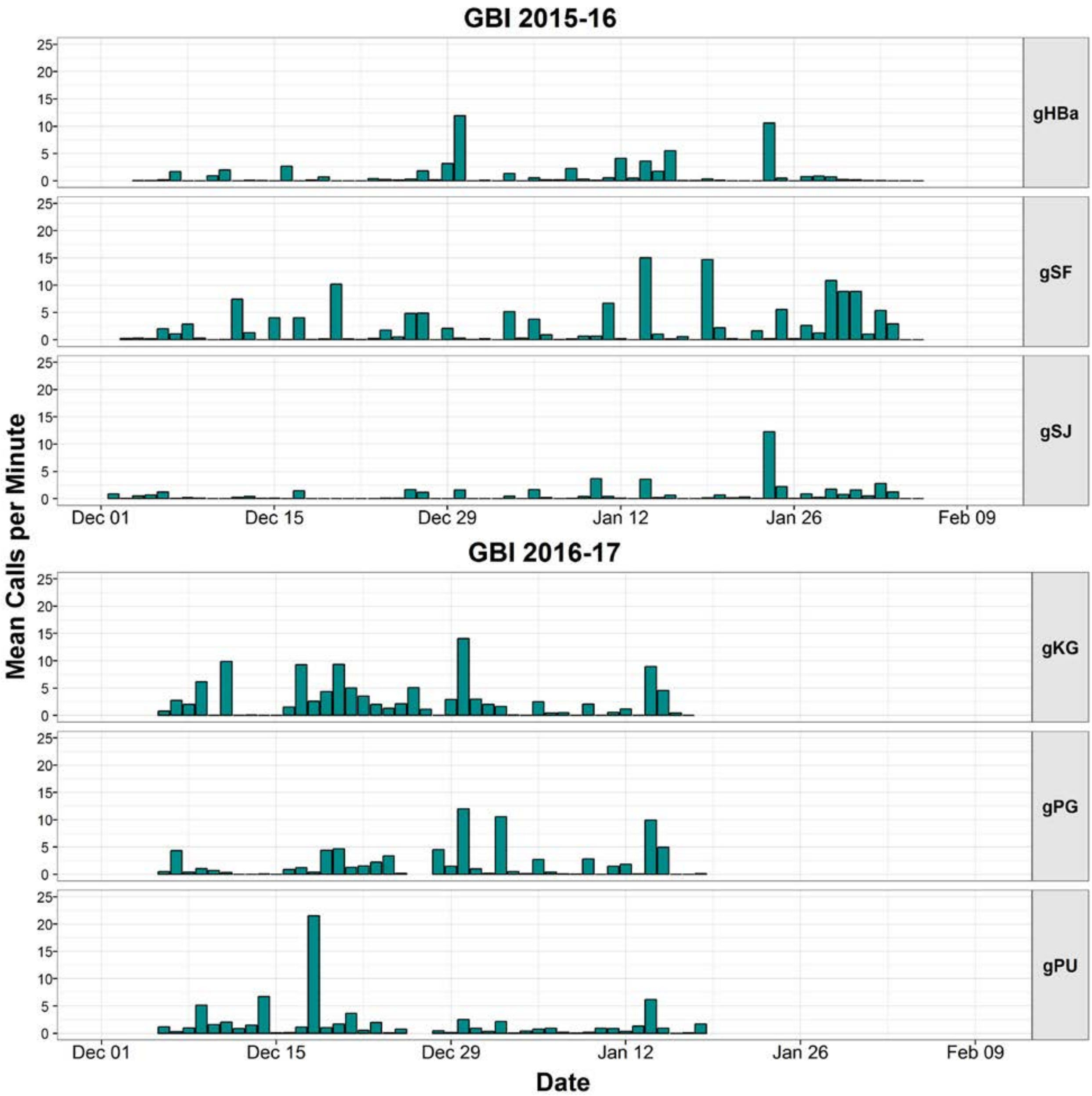

Figure 2.8: Seasonal variation in mean 'gump' call rates at the top three activity sites on Great Barrier Island during each season for the peak hour (150 to 210 minutes after sunset). Note that different seasons had different deployment periods.

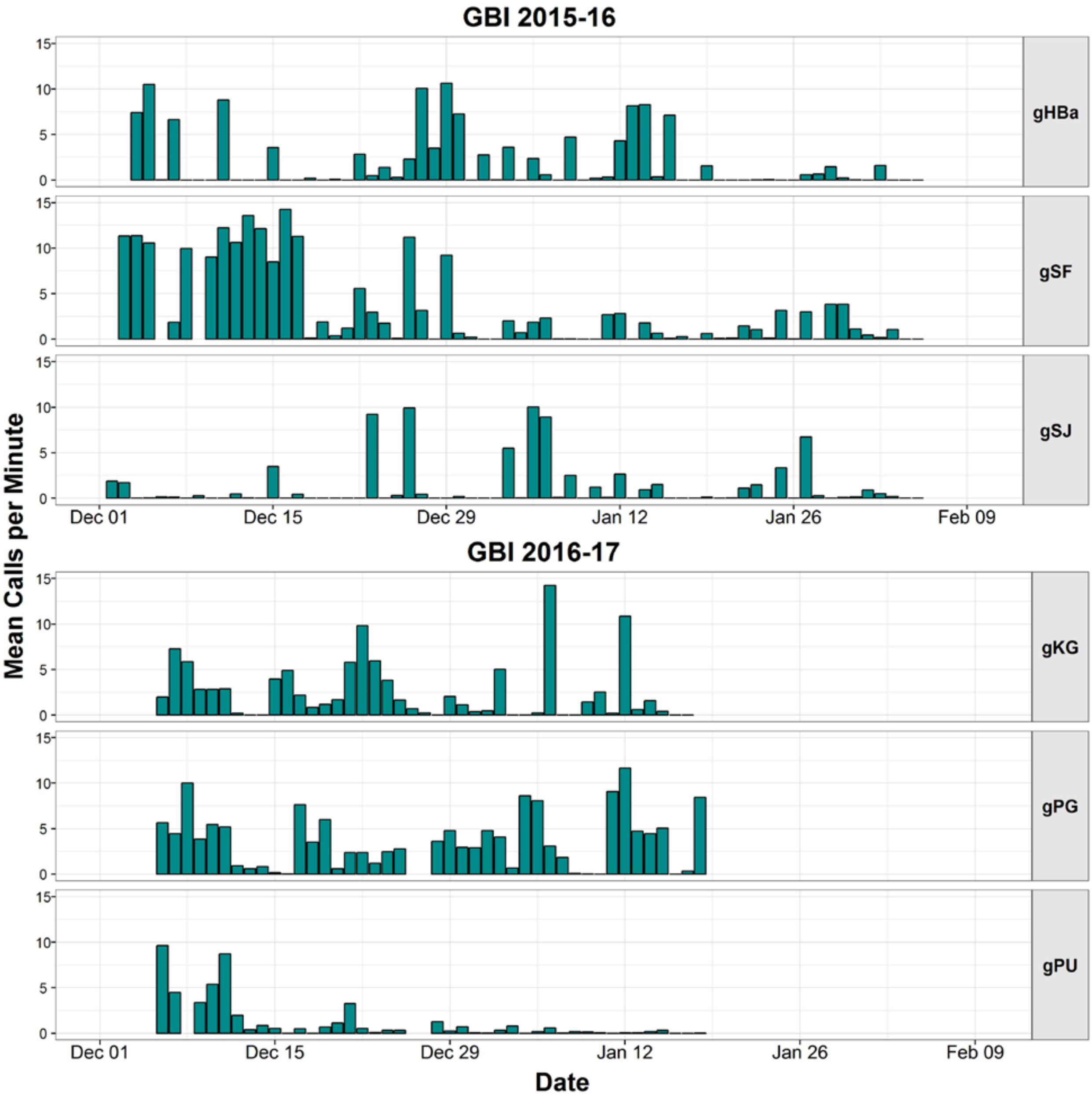

Figure 2.9: **Seasonal variation in mean 'clack' call rates at the top three activity sites on Great Barrier Island during each season for the peak hour (150 to 210 minutes after sunset). Note that different seasons had different deployment periods.**

Unreviewed raw model output form Great Barrier Island during the 2016–17 season indicates that recording started after the breeding season had begun, with call rates declining throughout the survey period (Figures 2.10 and 2.11).

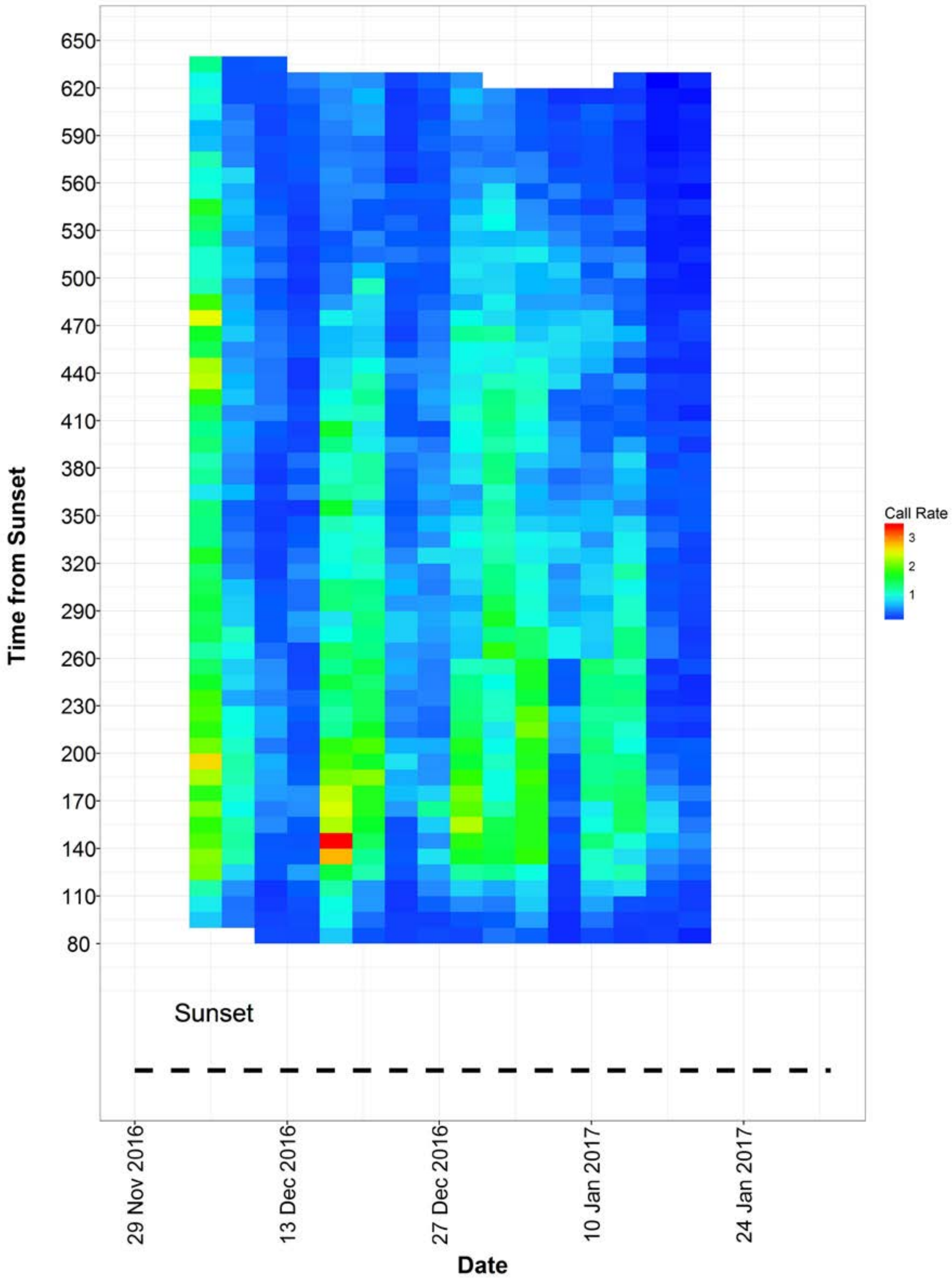

Figure 2.10: Mean 'gump' call rates at Great Barrier Island acoustic survey sites in the 2016–17 season. Call rates were calculated using 10–minute bins averaged daily over three days using unreviewed raw model output.

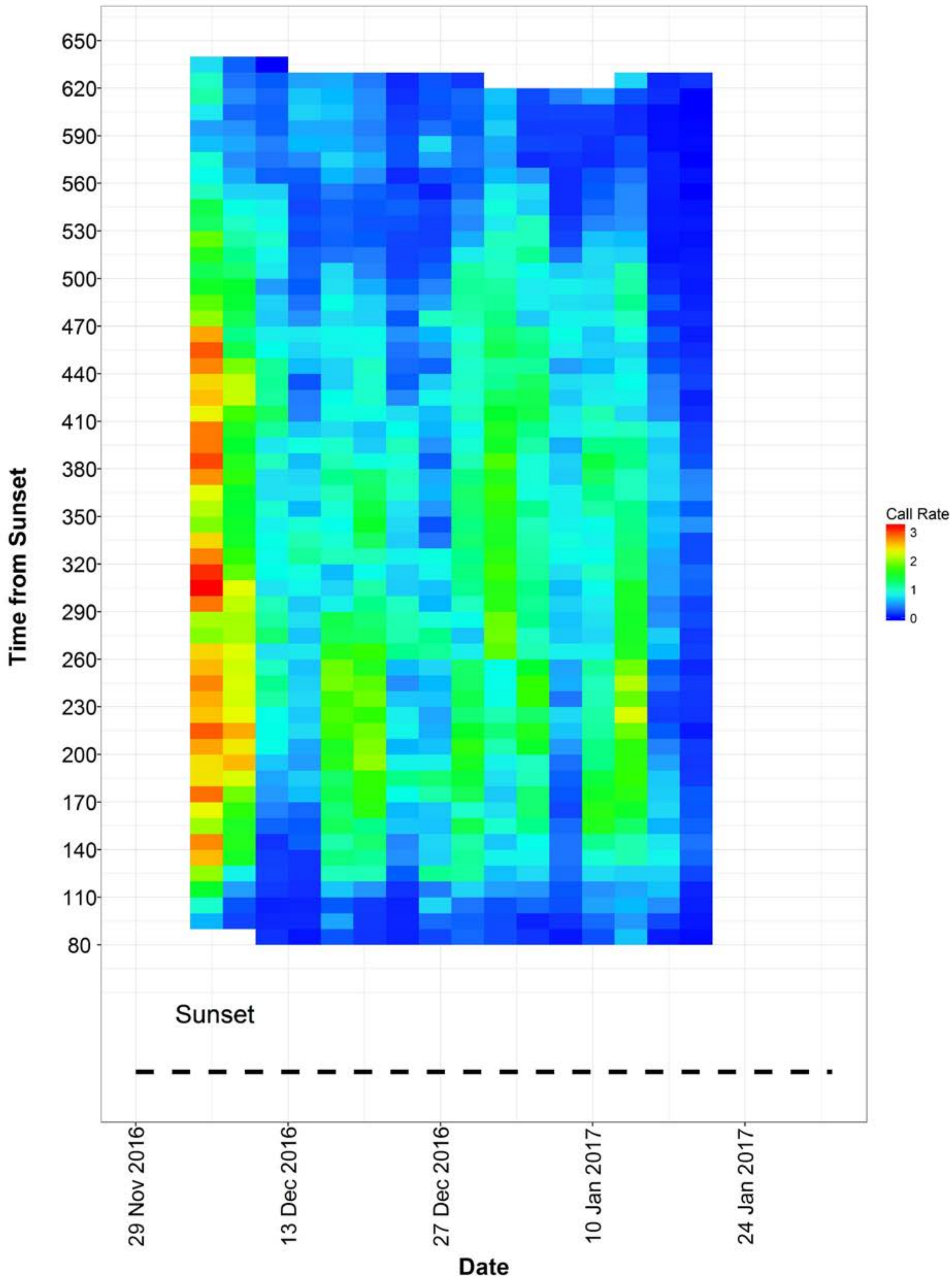

Figure 2.11: Mean 'clack' call rates at Great Barrier Island acoustic survey sites in the 2016–17 season. Call rates were calculated using 10–minute bins averaged daily over three days using unreviewed raw model output.

A peak calling period of 150–210 minutes after sunset was used to compare call rates. The highest mean 'gump' and 'clack' call rates for Great Barrier Island were 2.71 ± 3.47 calls/minute and 4.32 ±

4.99 calls/minute respectively. Most of the high activity sites on Great Barrier Island were located around Mt Hobson in the existing black petrel study area, however acoustic recordings from all of the outlying locations that were also sampled all contained black petrel calls (Figures 2.12 and 2.13).

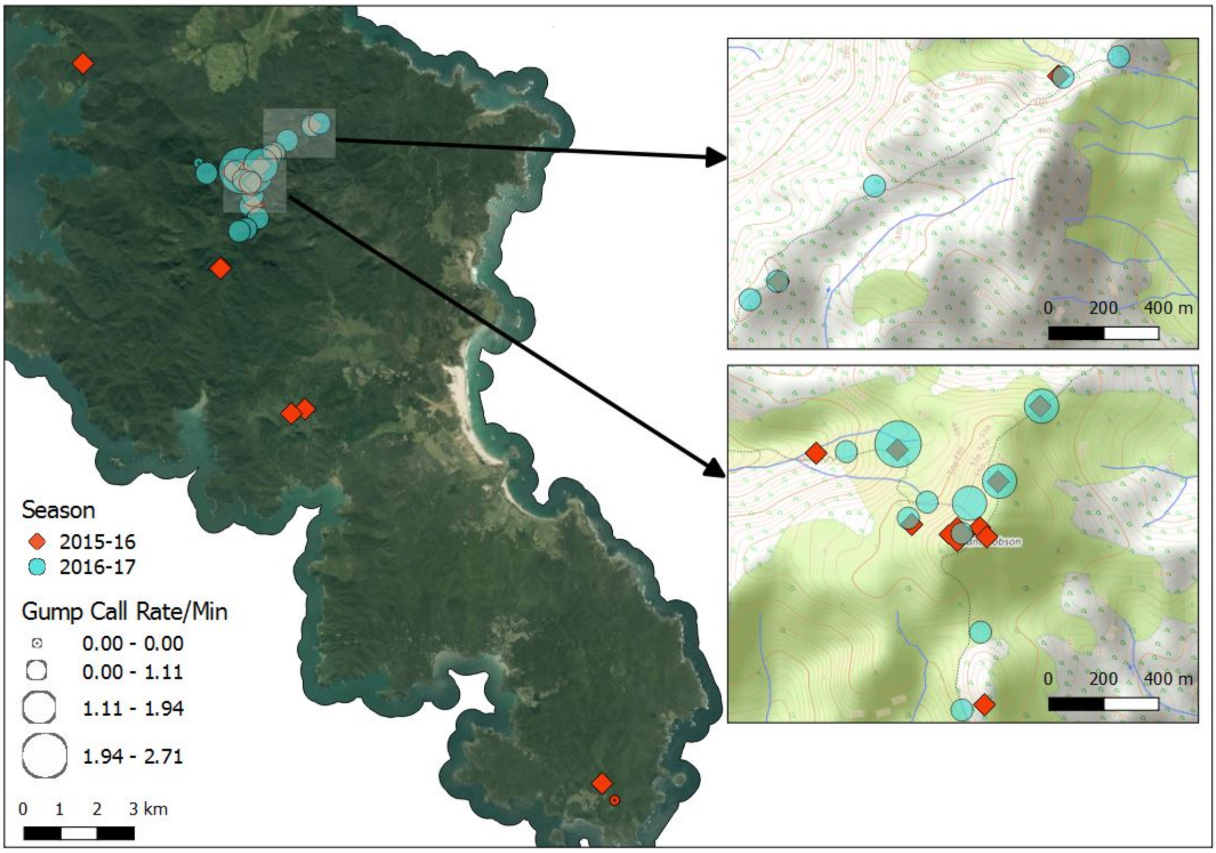

Figure 2.12: Mean 'gump' call rates at each site on Great Barrier Island between December 10 and January 10, 150 to 210 minutes after sunset.

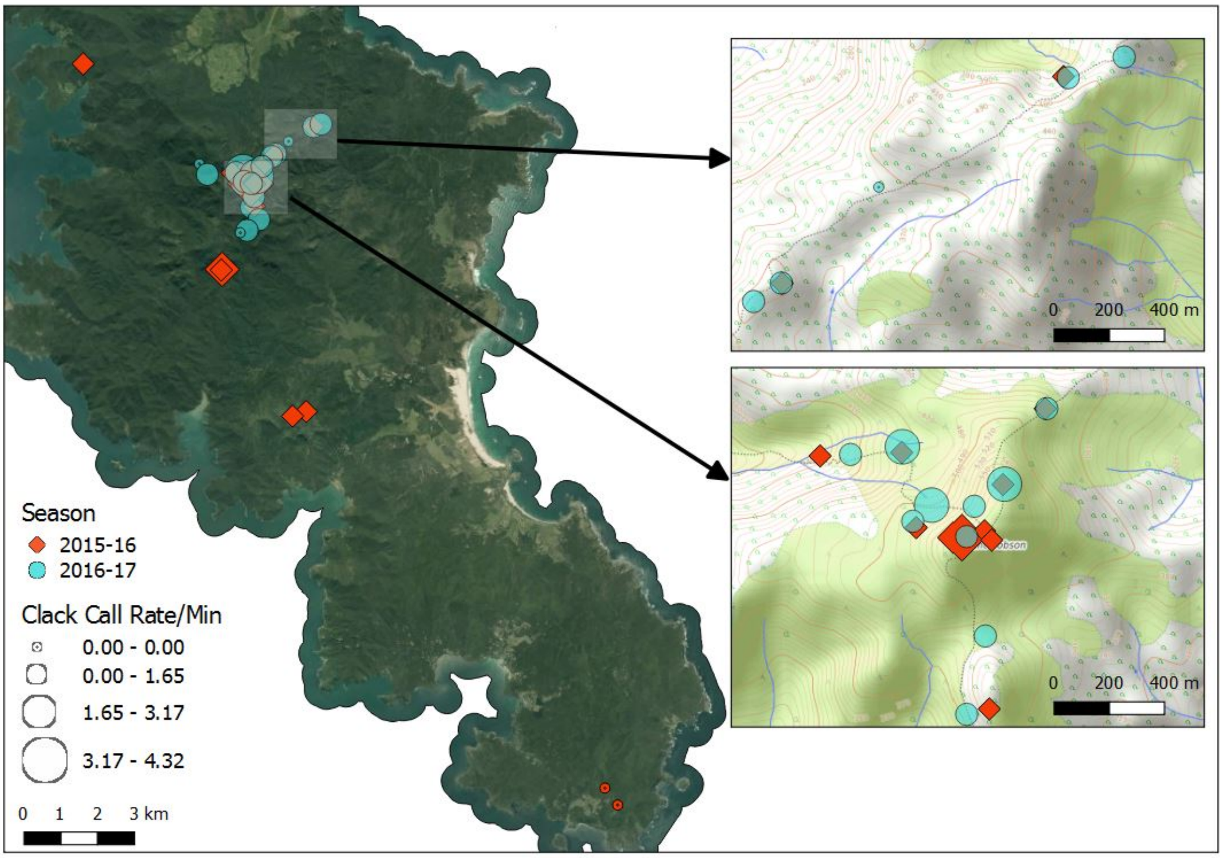

Figure 2.13: **Mean 'clack' call rates at each site on Great Barrier Island between December 10 and January 10, 150 to 210 minutes after sunset.**

Inter–annual comparisons were only possible for seven surveyed locations on Great Barrier Island. For the purposes of this comparison, only those sites that fell within 50 m of each other from one season to the next were compared. Although there were some differences in both 'gump' and 'clack' call rates between individual sites from one year to the next, overall there was no significant difference in call rates between the two years (paired t–test, p = 0.91 and p = 0.40 for 'gump' and 'clack' calls respectively; Figures 2.14 and 2.15).

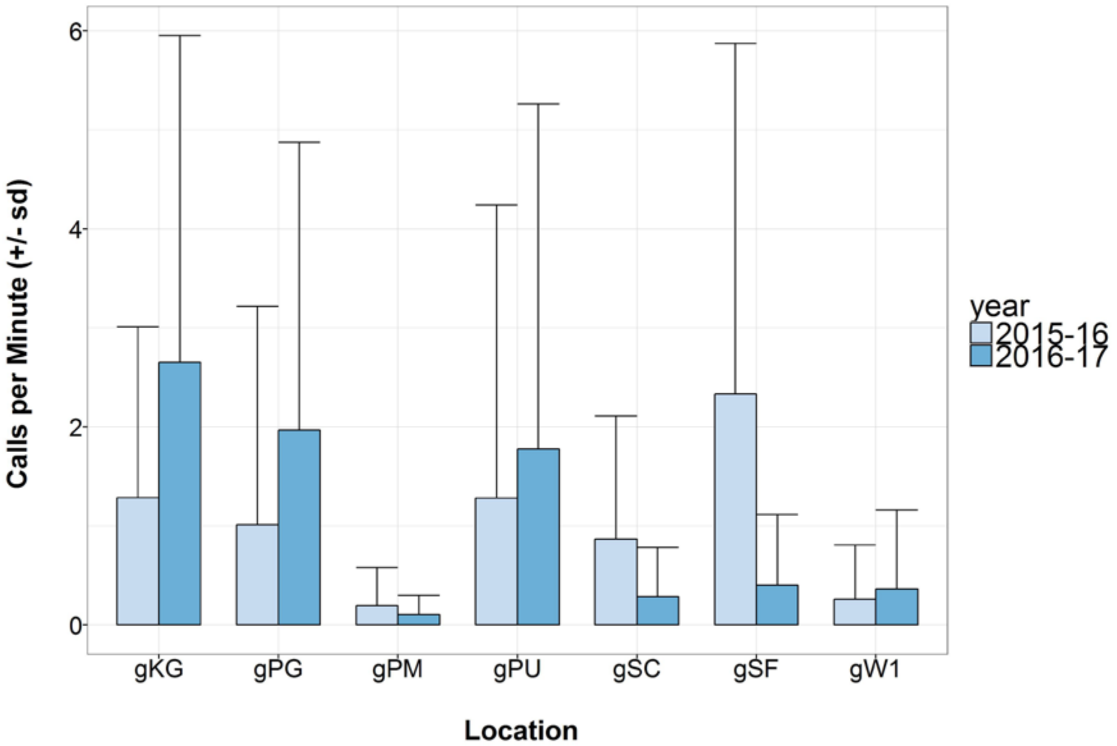

Figure 2.14: **Mean 'gump' call rates (mean calls per minute) by survey site and year on Great Barrier Island (December 10 and January 10, 150 to 210 minutes after sunset).**

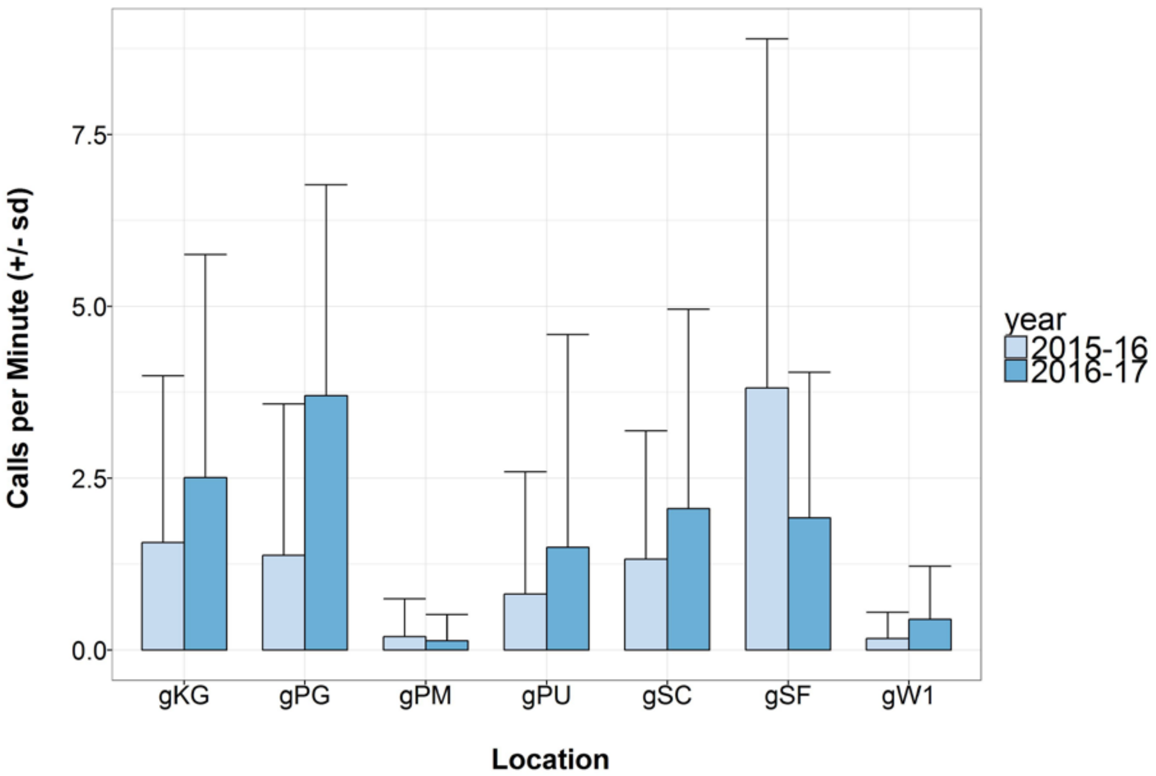

Figure 2.15: **Mean 'clack' call rates (mean calls per minute) by survey site and year on Great Barrier Island (December 10 and January 10, 150 to 210 minutes after sunset).**

Little Barrier Island

Black petrels were detected at all but two locations surveyed in 2014–15, and all but one location surveyed in both 2015–16 and 2016–17. Call rates were compared using recordings collected over the same period (December 10 to January 10 and 150–210 minutes after sunset) as were used on Great Barrier Island. Most high activity sites on Little Barrier Island were located within the existing study area on the summit ridges of the island (Figures 2.16 and 2.17). The highest mean call rates for 'gump' and 'clack' calls were 0.47 ± 1.3 and 0.16 ± 0.57 calls per minute respectively. There were 'gump' calls detected at almost all survey locations and the mean call rate for 'gump' calls was higher than the mean 'clack' call rate for almost every site surveyed. Overall call rates for Little Barrier Island are very low compared to Great Barrier Island. Inter–annual comparisons of call rates were only possible for four locations on Little Barrier Island, and no clear patterns were detected between years (Figures 2.18 and 2.19).

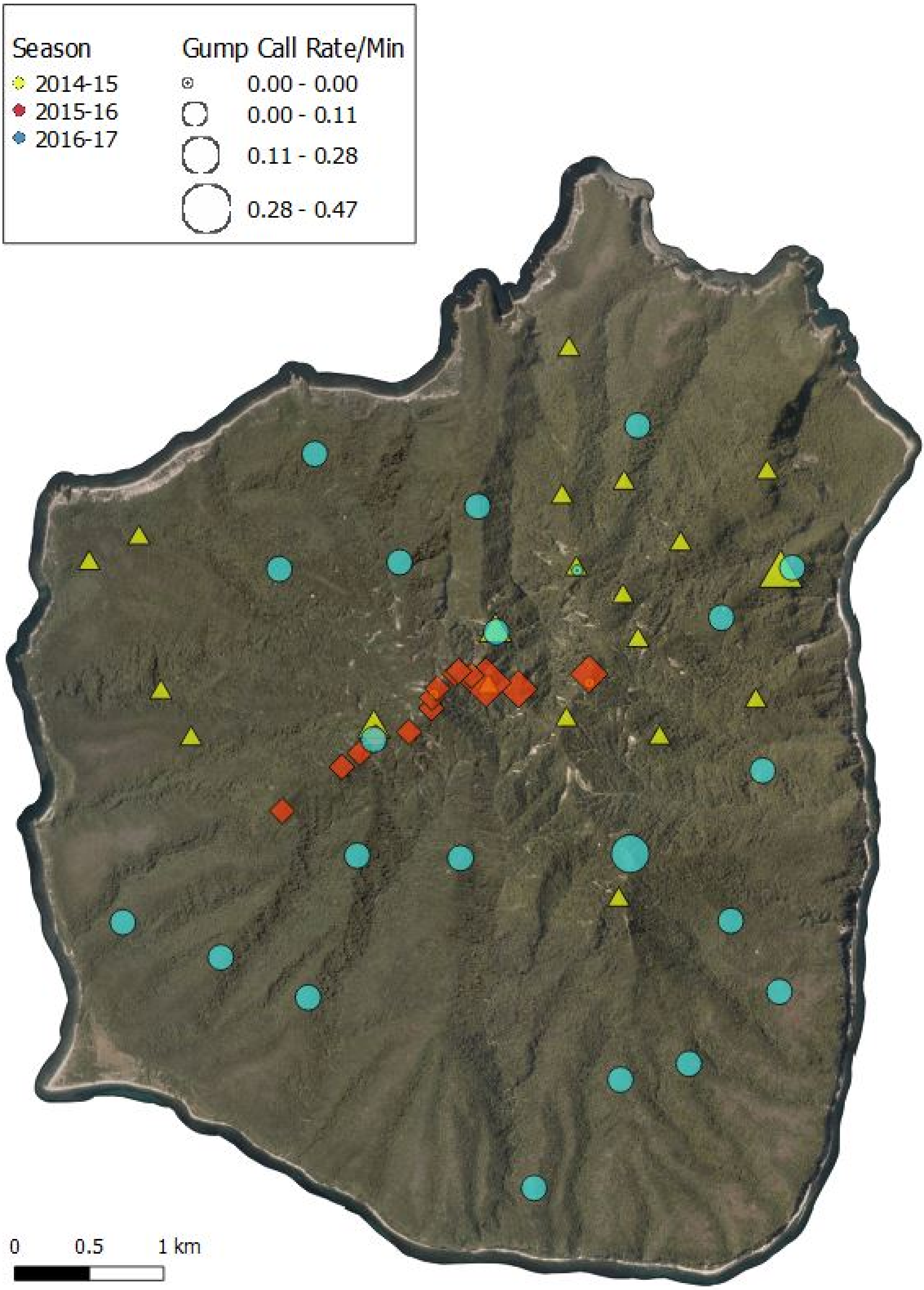

Figure 2.16: Mean 'gump' call rates at each site on Little Barrier Island (December 10 – January 10, 150 to 210 minutes after sunset). Note that because some sites did not collect data during the comparison period, they are not shown here.

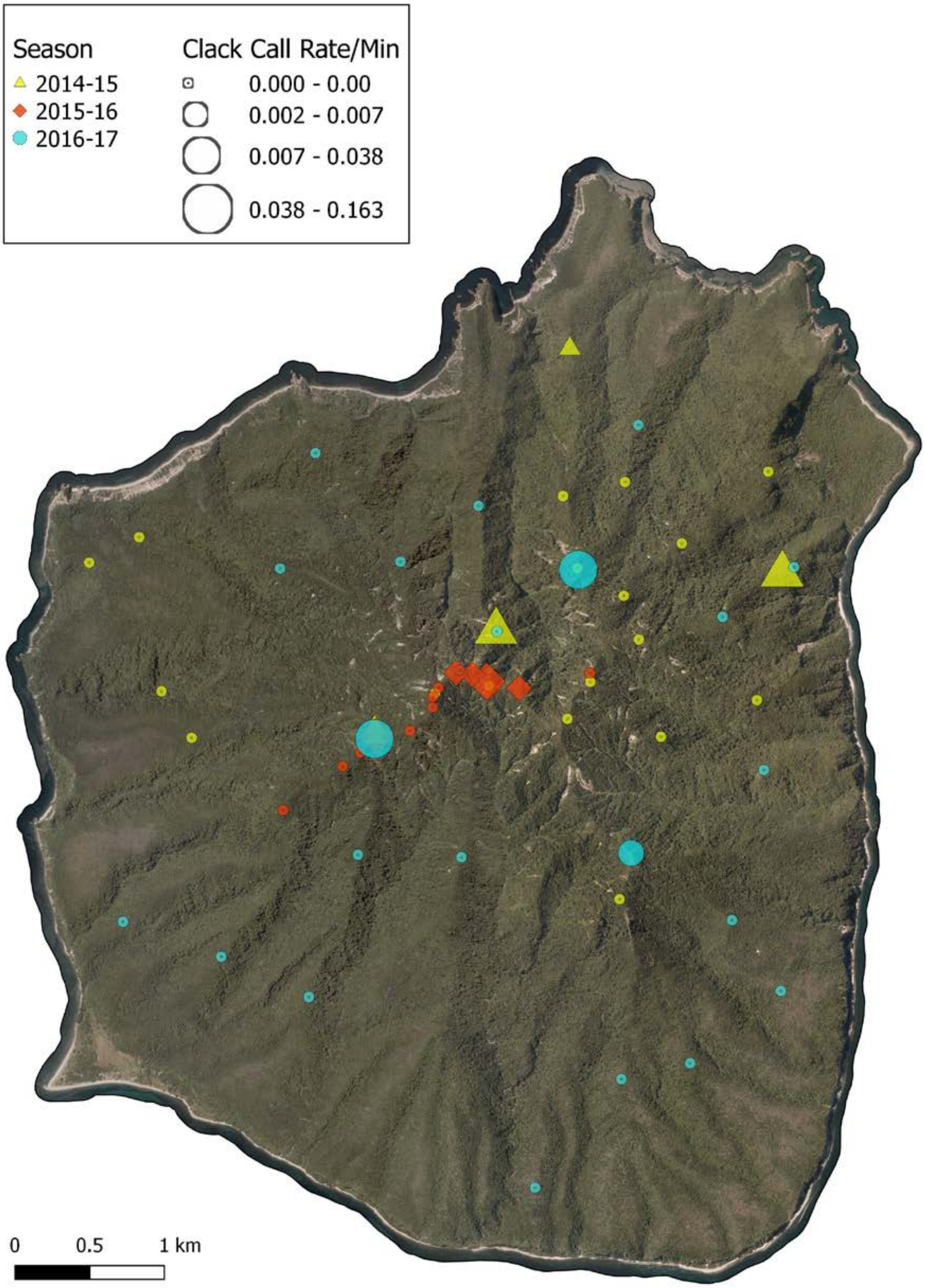

Figure 2.17: Mean 'clack' call rates at each site on Little Barrier Island (December 10 – January 10, 150 to 210 minutes after sunset). Note that because some sites did not collect data during the comparison period, they are not shown here.

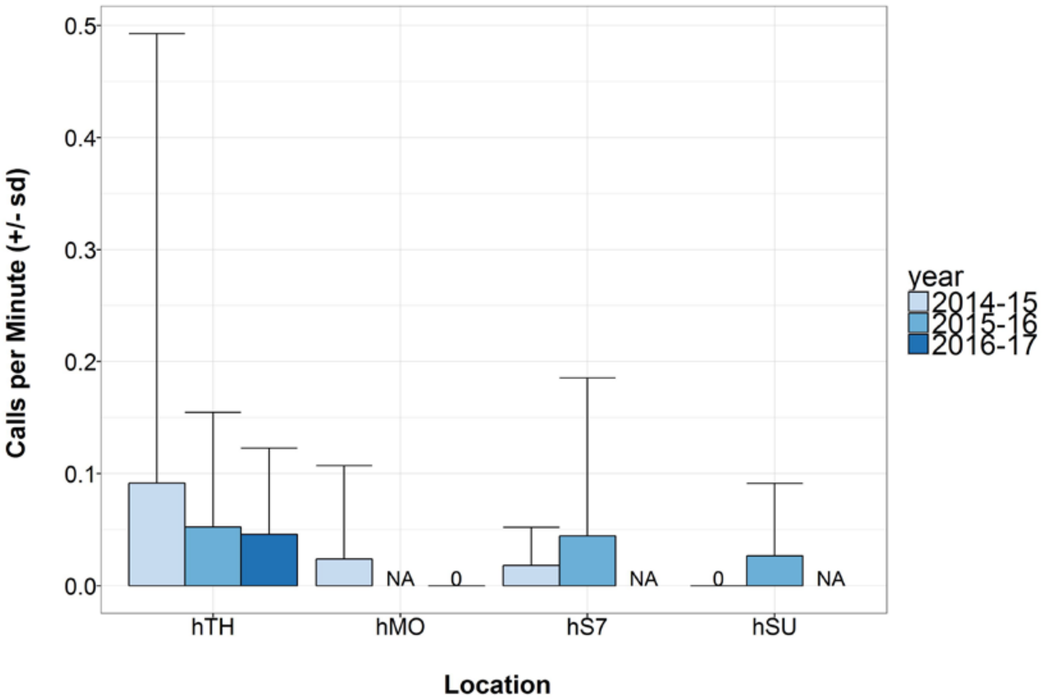

Figure 2.18: **Mean 'gump' call rates (mean number of calls per minute) by survey site and year on Little Barrier Island (December 10 – January 10, 150 to 210 minutes after sunset). An 'NA' indicates no data available for the site/year combination.**

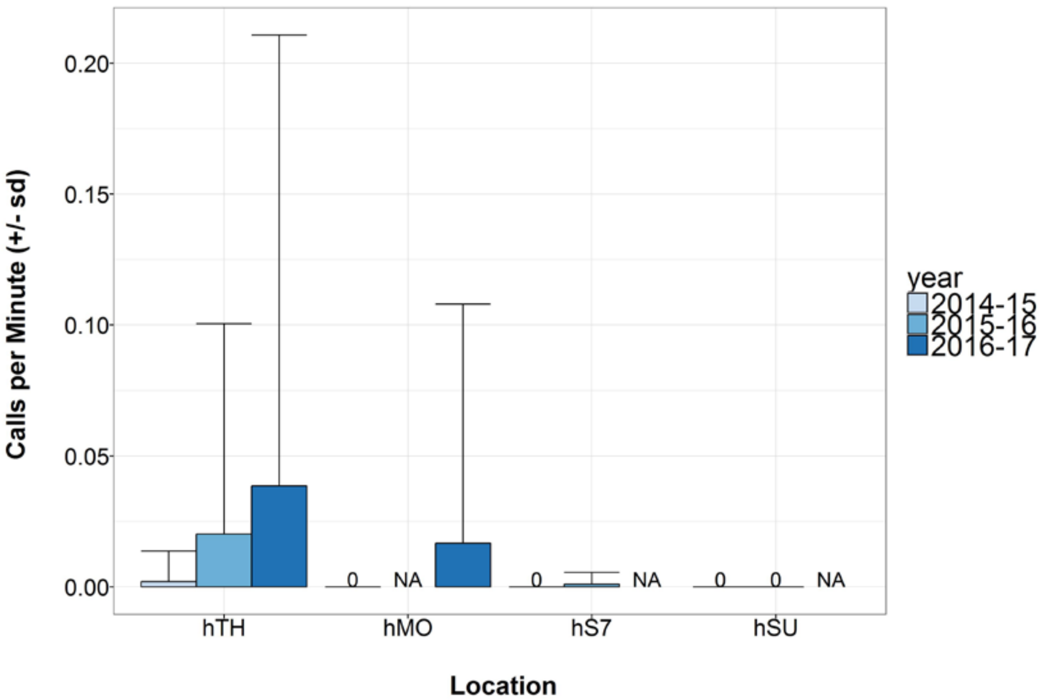

Figure 2.19: **Mean 'clack' call rates (mean number of calls per minute) by survey site and year on Little Barrier Island (December 10–January 10, 150 to 210 minutes after sunset). An 'NA' indicates no data available for the site/year combination.**

2.4 Discussion

We have now created a classification model for both ‘gump’ and ‘clack’ call types that has been used successfully to detect black petrels, and to quantify black petrel call rates on both Little Barrier and Great Barrier Islands.

Spatial patterns in black petrel detections and call rates confirm our understanding that black petrels are concentrated within the two existing study areas: the summit ridges on Little Barrier Island and the Mt Hobson area of Great Barrier Island. Call rates were substantially lower on Little Barrier Island, which also supports our understanding that the breeding population on Great Barrier Island is substantially larger.

Seasonal patterns in black petrel vocal activity were only discernible in the 2014–15 season on Little Barrier Island, and show a reduction in calling from the beginning of February. No such patterns were observed during other seasons, or on Great Barrier Island, however we suspect that this result is most likely due to differences in recording schedules between sites and seasons. Nightly activity pattern analysis was only possible for the 2016–17 season on Great Barrier Island, but showed that both ‘gump’ and ‘clack’ calls are present throughout the entire night. On Little Barrier Island, ‘gump’ call rates were higher relative to ‘clack’ call rates than on Great Barrier Island. It’s likely that this is a consequence of the large number of Cook’s petrels present on Little Barrier Island. Cook’s petrel calls overlap in frequency with black petrel ‘clack’ calls, but not ‘gump’ calls, so on Little Barrier Island, a greater proportion of ‘clack’ calls may be masked from both the detector and the human reviewers.

Our research has demonstrated that passive acoustic monitoring is an effective tool to detect the presence of black petrels, and that it can provide a coarse measure of local abundance/activity rates. As such passive acoustic monitoring will be an effective tool to deploy at sites where black petrel are suspected to occur (other sites on Great Barrier Island/Aotea), or are possibly colonising (i.e. Moehau, Mt Taranaki, areas of intense predator control on GBI/Aotea). Call rates at these sites could be compared with those that we’ve obtained from LBI & Mt Hobson to make rough inferences about likely local burrow densities at these new sites.

2.5 Recommendations

We recommended that passive acoustic monitoring devices be deployed when assessing new sites for black petrel use, to help determine potential population levels.

3. TRENDS IN POPULATION SIZE WITHIN THE MT HOBSON STUDY AREA, GREAT BARRIER ISLAND

3.1 Introduction

Another vital piece of information required to assess the conservation status of black petrels is an accurate estimate of population size.

Estimates of population size for burrowing seabirds are often obtained by extrapolating the results of burrow surveys carried out within a small proportion of occupied breeding habitat across the entire estimated extent of occupied habitat (Parker & Rexer–Huber 2015).

This is difficult to do for black petrels, given the large size of the two islands on which these birds breed (Great Barrier and Little Barrier islands), the rugged topography, dense vegetation and our imperfect knowledge of the breeding distribution of this species on these two islands.

Previous surveys have established that black petrels are concentrated along the summit ridges of Little Barrier Island, and within a small area of high–altitude forest in the vicinity of Mt Hobson/Hirakimata on GBI.

Early population estimates for the 35 ha Mt Hobson/Hirakimata study area were derived by extrapolating the results of surveys carried out within the nine 40 m x 40 m census grids. However, it's now known that these estimates are likely to have overestimated the number of breeding black petrels within the study area, due to the fact that these census grids had been established in areas with particularly high burrow densities (Bell et al. 2007).

To reduce this bias, random transects have been surveyed within the study area in the 2004–05, 2009–10 and 2012–13 breeding seasons. Burrow density and occupancy rates derived from these transect surveys were extrapolated across the study area after first stratifying the 35 ha study area into four 'habitat' grades representing differences in burrow density, vegetation and topography encountered along the transects.

For these population estimates we have extrapolated from the number of breeding burrows recorded on transects to obtain a population estimate of the number of breeding pairs in the 35 ha study area.

3.2 Methods

3.2.1 Census grids

Census grids are surveyed annually as part of the ongoing demographic programme, and burrows are checked for occupants, breeding status and breeding success as described previously. In addition each census grid is searched to locate any new burrows that have been developed within the study grid.

3.2.2 Transects

Transects survey methodology followed the previous 2004–05, 2009–2010 and 2012–13 breeding season surveys (Bell et al. 2007, Bell et al. 2010, Bell et al. 2013). Transect start points and bearing (transect direction) were randomly generated from within the 35 ha Mt Hobson/Hirakimata study area. Transects were 400 m in length, but were ended short of this if they extended beyond the study area or encountered cliffs or bluffs. In the field, transects were split into 20 m lengths, and burrows searched for in a 2m wide strip on either side of the transect (4 m wide total transect width). The habitat within each of these 20 m sections was graded as one of four habitat classes.
Black petrel habitat grade classes:

- High – Mature primary forest on ridges and spurs, high burrow density (more than 100 burrows/ha), 4.669 ha within the Mt Hobson/Hirakimata study area.
- Medium – Usually mature primary forest, but also older secondary regrowth forest, upper slopes, with medium burrow density (50–100 burrows/ha), 15.301 ha within the study area.
- Low – Secondary regrowth forest on lower slopes and flat ground, often boggy, with low burrow density (fewer than 50 burrows/ha), 13.561 ha within the study area.
- Non–petrel habitat – stream beds, cliffs, slips and swampy areas with no burrows, 1.751 ha of the study area.

Population estimates were achieved from extrapolated the recorded number of breeding burrows from transects stratifying for the habitat classes.

3.3 Results

3.3.1 Census grids

Nine census grids were re–surveyed and burrow occupancy determined. A total of 103 breeding burrows were found within census grids (mean 11.4 breeding burrows/grid, range 2–21 breeding burrows). With a mean breeding burrow density of 0.007153 burrows/m² (range 0.00125–0.013125 burrows/m²) (Table 3.1).

Table 3.1. Number of breeding burrows, and breeding burrow density in the nine black petrel census grids from within the 3 ha study area at the summit of Mt Hobson/Hirakimata during the 2016–17 breeding season.

Census grid	Breeding burrows	Breeding burrow density (burrows/m²)
Kauri Dam 1	17	0.010625
Kauri Dam 2	21	0.013125
Kauri Dam 3	6	0.00375
Palmers 1	20	0.0125
Palmers 2	8	0.005
Palmers 3	5	0.003125
South Forks 1	13	0.008125
South Forks 2	11	0.006875
South Forks 3	2	0.00125
Average	11.4	0.007153
SD		0.004009
95% CI		0.002619

As the census grids all occur within the high–grade petrel habitat, extrapolating this across the 4.6 ha of high–grade habitat from within the Mt Hobson/Hirakimata study area, the breeding population is estimated at 334 breeding pairs (95% c.i.: 212–456 breeding pairs).

The population estimate for the high–grade petrel habitat from the Mt Hobson/Hirakimata study area has been relatively stable since 1995 with a mean of 291 breeding pairs (Figure 3.1).

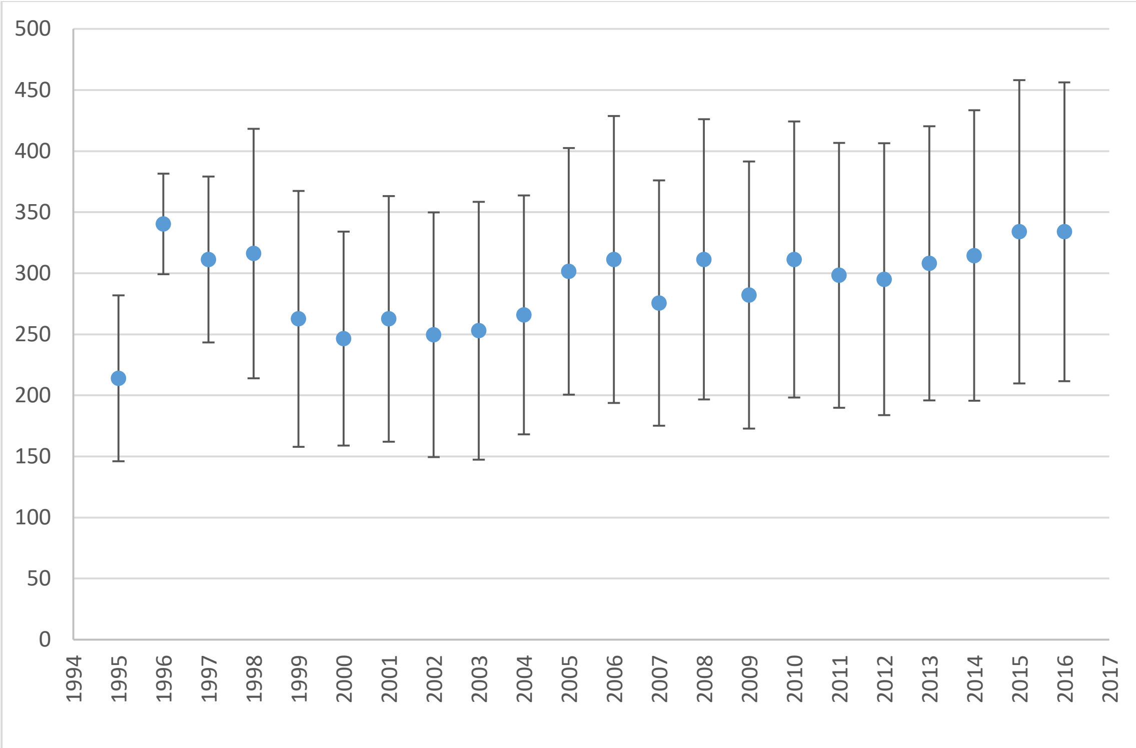

Figure 3.1. Annual black petrel breeding pairs population estimate for the high–grade petrel habitat derived from census grids for the Mt Hobson/Hirakimata study area 1995–2016.

3.3.2 Transects

A total of 20 random transects were surveyed from within the 35 ha study area at the summit of Mt Hobson/Hirakimata during the 2016–17 breeding season, with a total of 176 breeding burrows recorded (Table 3.2).

Table 3.2: Transect length, breeding, non–breeding and empty black petrel burrows found in each transect from the 35 ha study area.

Transect	Length	Breeding	Non–breeding	Empty	Total
1	246	12	1	3	16
2	400	6	2	5	13
3	400	17	3	5	25
4	400	4	9	3	16
5	400	5	5	5	15
6	420	9	3	6	18
7	240	4	1	2	7
8	400	11	4	4	19
9	90	6	1	2	9
10	120	5	1	0	6
11	400	25	4	5	34
12	289	21	4	7	32
13	400	11	4	5	20
14	400	8	2	1	11
15	400	4	5	3	12
16	240	3	0	0	3
17	142	3	0	4	7
18	320	11	1	3	15
19	400	6	1	3	10
20	400	5	2	3	10
Total	6 507	176	53	69	298

Stratifying for habitat the population estimate for Black Petrel from within the 35 ha Mt Hobson/Hirakimata study area is 2 427 breeding pairs (95% c.i.: 1 713–3 141) (Table 3.3).

Table 3.3. Breeding population estimate of black petrel in the 35 ha Mt Hobson/Hirakimata study area 2016–17 breeding season.

Habitat	Mean burrow density (burrows/m²)	s.d.	95% c.i.	Habitat class area (m²)	Population estimate	95% c.i.
High	0.011203	0.006914	0.003912	46 690	523	340 – 706
Medium	0.008081	0.005293	0.00232	153 010	1 237	882 – 1 591
Low	0.004919	0.002391	0.0013	135 610	667	491 – 843
Total					2 427	1 713 – 3 140

Data from 2004–05, 2009–10 and 2012–13 were reanalysed to determine the population trend. The breeding population in 2004–05 and 2009–10 was estimated at approximately 1 000 pairs, with the population estimate in 2012–13 and 2016–17 estimated at approximately 2 500 pairs (Figure 3.2).

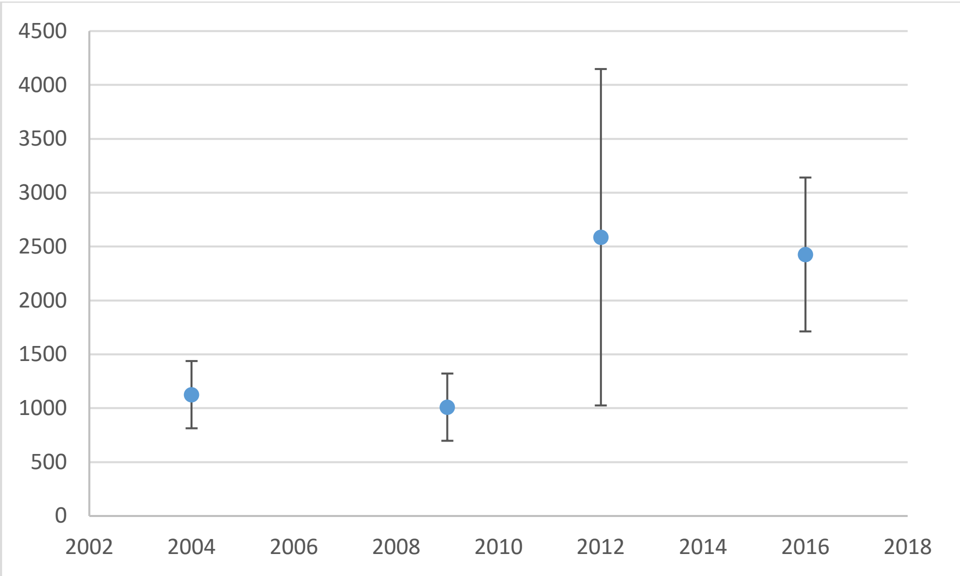

Figure 3.2. Breeding population estimates of black petrel in the 35 ha Mt Hobson/Hirakimata study area 2004–05 to 2016–17 breeding seasons.

3.4 Discussion

The two population estimate methods for black petrels are producing differing results. Extrapolating from the nine census grids from the Mt Hobson/Hirakimata study area indicates that the population has likely been stable for the past 20 years. However, this conflicts with the transect survey results, which indicate an increase from the same area of high–grade habitat (2016 transect population estimate for 4.6ha high grade habitat of 523 pairs compared to 334 breeding pairs from census grids).

The transect survey results suggest that the black petrel population from within the study area is increasing, however caution needs to be taken when interpreting the results. The results of the two most recent surveys (2012–13 and 2016–17) are significantly higher than the original 2004–05 and 2009–10 results. This suggests that over time there has been an improvement in burrow detection probability that has led to an improved population estimate in the last two survey periods.

Work using a seabird detection dog has indicated that a number of black petrel are breeding in the Mount Heale/ Hogs Back area, outside the 35 ha Mt Hobson/ Hirakimata study area. Further work is warranted to determine the population size of black petrel on Great Barrier Island by undertaking survey work outside of the study area. An island–wide population estimate of black petrels using a seabird dog should be carried out to gain a precise estimate of the Great Barrier Island/Aotea black petrel population.

3.5 Recommendations

We recommend that a systematic survey to estimate the Great Barrier Island/Aotea black petrel population be undertaken. This should be a stratified, random, quadrat survey using a seabird detection dog to improve burrow detection probability.

4. A PILOT TRIAL OF SATELLITE TRACKING DEVICES ON JUVENILE BLACK PETRELS

4.1 Introduction

Black petrels have been identified as the seabird species most at risk of population decline as a result of incidental captures in commercial fisheries within New Zealand's Exclusive Economic Zone (Richard & Abraham 2013). Under Article 61 of the United Nations Convention on the Law of the Sea 1982 (UNCLOS), the New Zealand government has an international obligation to deal with threats to black petrels stemming from commercial fishing operations. Specifically, New Zealand is obliged to ensure 'through proper conservation and management measures, that the maintenance of the living resources in the Exclusive Economic Zone (EEZ) is not endangered by over–exploitation' (Article 61(2); UNCLOS 1982). Furthermore, New Zealand is obliged to ensure that these measures 'take into consideration the effects on species that are associated with, or dependent upon harvested species, with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened' (Article 61(4); UNCLOS 1982).

Responsibility for the implementation of Article 61 of UNCLOS in New Zealand sits primarily with the Ministry for Primary Industries (MPI). To meet this obligation, MPI have prepared the National Plan of Action – 2013 (NPOA), with the objective of maintaining the 'incidental mortality of seabirds in New Zealand fisheries…at or below a level that allows for the maintenance at a favourable conservation status, or recovery to a more favourable conservation status for all New Zealand seabird populations (Ministry for Primary Industries, 2013). A second objective of the NPOA involves producing 'research outputs relating to seabird biology, demography and ecology [that] provide a robust basis for understanding and mitigating seabird incidental mortality' (Ministry for Primary Industries, 2013).

Although it's known that black petrels forage widely at sea, and migrate to waters off the eastern tropical Pacific during the Southern Hemisphere winter, we still have only a very poor understanding of their spatial distribution at sea, both within New Zealand's EEZ during the breeding season and in the eastern Pacific during winter months (Pitman & Balance 1992; Spear et al. 2005). This poor understanding of spatio–temporal patterns in the at–sea distribution of black petrels is limiting our ability to assess at–sea threats, specifically our ability to predict when and where black petrels are likely to be at highest risk of being caught as bycatch in commercial fisheries (Abraham et al. 2015). Without an accurate understanding of these patterns of risk, our ability to plan and implement measures to minimise this risk will also be limited.

The recent advent of miniaturised GPS and geolocator tracking technology has created the opportunity to fill these gaps in our knowledge (Latham et al. 2015). In 2006, GPS loggers were successfully deployed for the first time on nine adult black petrels that were rearing chicks on Aotea/Great Barrier Island. This work showed that birds travelled up to 1128 km from the colony during chick provisioning trips, and travelled between 248 and 2396 km per trip, spending a significant amount of time foraging in the vicinity of the continental shelf off the north–east coast of the northern North Island (Freeman et al. 2010). Further tracking work was carried out between 2005 and 2010, using both geolocators and GPS data loggers. Much of this tracking effort was focused on mapping habitat use by breeding birds during incubation and chick rearing, and found that black petrels ranged widely from the Tasman Sea in the west to waters off East Cape in the east (Bell et al. 2011; 2013). Habitat use varied substantially from year to year, a likely response to changes in the spatial patterns of food availability. A number of devices were also deployed on adults migrating to wintering grounds in the eastern Pacific, and the tracking data showed that birds spent a great deal of time within a relatively small area of the eastern Pacific, off the coasts of Ecuador and the Galapagos Islands (Bell et al. 2011).

The GPS and geolocator tracking work that has been done to date has by necessity been restricted to tracking breeding adults from known study burrows on both Little Barrier and Great Barrier Islands.

The reason for this is that the devices that have been deployed need to be recovered again in order for the tracking data to be retrieved. Because local survival rates of juveniles are so low, and because those that do return to their natal colonies don't do so for at least 2–3 years, the probability of recovering devices from juvenile black petrels is very low. The recent advent of GPS and satellite tracking devices with data transmitting capabilities has now made it possible to track the post–natal dispersal of juvenile black petrels once they leave the breeding colonies on Little Barrier and Great Barrier Islands, and for the first time compare whether the dispersal behaviour, distribution and habitat use of juvenile birds differs from those of adult birds.

The purpose of this part of the project was to test four different models of satellite tracking devices, to compare their performance and the quality and quantity of the data that they collect when deployed on juvenile black petrels departing from their natal colony. This assessment of the performance of these devices will be useful when it comes to selecting the most appropriate satellite tracking device for a larger project aimed at determining the at–sea distribution and habitat use of juvenile black petrels.

4.2 Methods

Six satellite tracking devices were deployed on chicks departing the Great Barrier Island colony between the 7 and 14 May 2017. Four different models of devices were deployed, and their weights, costs and specifications are summarised in Table 4.1 below.

These devices were deployed on fully grown black petrel chicks assessed to be within a few days of fledging. All chicks were chosen from known study burrows within the 35 ha study area in the vicinity of Mt Hobson/Hirakimata. Chicks were first weighed using 1.5 km Pesola™ scales to determine whether or not they were heavy enough to carry the devices, and also to assess how likely the birds were to fledge over the following few nights. These birds had weights that ranged from 920 – 980 g, so the total instrument load of these devices ranged from 2.0 – 2.7% of the birds' body weights. The devices were attached to contour feathers on the birds' backs, above the centre of gravity, using 5–6 strips of Tesa™ tape. Application of the devices took between 12 and 23 minutes. Five contour feathers were also collected from each bird, and were subsequently sent to Massey University's Equine Parentage and Animal Genetics Services Centre for DNA sex determination.

The Telonics™, GeoTrak™ and Desert Star™ devices were pre–programmed by the manufacturer to transmit periodic messages to Argos instruments on polar–orbiting satellites passing overhead. The Lotek™ devices were programmed by the user to take 84 GPS fixes at pre–defined intervals, and transmitted these GPS data to Argos satellites in a single batch once all 84 fixes had been taken. Once received, these transmitted messages are stored on the satellites' onboard recorder, then re–transmitted to receiving stations on the ground as the satellite passed overhead. The messages were then sent on to an Argos processing centre, where locations were calculated and data were processed. For the Telonics™, GeoTrak™ and Desert Star™ devices, location data were computed based on Doppler effect measurements. For the Lotek™ devices, GPS position fixes were transmitted, providing more precise location data in addition to the calculated Doppler location fixes. Location data were downloaded via the ArgosWeb web interface (https://argos–system.clsamerica.com/argos–cwi2/login.html), then processed using manufacturers' proprietary software before being visualised in ArcMap 10™.

Table 4.1: Product specifications for the four makes and models of satellite tracking devices used in this trial.

Device model	No. trialled	Cost per unit (NZD)	Weight	Power source	Location fix method	Location fix frequency
Telonics™ TAV2618	1	$2550	15g	Battery (min 233 hours)	Argos Doppler	Four hourly
GeoTrak™ GT20GB	1	$3700	20g	Battery (min 650 hours)	Argos Doppler	Eight hours on, 24 hours off
Lotek™ Pinpoint GPS Argos 240	2	$2375	15g	Battery (lifespan depends on location fix frequency)	GPS (Argos upload)	Four and six hourly respectively
Desert Star SeaTag–TT	2	$1375	17g	Solar panel (unlimited lifespan)	Argos Doppler	Four hourly

4.3 Results

The two chicks on which the Desert Star™ devices were deployed unfortunately lost too much weight prior to fledging (weighed less than 830g), so these two devices were removed from the birds on the day that the field team left the island, and were not deployed. The remaining four chicks all fledged successfully, and all of these devices returned either complete or partial tracks of the birds' subsequent movements.

Chick No. H42832 (a male), wearing the GeoTrak™ device, left its natal burrow on Great Barrier Island on the night of 10 of May. Once leaving the island, the bird followed a meandering south–westerly route, crossing the Auckland isthmus before taking the southerly, inland route through the Waikato, before turning north–east and crash–landing in an underweight and exhausted state in a paddock near Paeroa on 12 May (Figure 4.1). The bird was subsequently picked up by a member of public, handed in to the Department of Conservation and was then transferred to the care of Thames Bird Rescue. The device was removed from the bird and was returned to Wildlife management International Ltd (WMIL), and the bird was kept in captivity for two days before being released at a healthy weight on the Firth of Thames.

Figure 4.1: GPS track of a male black petrel chick H42832 that fledged from its natal burrow on Great Barrier Island overnight between 10 and 11 May, 2017.

Chick No. H42831 (a male), wearing the Telonics™ device, left its natal burrow on Great Barrier Island on the night 13 May. This bird was tracked for the next 60 days, until the device ceased transmitting on 12 July. For the first 24 days the bird travelled in an easterly direction, to approximately 25°S 125°W, a position near the Pitcairn Islands, approximately 5 500 km ENE of New Zealand. The bird then travelled in a northerly direction for the next 32 days, crossing the Equator on the 23rd June and continuing to 16°N 120°W, a position some 1 270 km SW of the southernmost tip of Baja California before the device stopped transmitting (Figure 4.2). Over the 60 days that this device transmitted for, this bird travelled a minimum distance of 15 914 km. The resulting track represents the first, and longest, GPS track to have been obtained describing the post–natal dispersal of a juvenile black petrel.

Chick No. H42973 (a female), wearing a Pinpoint GPS Argos™ device, left its natal burrow on Great Barrier Island on the night 15 May. The bird was tracked for the next 12 days, until the device ceased taking location fixes on 27 May. During this time, the bird spent several days in waters off the west coast of the North Island, before travelling in an easterly direction across the Pacific Ocean (Figure 4.3). The bird travelled a minimum distance of 7 316 km, and its last known location was at approximately 30°S 134°W, some 4 684 km ENE of New Zealand and 674 km SW of the Pitcairn Islands.

Chick No. H42833, also a female wearing a Pinpoint GPS Argos™ device, left its natal burrow on Great Barrier Island on the night 10 of May. The bird was tracked for 23 days between 13 May and 6 June. During this time, the bird spent several days in waters off the west coast of the North Island, before travelling in an ENE direction across the Pacific Ocean (Figure 4.4). The bird travelled a minimum distance of 8 182 km, and its last known location was at approximately 33°S 125°W, some 5 352 km ENE of New Zealand and 1 000 km south of the Pitcairn Islands.

All three birds followed similar routes eastward from New Zealand for the first 1 800 km, before their tracks began to diverge. All three birds appeared to travel fairly rapidly eastwards to longitudes 130–150°W, before their progress appeared to slow, possibly indicating a change in behaviour or weather conditions (Figure 4.5).

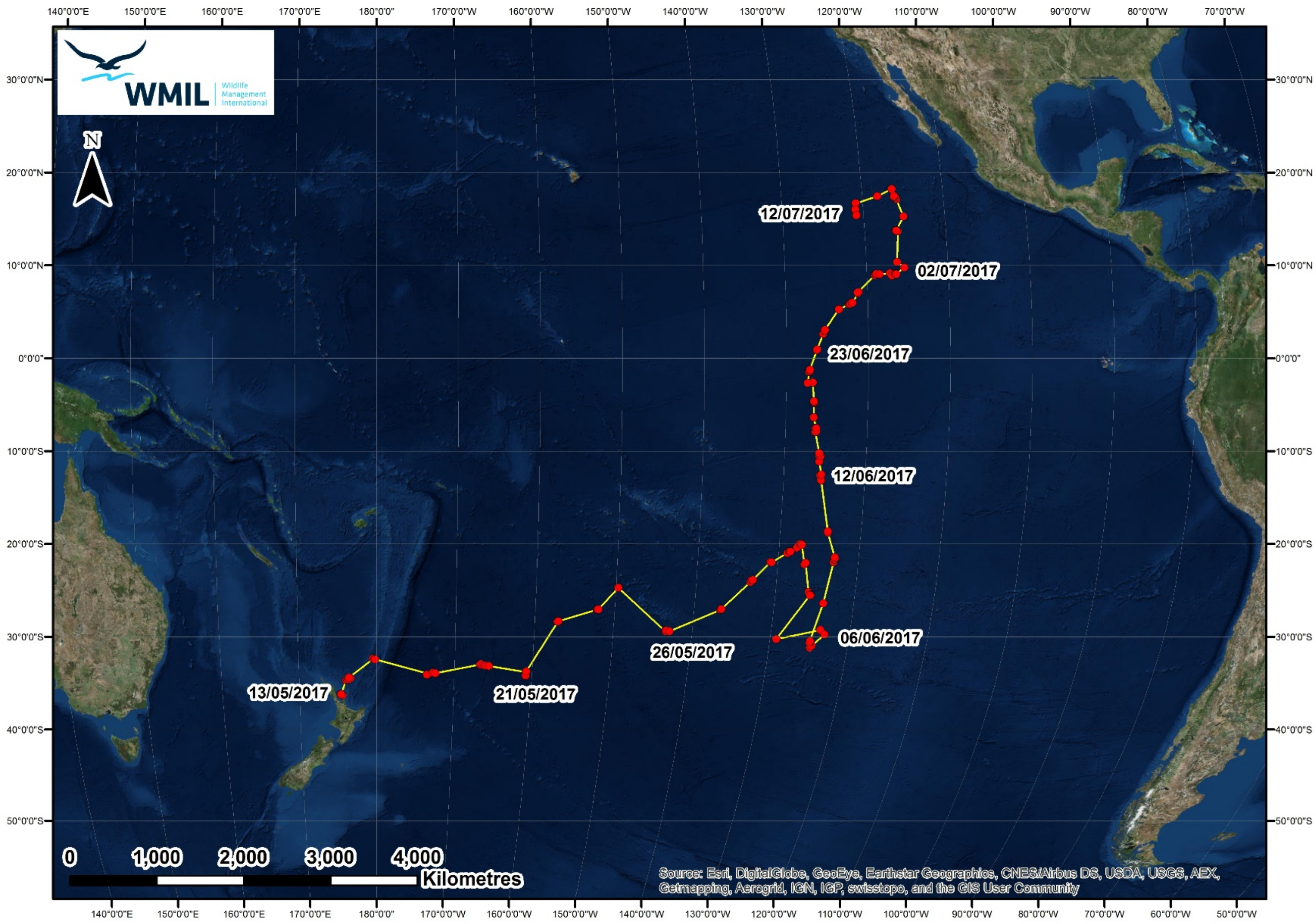

Figure 4.2: GPS track of a male black petrel chick H42831 that fledged from its natal burrow on Great Barrier Island overnight between 13 and 14 May, 2017.

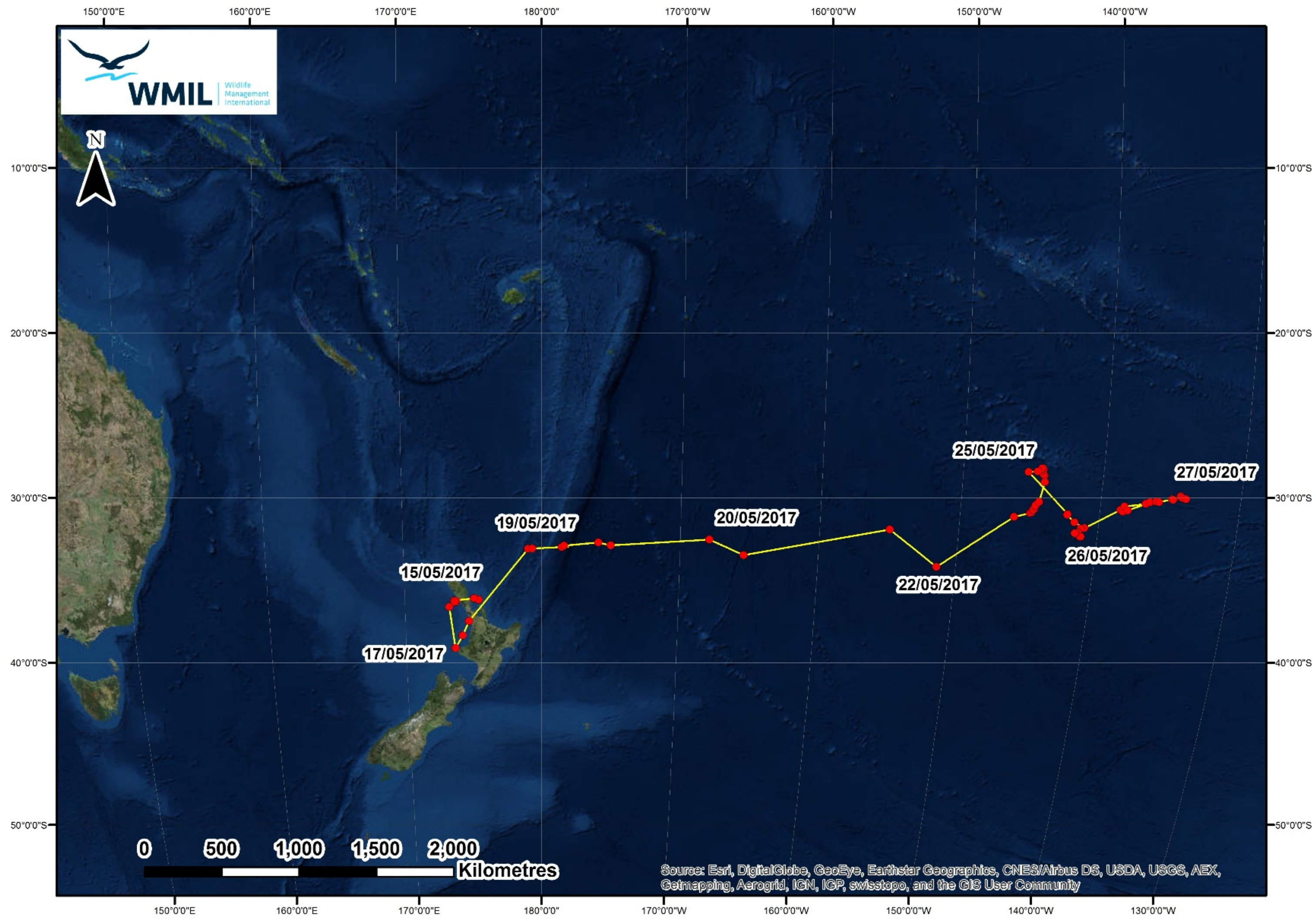

Figure 4.3: **GPS track of a female black petrel chick H42973 that fledged from its natal burrow on Great Barrier Island overnight between 15 and 16 May, 2017.**

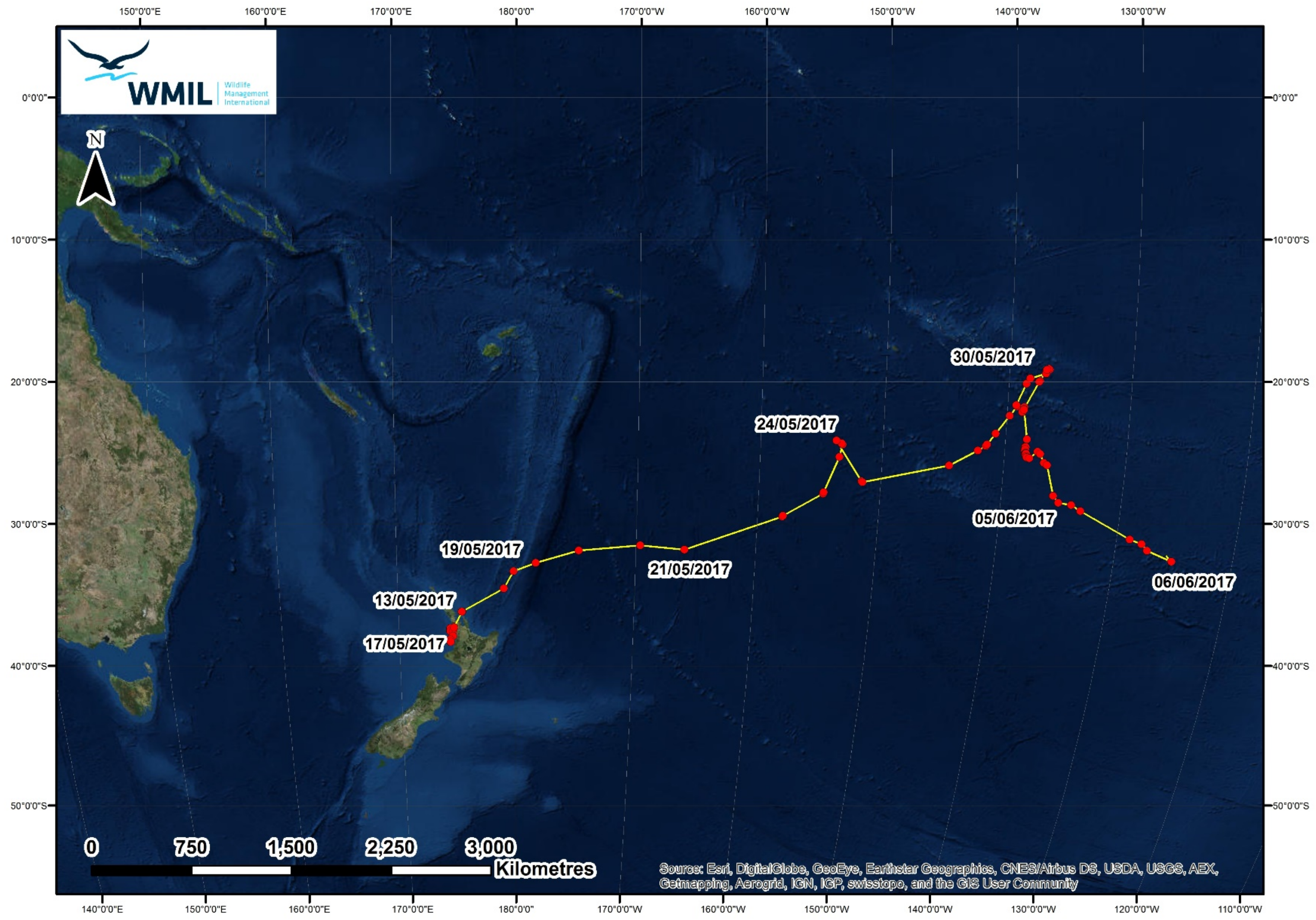

Figure 4.4: GPS track of a female black petrel chick H42833 that fledged from its natal burrow on Great Barrier Island overnight between the 11 and 12 May, 2017.

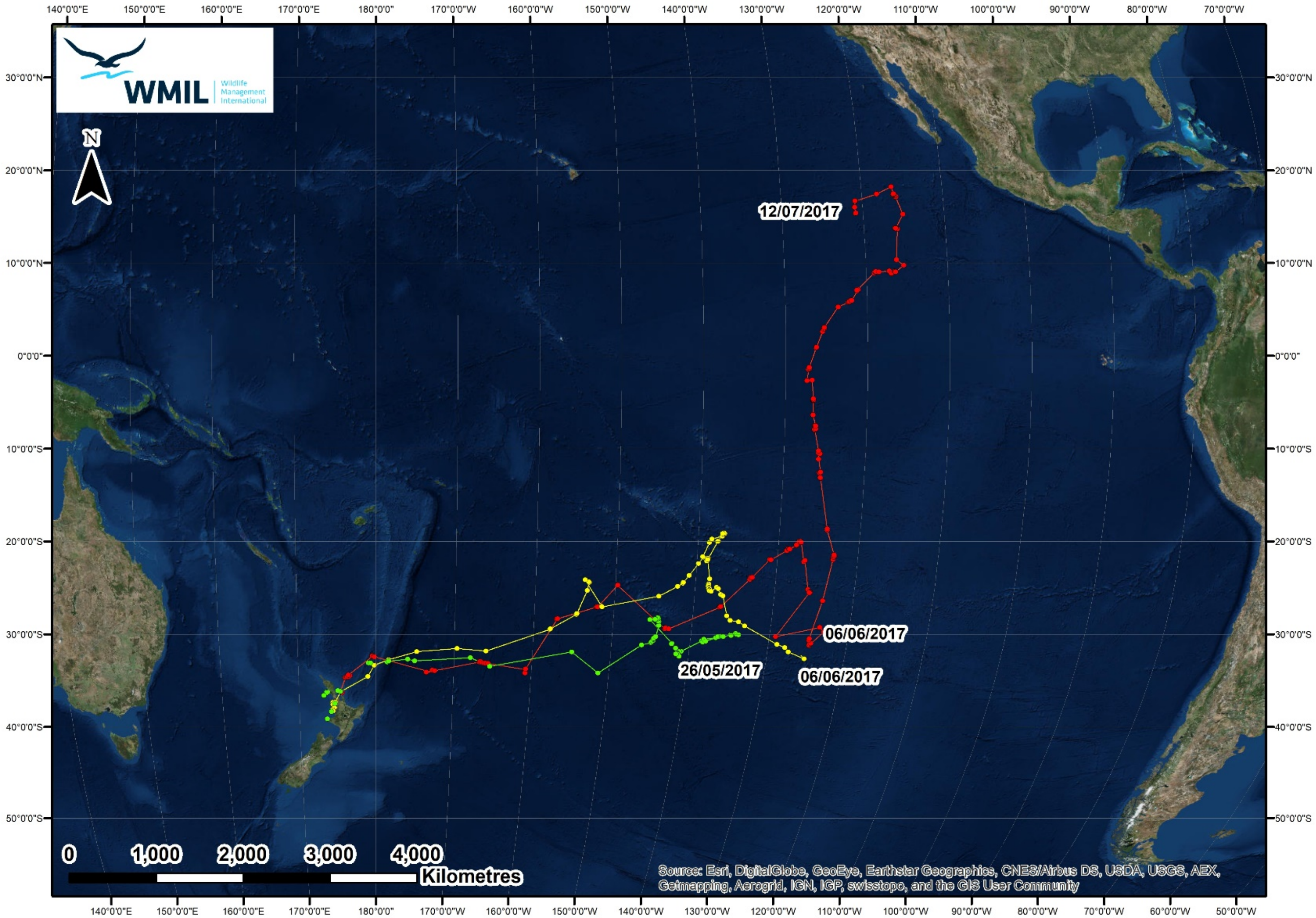

Figure 4.5: GPS tracks of three black petrel chicks that fledged from Great Barrier Island in May 2017. The red track is bird H42831, a male carrying a Telonics™ GPS device; the green track is bird H42973, a female carrying a Pinpoint GPS Argos™ device and the yellow track is bird H42833, another female carrying a Pinpoint GPS Argos™ device.

4.4 Discussion

Of the four models of satellite tracking device that we trialled, the Telonics™ device had the best performance. This device collected data for a total of 60 days as the bird travelled 15 914 km across the Pacific Ocean to waters off the western coast of Mexico. This represents the the first, and longest, GPS track to have been obtained describing the post–natal dispersal of a juvenile black petrel. This device was also relatively user–friendly, both in terms of pre–programming and the retrieval and processing of data; and its size and shape made it one of the easiest devices to fit to the bird.

The Lotek™ devices had the second–best performance in terms of the data collected. These two devices collected data for 12 and 23 days, as these birds travelled 7 316 km and 8 182 km respectively in an easterly direction across the Pacific Ocean. In comparison to the Telonics™ device however, these Lotek™ devices were substantially more difficult to use, being relatively complicated to programme and charge and requiring more data post–processing. These devices also carried the added risk that GPS data were transmitted in a single batch once all of the 84 programmed ‘fixes’ had been recorded, rather than being transmitted as they were recorded. These devices therefore carried a much higher risk of not returning any data at all, should the devices have malfunctioned part–way through deployment, or had they fallen off the bird.

The performance of the GeoTrak™ device was somewhat inconclusive, due to the fact that the bird that carried this device became disorientated and came to ground in a paddock in rural Waikato. It is possible however, that the device itself contributed to this outcome (it was the bulkiest and heaviest of the models that we tested), so as a precautionary approach we’d not recommend that this device be deployed on black petrels without carrying out further field trials.

Due to the fact that the two Desert Star™ devices were removed from the birds that they were deployed on before they left their natal burrows, we were unable to assess the performance of this model of device. However, we did notice that it took several days of solar charging before these devices began to transmit messages to Argos, so care needs to be taken to ensure that these devices are fully charged and are transmitting messages before being deployed on birds. We also noticed that once charged, these devices did not hold their charge for long if not left exposed to sunlight. Therefore, these devices may not be the best to use for burrow–nesting seabirds.

Due to the very small sample sizes involved, we cannot assume that the data collected from these three birds are representative of the at–sea distribution or movements of juvenile black petrels. However, it is clear that these three birds have followed a similar eastward migration route to that used by adult black petrels tracked in previous years (Bell et al. 2011). Once reaching the eastern Pacific, juvenile H42831 proceeded north to waters of the west coast of Mexico (Figure 4.2) rather than to the more southerly wintering range ‘hotspot’ off the west coast of Ecuador, favoured by adult black petrels tracked in previous years (Bell et al. 2011). Given that adult black petrels were found to heavily favour a relatively small sea area off the coast of Ecuador during winter months (Bell et al. 2011), but that black petrels are also known to range much more widely in the eastern Pacific (Pitman & Balance 1992, Spear et al. 2005), it’s possible that juvenile black petrels have a much wider distribution in the eastern Pacific than adult birds.

4.5 Recommendations

Based on the results of this trial, we recommend the use of Telonics™ TAV2618 devices for tracking the at–sea movements, distribution and habitat use of juvenile black petrels. Although this was the second–most expensive device trialled, this device was relatively user–friendly, easy to deploy on the bird, performed the longest in the field and returned the largest quantity of data of any of the four devices trialled.

We also recommend that further efforts be made to test the performance of the Desert Star™ devices however. At almost half of the price of the Telonics™ device, and with built–in solar panels, these Desert StarTM devices have the potential to function for even longer periods than the Telonics™ device, and could potentially provide a larger quantity of at–sea location data for the same price. As satellite tracking technology progresses further, other devices may also be available for future efficacy trials.

We recommend that a larger–scale satellite tracking study be carried out on juvenile black petrels during their natal dispersal, to determine whether their at–sea distribution and habitat use differs significantly from adult birds. Given the low apparent local survival rates of juvenile birds, this should be considered an important and necessary step towards assessing whether human–related threats are having a greater adverse effect on juvenile black petrels in relation to adult birds.

5. A SUMMARY OF BLACK PETREL ADVOCACY WORK COMPLETED DURING THE 2016–17 FIELD SEASON

During the 2016–17 field season, the WMIL team continued to engage with the fishing industry, local communities and the media to further the advocacy work carried out during previous field seasons. Key components to this work included responding to requests for talks and presentations, and hosting visitors to the Mt Hobson/Hirakimata study area on Great Barrier Island.

In early November 2016, Biz Bell delivered a seminar and led a guided walk to the Mt Hobson/Hirakimata study for attendees of the Great Barrier Island 'Love Our Birds' weekend organised by the Department of Conservation and the Great Barrier Local Board.

During the November 2016 fieldtrip to Great Barrier Island, the WMIL team hosted a visit by Kennedy Warne (Radio NZ), who subsequently put together a segment on the *Nine to Noon* radio programme about Great Barrier's black petrels, which went to air on 19 December, 2016 (http://www.radionz.co.nz/national/programmes/ninetonoon/audio/201828260/off–the–beaten–track–with–kennedy–warne; accessed 28/08/2017). Another visitor to the study area during November 2016 was Elizabeth Easther and her film crew, who were filming a segment on the black petrels for inclusion in the *Islands of the Gulf* TV series, a documentary series on the Hauraki Gulf scheduled to be aired on TVNZ 1 in 2018. Rachel Hufton, one of the WMIL volunteers who assisted with this trip also subsequently wrote a blog post for the Forest & Bird website describing her experiences participating on this project (Figure 5.1)

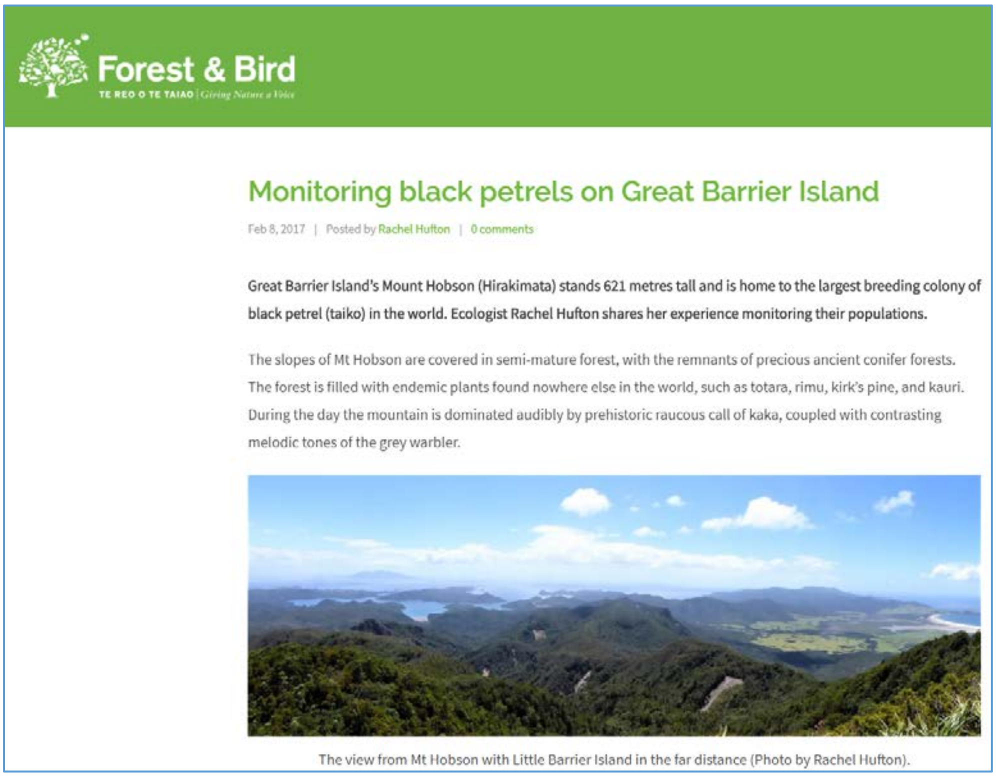

Figure 5.1: WMIL volunteer Rachel Hufton's blog post on the Forest & Bird website (http://blog.forestandbird.org.nz/monitoring–black–petrels–on–great–barrier–island/, accessed 28/08/2017)

In February 2017, Alanna Matamaru–Smith from the Cook Island Te Ipukarea Society joined WMIL staff member Dan Burgin on the Little Barrier Island fieldtrip. Alanna assisted with both WMIL's black petrel fieldwork, as well as the Northern NZ Seabird Trust's New Zealand storm petrel fieldwork, in order to acquire skills and experience with handling, banding and monitoring seabirds for use in the Cook Islands. Following her trip, Alanna wrote two articles describing her experiences, for the *Cook Islands News* and *Forest & Bird* magazine (Figure 5.2).


Sun Aug 27 2017 13:02:29

Cook Islands NEWS
AS SOLID AS THE ISLANDS WE STAND FOR

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From a 'petrol head' to keen 'petrel head'

Print | Email | 0 Comment

Tuesday February 28, 2017 | Written by | Published in Local

A fluffy Black Petrel chick being checked by Dan Burgin from Wildlife Management International (New Zealand). 17022416

An online dictionary defines a "petrol head" as a person who is overly reliant on the use of their car, resisting any suggestion to use other means of transport.

As readers will know from our articles in the past, that hardly sounds like a description of an employee of Te Ipukarea Society, as we actively promote cycling and electric vehicles as a preferred means of transport. However, it seems we do now have our very own "Petrel Head"!

Petrels are tube-nosed seabirds, and a number of different petrel species are known from the Cook Islands. In order to learn more about these birds, and how to survey them, Te Ipukarea Society project officer Alanna Smith recently spent two weeks on Little Barrier Island off Auckland with a number of petrel experts, an experience she says she will never forget. This is her story.

Birdlife International

Lessons from Little Barrier

Alanna Matamaru-Smith, from our Cook Islands' Birdlife partner Te Ipukarea Society finds out more about seabird conservation during a recent visit to Hauturu.

I'd never been to an island that was solely dedicated to being a nature reserve, but once I landed on Hauturu/Little Barrier Island it didn't take long to realise I was in a Garden of Eden. Straight away I could see kākā and kākāriki flying overhead, tūī and bellbirds trying to out-sing each other, and kōkako bouncing across the ground nearby.

In the Cook Islands the closest we have to a nature reserve is Suwarrow, our national park, which is is 825km north-west of Rarotonga and home to millions of seabirds, thousands of huge coconut crabs, hundreds of sharks, and rare species of turtles. Suwarrow was predator-free until last year when one of the rangers noticed rats on one of the islets (Motu Tou). A team is to return there this year to complete a rat eradication programme.

Back on Hauturu, my first week involved helping Dan Burgin, of Wildlife Management International, and Leigh Joyce, DOC's assistant ranger on Hauturu, conduct a population survey on the taiko/black petrel. I got a real hands-on experience holding these big seabirds and carefully learnt how to direct them in and out of their burrows. After handling the bird, with Dan banding it, we checked its nest for eggs or chicks.

My second week involved a New Zealand storm petrel project with the Northern New Zealand Seabird Trust. It was interesting to see how these birds were caught through the use of high beam lights, mesmerising the small petrel towards the ground. I was told back at home, old mamas on Mauke, one of our outer Cook Islands, used this technique too, but that was for chickens!

I had the job of placing captured birds into their new artificial burrows. Walking by myself in the dark forest to the burrows some 200m away, I saw what I thought was a kiwi but it turned out to be a kākāpō right there in the middle of the track. We both stood still for a good eight seconds before the kākāpō realised I had spotted it and headed off into the nearby bush. After that, I had a lot more helpers join me on my walks to the burrows!

Having arrived back home, I'm looking forward to utilising my skills learnt on Hauturu. For instance (funding dependent), I hope to work on a new project surveying and monitoring the herald petrel population on Rarotonga. Little is known about this species, which is a major obstacle to developing a conservation plan and starting predator control work.

There has been little recent activity in terms of seabird projects being conducted in the Cook Islands. So, with my new passion and drive for seabird conservation, I hope to jump-start a bit more excitement within this area, especially among our young people.

BirdLife INTERNATIONAL

OUR PARTNERS IN THE PACIFIC

BirdLife International is the world's largest nature conservation partnership, with 120 partners worldwide, including Forest & Bird. Our society is a member of Birdlife's Pacific Partnership, which includes national conservation groups from the Cook Islands, Fiji, French Polynesia, New Caledonia, Palau, and Australia.

The Pacific has more threatened bird species per unit area of land, or per person, than anywhere else in the world. There are 34 critically endangered bird species in the region that are on the brink of extinction, with many more edging closer to being wiped out every year.

Figure 5.2: WMIL volunteer Alanna Matamaru–Smith's articles in the *Cook Islands News* and *Forest & Bird* magazine (http://www.cookislandsnews.com/national/local/item/63182-from-a-petrol-head-to-keen-petrel-head; accessed 28/08/2017).

During our February 2017 fieldtrip to Great Barrier Island we also hosted two Sir Peter Blake Trust Ambassadors, Jemma Welch and Bokyong Mun. Jemma and Bokyong both made outstanding contributions towards achieving the aims of the trip, and subsequently wrote about their experiences in blog posts for the Sir Peter Blake Trust website, and in an article for the Otago University website (Figure 5.3). During this trip, the WMIL team also hosted a day visit by staff and students from Okiwi School. Some kids were given the chance to hold black petrel chicks, under the watchful supervision of WMIL staff member Dan Burgin, an experience, that for those kids, will unlikely be forgotten.

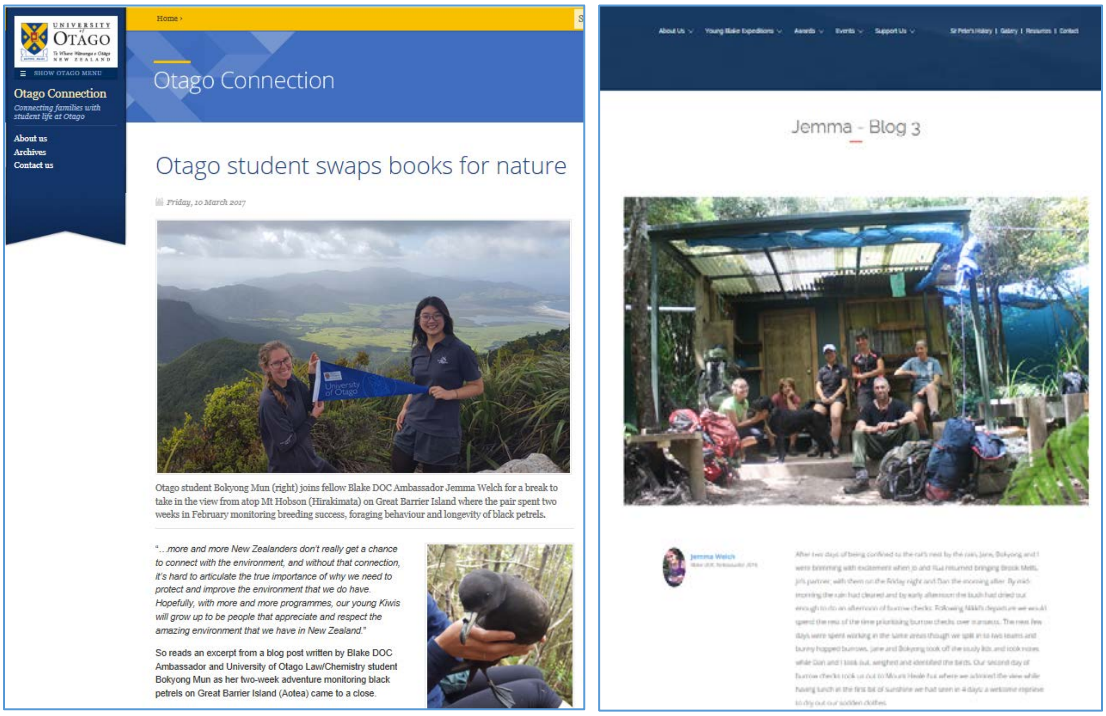

Figure 5.3: **Bokyong Mun's Otago University website article (left; http://www.otago.ac.nz/otago–connection/otago637891.html; accessed 28/08/2017) and Jemma Welch's Sir Peter Blake Trust website blog post (right; http://sirpeterblaketrust.org/posts/2017/3/16/jemmablog03; accessed 28/08/2017).**

During our May 2017 fieldtrip to Great Barrier Island, the WMIL field team hosted a group of staff and fishers from Sanford Ltd who had come up to the colony to film a short video for advocacy, staff training and engagement. The group was shown the study area and had the opportunity to remove birds from burrows and handle them under the supervision of WMIL staff. The aims of the research project were explained, and some stimulating discussions were held regarding the threats to black petrels and how they could be managed. A night visit to the summit of Mt Hobson to watch black petrel chicks take off on their maiden flights was a real highlight. The visit was highly successful, with the entire group thoroughly enjoying their overnight stay. Sanford Ltd subsequently produced an excellent short video of their visit, featuring project leader Biz Bell and some stunning aerial footage of Mt Hobson: https://www.facebook.com/SanfordLimited/videos/1875725772677421/ (accessed: 28/08/2017).

During the course of the 2016–17 field season, the WMIL team also hosted three overnight visits by local fishers and Ministry for Primary Industries staff. These visits usually involve the visitors getting some hands–on experience assisting with black petrel monitoring work, as well as an overnight trip to either the Mt Hobson/Hirakimata summit or a local 'launch rock' to watch black petrels arriving and departing the island just after dusk.

In late June 2017 Biz Bell also gave a presentation to the Christchurch regional meeting of Birds New Zealand, summarising the results of 21 years of black petrel research on Great Barrier Island. Birds New Zealand members have frequently volunteered to assist with black petrel monitoring over the 21–year lifespan of this project, and WMIL has a close working relationship with this society and it's approximately 1200 members.

6. SUMMARY OF RECOMMENDATIONS

Table 6.1 below provides a summary of the recommendations made in the previous sections of this report.

Table 6.1: Summary of black petrel research and management recommendations made in this report.

Project component	Recommendation
Population demographics	That the issue of potential upward bias in observed burrow occupancy be investigated, and a statistical technique for overcoming any upward bias be investigated.
Population demographics	That either no further burrows be added to the study burrow network on GBI outside of the census grids, or that additional burrows are selected on a strictly random basis to eliminate any bias towards selecting burrows occupied by breeding birds.
Population demographics	We support the recommendation by local DoC staff on GBI that feral cat trapping should continue on Mt Hobson/Hirakimata during subsequent black petrel breeding seasons, in an effort to reduce losses of both adults and chicks to cat predation.
Population estimate	That an island–wide population estimate be undertaken on GBI using a trained seabird detector dog to improve burrow detection probability.
Satellite tracking	That a large–scale satellite tracking project focusing on mapping the at–sea movements and distribution of juvenile black petrels be carried out, using Telonics™ TAV2618 devices.
Satellite tracking	That a second attempt is made to trial the use of Desert StarTM SeaTag–TT devices on juvenile black petrels, given their potential to be both more cost–effective and longer–lasting than Telonics™ TAV2618 devices.

7. ACKNOWLEDGMENTS

This work was co–funded by the Ministry for Primary Industries and Wildlife Management International Ltd, with additional support from the Department of Conservation, the Great Barrier Local Board and Southern Seabirds Solutions Trust.

We are very grateful for the assistance we received from the Department of Conservation with logistics, transport and accommodation on both Great Barrier and Little Barrier Islands. In particular we'd like to thank Louise Mack on Great Barrier Island, Richard Walle, Leigh Joyce, Pete Mitchell and Cathy Mitchell on Little Barrier Island and Jenny Heath from the Mahurangi/Warkworth Office for their assistance. Michelle Bradshaw from the DoC National Banding Office also provided assistance with the procurement of bands, and the management of banding licences and records. Piers Barney of Norma Jean Charters provided us with boat transport to and from the islands.

We'd also like to thank Patrick Stewart of Sound Counts, as well as Chris Gaskin, Neil Fitzgerald and other members of their New Zealand Storm Petrel Research Group for their assistance with the deployment and retrieval of the acoustic recording devices, and the management of the acoustic files.

Janine Kelly from Massey University's Equine Parentage and Animal Genetic Services Centre carried out the DNA sex determination on our GPS–tracked birds, and Glen Fowler (LotekTM) and Catalina Amaya–Perilla provided technical assistance with the use of the satellite tracking devices and the processing of location data. Special thanks should also go to Graeme Taylor of the Department of Conservation, who helped reunite us with one very geographically challenged, GPS–tracked black petrel that crash–landed in a paddock near Paeroa. Thanks also to staff at the Paeroa office of the Department of Conservation and at Thames Bird Rescue for caring for this bird, enabling it to be subsequently released.

We are also very grateful for the dedication and enthusiasm of a number of volunteers who assisted us in the field this season, including Jono Walter, Paul Garner–Richards, Rachel Hufton, Darren Gash, Alanna Matamaru–Smith, Bokyong Mun, Jemma Welch, Jane Russell, Kim Broad and Darren Lees.

This fieldwork was carried out under Wildlife Act Authority Authorisation No. 40062–FAU.

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