EVALUATING ON-LAND CAPTURE METHODS FOR MONITORING A RECENTLY REDISCOVERED SEABIRD, THE NEW ZEALAND STORM-PETREL *FREGETTA MAORIANA*

STEFANIE M.H. ISMAR[1,2], CHRIS P. GASKIN[3], NEIL B. FITZGERALD[4], GRAEME A. TAYLOR[5], ALAN J.D. TENNYSON[6] & MATT J. RAYNER[2,7]

[1]*GEOMAR Helmholtz Center for Ocean Research, Experimental Ecology, Düsternbrooker Weg 20, 24105 Kiel, Germany (sismar@geomar.de)*
[2]*University of Auckland, School of Biological Sciences, 3A Symonds Street, PB 92019, Auckland 1142, New Zealand*
[3]*Northern New Zealand Seabird Trust, 400 Leigh Road, RD5, Whangateau, Warkworth 0985, New Zealand*
[4]*Landcare Research, Private Bag 3127, Hamilton 3240, New Zealand*
[5]*Department of Conservation, PO Box 10420, Wellington 6143, New Zealand*
[6]*Museum of New Zealand Te Papa Tongarewa, PO Box 467, Wellington 6011, New Zealand*
[7]*Auckland War Memorial Museum, PB 92018, Auckland 1142, New Zealand*

Received 17 Aug 2015, accepted 29 Sept 2015

SUMMARY

ISMAR, S.M.H., GASKIN, C.P., FITZGERALD, N.B., TAYLOR, G.A., TENNYSON, A.J.D. & RAYNER, M.J. 2015. Evaluating on-land capture methods for monitoring a recently rediscovered seabird, the New Zealand Storm-Petrel *Fregetta maoriana*. *Marine Ornithology* 43: 255–258.

We provide a first assessment of various on-land capture methods for a procellarid seabird, the New Zealand Storm-Petrel *Fregetta maoriana*, which had been presumed extinct but for which a breeding site has just been discovered on Little Barrier Island. In the vicinity of an active breeding site, playback only, also involving a newly isolated call from *in situ* deployed sound-recording devices, could efficiently be employed for capture, while light attraction in combination with playback achieved comparable capture success further afield. We consider that these findings can be relevant for breeding ground searches and capture operations in other storm-petrel species, and more generally in seabirds that visit their breeding sites at night.

Key words: breeding grounds, Hydrobatidae, nocturnal seabirds, population monitoring, sound attraction, spotlighting.

INTRODUCTION

The New Zealand Storm-Petrel *Fregetta maoriana* (NZSP) (Fig. 1a) had been presumed extinct for more than a century, but was rediscovered by photography at sea in 2003 (Flood 2003, Saville *et al.* 2003, Stephenson *et al.* 2008a). Since then, genetic evidence has shown that these birds are indeed the same taxon as the only three existing NZSP museum specimens (Robertson *et al.* 2011). Following the accumulation of at-sea sighting records (Gaskin & Baird 2005), and the strong indication of local breeding in the Hauraki Gulf area, New Zealand (Gaskin *et al.* 2011, Rayner *et al.* 2013), a breeding ground of the species was recently discovered within the Gulf, on Little Barrier Island, Te Hauturu-o-Toi (hereafter Little Barrier; S36°16′, E175°06′). The discovery was made by searching for radio-tagged birds, captured and tagged at sea, on candidate islands in the wider Hauraki Gulf (Rayner *et al.* 2015). A novel net-gun method was specifically developed for catching NZSPs at sea (Stephenson *et al.* 2008b, Rayner *et al.* 2013), and has subsequently been employed in the discovery of the Pincoya Storm-Petrel *Oceanites pincoyae* (Harrison *et al.* 2013), a species for which breeding grounds are as yet unknown.

Here, we evaluate the suitability of different capture techniques of NZSP to enable monitoring of the newly discovered breeding population. To this aim, we specifically addressed three questions: (1) Is there a difference in NZSP capture rates when using playback only versus a combination of spotlighting and playback? (2) Do capture rates vary with distance from a confirmed NZSP breeding site, and could this information serve to help indicate breeding sites in future island searches for unknown breeding grounds in this or other storm-petrel species? (3) Are there differences in breeding status, as indicated by brood patch score, of NZSP caught by newly developed techniques on land versus those attracted by chumming at sea?

STUDY AREA AND METHODS

Our NZSP research on Little Barrier Island spanned two Austral summer seasons. During two research excursions in 2014, 17 February–5 March and 22–27 March, the suitability of light attraction and sound attraction in combination with mist-netting was tested to establish a banded sample of NZSP through on-land captures (Fig. 1b). Capture sites were chosen along a presumed NZSP flight path inland from the sea along a distance gradient from a previously identified NZSP breeding site, where signals of radio-tagged birds had been detected in a former breeding ground search (Rayner *et al.* 2015), and at two sites on a coastal flat that offered suitable terrain for a generator floodlight set-up and spot lighting. Breeding status of all captured birds was evaluated by scoring the state of the brood patch as in Rayner *et al.* (2013): 0 = fully downy to 4 = fully bare, and R = refeathering. Capture sessions were timed during night hours after sunset and before moonrise (covering the peak period of NZSP activity in land attendance; Rayner *et al.* 2015); at this time and latitude, the period 20h30–01h30 was typically covered. Playback calls of the closely related Black-bellied Storm-Petrel *F. tropica* (until 22 February 2014; Fig. 1c) and newly identified suspected NZSP calls (after 22 February 2014 and in 2015) (Fig. 1d) recorded *in situ* using an acoustic recorder at the previously discovered breeding site (Rayner *et al.* 2015) were used for sound attraction. Spectrograms were produced using Seewave (Sueur *et al.* 2008) in the R statistical computing environment (R Core Team 2013). A generator-run floodlight and handheld torches and headlights were used for spotlighting sessions in combination with these playbacks. NZSP captures per hour were quantified for both methodologies, playback only or in combination with light attraction. During the second season, we continued to conduct land-based captures on Little Barrier at a comparable time of year, 9–20 February 2015. Spotlight and playback attraction were deployed at the same site used in 2014. Additional brood patch scores were obtained for NZSP attracted to a nearby artificial trial colony established in the 2015 season. This trial colony consisted of 25 artificial nest boxes (20 × 20 × 20 cm plywood boxes with 6 cm diameter corrugated plastic entrance tunnels) and a playback system broadcasting the same NZSP calls as used at the spotlighting site. The trial colony was unattended by observers at most times, except when birds were released into the artificial burrows, to minimize disturbance. Therefore, birds captured at this site could be included in an assessment of brood patch scores of birds brought in by sound attraction only, but no catch per unit effort comparisons are calculated from the 2015 data.

As capture data were non-normally distributed, Mann-Whitney *U* tests were performed to assess capture efficiencies of both methods against each other. First, capture efficiencies in all sessions using only playback were compared with capture efficiencies achieved by deploying light and sound attraction in combination. Second, efficiency in playback capture sessions close to the known breeding site (straight line distance <50 m) was compared with the capture efficiency of spotlighting and playback further afield (straight-line distance >1 km).

Observed versus expected brood patch score frequencies in the birds attracted by playback only were compared with those found in birds attracted by playback and lights across all NZSPs captured in 2014 and 2015. Subsequently, brood patch score distributions among those birds captured on land in 2014 and 2015 were compared with a sample of birds captured at sea over a comparable time of year in 2013 (Rayner *et al.* 2015); both analyses were conducted applying *G*-tests. All statistical tests were performed to a significance level of $\alpha = 0.05$.

RESULTS

Capture rates with playback alone versus playback combined with spotlighting

Our results show that both spotlighting and call playback techniques can be successfully applied to capture NZSPs onshore. In total, 39 NZSP were caught in February–March 2014 using playback only or using playback in combination with light attraction (Table 1). Mist nets were deployed in most 2014 sessions, except two that involved

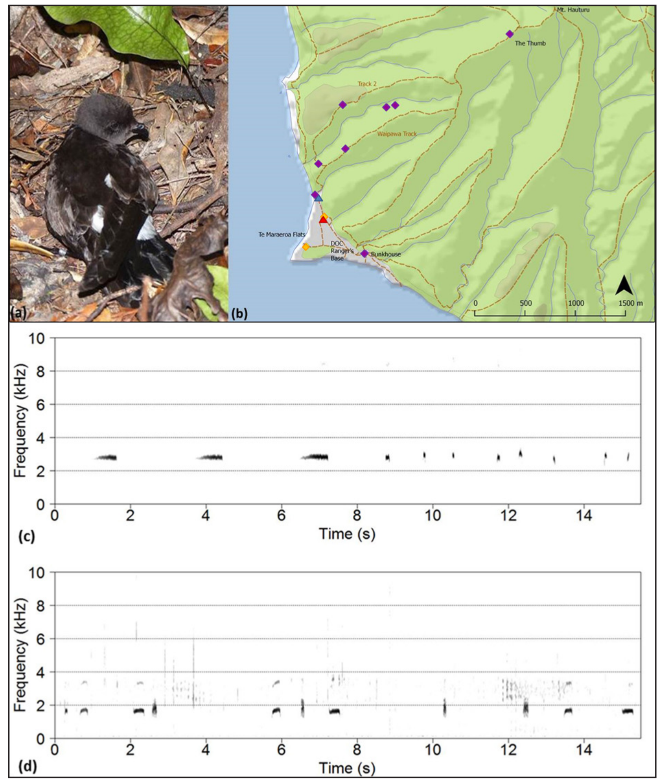

Fig. 1. (a) New Zealand Storm Petrel (photo S. Ismar); (b) capture sites on Little Barrier Island: playback only (purple diamonds), a combination of playback and light attraction (yellow diamonds), spotlight capture (red triangle) and trial colony sites (blue triangle); (c) and (d) spectrograms of playback deployed for sound attraction: (c) ground calls of related Black-bellied Storm-Petrel; (d) suspected NZSP ground calls from recorders deployed in the vicinity of the recently discovered breeding site on Little Barrier Island (2014), note background noise of Cook's Petrel *Pterodroma cookii* flight calls visible in the 2–4 kHz frequency range.

TABLE 1
New Zealand Storm-Petrel capture effort and efficiency using playback only versus playback in combination with light attraction, 17 February–5 March and 22–27 March 2014

Method	Total time (h)	No. days	Individuals caught	Capture rate (per hour)	Lower quartile 25%	Upper quartile 75%
Floodlight, spotlights and playback	52.67	15	25	0.46	0.00	0.80
Playback only (all sites)	58.10	12	14	0.24	0.00	0.32
Playback only close to breeding sites	17.02	5	10	0.64	0.00	1.47

lights and six using only playback. However, only three birds were caught by net; these individuals would probably have landed even without the use of nets. All others were caught on the ground, either upon landing directly, or after first landing in a shrub or tree, and subsequently being lured down by spotlighting. For statistical assessment of weather predictors of NZSP catching success, more extensive data across different weather events, seasons and years would need to be collated. Our two most successful catching sessions in 2014, however, were conducted on a hazy night with light northwest winds (22–23 February) and on a calm night with few clouds (24–25 February), enabling the capture of six birds on each night.

In 2015, a total of 101 NZSPs could be scored for brood patch status, 87 from spotlighting and NZSP call playback sessions, and 14 NZSP captured and banded from the trial colony site, which was equipped with a sound attraction system only. In 2015 again, the most successful capture night (9–10 February; 19 NZSPs) was overcast with very light winds, with the second highest number of captures on a clear night (14–15 February; 14 NZSPs). Capture efficiency did not differ significantly between capture sessions using playback only (mean catches 0.24 NZSP/h) and capture sessions employing both light attraction and playback (mean catches 0.46 NZSP/h) (Table 1; $U = 91.000$, $t = 299.000$, $P = 0.090$, $df = 32$).

Captures with distance from a confirmed New Zealand Storm-Petrel breeding site

Particularly close to a known breeding site (in our sample <50 m distance-by-air; Fig. 2), playback alone could achieve catching success (mean catches 0.64 NZSP/h) similar to that of a combination of sound and light attraction further afield (>1 km from a known breeding site; $U = 33.500$, $t = 56.500$, $P = 0.755$, $df = 19$). While sessions with no capture success occurred at all sites and with both methods, particularly in adverse weather conditions (strong winds and rain), the maximum capture efficiencies achieved with playback only close to a known breeding site (1.82 NZSPs/h), and at a distance >1 km from known breeding with lights and playback (1.50 NZSPs/h) were comparable (Fig. 2).

Brood patch scores of New Zealand Storm-Petrels attracted on land versus by chumming at sea

There was no significant difference between brood patch scores in the birds caught by using playback only versus those caught by light attraction and playback, when pooling 2014 and 2015 captures (Table 2; $G = 5.76$, critical value $G = 11.10$, $df = 5$, $P > 0.05$). However, brood patch index as an indicator of breeding status of the NZSPs caught in this study (average score 1.26) differed significantly from a sample of 19 birds (average score 2.74) caught at sea in January–February 2013 (Rayner *et al.* 2015; $G = 107.37$, critical value $G = 11.10$, $df = 5$, $P < 0.05$). Indeed, our 2014 and 2015 land captures included a markedly higher proportion of birds with fully downy brood patches (54% versus 21% in the 2013 at-sea sample).

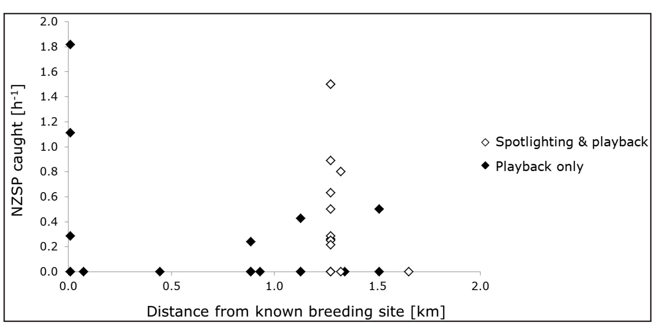

Fig. 2. New Zealand Storm-Petrel captures per hour effort on Little Barrier Island in 2014 using playback only (filled diamonds) and playback in combination with a floodlight and spotlights (hollow diamonds) over distance from a known breeding site.

DISCUSSION

Light attraction in combination with playback attracted more prospecting pre-breeding NZSPs and/or non-breeders than did chumming at sea, as indicated by the higher proportion of captures of birds with fully downy brood patches. This matches findings in some other procellariforms (e.g. Gummer *et al.* 2015, for Chatham Petrel *Pterodroma axillaris*). These birds would likely not frequent the breeding grounds once the breeding season had progressed further, and once the typical prospecting season had passed (Beck & Brown 1971, for Black-bellied Storm-Petrel). As also indicated in our study, pre-breeder/breeder ratio estimates in storm-petrels can vary substantially, depending on capture method (see e.g. Quillfeldt *et al*. 2000, for Wilson's Storm-Petrel *O. oceanicus*), suggesting caution when deriving population estimates from mark-recaptures based on bird numbers attracted by playback. The latter may result in inaccurate estimates of local storm-petrel populations.

Our results show that playback could be used efficiently for attracting NZSPs to the ground. Yet a notable rise in numbers of captured birds was evident only in the immediate vicinity (<50 m) of a known breeding site. Information on capture rates in this preliminary study could be used in other breeding ground searches; an increase in capture rates in areas where breeding of storm-petrels is suspected may provide a hint that helps uncover a local population.

One possible explanation of differences in breeding status among the three sampling years could be inter-annual variation in the timing of the NZSP breeding season, which remains to be determined. However, such variation would be unexpected in a high-latitude breeding storm-petrel. Alternatively, the chumming conducted to attract birds for net-gun capture at sea may be sampling a more

TABLE 2
Brood patch scores of New Zealand Storm-Petrels captured by playback only, and by light attraction and playback on land in 2014 and 2015, and in 2013 using a net-gun at sea[a]

Capture method	Brood patch score, number of individuals						Total
	0	1	2	3	4	R	
2015 light and sound	45	12	3	9	18	0	87
2015 sound only	12	1	0	0	1	0	14
2015 total	57	13	3	9	19	0	101
2014 light and sound	15	0	5	1	4	0	25
2014 sound only	4	1	3	5	1	0	14
2014 total	19	1	8	6	5	0	39
2013 at sea	4	1	1	4	8	1	19

[a] Scoring as in Rayner *et al*. 2013.

natural proportion of the breeding and non-breeding population than our on-land capture techniques.

Our findings also demonstrate that spotlighting with call playback is a very useful technique to sample prospecting NZSPs, whereas breeders may be more effectively targeted by captures at sea or by vocal attraction close to known breeding sites at later stages in the breeding season. We believe that deployment of mist nets may be superfluous for future NZSP capture operations.

Our findings are relevant to future searches for NZSP on other potential breeding islands (Gaskin *et al.* 2011), and may be applicable to breeding location searches and capture operations for other storm-petrel species as well. More generally, our findings may also prove useful for the planning of capture operations and population monitoring in other seabirds that visit their breeding sites nocturnally.

ACKNOWLEDGEMENTS

We gratefully thank Karen Baird, Karen Burgeois, Lucy Bridgman, Ian Southey, James Ross; Richard, Leigh, Mahina and Liam Walle; and Pete and Cathy Mitchell for their help in the field; Martin Berg and Vivian Ward for photography and artwork; the New Zealand Department of Conservation for Research and Landing permits; Ngāti Rehua, Ngāti Manuhiri, and Ngāti Wai for kindly supporting our research; and skippers (Assassin (Brett Rathe), Sumo (Dave Wade), Norma Jean (Piers Barney) and Kawau Water Taxis) for excellent transport to and from Little Barrier Island. C.G. acknowledges the volunteer work by Cliff Spain, Kerry McGee and James Ross to construct the nest boxes. M.J.R. acknowledges the support of Wendy Rayner during this research. This work was financially supported by the Mohammed bin Zayed Species Conservation Fund, the BirdLife International Community Conservation Fund, the Little Barrier Island Hauturu Supporters Trust and ASB Trust, Auckland Council, Forest & Bird Central Auckland Branch, and Peter Harrison/ Zegrahm Expeditions, with further support from the Department of Conservation, Hauraki Gulf Forum and Landcare Research.

REFERENCES

BECK, J.R. & BROWN, D.W. 1971. The breeding biology of the Black-bellied Storm-Petrel *Fregetta tropica*. *Ibis* 113: 73–90.

FLOOD, R. 2003. The New Zealand Storm Petrel is not extinct. *Birding World* 16: 479–483.

GASKIN, C. & BAIRD, K. 2005. Observations of black and white storm petrels in the Hauraki Gulf, November 2003–June 2005: Were they of New Zealand storm petrels? *Notornis* 52: 181–194.

GASKIN, C., FITZGERALD, N., CAMERON, E.K. & HEISSDUNLOP, S. 2011. Does the New Zealand storm-petrel (*Pealeornis maoriana*) breed in northern New Zealand? *Notornis* 58: 104–112.

GUMMER, H., TAYLOR, G., WILSON, K.-J. & RAYNER, M.J. 2015. Recovery of the endangered Chatham petrel (*Pterodroma axillaris*): a review of conservation management techniques from 1990 to 2010. *Global Ecology and Conservation* 3: 310–323.

HARRISON, P., SALLABERRY, M., GASKIN, C.P., ET AL. 2013. A new storm-petrel species from Chile. *The Auk* 130: 180–191.

QUILLFELDT, P., SCHMOLL, T. & PETER, H.-U. 2000. The use of foot web coloration for the estimation of prebreeder numbers in Wilson's Storm-Petrels, *Oceanites oceanicus*. *Polar Biology* 23: 802–804.

R CORE TEAM 2013. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. [Available online at: http:\\www.R-project.org; accessed 7 October 2015]

RAYNER, M.J., GASKIN, C.P., STEPHENSON, B.M., ET AL. 2013. Brood patch and sex-ratio observations indicate breeding provenance and timing in New Zealand Storm-Petrel *Fregetta maoriana*. *Marine Ornithology* 41: 107–111.

RAYNER, M.J., GASKIN, C.P., FITZGERALD, N.B., ET AL. 2015. Using miniaturized radiotelemetry to discover the breeding grounds of the endangered New Zealand Storm Petrel *Fregetta maoriana*. *Ibis* 157: 754-766.

ROBERTSON, B.C., STEPHENSON, B.M. & GOLDSTEIN, S.J. 2011. When rediscovery is not enough: Taxonomic uncertainty hinders conservation of a critically endangered bird. *Molecular Phylogeny and Evolution* 61: 949–952.

SAVILLE, S., STEPHENSON, B. & SOUHEY, I. 2003. A possible sighting of an 'extinct' bird – the New Zealand storm petrel. *Birding World* 16: 173–175.

STEPHENSON, B.M., FLOOD, R., THOMAS, B. & SAVILLE, S. 2008a. Rediscovery of the New Zealand storm petrel (*Pealeornis maoriana* Mathews 1932): two sightings that revised our knowledge of storm petrels. *Notornis* 55: 77–83.

STEPHENSON, B.M., GASKIN, C.P., GRIFFITHS, R., JAMIESON, H., BAIRD, K.A., PALMA, R.L. & IMBER, M.J. 2008b. The New Zealand storm-petrel (*Pealeornis maoriana* Mathews, 1932): first live capture and species assessment of an enigmatic seabird. *Notornis* 55: 191–206.

SUEUR, J., AUBIN, T. & SIMONIS, C. 2008. Seewave: A free modular tool for sound analysis and synthesis. *Bioacoustics* 18: 223–226.