

SHORT NOTE

Observations of New Zealand fairy tern (*Sternula nereis davisae*) foraging at Te Arai dune lakes, New Zealand

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The New Zealand fairy tern (*Sternula nereis davisae*; NZFT) is New Zealand's rarest endemic breeding bird and is ranked Nationally Critical (Robertson *et al.* 2013). At the start of the 2015/16 breeding season c.37 NZFT were alive (D. Wilson *pers. comm.*). During that season, 7 pairs attempted to nest at 3 regular breeding areas (Papanui, Mangawhai and Waipu sandspits) and also at the seldom-used Te Arai Stream mouth. Four chicks fledged over the 2015/16 breeding season.

Te Arai Stream mouth has long been known as a post-breeding flocking site for NZFT (Ornithological Society of New Zealand records and also see Fig. 1). Jeffries *et al.* (2016) recorded NZFT flying over the

stream mouth and heading mainly south-southwest over the forest and dunes in the direction of the three dune lakes; Slipper (9.0 ha), Spectacle (43.8 ha) and Tomarata (14.4 ha) (Fig. 2). It appears that NZFT only investigate freshwater bodies during their post-breeding period (GAP *pers. obs.*). Of the three dune lakes, NZFT are known to use Slipper and Spectacle lakes, some 2.5 km southwest of the Te Arai stream mouth (Ornithological Society of New Zealand records and also see McKenzie (1972)), but we are not aware of any records of NZFT using Tomarata Lake.

The northern edge of Tomarata Lake is a Recreation Reserve with boat access. This lake has a wide fringe of native bog and swamp vegetation, whereas Slipper and Spectacle lakes both have narrow reed bed margins and are surrounded by farmland. Tomarata Lake has been identified

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Fig. 1. Mr James Prickett counting New Zealand fairy tern at Te Arai Stream mouth on 17/1/1953 (Photo: Noelle MacDonald).



Fig. 2. Te Arai dune lakes: Slipper, Spectacle and Tomarata.

as having better water quality than Slipper and Spectacle lakes (de Winton & Edwards 2012; Hamill & Lockie 2015). There are no large open areas beside any of the lakes where NZFT could roost; the closest roost site to Slipper and Spectacle lakes being Te Arai Stream mouth (Fig. 2).

Very little has been published about the importance of the dune lakes to NZFT, or linking their use to the Te Arai Stream mouth flock site. This study used NZFT foraging and flight path observations, recording of recreational activities, and a literature search of available prey, to gain an understanding of NZFT freshwater foraging habitat preferences at these three lakes.

Observations at Slipper and Spectacle lakes were conducted over 4 days on 31/1/16 (1040 to 1644 h), 6/2/16 (0830 to 1531 h), 13/2/16 (0810 to 1759 h) and 20/2/16 (0800 to 1859 h) from a position on Ocean View Road, which provided extensive views of Slipper Lake and good views over Spectacle Lake to the south (Fig. 2). At Tomarata Lake observations were made from the Recreational Reserve on 10/2/16 (1440 to 1640 h), 11/2/16 (1345 to 1545 h) and 20/2/16 (1300 to 1700 h) (Fig. 2). The observations were timed to commence a week after NZFT numbers at Te Arai Stream mouth had peaked and covered the period when their numbers at the stream mouth were still high, and before they declined (I. Southey & S. Plowman *pers. comm.*, JMP & GAP *pers. obs.*). Most east coast NZFT move to the Kaipara Harbour by the end of March (Parrish & Pulham 1995a). At each lake we recorded the number and times of NZFT presence, their foraging behaviour, their flight directions, and the number and timing of any human recreational activities. Only at Slipper Lake was the frequency of NZFT foraging dives recorded, as diving data were derived solely by tracking birds that were continually in sight, circling and dip-diving. Although birds were seen diving into Spectacle Lake, continuous tracking of them was not possible as they passed behind trees and were temporarily out of sight. Weather conditions over all study days were fine with variable cloud cover, and it was either calm or with a light breeze. Binoculars of 8x25 magnification were used.

On 31/1/16 observations covered a 6-hour period, 3 hours either side of the east coast high tide (ECHT; measured at Marsden Point) at 1327 h. One or more NZFT were observed for 38 of 365 minutes (10% of the time; Table 1). On 6/2/16, observations covered 3 hours either side of the east coast low tide (ECLT) at 1231 h. One or more NZFT were observed for 49 of 422 minutes (12% of the time; Table 1). This initial result did not show any noticeable difference between lake usage over the high tide vs. the low tide period, even though the highest numbers of NZFT at Te Arai Stream mouth are recorded during an ECHT (NZFT Recovery Project records).

Two longer days, replicating a midday high tide and a midday low tide, were then conducted to investigate further any lake use by NZFT with respect to tide or time of day. On 13/2/16, observations were conducted to encompass a flooding tide, midday high tide and subsequent

Table 1. Number of minutes NZFT recorded over Slipper and Spectacle lakes during each observation period and east coast tidal cycle.

Date	Tidal cycle	Observation period (total minutes)	Minutes NZFT observed (minutes present)
31/1/16	3 hours either side high tide (1327 h)	365	38
6/2/16	3 hours either side low tide (1231 h)	422	49
13/2/16	Flooding tide, midday high tide (1211 h), ebbing tide	590	214
20/2/16	Ebbing tide, midday low tide (1241 h), flooding tide	660	212
Total		2037	513

Table 2. Recorded ($n = 18$) NZFT flight times between Te Arai Stream mouth and Slipper and Spectacle lakes.

Number of NZFT	Departure time	Flight time (minutes)	Flight direction
1	0812 h	3	Depart Te Arai to SW/arrives Slipper from NE
3	0812 h	4	Depart Te Arai to SW/arrive Slipper from NE
2	0830 h	4	Depart Te Arai to SW, arrive Spectacle from NE
1	0831 h	9	Depart Slipper to NE/arrives Te Arai from SE along beach
1	0852h	9	Depart Slipper to NNE/arrives Te Arai from SE along beach
1	0852 h	4	Depart Te Arai to S/arrives at Slipper from NE
1	0908 h	3	Depart Slipper to NNE/arrives at Te Arai from SE along beach
4	0910 h	4	Depart Te Arai to S/arrive Slipper from NNE
2	0936 h	3	Depart Slipper to NE/arrive at Te Arai
1	0948 h	3	Depart Slipper to NNE/arrives at Te Arai from SE along the beach
1	1023 h	6	Depart Te Arai to S/arrives at Slipper from NE

ebbing tide. On 20/2/16, observations covered an ebbing tide, a midday low tide, then a flooding tide. While NZFT were present for more sample minutes over both of these longer days, again there was no obvious pattern of lake use relative to tide or time of day, with birds seen in 214 of 590 minutes (36% of the time) over the midday ECHT, and 212 of 660 minutes (32% of the time) over the midday ECLT (Table 1).

Overall, one or more NZFT were observed over either Slipper or Spectacle Lake for 513 of 2037 observation minutes or 25% of the total observation time (Table 1). Birds were more frequently observed over the larger Spectacle Lake (65% of the minutes when birds were present) compared with the smaller Slipper Lake (35%). No NZFT were sighted

during the 8 hours of observations conducted at Tomarata Lake.

Most NZFT visiting either Slipper or Spectacle lakes remained and foraged, rather than continuing on in direct flight. Of the 37 records involving 62 birds over the 4 days of observations, 51 were seen diving, or attempting dives or circling (82%). The remaining 18% of records ($n=11$ birds, mostly singles) were traversing the lakes.

Of the 37 non-continuous sightings, only 2 occurred on 31/1/16 and 4 on 6/2/16. The 2 longer observation days yielded more sightings with 12 on 13/2/16 and 19 on 20/2/16. Most encounters ($n=21$; 57%), were of singles, 9 were of 2 terns (24%), 5 were of a group of 3 terns (14%) and a maximum of 4 was seen together twice (5%). On average, birds

were observed, but not continually in sight, for 14.6 minutes ($sd=16.5$, range 1–78 minutes, $n=37$) before leaving Slipper or Spectacle lakes.

NZFT flight times between Te Arai Stream mouth and Slipper and Spectacle lakes were recorded on 20/2/16 from 0800 to 1030 h, by observers at each location using text messaging and noting the time and direction of arriving or departing birds. On average NZFT took 4.4 minutes ($sd=1.8$, $n=18$), with most taking either 3 or 4 minutes ($n=15$) (Table 2). The minimum distance between the northern tip of Slipper Lake and Te Arai Stream mouth is 2.5 km. Thirteen birds were observed to arrive at or depart from this northern tip. Assuming they took a direct flight path, then their average speed was 42.3 ± 6.3 km/h. This lies within the known range of flying speeds for gulls and terns (Alerstam *et al.* 2007).

At Slipper Lake all arrivals and departures were to or from a northeasterly direction ($n=17$), and 2 birds arrived from the northeast to Spectacle Lake. At Te Arai Stream mouth most arrivals and departures were either to or from the south ($n=6$) or southwest ($n=6$), with fewer to or from the southeast ($n=3$). This is consistent with previous observations. During an observational study of NZFT breeding (1993/94 season), the major NZFT flight paths recorded into and out of the stream mouth were either in a northwesterly direction along the beach, or a southwesterly direction above the forest. Arrivals at and departures from the stream mouth in a southeasterly direction along the beach were less common (GAP, unpubl. data).

While no juvenile NZFT were confirmed during this study, they have previously been seen using Slipper Lake. On 1/2/14, GAP saw an adult accompanied by a juvenile arriving at Slipper Lake from the northeast 2.25 h after ECHT. The adult dived twice before flying off to the northeast, while the juvenile continued circling and attempting dives for another 25 minutes. Similar sightings were reported late in the 2013/14 breeding season (NZFT Recovery Project records) when a record 9 chicks fledged from Mangawhai (*cf.* just 2 chicks fledged there over the 2015/16 season). These sightings were consistent with Jeffries *et al.*'s (2016) records of juveniles at Te Arai Stream mouth in February 2014. Their observations indicate that the stream mouth is a valuable site during the post-fledging period. Slipper and Spectacle lakes may play a similar role for newly fledged NZFT learning to forage. Further observations at the lakes following seasons of high NZFT productivity are needed to confirm this.

Of the continuous foraging sightings, NZFT spent an average of 8.0 minutes foraging at Slipper Lake ($sd=4.3$, range 1–15 minutes, $n=12$ foraging bouts). On average birds attempted 3.5 dives that broke the surface ($sd=0.3$, range 0–12 dives, $n=12$) before leaving Slipper Lake; not all foraging dives

broke the surface. It is unknown if dives were successful given the distance from the observer. The diving rate averaged 0.43 dives per minute ($sd=0.28$, range 0–1 dives per minute, $n=12$). This rate is within the range of other recorded NZFT diving rates: during pre-egg laying the male can provision the female with a small fish every 1–3 minutes equating to diving rates of 0.33–1 dives per minute (Plowman 2011); and the range for adults provisioning a juvenile was 0.29–0.50, inferred from the number of fish fed per minute to the juvenile by one parent (Preddey 2008).

Estuarine and oceanic NZFT food items have been identified by Parrish & Pulham (1995b). Ismar *et al.* (2014) modelled the diet of adult NZFT ($n=5$) as 47–74% gobies, 19–32% flounder and 0–21% shrimps. A regurgitated NZFT pellet retrieved from a Kaipara harbour roost on 8/4/12 contained juvenile kahawai (*Arripis trutta*) otoliths, and another pellet retrieved from Te Arai Stream mouth on 10/2/16 was consistent with suborder Gobioidae, which includes gobies and bullies (T. Trnski *pers. comm.*). There is no information about which prey species are taken by NZFT from Slipper and Spectacle lakes, and none was identified in this study.

The reason for NZFT favouring Slipper and Spectacle lakes and not Tomarata Lake may be linked to fish stocks (Table 3). All 3 lakes contain exotic species and liberations are well documented during the latter half of the 20th century (Hicks 2003; Sullivan 1998). Tomarata Lake was last stocked with rainbow trout (*Oncorhynchus mykiss*) in 2008 but these are likely to have perished by 2010 (A. Daniel *pers. comm.*). A release of carnivorous perch (*Perca fluviatilis*) is recorded for Tomarata Lake only. Grey mullet (*Mugil cephalus*), an ocean-dependent species, has been recorded in Spectacle and Slipper lakes. It is therefore important that the Te Arai Stream, which links these 2 lakes to the sea, is not obstructed by anything that could hinder or block fish passage. Prey availability for NZFT in all 3 lakes requires confirmation.

Disturbance of Tomarata Lake by recreational boating activities may discourage NZFT from foraging there. NZFT are dip-divers, rarely immersing their entire bodies. Ismar *et al.* (2014) estimated that NZFT can only feed in the upper 5–8 cm of water. Continuous and multiple power-boating and water-skiing were recorded during the 8 hours of observation at Tomarata Lake, compared with just 3 brief boating activities on Slipper and Spectacle lakes, during 34 hours of observations.

This study confirms Slipper and Spectacle lakes as foraging sites for NZFT during their post-breeding period. Given that Jeffries *et al.* (2016) observed NZFT adults traversing Te Arai Stream mouth when Mangawhai birds were provisioning their chicks, further work is needed to confirm

Table 3. Fish species recorded present or released into Slipper, Spectacle and Tomarata lakes. Introduced species *; species present +; prior record but likely died out (+). Slipper and Spectacle lakes are linked by a drainage channel and thus share the same species, while Tomarata Lake is landlocked. Data collated from Auckland Council records (M. Bloxham *pers. comm.*) and liberations by J. Stewart Smith from Department of Conservation archives (N. Grainger *pers. comm.*).

Fish species	Slipper and Spectacle lakes	Tomarata Lake
Banded kokopu (<i>Galaxias fasciatus</i>)		+
Black mudfish (<i>Neochanna diversus</i>)		+
Brown trout (<i>Salmo trutta</i>)*		(+)
Common bully (<i>Gobiomorphus cotidianus</i>)		+
Gambusia (<i>Gambusia affinis</i>)*	+	+
Goldfish (<i>Carassius auratus</i>)*	+	
Grey mullet (<i>Mugil cephalus</i>)	+	
Koi carp (<i>Cyprinus carpio</i>)*	+	+
Longfin eel (<i>Anguilla dieffenbachii</i>)		+
Perch (<i>Perca fluviatilis</i>)*		+
Rainbow trout (<i>Oncorhynchus mykiss</i>)*	(+)	(+)
Rudd (<i>Scardinius erythrophthalmus</i>)*	+	+
Shortfin eel (<i>Anguilla australis</i>)	+	+
Tench (<i>Tinca tinca</i>)*	+	+
Unidentified galaxid (<i>Galaxias</i> sp.)		+
Invertebrates		
Koura (<i>Paranephrops planifrons</i>)		+

whether they use the lakes during the pre-breeding and breeding periods. Even if these lakes are only used for part of their annual cycle, they are nonetheless an important foraging resource which NZFT cannot afford to lose.

With Hansen (2006) estimating up to 40 NZFT existed at that time and D. Wilson (*pers. comm.*) estimating 41 birds at the close of the 2015/16 breeding season, the recovery of NZFT would appear to be static. Among other measures, it is imperative that all of their currently known habitats for breeding, roosting and foraging are protected and enhanced if this critically threatened species is to survive.

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