

## Changes in the breeding status of the southern black-backed gull (*Larus dominicanus*) colonies on Rangitoto Island, Hauraki Gulf, New Zealand

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**Abstract** The southern black-backed gull (*Larus dominicanus*) is a common species throughout New Zealand, and has a significant presence in Auckland City. Large colonies are present on Rangitoto Island only 8 km from the city's centre. The proximity of these colonies to the anthropogenic resources of the city may have influenced breeding locations and local populations. Using field data from the 2012/13 breeding period, we compare the current status of the breeding population on Rangitoto Island with historical data collated from literature. The Rangitoto population exhibited rapid growth throughout the early 20<sup>th</sup> century, a pattern attributed to environmental changes associated with European settlement and development. Since the 1980s, the colony sizes have declined, a change that is consistent with other gull populations both nationally and globally. The driver of the population changes is likely to be the availability of food and the expansion of vegetation into the colonies. Human disturbance and predation are discounted as impacting on population change.

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**Keywords** black-backed gull; kelp gull; colony; *Larus dominicanus*; Rangitoto

### INTRODUCTION

The southern black-backed gull or kelp gull (*Larus dominicanus dominicanus* Lichtenstein 1823) is a familiar species breeding in coastal and inland areas in New Zealand (Higgins & Davies 1996). The species is common within the Auckland region and metropolitan area. It occupies all coastal habitats (including beaches, estuaries and the port environs), parks and developed commercial and urban areas, and is one of the few native bird species that has

increased in numbers in the region as a result of human activities (Larcombe 1973).

The species was recorded in New Zealand during James Cook's first and second voyages (1770 and 1773) (Biswell 2005; Watola 2012), although it may have been relatively uncommon at that time (Oliver 1955). In 1888, W.L. Buller reported that the black-backed gull population had increased quickly following European colonisation of New Zealand (Turbott 1967). This pattern of population growth continued with the progressive development of ports, freezing works, whaling stations and farmland (Oliver 1955). Fordham (1968) attributed

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the rapid growth of the black-backed gull in the Wellington Harbour region from the 1890s to the establishment of 2 meat-works and an abattoir and numerous refuse tips throughout the period 1883-1909.

The black-backed gull is widely distributed in New Zealand, being present in 76.1% of the map squares surveyed over the period 1999-2004 for the *Atlas of Bird Distribution in New Zealand* (Robertson *et al.* 2007). The species is considered to be New Zealand's most common gull (Higgins & Davies 1996), and has been accorded a "super-abundant" status (Miskelly 2013). Robertson and Bell (1984) estimated the New Zealand black-backed gull population to be 1 million birds in 1984. The Auckland population is considered to have peaked in 1970s at around 27,000 (Oliver 1973), with more recent estimates placing the population at around 5000-7500 (Biswel 2005).

Within the Auckland region, the black-backed gull breeds in scattered locations around the coast and on the islands of the Hauraki Gulf (Fig. 1) either as solitary pairs or in small groups (Gaskin & Rayner 2013), and occasionally atop buildings within the city (Turbott 1969; Medway 2000). However, notable monospecific colonies are present on Rangitoto Island (Gaskin & Rayner 2013), situated 8 km from the Auckland CBD (Figs. 1, 2). Rangitoto is a Scenic Reserve within the Hauraki Gulf Marine Park, managed by the Department of Conservation (DOC). Dogs are not permitted on this reserve.

Rangitoto Island is the youngest and largest volcano of the Auckland Volcanic Field (Hayward *et al.* 2011) with an area of 2333 ha (DOC 1995). Rangitoto consists of central cones surrounded by a gently sloping circular shield formed from flows of predominately basaltic a'a lava that formed an extremely dissected surface of broken and jagged rock when it solidified (Hayward *et al.* 2011). The terrestrial habitats of the island consist of a mosaic of bare lava, vegetation 'islands' and continuous forest (Haines 2007), and lacks any permanent surface freshwater sources. Rangitoto Island was gazetted as a reserve in 1890, although leases permitting holiday homes to be built were granted between 1919 and 1935 (Yoffe 2000). The island has been a destination for tourists since the early 1900s, although now there is no overnight accommodation on the island for tourists.

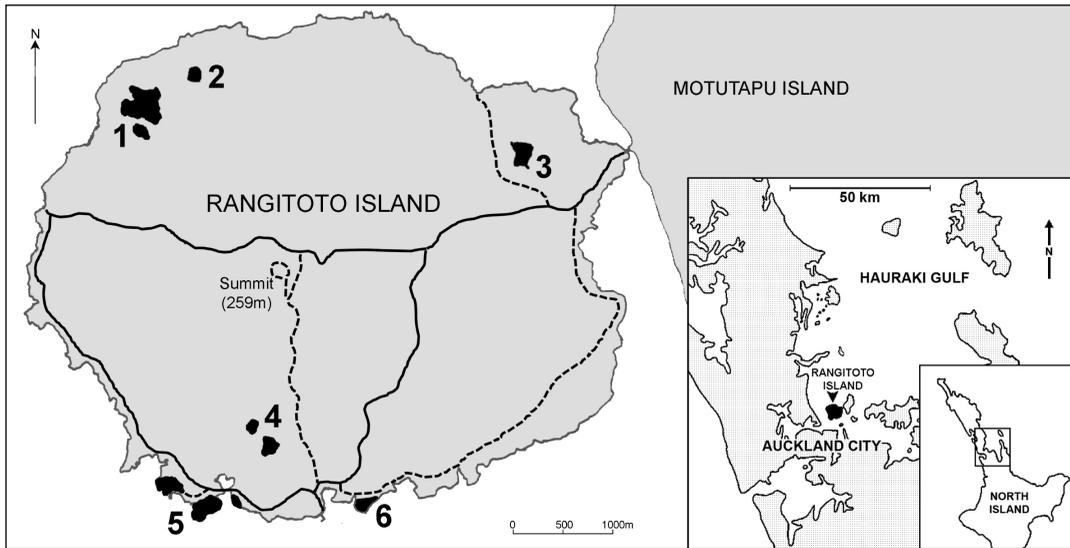
The black-backed gull colonies on Rangitoto were first reported by leasees establishing holiday homes on the island in the 1920s (Oliver 1973). Eight colonies were recorded in the 1970s (Oliver 1973), although these were unlikely to represent discrete stable units as individuals birds move between colonies (Coulson 2002). Spatial grouping of the colonies towards either the northern or

southern coasts of the island was evident in the 1970s (Francis 1970; Oliver 1973). Collectively, the colonies were comparable in size to other significant concentrations elsewhere in New Zealand (Higgins & Davies 1996).

Historical records indicate that the Rangitoto population grew markedly between the 1920s and 1970s. Holiday home owners, who knew the island well in the 1920s, described most of the gull colonies as being small, each probably fewer than 20 nests (Oliver 1973). By the 1970s, there were at least 3300 nests on the island (Oliver 1973; Woolnough 1984). This growth is similar to black-backed gull populations elsewhere in New Zealand (Fordham 1967), and to other gull species globally (Blokpoel & Spaans 1991; del Hoyo *et al.* 1996; Yorio *et al.* 1998). The increase coincided with the development of the Auckland region, and is considered to be associated with the increased availability of anthropogenic food sources. These sources would have included outfalls from meat processing works and sewage, and general refuse. The meat processing plants were located adjacent to the Manukau Harbour, 15 km from the Rangitoto colonies. These plants closed in the 1980s (McKinnon 1997). The point of sewage discharge into the Waitemata Harbour was 5 km from the Rangitoto colonies, but discharge ceased in 1960 (Fitzmaurice 2009). There are no reports of black-backed gull concentrations at waste outfalls into the harbours.

Metropolitan refuse from Auckland city is considered to be the principal anthropogenic resource for the gulls (Oliver 1973; Biswell 2005). Eight open refuse 'tips' were established to serve the city, most in coastal margins. Since black-backed gulls and other gulls of comparable size have been known to fly up to 50 km between feeding, roosting and nesting sites (Fordham 1967; Horton *et al.* 1983), all of these refuse tips were readily accessible to the Rangitoto colonies. Oliver (1973) noted a correlation between the predominant flight paths of gulls to the Rangitoto colonies and the location of the refuse tips. In addition, a refuse barge dumped wharf-collected garbage on a daily basis off the northern shore of Rangitoto Island from the 1910s-1971. Up to 2000 gulls were observed at such dumping events (Oliver 1973).

Changes in urban waste management from the early 1970s are likely to have reduced the availability of anthropogenic sources of food to gulls, and affected their population (Oliver 1973; Biswell 2005). However, counts as late as 1983 suggest little impact on gull populations between 1970 and 1980 (Baker 1981). The present study evaluates the current status of black-backed gull colonies on Rangitoto Island subsequent to further changes in habitat quality, particularly changes in waste management practices in Auckland City, the



**Fig 1.** Location of black-backed gull colonies on Rangitoto Island (\* = recorded as inactive 2012/13): 1 – White’s Beach; 2\* – Northwest; 3\* – Islington Bay; 4\* – inland Flax Point; 5 – coastal Flax Point; 6 – Rangitoto Wharf (solid line represents roads, dotted line walking tracks) (after Francis 1970).

natural expansion of forest into colony areas, and human disturbance at colony locations.

## METHODS

The black-backed gull breeding colonies on Rangitoto (Fig. 1) were visited repeatedly between November and March over the 2012/2013 breeding season. They were surveyed by direct counts of birds and active nests, replicating the field surveys carried out by Francis (1970) and Oliver (1973). Nest locations were recorded using GPS technology and mapped using ArcMap (a Geographic Information System) and Google Earth. Since the colonies are relatively small and incubating adults and nest sites are conspicuous against the black basaltic lava on which they are located, observational and disturbance problems commonly associated with the counting of colonial nesting seabirds (Bibby *et al.* 2000; Wheatler *et al.* 2011) are minimal. It is unlikely that nests were missed in the field surveys.

Nests from the current breeding season can be discriminated from unoccupied historical nests as nesting material degrades substantially between seasons, with new material being added during pair-bonding at the start of the breeding season (Oliver 1973; Higgins & Davies 1996). Field observations were supported with photographic records, a method identified as being appropriate where individual birds are visually obvious (Bibby *et al.* 2000). The names assigned to the colonies in previous studies (Francis 1970; Oliver 1973) were maintained. Evidence of undigested food items

found at the nests (regurgitated pellets, bones, etc.) was also recorded.

Re-nesting was not recorded in the survey. Although the black-backed gull may re-nest if the first clutch is lost (Fordham 1964; Wilkinson 1992), a seasonal decline in nesting success has been recorded (Fordham 1964; Borboroglu *et al.* 2008), suggesting that re-nesting is not a significant contributor to population recruitment.

Historical data on the breeding colonies were obtained from the literature, personal communications with holiday home leasees, and from aerial photographs. Aerial imagery is valuable as the black basaltic lava (Hayward *et al.* 2011) exposed on the island’s lower slopes contrasts with the light colour of ornithocoprophilous encrusting lichens associated with the gull colonies (Blanchon *et al.* 2007). This method was identified by Francis (1970) as useful for detecting and monitoring the gull colonies. Aerial photographs from 1940 to 1952 were sourced from the Alexander Turnbull Library, Wellington, and University of Auckland library archives, and used in conjunction with satellite imagery from Google Earth to assess the historical and present status of colonies. Strayer *et al.* (1986) and Spellerberg (2005) acknowledge that such retrospective analyses can make a valuable contribution to long-term ecological studies, particularly when meshed with more recent field data.

A comparison of the aggregated colonies on the northern and southern coasts of Rangitoto was carried out to investigate a suggestion that

**Table 1.** Breeding pairs of black-backed gull or active nests recorded at colonies on Rangitoto Island 1920-2012.

Year	Colony location						Total <sup>a</sup>	Data source
	Flax Point coastal	Flax Point inland	White's Beach	NWest	Islington Bay	Rangi Wharf		
1920	20 <sup>b</sup>	-	"large"	-	-	-		Oliver (1973)
1930	12 <sup>b</sup>	E <sup>1</sup>		E <sup>1</sup>	E <sup>2</sup>	-		<sup>1</sup> Oliver (1973); <sup>2</sup> Whites Aviation (1946)
1951			640 <sup>c</sup>			-		McKenzie (1953)
1959			1500			-		Sibson (1959)
1964	< 50					-		Oliver (1973)
1969	570	180	730 <sup>d</sup>	90 <sup>d</sup>	160	-	2000	Francis (1970)
1971	774 <sup>3</sup>	244 <sup>3</sup>	1615 <sup>3</sup>	196 <sup>3</sup>	187 <sup>3</sup>	E <sup>4</sup>	3307 <sup>3</sup>	<sup>3</sup> Oliver (1973); <sup>4</sup> J. Wash ( <i>pers. comm.</i> )
1980	600							Baker (1981)
1983	342 <sup>5</sup>	X <sup>6</sup>			X <sup>6</sup>			<sup>5</sup> Baker (1983); <sup>6</sup> Broome (1985)
2012	377		69	X		114	605	This study

a : totals, where available, may not equal the summed colony counts as isolated coastal nests may also be included;

b : estimates based on personal communication between R. Oliver and local holiday home leaseholders (1973);

c : colony location not specified, but assumed to be the White's Beach colony given the count magnitude, and contrasting status of the Flax Point colony size reported by Oliver (1973);

d : data considered to be conservative as portions of the colony may have been obscured amongst vegetation groves (Oliver 1973);

- : colony known not to be present;

E : colony recorded as in establishment phase;

X : colony recorded as no longer active.

the establishment and growth of colonies on the northern side of the Rangitoto were dependent on the regular dumping of garbage from the garbage barge (Oliver 1973).

The study was carried out under a Department of Conservation research permit (AK-32734-RES).

## RESULTS

Data on the black-backed gull nesting populations on Rangitoto, collated from this study and historical records for the period 1920s to the present (Table 1) show a period of colony establishment in the 1920s and 1930s, followed by a growth of active nests to a peak in the 1970s, then a drop in the number of active nests throughout the period to 2012. The study confirmed that the 2 main colonies (White's Beach and coastal Flax Point) identified by Oliver (1973) were still identifiable as discrete units (Fig. 1). However, 3 of the formerly identified colonies were inactive, and one new colony had established (Rangitoto Wharf, Fig. 1).

Although the scattered groups of nesting black-backed gulls on Rangitoto Island fulfill the definition of separate "colonies" (Coulson 2002), the physical attributes of the areas occupied and proximity of the colonies to each other suggests that their distribution may be a function of suitable nesting habitat rather than that of discrete biological units.

The Rangitoto gull colonies fall into 2 geographically distinct groups: a northern group consisting of the White's Beach, Northwest and Islington Bay colonies, and a southern group consisting of the coastal Flax Point, inland Flax Point and Rangitoto wharf colonies (Fig. 1). The colonies all lie below the island's 45 m contour (Oliver 1973), with the 2 groups separated by the island's summit and higher slopes at a distance of at least 4 km. A comparison of the nesting activity of the northern and southern groups throughout the period for which data was available indicates a similar pattern of growth up to the 1970s, but a difference in the pattern of breeding activity throughout the period from the 1970s to the present (Fig. 3). The northern colonies have continued to decline, while the southern colonies show an initial decline followed by stabilisation at 350-400 pairs.

## DISCUSSION

The collation of additional historical data confirms the substantial growth in the black-backed gull colonies on Rangitoto up to the 1970s as detailed by Francis (1970) and Oliver (1973). Our data indicates a subsequent reduction in the number of active nests to the present day (Table 1; Fig. 3). These changes in the location and activity of specific colonies may be attributed to changes in habitat 'quality' (Kidlaw



**Fig 2.** Black backed gull colony on the Rangitoto Island a'a lava.

*et al.* 2005). Habitat quality for colonial seabirds has been shown to be influenced by abundance and accessibility of food resources, prevalence of predators, diseases and parasites, nest site suitability and availability, and the level of human disturbance (Burger 1981; Boulinier & Lemel 1996; Kildaw *et al.* 2008; Valente & Fischer 2011). These attributes are considered for the black-backed gull colonies on Rangitoto Island.

#### **Availability of food resources**

Gulls are opportunistic omnivores, and adaptable to changing environments (del Hoyo *et al.* 1996; Duhem *et al.* 2003). These characteristics, plus their gregarious nature, makes them highly adapted to living in human-modified habitats (Blokpoel & Spaans 1991). The prevalence of refuse dumps as a significant foraging habitat for gulls is a global phenomenon (Spaans & Blokpoel 1991; Duhem *et al.* 2003), supporting population increases that have led to a number of gull species, including the black-backed gull in New Zealand, being referred to as superabundant species (Blokpoel & Spaans 1991; Vidal *et al.* 1998; Miskelly 2013). The Auckland black-backed gull population has mirrored this global pattern.

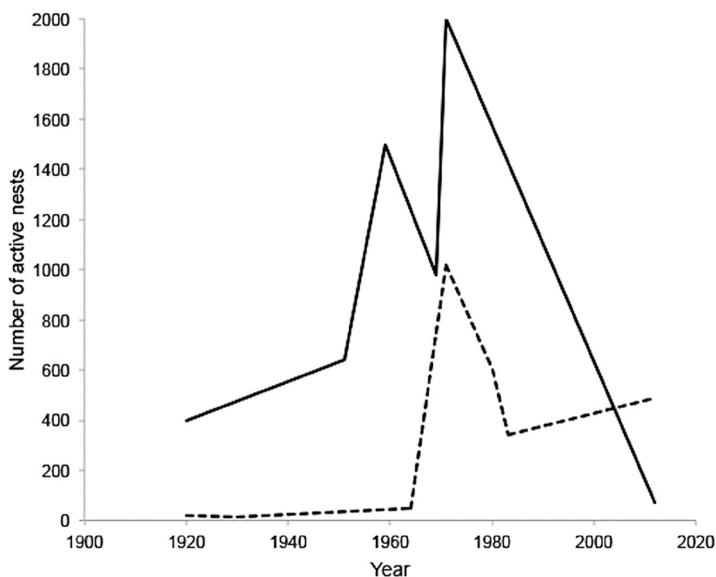
Despite the previous increase in gull numbers in the Auckland area, our more recent surveys suggest a substantial decrease in the breeding activity of the black-backed gull on Rangitoto over the last 4 decades. Decreases in old, stable gull colonies in other countries, particularly those of the herring gull

(*Larus argentatus*) in Europe, have been attributed to the improved management of waste and closure of refuse tips (Kihlman & Larsson 1974; Pons 1992; Kilpi & Öst 1998). This decrease has been recorded at other New Zealand colonies of black-backed gull, also linked to the change in management of human refuse (Wilkinson 1992).

Since the early 1970s, Auckland's open-air coastal refuse tips have been closed-down progressively, replaced initially by incineration of waste (Biswell 2005), and then by fewer municipal solid waste landfills (or sanitary landfills, Centre for Advanced Engineering 2000). Sanitary landfills are closed facilities, where the operation includes the compaction and covering of refuse on a daily basis, thus minimising access to the waste by scavengers, including gulls (Centre for Advanced Engineering 2000). The refuse barge serving the port ceased operation in 1971. Other changes to refuse management include a switch to kerbside handling of refuse from rubbish bins to plastic rubbish bags, and then increasingly to wheelie bins. Although rubbish bags are easily ripped open by gulls, wheelie bins are impenetrable unless blown or knocked over prior to collection. These changes, initiated from 1971 onwards (Biswell 2005), have further reduced the food resources available to gulls.

Although capable of flying long distances to access food resources, black-backed gulls will shift their diets to readily accessible, energetically rich anthropogenic foods when they are available

**Fig 3.** Changes in active nests recorded on northern (solid line) and southern (hatched line) black-backed gull colonies on Rangitoto Island 1920–2012.



(Silva-Costa & Bugoni 2013). However, sensitivity to change in food resources, and a subsequent rapid population response to change, has been demonstrated in studies of stable gull colonies (Kilpi & Öst 1998; Pons 1992). Thus, the gull colonies on the northern coast of Rangitoto may have been affected most by the cessation of the 6-days-a-week dumping of wharf garbage that had been initiated in the 1910s (Oliver 1973). The White's Beach colony is the only one that is currently active, though it has reduced in size since the 1970s surveys. The Northwest and Islington Bay colonies have become inactive, supporting Oliver's (1973) suggestions that the establishment and success of these colonies was dependent on the dumping of the port refuse off that coast. The Northwest and Islington Bay colonies may have become inactive by the 1980s, as neither is depicted in maps published at that time (Woolnough 1984; Broome 1985).

Oliver (1973) inferred that the Islington Bay colony had probably established in the early 1960s. However, colouring of lava consistent with the presence of lichens associated with a colony is discernable in a 1940 aerial photograph (Department of Lands & Survey 1940), and is very evident in a 1946 photograph (Whites Aviation Ltd 1946). Since ornithocoprophilic lichens may establish within 10 years of the establishment of a gull colony (Oliver 1973), we can assume that the Islington Bay colony was establishing in the 1930s, a date that is consistent with rapid population expansion of the gull population in response to the appearance of the rich supply of food from the refuse barge. The lichens encrusting the lava in this area are still clearly visible in current aerial views (Google Maps 2014).

Aerial photographs support Oliver's (1973) suggestion of expansion of the coastal Flax Point colony throughout the 1960s. This colony appears to have been stable over the last 30 years, although the breeding population is smaller than the 1970s peak (Fig. 3). While the decrease in magnitude can be explained by the reduction of anthropogenic foods in general, the ongoing stability suggests consistent access to food resources. Field observations on the colony indicate that anthropogenic food is still an important component of the gull's diet. There is evidence (*pers. obs.*) of foods that could only have been sourced from the Auckland mainland - for example chicken bones, butchered mammal bones and rice, with tomato plants growing amongst nesting material. The southern side of the island is a relatively short flight to popular recreational beaches and parks around Auckland city, where it is not uncommon to see gulls being fed, or scavenging food scraps. With the loss of the refuse dumping on the northern side of Rangitoto, the southern side of the island may now constitute a higher habitat quality than that of the northern side.

The establishment of a new colony east of Rangitoto Wharf further supports the higher habitat quality of the southern side of the island. Anecdotal reports suggest that gulls were nesting here in the 1970s (J. Walsh, *pers. comm.*), although the few gulls observed nesting in this area in the 1970s fell into the category of a "scattering along the coast" (Oliver 1973), and historical aerial photographs tend to support this (Department of Lands & Survey 1946; Whites Aviation Ltd 1952). Rapid establishment of a colony at this location may have been facilitated by the presence of solitary gull pairs

overriding the prospecting period often associated with establishment of new seabird colonies (Oro & Ruxton 2001; Coulson 2002).

Documentation of the establishment of new seabird colonies is rare (Kidlaw *et al.* 2005). It is generally accepted, however, that new colonies form when low habitat quality affects existing colonies, and that immigration from such colonies may fuel rapid growth of new colonies (Oro & Ruxton 2001; Kidlaw *et al.* 2005). Studies of gulls and other seabird species elsewhere (Pons 1992; Oro & Ruxton 2001) have demonstrated that colonisation rates of such opportunistic species are correlated with the availability of food resources derived from human activities, new colonies may form because of poor habitat quality at the sites of old colonies (Kidlaw *et al.* 2005), and that changes may operate at localised scales (Kidlaw *et al.* 2008). The expansion and establishment of the colonies of the southern side of Rangitoto may simply be the consequence of poor habitat quality of the northern colonies following the loss of localised refuse availability.

The now inactive inland Flax Point colony would have had a similar access to food resources as the other southern sub-colonies, thus it is likely that factors other than access to food resources was a causal factor in the colony ceasing activity.

### **Predators, disease and parasites**

Seabird colonies are known to be vulnerable to predators because of the aggregation of numbers in a confined space (Coulson 2001), with greatest mortality occurring at the egg to fledging stages (Emlen 1956; Congdon 2008). There is ample evidence of the catastrophic effect of introduced mammalian predators reaching island seabird colonies (Furness & Monaghan 1997; Towns *et al.* 2011). Rangitoto Island, although now free of introduced mammalian predators following eradication programmes in 1990 and 2009 (Griffiths *et al.* 2014), did have introduced mammals predators present for most of the period for which the gull colony data covers: brushtail possum (*Trichosurus vulpecula*), ship rat (*Rattus rattus*), mouse (*Mus musculus*), stoat (*Mustela erminea*), cat (*Felis catus*) and hedgehog (*Erinaceus europaeus*) (Towns *et al.* 2011; Griffiths *et al.* 2014).

The growth of the black-backed gull colonies up to the 1970s suggests that the presence of introduced predators had little impact. Oliver (1973) attributed the main (known) cause of chick mortality (12%) to the rugged terrain, with only 3.2% mortality due to predation. The Australasian harrier (*Circus approximans*) was a confirmed predator, with mammal predation suspected but not confirmed (Oliver 1973). Although mice were detected at gull colonies during monitoring prior

to the eradication of predatory mammals (Miller 1995), and are known to depredate seabird eggs and chicks (Angel *et al.* 2009), there is no evidence of their having an effect on chick recruitment into the population.

The interspecific interactions of the mammalian predators on Rangitoto, and their behaviour in the exposed and rugged lava habitat, may have limited their impact on the gull colonies prior to eradication. For example, brushtail possums, hedgehogs and stoats are unlikely to leave the cover of forested areas (Cowan 2005; Jones & Sanders 2005; King & Murphy 2005); larger surface-nesting seabirds are least affected by ship rats (Towns *et al.* 2011); cats may maintain rodent levels at low levels (Courchamp *et al.* 1999); and mice tend to remain in low densities in the presence of rats (Towns *et al.* 2011). Some studies suggest that, because predation effect varies considerably at both spatial and temporal scales, it may be the least important influence of habitat quality (Kidlaw *et al.* 2008). This may reflect the situation for the black-backed gull on Rangitoto Island, suggesting that predation has not been a significant driver of population change.

Intraspecific predation on breeding colonies is documented in the black-backed gull (Fordham & Cormack 1970; Higgins & Davies 1996). On Rangitoto, Oliver (1973) recorded that chick deaths as a result of predation by adults at 7-12% of all mortality causes, and noted that this was low compared to other gull studies. The attacks on juveniles that did occur were interpreted as probably territorial in nature, however it was acknowledged that the proportion of intraspecific mortality may increase in years of reduced food supply as reported by Fordham & Cormack (1970).

The close proximity of birds in a colony may aid the transfer of microbes and parasites (Coulson 2001). However, there are no reports of disease or parasites affecting the individual black-backed gulls at the Rangitoto colonies. The effect of disease and parasites is also discounted as a significant driver of population change for the Rangitoto black-backed gull colonies.

### **Suitable habitat for colonial breeding**

The growth of pohutukawa (*Metrosideros excelsa*) forest is an environmental change with potential to impact on the gull colonies. Ecological succession of woody vegetation on the lower slopes of Rangitoto is characterised by the colonisation of lava by pohutukawa (Haines *et al.* 2007). This process ultimately makes the lava unsuitable for gull nesting through loss of suitable ridges and mounds for nest sites, with a subsequent loss of clear vision. These are features identified to determine the suitability of an area for gull nesting (Oliver 1973).

At the time of the 1971-73 study, the inland Flax Point colony was already distributed amongst patches of woody vegetation, and characterized by the presence of ornithocoprophilous lichens (Oliver 1973). Recent aerial photographs (Google Maps 2014) show no evidence of encrusting lichens. This suggests that the growth of pohutukawa forest since the 1970s may have rendered the site unsuitable for both the gull colony and lichen communities. The now-inactive Northwest and Islington Bay colonies, however, have not been affected by the expansion of pohutukawa forest, as aerial maps (Google Maps 2014) show areas of bare lava and lichens still present.

### Human disturbance

There is evidence that colonial-nesting gulls avoid nesting in areas subjected to human activity (Burger 1981; Valente & Fischer 2011), and human disturbance is reported to be a primary threat to breeding sites of the black-backed gull (Gaskin & Rayner 2013; Department of Conservation n.d.).

Rangitoto Island is a popular local tourist destination, with in excess of 100,000 visitors a year (Gibbs 2001). The peak visitor period is December to February (Hughes 2000; Gibbs 2001), which overlaps with the October-January nesting period recorded for the black-backed gull (Miskelly 2013). However, surveys indicate that the majority of visitors ascend to the summit (Hughes 2000; Gibbs 2001), and, given the time available by the ferry schedules, are thus unlikely to also visit the gull colonies. The physically taxing nature of the off-track terrain on Rangitoto deters visitors from venturing far from the formed road and tracks, and the defensive behaviours of the gulls would also dissuade the casual visitor from venturing onto the colonies. It is unlikely that passive recreation has generated any sustained disturbance that may have resulted in substantial impact on any of the colonies.

Some maps of Rangitoto (Francis 1970, Woolnough 1984) indicate the presence of a walking track (Wreck Bay Track) through the centre of the now inactive Islington Bay colony. This was not the observed situation in the 1970s, and analysis of historic aerial photos (Whites Aviation Ltd 1946) and recent aerial imagery (Auckland Council 2014) supports the separation of the track and the colony. However, even if the colony was situated on or close to this track, it is unlikely that human disturbance would have contributed to its desertion. The track is one of the least used on the island as it is poorly defined (Woolnough 1984) and a considerable walking distance from the main ferry access point to the island, Rangitoto Wharf.

Further down-playing the role of human disturbance as having a role in the changes to some

colonies is a study (Nisbett 2000) that questions the impact of human disturbance on gull colonies. This study asserts that gulls are not substantially affected by human disturbance, an attribute that appears supported by the establishment of the Rangitoto Wharf gull colony close to the main ferry access point and adjacent to a coastal track.

### CONCLUSION

The black-backed gull colonies on Rangitoto Island represent a significant regional concentration of nesting black-backed gulls, our study revealing a number of key changes in colonies when compared to historical records and previous surveys. Although the ongoing expansion of pohutukawa forest on the island will reduce habitat suitable for inland colonies in the future, the availability of nesting habitat at present is still very high, particularly in the southern coastal areas where wide expanses of unvegetated lava persist. The black-backed gull is expected to remain abundant within the Auckland region, with the Rangitoto colonies making a major contribution to the population.

There is value in further research on the ecology of the black-backed gull in urban Auckland, particularly as there is evidence that anthropogenic food sources remain an important resource for the species. The ongoing monitoring of the Rangitoto colonies should be continued, and future studies could include the investigation of the nature of the current anthropogenic resources supporting the population, the foraging patterns from the colonies, the evaluation of predation by the black-backed gull on threatened coastal species, and the evaluation of the black-backed gull as a pathogen vector.

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