

## Recent increase in population size of red-billed gulls (*Larus novaehollandiae scopulinus*) at Otago, southern New Zealand

LYNDON PERRIMAN\*

298 Harington Point Rd, RD2 Dunedin, New Zealand

CHRIS LALAS

Department of Marine Science, University of Otago, PO Box 56 Dunedin, New Zealand

**Abstract** The New Zealand endemic red-billed gull (*Larus novaehollandiae scopulinus*) was designated as a 'Nationally Vulnerable' species in 2008 as a consequence of recent substantial population declines at large breeding colonies, particularly the one situated at Kaikoura, north-east South Island. In contrast, numbers increased further south along the Otago coastline, south-east South Island. Nest numbers from 7 surveys from Moeraki to Nugget Point increased from 565–1480 in 1992 to 4612–4652 in 2011 and corresponded to an average annual increase of 6–10% through 20 years. The recent decline at Kaikoura has been attributed mainly to a decline in prey availability linked to changes in oceanographic indicators, including sea surface temperature (SST). Fluctuations in SST at Otago and Kaikoura are negatively correlated and may explain the concomitant opposite trends in population sizes. Conservation management at Taiaroa Head and at other key mainland breeding locations is necessary to ensure the viability of red-billed gulls at Otago.

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**Keywords** red-billed gull; *Larus novaehollandiae scopulinus*; Otago; population increase; oceanography; conservation management

### INTRODUCTION

Morphologically and genetically different from the other subspecies of *Larus novaehollandiae* (Given *et al.* 2005), the red-billed gull (*L. n. scopulinus*) has a distribution restricted to the New Zealand region and breeds almost exclusively at coastal sites (Gurr & Kinsky 1965; Mills 1969; Higgins & Davies 1996; Taylor 2000; Gill *et al.* 2010). They are highly philopatric, often nest in large colonies and generally retain partners for life (Mills *et al.* 1996). In the only review of the distribution and population size of the

red-billed gull, Gurr & Kinsky (1965) concluded that the majority of nests occur in large colonies that are occupied annually, including 3 locations with >5000 nests: Three Kings Is and Mokohinau Is in northern North I, and Kaikoura in north-east South I (Fig. 1). In contrast, small colonies often are ephemeral with breeding locations changing annually (Gurr & Kinsky 1965).

The largest congregations of red-billed gulls about nutrient-rich oceanic upwellings that provide near-shore sources of food, primarily the planktonic euphausiid krill *Nyctiphanes australis* (Mills 1969; Mills *et al.* 2008). Red-billed gulls were designated as 'Nationally Vulnerable' in 2008 under the New

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Correspondence: Lyndonthealbatross@yahoo.co.nz

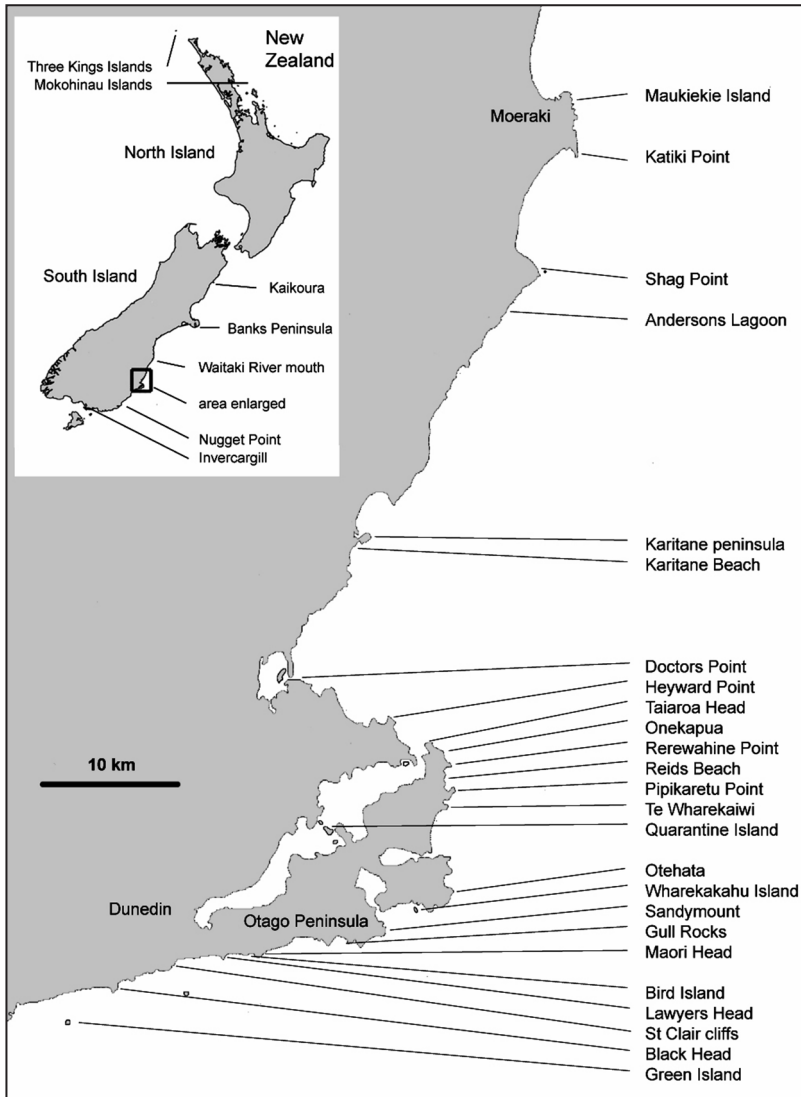


Fig. 1. Maps of New Zealand and the Otago coast from Moeraki to Green I, showing locations mentioned in the text.

Zealand Threat Classification System (Miskelly *et al.* 2008) in response to recent substantial declines at the 3 locations with the greatest numbers of nests (Hitchmough *et al.* 2007). The most comprehensive monitoring of red-billed gulls has been at Kaikoura where population size remained relatively stable through the 11 years from 1983–1993 but then halved through the subsequent 10 years, a decline attributed to changes in oceanic productivity and subsequent food availability (Mills *et al.* 2008). In addition, localised decreases in red-billed gull nest numbers and breeding success have been reported and attributed to human disturbance, and to predation of eggs, chicks and adults by introduced mammals (stoats *Mustela erminea*, ferrets *M. furo*, cats *Felis catus* and hedgehogs *Erinaceus europaeus*),

predation of chicks by southern black-backed gulls (*L. dominicanus*) and intraspecific predation of eggs by neighbouring red-billed gulls (Mills 1989; Higgins & Davies 1996; Mills *et al.* 1996; Taylor 2000; Mills *et al.* 2008).

Given the recent declines noted in some colonies, there is a need to determine whether such a pattern is occurring elsewhere. We investigated trends in the population size of red-billed gulls at Otago, in the south-east of the South I, from Moeraki to Nugget Point, along a coastline from 400 to 550 km south-west of Kaikoura (Fig. 1). Numbers presented in Gurr & Kinsky (1965), the only published records for this region, were imprecise but indicated that breeding by red-billed gulls at Otago in the mid 20th century

was restricted to the vicinity of Otago Peninsula (probably <1000 nests annually) and at Nugget Point (1000–2000 nests annually). We estimated total nest numbers along this coastline for 7 years from 1992 to 2011, compared trends with the recent decrease at Kaikoura, and investigated the impact of conservation management in the viability of red-billed gulls nesting at mainland locations.

## METHODS

Our survey area encompassed a linear distance of 200 km of the Otago coast from Waitaki River (44°56'S, 171°09'E) to Nugget Point (46°21'S, 169°27'E) (Fig. 1).

Data were derived primarily from counts of red-billed gull nests we made from 1983 to 2011, with early records restricted to a few locations. Red-billed gulls breed from Sep to Feb (Higgins & Davies 1996). Analyses included only counts considered representative of annual maxima, typically counts from Nov or Dec, and counts were assigned to the calendar year of the start of the breeding season. Most breeding locations were first found from sea using small boats operated by the Department of Marine Science, University of Otago. Nest counts were made from land or sea, typically using binoculars, or from photographs taken from boats or low-flying small aircraft. We defined a nest as a formed nest site with a gull sitting or a nest site that contained eggs or chicks.

Most of our counts encompassed a linear distance of 150 km from Moeraki (45°21'S, 170°52'E) to Nugget Point (Fig. 1) and so our results concentrated on this section of the Otago coast where data from 7 years were sufficiently comprehensive to be able to report on annual nest numbers of red-billed gulls. The counts from the first 2 years, 1992 and 2001, were made incidentally in association with surveys targeting other seabirds. These were followed by counts from 5 consecutive years, 2007–2011, that targeted red-billed gulls. The number of breeding locations depends on the designation of minimum distance between neighbouring colonies. For example, Kaikoura is designated as 1 breeding location but has up to 7 colonies on the 3 km headland of Kaikoura Peninsula (Mills *et al.* 2008). At Otago we allocated nests to the nearest named location, with neighbouring breeding locations at least 1 km apart. Values for annual counts were presented as likely ranges rather than exact numbers in order to account for imprecision in some counts and for missed locations. The likely range for each missed location in any year was deduced from trends in counts for each location from preceding and succeeding years. Temporal trends in nest numbers were estimated with exponential curves

of best fit in the form  $y \propto e^{\lambda x}$ , where  $\lambda$  = average exponential annual growth rate. Annual growth rates were presented as average arithmetic rates =  $e^{\lambda} - 1$ , following Gerrodette (1987). Red-billed gull nest numbers at Otago were compared with Kaikoura, where annual nest numbers at Kaikoura for 1983–2004 were read from Fig. 3 in Mills *et al.* (2008) and for 2006–2011 were provided by Jim Mills (*pers. comm.* to LP).

The accessibility for rats (*Rattus* spp.) to red-billed gull nests at mainland locations were categorised qualitatively as 'High' if nests were readily accessible, 'Nil' if nests were inaccessible on cliff ledges and 'Low' if most nests were inaccessible. The 4 vegetated islands were categorised as 'Nil' for Wharekakahu I and Green I where CL verified the absence of rodents by deploying gnaw sticks (wooden tongue depressors dipped in candle wax) in 1983–1985; 'Nil?' for Maukiekie I where the abundance of breeding seabirds indicated a likely absence of rodents; and 'High' for Quarantine I where we have seen rats. The other islands were bare rocks, with most referred to as islets, where those considered too small (area <100 m<sup>2</sup>) to sustain rats were designated 'Nil' and the remainder were designated 'Nil?'. We assumed that nests at all locations categorised as 'High' were accessible to larger introduced predatory mammals.

Our most comprehensive data set for red-billed gull nest numbers at one location was for Taiaroa Head (45°46.5'S, 170°43.7'E) that included annual counts and continual monitoring by LP through 13 consecutive years (1999–2011). Monitoring included searches for banded birds. The nearest banded population of red-billed gulls is at Kaikoura where chicks have been banded annually since 1958, with over 70000 banded by 2005 (Mills *et al.* 2008). Monitoring at other Otago locations was insufficient to reliably detect banded birds.

An indication of nest numbers and breeding locations of red-billed gull nests from the south-east of the South I before 1992 was taken from records for 1950–1963 in Gurr & Kinsky (1965). We also checked entries in 'Classified Summarised Notes' in *Notornis* 1961–2003. Unpublished data for red-billed gulls at Otago Peninsula were extracted from the field notebooks of Stan Sharpe (ranger in charge at Taiaroa Head 1951–1968) held at Hocken Library, Dunedin; from Taiaroa Head ranger field notebooks 1968 held by the Department of Conservation, Dunedin; and information provided for 1968–1980 by the late Alan Wright (Ranger in charge at Otago Peninsula and Taiaroa Head 1968–1980) in interviews with LP in 2010. Unpublished data for red-billed gulls at Katiki Point were extracted from the notebooks of Janice Jones (resident at Katiki Point 1982–2002) held by CL.

**Table 1.** Locations and annual numbers for red-billed gull nests at Otago from Moeraki to Nugget Point for 7 years with comprehensive surveys (1992–2011). Ranges in italics represent likely ranges for missed locations. All counts by LP or CL except Katiki Point for 1992 and 2001 from Janice Jones (notebooks); St Clair cliffs and Black Head for 2008–2010 from Graeme Loh (*pers. comm.*) and Green I for 2007, 2009; and 2010 from Mel Young (Department of Conservation, *pers. comm.*). ‘Access for rats’ is explained in Methods.

Location	Access for rats	Calendar year (start of breeding season)						
		1992	2001	2007	2008	2009	2010	2011
Maukiekie Island	Nil?	0	0	6	<i>0-50</i>	<i>0-50</i>	<i>0-50</i>	49
Katiki Point	High	100-200	270	450	0	476	478	317
Shag Point	High	0	0	0	0	0	0	274
Andersons Lagoon	Low	0	10	0	<i>0-10</i>	<i>0-10</i>	<i>0-10</i>	0
Karitane peninsula	High	<i>0-150</i>	56	152	0	0	0	21
Karitane Beach islets	Nil	<i>0-100</i>	70	57	<i>45-75</i>	42	65	114
Doctors Point	Nil	<i>0-15</i>	15	0	0	0	<i>0-15</i>	8
Heyward Point islet	Nil	60	167	0	0	0	0	0
Taiaroa Head	High	145	549	1659	2042	2115	2079	2423
Onekapua	High	0	250	50	0	0	0	0
Rerewahine Point	Nil	30	10	0	0	0	0	0
Reids Beach	High	0	80	208	6	<i>0-200</i>	30	153
Pipikaretu Point	High	0	50	0	0	0	0	0
Te Wharekaiwi	Low	0	120	0	0	0	0	0
Quarantine Island	High	0	284	0	0	0	0	0
Otehata	Nil	80	0	<i>3-10</i>	<i>0-10</i>	<i>0-10</i>	0	0
Wharekakahu Island	Nil	50	65	80	<i>0-80</i>	<i>0-80</i>	0	50
Sandymount	Low	0	0	<i>14-25</i>	<i>0-25</i>	<i>0-25</i>	0	0
Gull Rocks	Nil?	0	35	<i>33-50</i>	<i>0-50</i>	<i>0-50</i>	0	50
Maori Head	Nil	<i>0-100</i>	95	0	50	0	0	0
Bird Island	Nil?	0	0	499	230	140	30	15
Lawyers Head	Low	<i>0-300</i>	270	0	<i>0-300</i>	150-200	306	238
St Clair islet	Nil	0	0	0	0	0	0	120
Black Head	High	0	0	0	<i>100-300</i>	<i>100-300</i>	<i>100-300</i>	280
Green Island	Nil	0	0	<i>5-10</i>	<i>0-10</i>	0	0	0
Nugget Point islets	Nil?	<i>100-250</i>	<i>100-250</i>	<i>300-400</i>	<i>300-400</i>	405	313-333	500-540
Minimum number of nests		565	2496	3516	2773	3428	3401	4612
Maximum number of nests		1480	2946	3656	3638	4153	3696	4652
Number of breeding locations		6-11	18	14	7-15	7-14	8-11	15

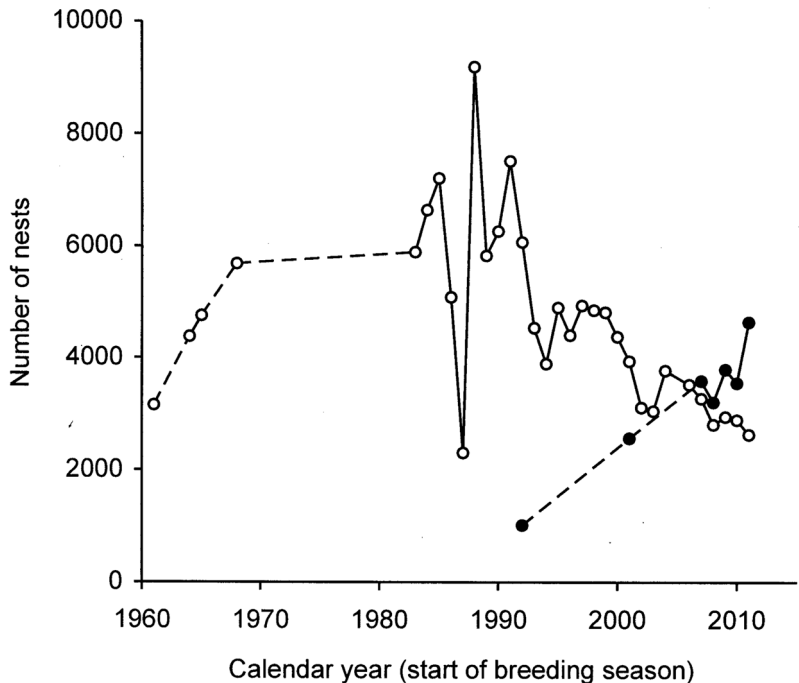
## RESULTS

### Comprehensive surveys from Moeraki to Nugget Point

Seven comprehensive surveys along the south-east coast of South I from Moeraki to Nugget Point from 1992 to 2011 found a total of 26 breeding locations  $\geq 1$  km apart. The number of red-billed gull nests at

least quadrupled through the 20 breeding seasons from 565–1480 in 1992 to 4612–4652 in 2011 (Table 1). Annual minima and maxima for nest numbers from the 7 surveys generated 2 extremes that encompassed the possible range in the average arithmetic annual growth rate from 5.8% ( $r = 0.95$ ,  $P < 0.001$ ) for annual maxima to 10.3% for annual

**Fig. 2.** Comparison of trends in red-billed gull nest numbers for Otago and Kaikoura. Black circles = midpoints between minima and maxima from Table 1 for 7 counts at Otago from Moeraki to Green I from 1992 to 2011. Open circles = 32 counts at Kaikoura from 1961 to 2011: see text for sources of data. Solid lines = counts from consecutive years; dashed lines = counts >1 year apart.



minima ( $r = 0.99$ ,  $P < 0.001$ ). The temporal increase in nest numbers was not reflected by the number of breeding locations  $\geq 1$  km apart after 2001: nest numbers increased from 6–11 in 1992 to 18 in 2001 but then did not exceed 15 locations through 2007–2011 (Table 1).

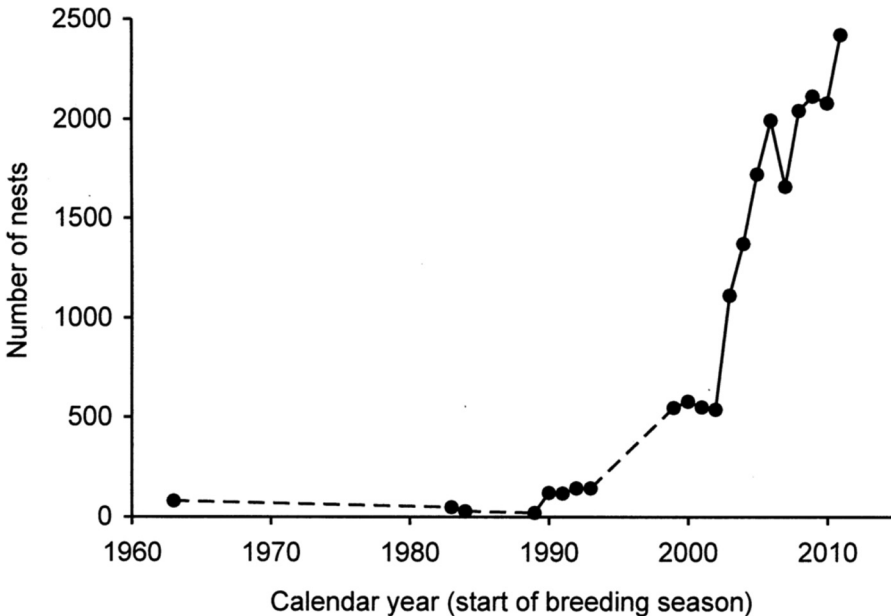
Taiaroa Head accounted for the most of the increase with >2000 red-billed gull nests through the 4 most recent years, 2008–2011 (Table 1). The most substantial and sustained increases in nest numbers at other locations through these years were: Katiki Point with c. 300–500 nests; Lawyers Head with c. 150–300 nests; and Nugget Point with c. 300–500 nests. Other locations with records of > 200 nests from the 7 surveys (1992–2011) were either recent (Shag Point and Black Head), erratic (Reids Beach and Bird I) or only in 1–2 years (Onekapua and Quarantine I).

Gurr & Kinsky (1965: Table 1) documented 9 breeding locations for red-billed gulls from Moeraki to Nugget Point. Eight of these 9 locations were in the vicinity of Otago Peninsula and 5 of these matched locations we recorded for 1992–2011: Taiaroa Head with c. 80 nests in 1963; Onekapua with c. 120 nests in 1963; Rerewahine Point with c. 150–220 nests for 3 years, 1959–1963; Wharekakahu I with c. 77 nests in 1960; and Sandymount with 'Large numbers' in 1962. We did not find red-billed gulls nesting at the other 3 locations documented by Gurr & Kinsky (1965: Table 1): Potato Point with c. 40 nests in 1963; Telfers Bay with 'a few' nests

in 1962; and Sandfly Bay with 'hundreds' of nests in 1950. For Potato Point, Allen (in Edgar 1972) recorded 80 nests in 1964. Alan Wright (*pers. comm.* to LP) provided an indication of activity at these 3 locations during the 1970s. Potato Point (45°44.1'S, 170°37.3'E) is located between Doctors Point and Heyward Point (Fig. 1): red-billed gulls occasionally bred there through the 1970s, with <100 nests on a nearshore islet (A. Wright, *pers. comm.*). Telfers Bay (45°54.0'S, 170°39.6'E) is a local name for a small bay beside Sandfly Bay and ashore from Gull Rocks (Fig. 1): Alan Wright did not recall red-billed gulls nesting there. Cliffs at the west end of Sandfly Bay (45°53.9'S, 170°38.2'E), 1.5 km west of Telfers Bay, held a colony of a few hundred red-billed gull nests in the early 1970s (A. Wright, *pers. comm.*). Alan Wright also recalled red-billed gulls nesting during the early 1970s at a previously unreported location at Otekiho Beach (45°46.8'S, 170°42.6'E), on the west side of Otago Peninsula within Otago Harbour, 1 km south of Taiaroa Head (Fig. 1).

The ninth breeding location for red-billed gulls reported by Gurr & Kinsky (1965) from Moeraki to Nugget Point was at Nugget Point with c. 1000 nests in 1941 and c. 2000 nests in an unspecified year. Our first 4 comprehensive surveys (1992–2008) did include counts at Nugget Point (Table 1). For these years we deduced likely ranges from 4 counts of nests from other years encompassing this duration: c. 200 in 1988, 235 in 1991, 85 in 1998 and 405 in 2009, with practically all nests on islets.





**Fig. 3.** Number of red-billed gull nests at Taiaroa Head, Otago Peninsula, recorded for 21 breeding seasons from 1963 to 2011. All counts by LP or CL except for 1963 from Gurr & Kinsky (1965) and for 1989 by Isobel Burns (Taiaroa Head ranger field notes). Solid lines = counts from consecutive years; dashed lines = counts >1 year apart.

#### Other breeding locations along the southeastern coast of South Island

Two flights verified that locations from Moeraki to Nugget Point (Table 1) accounted for all but one of the large (>100 nests) red-billed gull breeding colonies along the southeastern coast of South I during the 2011–12 breeding season. The 1st flight followed the c. 150 km of coastline from Nugget Point to Invercargill on 9 Oct 2011. This flight was too early in the breeding season to indicate nest numbers but no concentrations of >50 red-billed gulls were encountered. The 2nd flight followed the coastline from the Waitaki River to Nugget Point on 14 Nov 2011 when the only breeding location of red-billed gulls found north of Moeraki was near the mouth of the Waitaki River. On 3 Dec 2011, we surveyed the 4 km of the Waitaki River from the river mouth to the State Highway 1 bridge and found red-billed gulls breeding on 2 shingle islands. Both colonies were a mix of 2 species and totalled 221 red-billed gull nests and 568 black-billed gull nests (*L. bulleri*). Although this represented our only survey for breeding by red-billed gulls at this location, CL had visited once previously and noted the 2 species of gulls breeding together in Dec 1983.

#### Trend in nest numbers at Otago compared with Kaikoura

The population size of adult red-billed gulls at Kaikoura was relatively stable at c. 16000–19000 from 1983 to 1993 but numbers then halved to c. 9000 by 2003 (Mills *et al.* 2008). However, corresponding nest numbers for 1983–93 fluctuated annually with

average c. 6050 (range c. 2300–9200), and through the decline in 1994–2004 annual nest numbers averaged c. 4200 (range c. 3050–4950) (Mills *et al.* 2008) (Fig. 2). This decline continued through subsequent years and annual nest numbers dropped from 3519 in 2006 to 2635 in 2011 (J. Mills, *pers. comm.*), with an annual average 3014 from 6 years (Fig. 2). The increase in nest numbers we recorded at Otago from 1992 to 2011 coincided with the halving in nest numbers recorded from 1993 to 2011 at Kaikoura (Fig. 2). The period of stability in population size at Kaikoura from 1983 to 1993 was preceded by an increase in nest numbers through the 1960s from 3160 in 1961 (Gurr & Kinsky 1965), 4380 in 1964 (Mills 1973, 1989), 4752 in 1965 (Mills 1973), to 5678 in 1968 (Mills 1973, 1989), where the number in 1968 was similar to the 5888 nests for 1983 in Mills (1989) (Fig. 2).

Records indicated that red-billed gull nest numbers at or near Taiaroa Head have been relatively high in the past. Stan Sharpe mentioned red-billed gulls only once in his 1951–1968 field notebooks: ‘thousands of eggs and chicks between Taiaroa Head and Penguin Beach’ in 1951. Hamel (in Edgar 1972) also recorded a large colony of up to 4000 birds near Taiaroa Head in 1967. However, in between these years numbers were relatively low with records indicating fewer than 300 nests (Gurr & Kinsky 1965; Allen in Edgar 1972). A pattern of a substantial decrease followed by recovery was repeated at Nugget Point where Gurr & Kinsky (1965) reported c.1000 nests in 1941, and c. 2000 in an unspecified year. In contrast, our highest count

for Nugget Point was 235 nests for 3 years from 1988 to 1998, followed by a rise to a maximum of 500–540 nests from the most recent 3 years, 2009–2011.

Monitoring through the 13 years from 1999–2011 at Taiaroa Head detected only 1 banded red-billed gull (E183757), a bird banded as a chick at Kaikoura on 15 Dec 2000 (Jim Mills, *pers. comm.* to LP) and found nesting annually at Taiaroa Head for 4 years from 2004–2007. We do not have any records for banded red-billed gulls seen elsewhere at Otago, but monitoring at other locations was insufficient to reliably detect banded birds.

### Impact of conservation management at 2 mainland locations

Conservation management relevant to red-billed gulls at 2 mainland locations, Taiaroa Head and Katiki Point, has targeted mitigation of the impacts of introduced mammalian predators and human disturbance.

Conservation management at Taiaroa Head was instigated to protect nesting northern royal albatrosses (*Diomedea sanfordi*). Trapping of introduced mammal predators by Taiaroa Head rangers began in 1951 with the targeting of cats, stoats and ferrets, and security fences to block access by people and dogs (*Canis familiaris*) were erected in 1964 (Robertson 1997, 2001). Twenty-one counts of red-billed gull nests at Taiaroa Head began with <100 nests in 1963–1989, rising to 118–145 nests in 1990–1993, 540–580 nests in 1999–2002, followed by a rapid increase starting in 2003 and culminating with 2423 nests in 2011 (Fig. 3, Table 1).

During monitoring of little penguins (*Eudyptula minor*) at Taiaroa Head that began in 1992 (Perriman & Steen 2000), LP noticed large numbers of red-billed gull eggshell fragments in small burrows close to the gull nests and during a visit at night in Nov 1993, LP saw a rat feeding on the remains of a freshly broken gull egg. Beginning in 1994, rat poison was laid around red-billed gull nests and this resulted in a notable increase in the number of gull chicks that survived and no obvious scavenging or loss of red-billed gull eggs attributable to rats. The subsequent increase in the number of red-billed gull nests at Taiaroa Head from 145 in 1993 to 548 in 1999 coincided with a reduction from 7 separate breeding sites into a single site. Poisoning of rats at Taiaroa Head ceased in 1999 with no apparent subsequent detrimental effects on the increase in nest numbers.

Territorial disputes among red-billed gulls at Taiaroa Head can lead to breakage of eggs or death of chicks but we have not seen any cases of intraspecific predation or scavenging of eggs or chicks. Two common bird species at Taiaroa Head, black-backed gull and swamp harrier (*Circus approximans*), are mobbed by red-billed gulls during

the breeding season. Black-backed gulls not only take red-billed gull chicks from within the colony but also take fledglings and occasionally adults while both species forage together on the sea surface around the headland (LP, *pers. obs.*). Swamp harriers have been seen feeding on red-billed gull carcasses but this may represent scavenging because predation has not been verified (LP, *pers. obs.*). However, nesting red-billed gulls at Taiaroa Head react to swamp harriers by taking flight. The most extreme example was seen early in the breeding season on 24 Oct 2009: all 3000–4000 red-billed gulls took flight in response to the landing of a swamp harrier in the breeding colony, including gulls that had begun incubating.

Conservation management at Katiki Point has been carried out mainly by resident volunteers, from 1982 to 2002 by Janice and Bob Jones and since 2002 by Rosalie Goldsworthy. The 1st year that red-billed gulls were recorded breeding at Katiki Point was in 1991 with 100–200 nests (Janice Jones notebooks). This coincided with the trapping of cats, stoats, ferrets, hedgehogs and brushtail possums (*Trichosurus vulpecula*) and poisoning of rats that were instigated in Sep 1991 to protect yellow-eyed penguins (*Megadyptes antipodes*) nesting for the 1st time at Katiki Point. Although red-billed gulls have nested at Katiki Point in most subsequent years, there are few accurate counts of nest numbers because this headland suffers human disturbance as a consequence of unrestricted public access. The typical outcome of people walking among nests has been predation of eggs and chicks by black-backed gulls, with few chicks fledged in most years before 2002. This impact was witnessed and documented 3 times by Janice or Bob Jones (Janice Jones notebooks) and/or CL: numbers were reduced from c.110 to 8 nests on 28 Nov 1995, from c. 220 to 92 nests on 31 Dec 1999, and from 270 to 60 nests on 15 Dec 2001. Breeding success appears to have improved since 2002 with Rosalie Goldsworthy erecting temporary fencing around breeding areas, with signs asking people to stay away from nests.

The responses of red-billed gulls to human disturbance have been similar at Taiaroa Head (LP, *pers. obs.*) and Katiki Point (CL, *pers. obs.*). Quiet and slow approaches to within 10–20 m of the nearest gulls during the nest-building period typically caused all gulls in the colony to take flight. This response became less extreme once most nests had eggs or chicks, and typically only to gulls within 1–5 m of approaching people left their nests.

### Importance of mainland breeding locations

Sixteen of the 26 red-billed gull breeding locations we documented from Moeraki to Nugget Point were on the mainland and the other 10 were on

vegetated islands or bare islets (Table 1). Eight of the 15 breeding locations used by red-billed gulls in 2011 were on the mainland and these accounted for 80% (3714) of the annual total of 4612–4652 nests (Table 1). At least 3468 (93%) of nests on the mainland in 2011 were accessible to rats, with most if not all also accessible to larger mammalian predators (Table 1).

## DISCUSSION

The number of red-billed gull nests at Otago at least quadrupled through the 20 breeding seasons from 1992 to 2011. This increase coincided with the large decline that occurred 400–550 km further north along the east coast of South I at Kaikoura. The population size of adult red-billed gulls at Kaikoura halved through 1993 to 2003, a decline attributed to changes in oceanic productivity and subsequent food availability (Mills *et al.* 2008). The coastal oceanography off Kaikoura is a complex mix of coastal upwelling and relatively cool and nutrient-rich surface water, with incursions of relatively warm and nutrient-poor surface water generated by north-east winds (Mills *et al.* 2008). Here the availability of *N. australis*, the main prey of red-billed gulls at Kaikoura, was negatively correlated to sea surface temperature (SST): higher prey availability, and subsequently higher red-billed gull breeding success, coincided with colder SST (Mills *et al.* 2008).

The Otago coast abuts the relatively cool Southland Current, the shoreward edge of the circumpolar Subtropical Front that flows north past Otago and then diverts east at Banks Peninsula, south of Kaikoura (Sutton 2003). Fluctuations in SST in the Subtropical Front are negatively correlated to those further north, including Kaikoura (Uddstrom & Oien 1999). Consequently, the recent increases in numbers of red-billed gull nests at Otago may be a reflection of concomitant decreases at Kaikoura. We presented evidence that this interpretation was supported by past records for Otago from 1941 in Gurr & Kinsky (1965) and from 1951 in Sharpe (unpublished field notebooks) indicating a period when nest numbers were relatively large, and by past records for Kaikoura from the 1960s in Gurr & Kinsky (1965) and Mills (1973, 1989) indicating a period when nest numbers were relatively small.

Red-billed gulls are highly philopatric: for chicks banded at Kaikoura and later found breeding, 99% nested at or within 25 km of Kaikoura (Mills *et al.* 2008). Our record for a chick banded at Kaikoura emigrating south to breed at Taiaroa Head is the only breeding record for red-billed gulls from Kaikoura breeding at Otago or further south (Jim Mills, *pers. comm.* to LP). However, some Kaikoura

birds disperse as far south as Invercargill outside the breeding season (Jim Mills, *pers. comm.* to LP). The paucity of breeding red-billed gulls from Kaikoura indicates that the concomitant population increase at Otago and decrease at Kaikoura was not caused by a southward emigration of birds from Kaikoura.

In common with Kaikoura, *N. australis* at Otago is abundant (Jillett 1969; O'Driscoll & McClatchie 1998) and an important prey of red-billed gulls but, in addition, the shoaling phase of the galatheid crab *Munida gregaria* is periodically an important prey for gulls at Otago (McClatchie *et al.* 1989, 1991; O'Driscoll *et al.* 1998). The duration and abundance of the shoaling phase of *M. gregaria* varies from year to year (Zeldis & Jillett 1982; Zeldis 1985). Shoals of *M. gregaria* occur off most of the east coast of South I but reach their highest abundance off Otago (Zeldis 1985). Nearshore, nutrient-rich upwelling, a feature that enhances plankton abundance off Kaikoura (Mills *et al.* 2008) does not occur off Otago. Instead, a coastal eddy retains and concentrates plankton, including *N. australis* and *M. gregaria*, in an anti-clockwise gyre between Taiaroa Head and Shag Point (Murdoch 1989; Murdoch *et al.* 1990; Bradford-Grieve *et al.* 1991). The proximity of Taiaroa Head to this concentrated source of prey may explain why Taiaroa Head holds the greatest number of red-billed gull nests at Otago.

Eighty percent of red-billed gull nests surveyed at Otago in 2011 were on the mainland where most are vulnerable to predation by introduced mammals and to human disturbance. Results from Taiaroa Head and Katiki Point showed that these threats can be mitigated by conservation management. In addition to the known threat from introduced mammalian predators (especially stoats, ferrets and cats), we found that rats ate red-billed gull eggs and consequently pose a threat, particularly to small colonies. Rats at Taiaroa Head were also suspected of taking little penguin eggs (Perriman & Steen 2000). The instigation of rat control by poisoning around gulls at Taiaroa Head was followed not only by a rapid increase in red-billed gull nest numbers but also by a coalescence of scattered, small groups into a single colony. Rat control ceased in 1999 when the gull population exceeded 500 pairs. Rats are known to still be present in the area, however it is unknown if the increased number and density of gulls has led to a reduction of egg depredation. Red-billed gulls respond to potential diurnal predators with communal aerial attacks (Higgins & Davies 1996). We suggest that size matters: larger colonies may be more viable because more gulls are available, especially to drive off avian predators such as black-backed gulls and swamp harriers. Human disturbance is not a problem at Taiaroa Head



where unauthorised entry is blocked by security fences. In contrast, Katiki Point has unrestricted public access and human disturbance reduces breeding success: red-billed gulls leave their eggs and chicks exposed to predation by black-backed gulls when people walk among nests. Related to human disturbance but beyond our experience, Taylor (2000) highlighted the threat imposed by pet dogs let loose in red-billed gull colonies.

Surveys will need to continue in order to determine the duration of the present increase in nest numbers of red-billed gulls at Otago. In particular, recent surveys have indicated the possibility of a trend towards fewer and larger colonies as numbers have increased. Future monitoring will help establish whether the recorded declines at the main colonies either reflect an actual overall decline in the New Zealand population or these declines are compensated by increases at Otago. Readily-accessible mainland locations offer scope for research at Otago, especially for the investigation of breeding success. Above all we regard control of predators and people at important mainland locations, especially Taiaroa Head and Katiki Point, as key to the viability of red-billed gulls at Otago.

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