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RESEARCH ARTICLE

Population trends of New Zealand fur seals in the Rakiura region based on long-term population surveys and traditional ecological knowledge

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We estimated population abundance of New Zealand fur seal (*Arctocephalus forsteri*) pups on Bench Island off Stewart Island, New Zealand seven times between 1996 and 2012. Overall, there was a 29% increase in pup abundance from 1996 to 2012 at the Main Beach colony, corresponding to a mean annual growth rate of 1.6% and a doubling time of approximately 40 years. At the Sprat Point colony, there was an overall increase of 29% between 2003 and 2012 corresponding to a mean annual growth rate of 2.9% and a doubling time of approximately 25 years. The area occupied by both colonies has also increased. In 2006, we surveyed East Beach and counted a total of 201 pups. We obtained traditional ecological knowledge of fur seal distribution and breeding status from local Māori for 46 locations around Stewart Island, 36 of which have not been surveyed since Wilson in 1971–1974; this supports an expansion of fur seal presence and breeding areas in the region in the last 41 years.

Keywords: abundance; *Arctocephalus forsteri*; Bench Island; mark-recapture; Rakiura; traditional ecological knowledge

Introduction

The paucity of previous comprehensive surveys for New Zealand fur seals (*Arctocephalus forsteri*) in the Rakiura region presents a challenge for assessing the current state of this region's population. Estimating the abundance of pinnipeds presents a problem for population management because, at any one time, there are an unknown proportion of adults at sea that are not countable (Kenyon et al. 1954; Eberhardt el al. 1979; Shaughnessy et al. 1994). However, pups of most pinniped species are easy to identify and confined to land in well-defined, exclusive breeding colonies for the first few months of life, which means one can assume the pup population is constant during the period after all pups are born and before they go to sea at about six months of age (Chapman & Johnson 1968; Berkson & Demaster 1985; Shaughnessy et al. 1994, 1995b; Lalas & Harcourt 1995; Taylor et al. 1995). Dead pups are also readily visible to observers. These qualities allow pups to be used as an index of pup abundance and a basis for estimating breeding adult numbers by the application of a multiplier derived from the ratio of pups to older seals deduced from population models (Lalas & Bradshaw 2001). A minimum number alive can also be determined for use in basic comparisons.

Another potential source of information available for trends in fur seal numbers in the region is Māori traditional ecological knowledge (mātauranga). The definition of traditional ecological knowledge used here is consistent with its use by Huntington (1998), Berkes (1999) and Noongwook et al. (2007) to mean 'knowledge and values, which have been acquired through experience, observation from the land, or spiritual teachings

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and passed down from one generation to the next'. Many cases of co-management have shown that traditional ecological knowledge can be used to narrow the focus of a scientific study, formulate hypotheses, and provide intricate, detailed and subtle knowledge over time periods far exceeding those usually obtained using standard scientific methods (Huntington 1998; Berkes et al. 2001; Lyver & Łutsel K'é Dene First Nation 2005; Newman & Moller 2005).

The Rakiura region generally encompasses Stewart Island (Rakiura) and its outlying islands. In this paper we have also included additional islands located in the Foveaux Strait between Rakiura and the South Island town of Bluff. A complete list is included in Table 3. The only town on Rakiura is Oban, located on the north coast of Paterson Inlet, which is a large natural harbour on the eastern coast of the island. Māori have harvested sooty shearwaters (*Puffinus griseus*) yearly at multiple sites throughout the region for at least 350 years (Hawke et al. 2003), so their long-term knowledge of the system could be insightful. Therefore, we consulted with Rakiura Māori elders about fur seals in the region and were provided with information on the (subjective) relative abundance of fur seals at 46 locations on 44 islands.

Bench Island is located 7 km east of Oban township, Stewart Island. Fortunately, there is a long historical record of counts dating back to 1943 (Wilson 1981) for Bench Island, and it can be considered a good barometer for the status of fur seals in the Paterson Inlet area because of the longevity of fur seal usage of this island. Trends on Bench Island are likely to mirror trends on the surrounding islands in that same group, and, we assume, the whole of the Foveaux Strait area. During the last comprehensive boat and land survey of the fur seal population in the Rakiura region (1971–1974), Wilson (1981) estimated 425 (375–475) individuals on Bench Island for January/February of 1973 using multipliers of November 1971 counts. In 1990, Department of Conservation (DOC) staff (DOC, unpubl. data) found fur seals breeding on the south and northeast coasts only and counted 1835 individuals by boat. Bradshaw et al. (1999, 2000a,b) did mark-recapture surveys of fur seal pups in March/April 1996–1998 on Bench Island, and Watson et al. (2009) also did total counts and mark-recapture surveys on Bench Island in April 2003. In spring 2006, 2009 and 2012, Beaven established and led ongoing monitoring of New Zealand fur seals pups on Bench Island for the DOC using mark-recapture methods.

Study area

Breeding colonies of New Zealand fur seals in New Zealand are delineated as discrete aggregations of pups along rocky coastlines in a variety of habitats (Ryan et al. 1997; Bradshaw et al. 1999). Pups spend much of their time hiding in crevices in the rocks and large numbers of pups in rocky colonies are inconspicuous. Other age classes rarely haul-out in a breeding colony, instead choosing other distinct areas of shoreline, but are also easily distinguished from pups by their larger size and different coat colour and texture. The majority of surveying on Bench Island has been done at the two largest breeding colonies (Main Beach and Sprat Point; Fig. 1) and at East Beach, although small breeding congregations have been noted on the south coast and elsewhere around the island. The Main Beach colony on the western end of Bench Island encompasses three breeding areas separated by areas of land at the water's edge not used by pups. However, mixing between the three areas at the time of our studies (late April) is evident; therefore, we combined counts from all three breeding areas to uphold population 'closure' assumptions (White & Burnham 1999).

The Main Beach colony encompasses an area of approximately 1 km^2 with a northern edge at 46° 54.542′S, 168°13.904′E and a southern edge at 46° 54.794′S, 168°13.710′E. The northernmost breeding area in Main Beach colony consists of a boulder beach approximately 20 m wide. The boulder beach ends in thick vegetation consisting of trees, bushes and bracken that is used by adults and pups. This breeding area is approximately 500 m long. At the end of this area is a small, shingle beach not used by seal pups. This leads to the second breeding area consisting of a small boulder beach

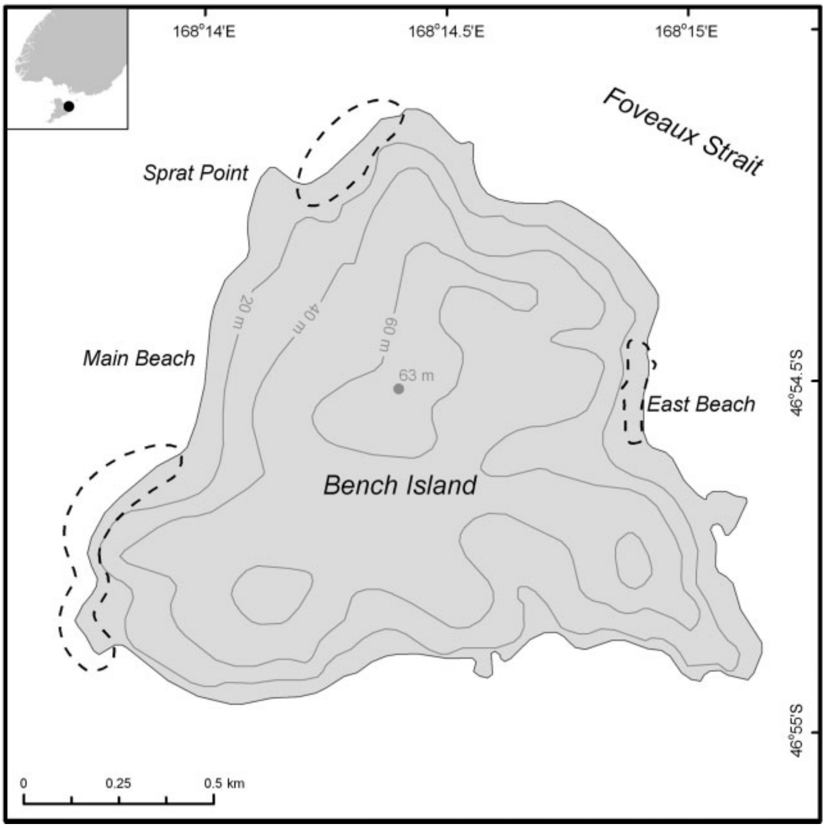

Figure 1 Map of Bench Island, New Zealand with fur seal colony locations (dashed outlines) studied.

with several pool areas exposed at low tide and a grassy slope up from the beach. This area is on a small peninsula, the isthmus of which is a thickly vegetated saddle area, approximately 100 m long and heavily used by seals. On the southern side of the isthmus is the third breeding area approximately 300 m long, comprised of large boulders with some platform areas and two large caves capable of holding at least 30 pups. This breeding area ends at a section of sheer cliffs, beyond which seals are not visible. On the northern point of Bench Island is the Sprat Point colony (46°54.204′S, 168°14.078′E to 46°54.103′S, 168°14.360′E), approximately 300 m long, which consists of a boulder beach, vegetated slopes and a few platform areas with pools. There is another colony at East Beach (46°54.426′S, 168°14.850′E to 46°54.570′S, 168°14.832′E). This colony is a broad, rocky beach, about 400 m long, bordered by dense vegetation.

Methods

Timing of study

Pups are born in breeding colonies between the end of November and the beginning of January and are confined to land for approximately the first 6 months of life (Lalas & Harcourt 1995; Shaughnessy et al. 1995b). The field season is restricted by the presence of aggressive territorial males until mid-January and pups going to sea in June/July (Shaughnessy et al. 1994; Lalas & Harcourt 1995). Abundance surveys of pups are timed to occur after most breeding and pupping is done so as to avoid contact with aggressive adult males and ensure the maximum number of births has occurred. The ideal time period for counting New Zealand fur seal pups is between early February and late April.

Capture-mark-recapture

On Bench Island, capture-mark-recapture has been the primary method used to estimate pup abundance. Mark-recapture surveys of fur seal pups have been done in austral autumn on Bench Island seven times in the last 16 years (Bradshaw: 1996, 1997, 1998; Watson: 2003; Department of Conservation: 2006, 2009, 2012). All surveys took place in March or April, except for 1996 when they occurred in January.

Pups were caught by hand (Lalas & Harcourt 1995) or with a noose pole (Gentry & Holt 1982). We attempted to catch all pups encountered in colonies to ensure a high ratio of marked to unmarked pups in our recounts, which enhances robustness of estimates and narrows confidence intervals. We applied *Allflex®* tags (Palmerston North, New Zealand) to the trailing edge of both flippers to mark pups on Bench Island between 1996 and 1998 (Bradshaw et al. 1999, 2000a,b), and marked pups in later years by clipping a small patch (2–5 cm^2) of fur from the top of the head to expose the pale underfur (Shaughnessy et al. 1995a; Watson 2004a; Watson et al. 2009).

We piled dead pups found during the initial marking session in a communal location and ignored these for all analyses. If we found a marked pup dead during surveys, we reduced the total number of marked animals by one for calculations, and excluded it from subsequent estimates. We removed unmarked dead pups found during recapture sessions to the communal location and ignored them for analysis because the mark-recapture method is robust to single instances of unknowns, and they are unlikely to affect the overall ratio of marked to unmarked animals and pup abundance estimate greatly. We excluded from the analysis resighted pups whose mark status could not be confirmed, usually due to difficulty seeing the animal in a rock crevice.

We followed the total count method of Lalas & Harcourt (1995) and Lalas & Murphy (1998) for our recapture sessions, whereby pups were counted by several observers while walking in a line from one end of the colony to the other checking all potential hiding places and noting the number of pups visible as they passed each individual. We avoided double-counting of pups by ignoring any animals that ran ahead of observers and only counting them when they were passed. We repeated recapture sessions (counts) of pups two to nine times over 1 to 4 days by up to four people, after marking at each colony. During recapture sessions tallies of marked and unmarked individuals were recorded. The duration between successive counts was at least 15 min during 1996–1998 and at least 30 min in all other surveys to ensure sufficient mixing, and therefore, independence between counts (Shaughnessy et al. 1994, 1995b).

We estimated pup population size at each colony after each count (N_i) using the Chapman version of the Lincoln-Petersen estimator:

$$\hat{N} = \frac{(m_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1 \qquad (1)$$

where m_1 is the number of animals marked in the initial session, m_2 is the number of marked animals seen in a recapture session, n_2 is the number of animals caught or seen in a recapture session, and $\hat{N}$ is the population estimate (Williams et al. 2002). We generated an estimate from the combination of all recapture sessions for individual years using the program NOREMARK (White 1996), which applies the joint hypergeometric maximum likelihood estimation method of Bartmann et al. (1987) to produce a single mean and 95% confidence interval for multiple recapture sessions.

We calculated the mean annual exponential growth rate (r) following Shaughnessy et al. (1995a) using the following formula:

$$r = \frac{\text{In}\,\hat{N}_{t+1} - \text{In}\,\hat{N}_1}{\text{number of years between counts}} \qquad (2)$$

where $\hat{N}_{t+1}$ and $\hat{N}_1$ are the pup population estimates from two different years.

The minimum number alive can be a useful indicator for population studies dealing with species of management concern where decisions are based on a threshold. It combines the highest number of unmarked animals of interest (pups) seen during any count at a location with the total number of marked animals at that location to give a confident minimum population size. This parameter is often compared to mark-recapture estimates to ensure the estimator is within the realm of possibility. This parameter is particularly helpful when dealing with inconspicuous species, such as New Zealand fur seals, and many management decisions are based on a minimum pup abundance estimate.

In 2006, we did a total count of all pups visible at a third site, East Beach. Due to time constraints, we could not repeat this count in later years. Watson et al. (2009) did mark-recapture and total count surveys of pups simultaneously at several New Zealand fur seal colonies, including Main Beach and Sprat Point on Bench Island, to create a calibration between the total count index and mark-recapture estimates for pups. This calibration allows land-based total counts of pups to be converted into an abundance estimate with confidence intervals normally generated during mark-recapture surveys. Using the calibration for colonies with rocky terrain containing hiding places, we analysed East Beach data, and produced a total pup population abundance estimate with confidence intervals for 2006.

Traditional ecological knowledge

In 2004, using the semi-directive interview technique of Huntington (1998), we showed Rakiura Māori elders a map (Kiwimaps Ltd 2002a,b) of the Rakiura region and asked them whether fur seals were present or absent on islands and whether they had ever seen pups at a location. We did not ask specifically at what time of year seals were observed, but it was assumed, since pups are visible in large aggregates only between November and June of each year, any location indicated as a colony would have been observed during that timeframe. Locations indicated as haul-outs could have been observed at any time of year since haul-out patterns of this species are not known to be strongly season-specific.

Results

Pup abundance estimates from the Main Beach colony span the years 1996–2012 (Table 1). The minimum number of pups alive varied from 162 to 278, with the highest occurrence in 1997. Abundance estimates varied from 234 to 547 with the lowest occurrence in 1998 (coinciding with an intense El Niño event) and the highest in 2006. Yearly percent change varied from −39% to 26%.

Table 1 Pup population estimates and percent change between years for Main Beach colony on Bench Island, New Zealand, 1996–2012.

Year	No. pups marked	L-P estimate	95% confidence intervals	Minimum number alive	Yearly % change in pup estimate	Mean annual exponential growth rate (%)
1996	70	304	255–377	162	–	–
1997	187	383	363–406	278	26↑	23.1
1998	174	234	225–244	205	39↓	−49.2
2003	145	372	355–391	258	12↑	9.2
2006	156	547	507–594	275	16↑	12.8
2009	181	464	433–500	269	5↓	−5.4
2012	100	393	347–451	180	5↓	−5.5

L-P, Lincoln-Petersen estimation method.
Main Beach colony is the same as 'BIW' in Bradshaw et al. (1999, 2000a,b).

Overall, there was a mean of 29% increase in pup abundance from 1996 to 2012 at Main Beach colony on Bench Island; however, there has been a decline (28%) since the peak in 2006. This corresponds to a mean annual exponential growth rate of 1.6% and a doubling time of approximately 40 years. Differences in the yearly exponential growth rates between individual surveys were substantially higher, ranging from a low of −49.2% to a high of 23.1% (Table 1).

Pup abundance estimates at the Sprat Point colony spanning the years 2003–2012 varied between 146 and 243, with the lowest occurrence in 2003 and the highest in 2009 (Table 2). Yearly percent change varied from −4% to 22%. Surveys indicate an overall increase (29%) in pup abundance between 2003 and 2012, with a decrease (22%) from 2009 to 2012. The mean annual exponential growth rate at Sprat Point colony is larger (2.9%) than at Main Beach colony, with a lower doubling time of slightly less than 25 years. Unlike Main Beach, Sprat Point maintained its population size between 2006 and 2009, and did not start to show a decline until after 2009. Despite the differences in timing of the declines seen in recent years, the overall percent increase over our survey period is identical between the two colonies (Table 2). Fig. 2 displays population trends for both colonies.

To test whether the exponential growth rate of 1.6% observed at Main Beach colony has been constant since the first confirmed mention of pups on Bench Island in 1971 ($n = 41$, K-J Wilson, West

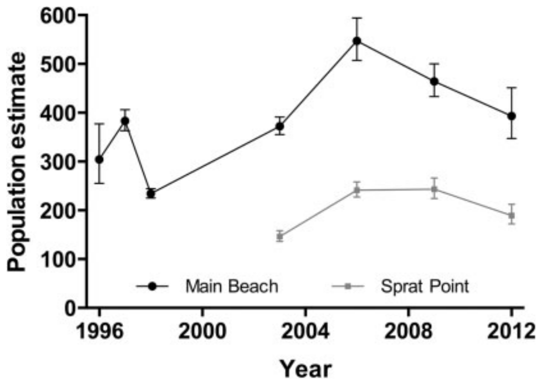

Figure 2 Time series of mark-recapture population estimates for New Zealand fur seal pups for Main Beach and Sprat Point colonies on Bench Island from 1996–2012.

Coast Penguin Trust,1 July 2012 pers. comm.), we extrapolated back to 1971, which gives an estimate of 203 pups for that year. To obtain the observed value from 1971 of 41 individual pups, a constant mean annual exponential growth rate of 5.35% over the last 41 years is required. Further, Watson et al. (2009) determined a calibration between total counts (done while walking through a colony) and mark-recapture estimates for the terrain type found on Bench Island to be $y = 1.51x$, with 95% confidence intervals (likely scatter of data) from $y = 1.47x - 34.9$ to $y = 1.56x + 34.9$. This would give a 1971 total estimate of 62 pups (25–99), which is still lower than would be expected assuming a constant annual exponential growth rate based on today's estimates.

Table 2 Pup population estimates for Sprat Point colony on Bench Island, New Zealand, 2003–2012.

Year	No. pups marked	L-P estimate	95% confidence intervals	Minimum number alive	Yearly % change in pup estimate	Mean annual exponential growth rate (%)
2003	77	146	136–158	109	–	–
2006	119	241	227–258	170	22↑	16.7
2009	102	243	224–266	149	0.34↑	0.2
2012	100	189	172–212	124	4↓	−8.3

L-P, Lincoln-Petersen estimation method.
Sprat Point colony same as 'Bench Mohawk' colony in Watson (2004a).

Table 3 Population status for New Zealand fur seals at several locations in the Rakiura region.

Location	Latitude(S)/Longitude(E)	Status in 1973 (Wilson 1981)	Status in 2004 (M. Bragg TEK)	Figure 3 abbreviation
Centre Is. (south of Colac Bay)	46°27.976/167°50.880	absent**	presence	CnI
Escape Reefs	46°28.900/167°56.755	absent**	absent	ER
Omaui Rocks (entrance to New River Estuary)	46°30.567/168°12.884	absent**	haul-out	OR
Dog Island (south of aluminium smelter, Bluff)	46°38.974/168°24.537	absent**	haul-out	DI
Ruapuke Is.	46°44.805/168°32.219	occasional haul-out	colony	RpI
Seal Rocks (off Ruapuke Is.)	46°44.805/168°35.859	absent**	colony	SR
Green Is.	46°45.860/168°34.400	colony	presence	GI
South Islets	46°47.928/168°30.421	absent**	colony	SI
Hazelburgh Group	46°49.371/168°27.908	haul-out possible	unknown	HG
North Is.	46°48.822/168°14.404	absent**	haul-out	NI
Womens Is.	46°49.240/168°14.723	absent**	presence	WmI
Edwards Is./Motunui	46°49.879/168°13.133	absent**	colony	EdI
Jacky Lee Is.	46°50.729/168°12.745	absent**	colony	JLI
Bunker Islets	46°51.802/168°15.925	colony	colony (lots)	BnI
Western Bunker Islet	46°51.915/168°15.702	colony	–	
Nugget at west end of islet	46°51.827/168°15.579	haul-out	–	
Eastern Bunker Islet	46°51.994/168°16.110	colony	–	
Kanetetoe Is.	46°52.524/168°16.769	haul-out	haul-out	KnI
Herekopare Is./Te Marama	46°51.959/168°13.662	absent	colony	HI
Flat Rock (near Bench Is.)	46°54.263/168°15.330	haul-out	haul-out	FR
The Haystacks (south of Bench Is.)	46°54.919/168°15.441	haul-out	haul-out	TH
Bench Island, Main Beach	46°54.112/168°14.913	haul-out	colony	BI-M
Bench Island, Sprat Point	46°54.606/168°13.717	haul-out (1 pup)	colony	BI-S
Bench Island, East Beach	46°54.527/168°14.865	haul-out	colony	BI-E
Tamihau Is.	46°56.009/168°06.494	haul-out	absent*	TmI
Ulva Is.	46°55.744/168°07.740	haul-out	absent	UI
Native Is.	46°54.863/168°09.135	absent**	absent	NtI
Tia Is.	47°04.188/168°13.336	colony	colony	TI
Weka Is.	47°03.667/168°13.050	haul-out	unknown	WkI
Breaksea Islands	47°06.063/168°12.226	colony	colony	BrI
Owen Is./Horomamae	47°07.302/168°09.427	colony	colony	OI
White Rock	47°07.964/168°00.150	absent**	absent	WR
Black Rock	47°09.908/167°57.656	absent**	absent	BR
North Trap	47°24.401/167°55.844	absent**	absent	NT
Pearl Is.	47°11.308/167°42.666	absent**	presence	PI
Ernest Is. (south)	47°04.295/167°39.881	colony	colony	ErI
Murphy Is.	47°17.342/167°30.128	absent**	colony	MI

Table 3 (*Continued*)

Location	Latitude(S)/Longitude(E)	Status in 1973 (Wilson 1981)	Status in 2004 (M. Bragg TEK)	Figure 3 abbreviation
Poutama Is.	47°15.941/167°23.830	haul-out	presence	PtI
Big South Cape Is.	47°14.246/167°24.597	colony	colony	BSC
Pohowaitai Is.	47°13.339/167°19.686	haul-out	colony	PhI
Tamaitemioka Is.	47°13.052/167°19.914	colony	colony	TmtI
Putauhina Is.	47°12.886/167°23.266	haul-out	colony	PthI
Putauhina Nuggets	47°13.557/167°22.007	haul-out	colony	PthN
Solomon Is.	47°13.186/167°26.213	absent	colony	SlI
Kaimohu Is.	47°12.168/167°27.229	absent	absent	KmI
Big Is.	47°08.029/167°31.683	haul-out	presence	BgI
Kundy Is.	47°07.164/167°33.159	likely haul-out	unknown	KdI
Chimney Is.	47°08.215/167°31.031	absent**	haul-out	ChI
Big Moggy Is./Mōkihinui	47°08.712/167°24.242	haul-out	colony	BMI
Little Moggy Is./Mokihiiti	47°08.286/167°24.959	haul-out	colony	LMI
Codfish Is./Whenua Hou	46°46.097/167°37.682	colony	colony	CdI
Rugged Is.	46°42.084/167°42.862	haul-out	absent	RI

*As of 2010 small numbers of individuals use Tamihau as a haul-out.
**Locations not specifically mentioned by Wilson (1981), therefore assumed to be absent of fur seals in 1972–1973.
1973 status comes from surveys done by Wilson in 1972–1973 and reported in Wilson (1981).
2004 status comes from Rakiura Māori traditional ecological knowledge as provided by M. Bragg and others.
Haul-out defined as fur seal colony without pups.
Colony defined as fur seal colony with actively breeding adults and pups.

The same situation applies for Sprat Point. In 1979, Wilson counted 49 pups on the southwest coast of Bench Island, a location roughly corresponding to today's Sprat Point colony (K-J. Wilson, West Coast Penguin Trust, 1 July 2012 pers. comm.). Using this historical record, the mean annual exponential growth rate at Sprat Point colony would need to be 4% to arrive at today's estimates. Using the calibration of Watson et al. (2009) would yield a 1979 population estimate of 74 (37–111) pups. This estimate does technically fall within the calibration's estimated range for the colony, but is still 1.5 times higher than the actual count in 1979.

Additionally, we counted 201 pups at East Beach in 2006 during a land-based total count. According to Watson et al. (2009), the calibration equation for a colony of East Beach's terrain type (rocky including hiding places for pups) is $y = 1.51x$, with 95% confidence intervals (likely scatter of data) from $y = 1.47x - 34.9$ to $y = 1.56x + 34.9$. This corresponds to a total pup population estimate for East Beach in 2006 of 304 (261–349).

The 2004 Rakiura Māori elder survey indicates fur seals were present in 2004 on 14 islands where Wilson (1981) saw none in 1973, and were absent from another three islands that Wilson (1981) indicated were non-breeding haul-outs. Of the 46 locations for which we obtained traditional ecological knowledge data, 16 locations were known to have breeding colonies that Wilson (1981) previously indicated had haul-outs or no fur seals present (Table 3; Fig. 3). Rakiura Māori also provided abundance data for fur seals at 17 specific locations not mentioned by Wilson (1981).

Discussion

The Rakiura region contains more than 50 islands. Watson (2004b) estimated that 7936 breeding adults and 2694 pups inhabited the Rakiura region in 2003 based on last known estimates for

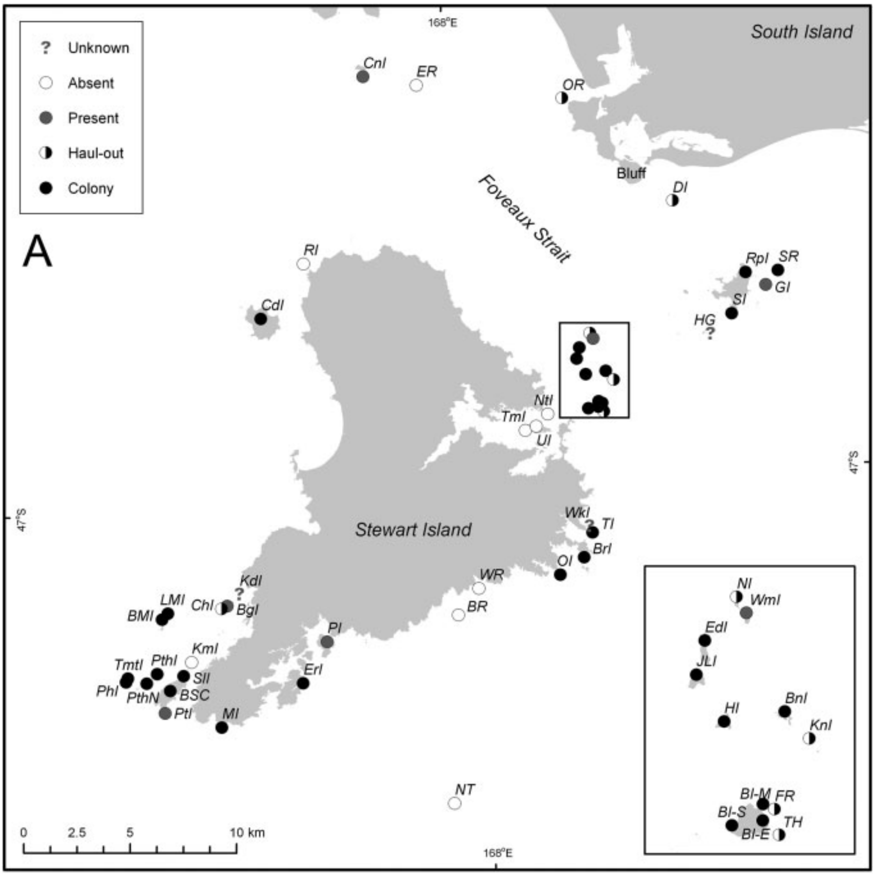

Figure 3 Map of Stewart Island/Rakiura Region with relevant New Zealand fur seal locations. **A,** Presence/absence of haul-outs and colonies per Rakiura Māori traditional ecological knowledge, 2004; **B,** relative status change in fur seal abundance between 1973 Wilson survey and 2004 Māori traditional ecological knowledge.

48 islands. Previously, Wilson (1981) estimated a total population of 3300 (2500–4500) fur seals for the region in 1973 based on counts from boats and land as well as consultation with local Māori and fishermen. If estimates and population increases on Bench Island since 2003 are any indication of the density of fur seals on even some of these islands, there might be as many as 12,000 pups in this region, but there has been no rigorous survey in 41 years.

Māori traditional ecological knowledge clearly indicates an expansion of fur seal territory in the Rakiura area and provides fine-scale regional knowledge of where to find breeding colonies that can be used to estimate pup abundance. Māori knowledge suggests an expansion of fur seals towards the South Island of New Zealand with several haul-outs being established in the vicinity of Bluff. It also indicates a conversion from sporadic haul-outs to successful breeding colonies on several islands off the southwestern coast of Rakiura (Stewart Island). There is also a general decline in fur seal presence in Paterson Inlet, but this is offset by an increase in fur seal abundance and pup presence in the cluster of islands, including Bench Island, just outside Paterson Inlet. A survey done by the DOC of seven locations near Paterson Inlet in 1990 mirrors information given

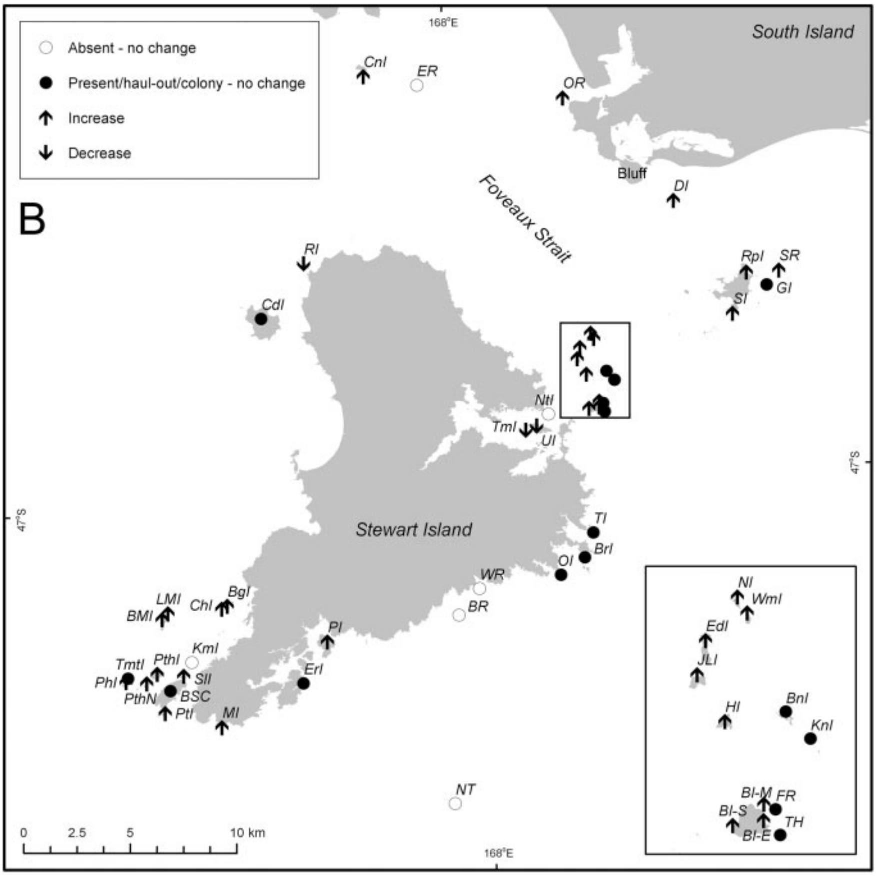

Figure 3 Continued.

by Rakiura Māori. All indications suggest that Rakiura Māori traditional ecological knowledge is a reliable indicator of the presence and breeding status of fur seals in the Rakiura region.

Historical sources provide fur seal population estimates for several islands in the region. Codfish Island (Whenua Hou) had a total population of approximately 100 fur seals in a breeding colony in November 1948 (Falla 1948 cited in Sorensen 1969), and 200–300 in January/February 1973 (Wilson 1981), but was estimated at over 1400 individuals in 2009 (DOC, unpubl. data), an increase of 600%. A DOC boat survey of fur seals showed Herekopare Island increased from zero in the early 1970s (Wilson 1981) to a total population of 429 individuals in 1990. Pohowaitai Island had 'plentiful' fur seals in 1939 (Falla 1948 cited in Sorensen 1969), and the southernmost Ernest Island had approximately 75 adults and 10 pups in January/February 1973 (Wilson 1981), but in March 1990 no fur seals were found on either island (DOC, unpubl. data). However, Rakiura Māori suggested that pups were present on both these islands in 2004.

Wilson's historic counts from 1971 and 1979 were primarily done in the months of November or January, prior to the birth of all pups for that year, which would possibly affect abundance estimates because the population would be effectively 'open' (to new births), thus violating the closure assumption for capture-mark-recapture estimates such as those used in the Watson et al. (2009) calibration.

Wilson's estimates for January/February 1973 were compiled from correction factors applied to counts taken in November in earlier years (usually 1971–1972). Our counts were done in April when the pup population is effectively 'closed'. Additionally, neither the counting protocols nor specific coordinates of the colonies were identical between Wilson's count and ours, so we cannot account for any potential biases arising via the application of a simple correction factor, such as the Watson et al. (2009) calibration; however, we have included it for comparison.

Mean annual exponential growth rates vary widely (−49.2% to 23.1% for Main Beach colony, and −8.3% to 16.7% at Sprat Point) and are comparable to the highest previously calculated mean population growth rates for the species (25%, Lalas & Harcourt 1995; 23%, Taylor et al. 1995). It is likely these short-term changes are the result of unmeasured environmental conditions and measurement error. When looking at long-term growth, the Sprat Point colony appears to agree with Crawley's (1990) estimate of 2%–5% annual increase in the New Zealand region. Additionally, Taylor (1996) found annual increases of 4.9% from 1903 to 1980, and 2.1% from 1980 to 1994 for New Zealand fur seals on the Bounty Islands (Taylor 1982). In Australia, Shaughnessy et al. (1995a) found exponential rate of increases ranging from 0.1% in an 'at capacity' breeding colony to 18.6% in a rapidly expanding one for New Zealand fur seals on Kangaroo Island. In terms of exploring exponential growth rates on Bench Island, the overall rates from our data for Main Beach and Sprat Point colonies are 20%–70% of what historical records indicate they needed to be to arrive at the abundance estimates of 2012, which were 22% (Main Beach) and 28% (Sprat Point) lower than estimates in 2006. Therefore, at some point in the past, the growth rate of the population of fur seals on this island must have been higher.

Conclusions

Comprehensive abundance data for New Zealand fur seals in the Rakiura region are lacking, the last survey having finished 41 years ago (Wilson 1981). In that time, large changes in abundance and demographics of the New Zealand population of New Zealand fur seals have occurred (Bradshaw et al. 2000a,b), with some suggesting the subantarctic islands, and potentially the Rakiura region, are the source of animals recolonising former northern territories (Bradshaw et al. 2000b; Lalas & Bradshaw 2001; Smith 2005). A comprehensive population survey including flipper and satellite tags, and consistent monitoring of the Rakiura region, is needed to shed light on its contribution to the fur seal population overall. This objective could be achieved through co-management partnerships between Rakiura Māori and the DOC that take advantage of the widely dispersed Māori presence in the islands during the fur seal breeding season.

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