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Distribution, abundance and growth of New Zealand sea lion *Phocarctos hookeri* pups on Campbell Island

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Abstract Nine weeks field work was completed during two trips in January/February and March/April 2003 to investigate the distribution and abundance of New Zealand sea lion *Phocarctos hookeri* pups at Campbell Island. A total of 161 pups were tagged and a further 138 dead pups were found. A closed mark-recapture model was used to estimate the total number of live pups (e.g., tagged plus untagged pups) at Campbell Island in April as 247 (SE = 28, 95% CI 198–308). Pup production at Campbell Island is estimated at 385, which comprises 13% of the total pup production for the species in the 2003 season. This is the first robust estimate of pup production for New Zealand sea lions at Campbell Island. The figure of 385 pups is considerably higher than any of the previous estimates reported from Campbell Island. The high level of pup mortality (36%) at Campbell Island for approximately the first 2 months after birth is higher than the 17% reported for the Auckland Islands for approximately the same period in 2003, but is similar to unusually high levels of mortality (20–30%) reported at the Auckland Islands in recent years. It was not possible to determine the cause of death of the 138 dead pups owing to scavenging and decomposition. Pups were found over the whole Island, with the exception of its northern end. Male pups were significantly heavier and faster growing than female pups over the same period.

Keywords *Phocarctos hookeri*; subantarctic; sea lion; New Zealand; Campbell Island; survey; breeding; distribution; abundance; pup growth

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INTRODUCTION

The breeding distribution of the New Zealand (Hooker's) sea lion *Phocarctos hookeri* is centred on the New Zealand subantarctic islands (Fig. 1) previous estimates suggesting that over 95% of all pups of the species are born at four colonies in the Auckland Islands (Gales & Fletcher 1999). The only other significant breeding population is at Campbell Island (McNally et al. 2001). Occasional births have been recorded at the Snares (Crawley & Cameron 1972), Stewart Island (Childerhouse & Gales 1998) and Otago Peninsula (McConkey et al. 2002a). The mean population size of New Zealand sea lions is estimated at 13 608 (95% CI 11 812–15 663) individuals for the 2003 breeding season (Wilkinson unpubl. data) and the population appears to be stable at c. 12 000–14 000 individuals since the mid 1990s (Gales & Fletcher 1999; Wilkinson et al. 2003). New Zealand sea lions are gazetted as a threatened species by the New Zealand Government and are also listed as threatened by the IUCN (IUCN 1996; Wilkinson et al. 2003).

Campbell Island was discovered in 1810, and both fur seals and sea lions were quickly reduced to low numbers by commercial sealing (McNab 1907;

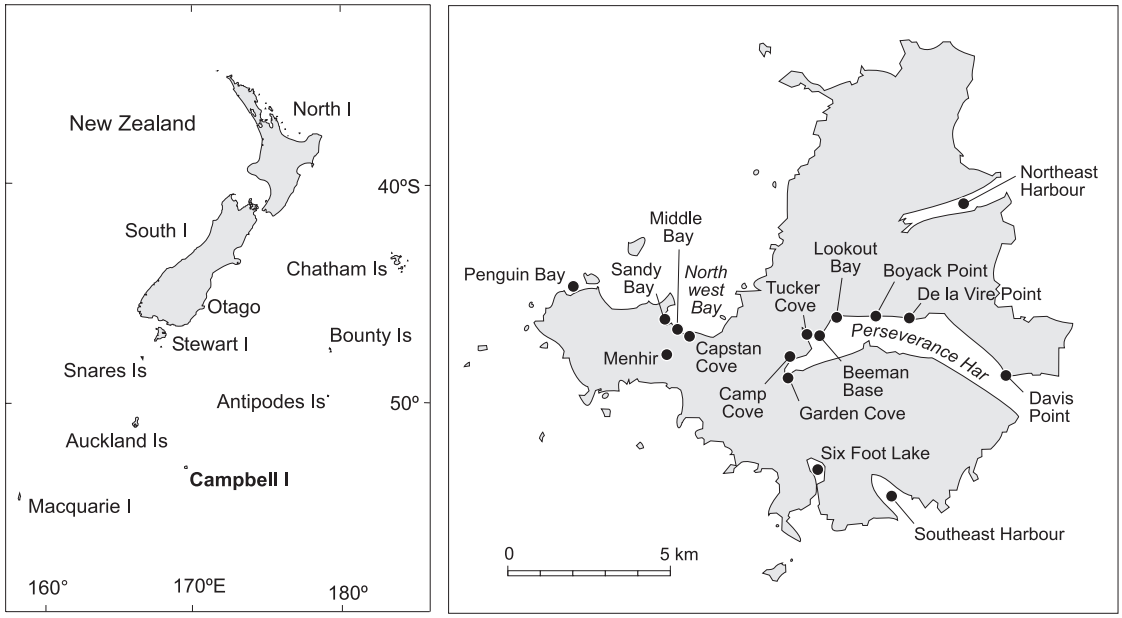

Fig. 1 Location of Campbell Island in the New Zealand subantarctic, and sites where New Zealand sea lions (*Phocarctos hookeri*) were seen on Campbell Island.

Warneke 1982). By 1830, sealing had declined to an unprofitable level and the industry collapsed (Kerr 1976), after which sea lion numbers on Campbell Island appear to have recovered by the late 19th century (Joyce 1894; Thomson 1912). Sea lions were again reduced to low numbers in the early 20th century from hunting by whalers based at the island (Timms 1978). Reports since the 1940s have documented a slow recovery of sea lions on Campbell Island (Bailey & Sorenson 1962; Russ 1980; Moore & Moffat 1990; McNally et al. 2001). A more detailed account of historical records from Campbell Island is provided in McNally et al. (2001).

There have been few estimates of pup production at Campbell Island and most have been derived from opportunistic surveys. Sea lion pups are born in December and January spanning two years. In this paper we use the year in January to refer to the breeding season (e.g., 2003 refers to the 2002/03 season). The following estimates have been reported from Campbell Island: 30 pups in 1985 (Taylor & Sadleir 1985), 51 pups in 1988 (Moore & Moffat 1990), 122 pups in 1992 (M. Fraser pers. comm.), 150 in 1993 (Cawthorn 1993), and 78 from an incomplete survey in 1998 (McNally et al. 2001). As New Zealand sea lions are listed as threatened based on their limited number of breeding locations, with Campbell Island comprising the only significant breeding location outside the Auckland Islands, it is important to have up-to-date and accurate estimates of pup production from Campbell Island.

This paper is an update from previous survey work for New Zealand sea lions on Campbell Island in 1998 reported in McNally et al. (2001). The 1998 survey was suspended before completion owing to an unusual mortality event among sea lions (reported in Baker 1998). The main aims of this study were to: (1) estimate total number of live pups; (2) investigate and estimate pup mortality; (3) describe adult and pup distribution; and (4) estimate pup growth rates on Campbell Island.

METHODS

The Campbell Island group (52°33′S, 169°09′E) is situated 660 km south of the New Zealand mainland and comprises one large main island and several smaller islands, with a total land area estimated at 11 331 ha (Anon. 1983). Campbell Island is covered with dense vegetation forming distinct plant communities (Meurk et al. 1994) including tussock meadows (*Poa* spp.), dwarf forest/scrub (*Dracophyllum* spp. and *Coprosma* spp.) and herb fields. The terrain is steep and much of the coastline is inaccessible to sea lions because of sheer cliffs (McNally et al. 2001).

Typically the breeding behaviour of sea lions on Campbell Island is non-colonial with most pups born in the scrub away from the coast in December and January (McNally et al. 2001). Pups are difficult to find in the scrub but by March or April, many pups can be found around the coastline and are more accessible (P. Moore pers. comm.). Colonial breeding, when it occurs, takes place in December–January. Two trips were timed to target different periods in the breeding cycle of sea lions in 2003: Trip 1 (from 29 January to 19 February) to investigate any colonial breeding sites and Trip 2 (from 23 March to 27 April) to find pups that had been born in the scrub and had subsequently moved to the coast. Visual surveys were conducted by searching the coastline and inland areas for sea lions. A total of 49 days of survey effort were completed, comprising 19 and 30 days on Trips 1 and 2 respectively. Based on previous surveys and reports, locations identified as sea lion breeding or haul out sites were visited at least once during each trip.

Most sea lion breeding habitat on Campbell Island is characterised by dense, low *Dracophyllum* and *Coprosma* scrub. Most land-based searches were done by either crawling or walking along sea lion and penguin pathways through the scrub. These pathways are common across most of the island and generally lead inland (and invariably uphill) from the coast. Land-based searches were carried out at known sea lion sites with teams of either four or five researchers systematically searching through an area while keeping in visual (where possible) and vocal contact. Streams and the sides of streams were also surveyed. Any areas showing signs of sea lion activity (e.g., recent tracks, scats, calls) were investigated to determine if a sea lion was present and, if so, to establish the sex and age. Some sites were surveyed more than once if there were extensive signs of sea lion activity. All survey track lines and the locations of all sea lions seen were recorded on a map. Locations of pups and track lines were estimated from local topographical features as it was not possible to get a GPS signal under the scrub canopy.

During Trip 2, a 4 m aluminium Stabicraft with 25 Hp Yamaha outboard was used to survey the shoreline of Perseverance Harbour (Fig. 1). This increased the area that could be covered and was especially useful in March and April when pups were commonly found along the coast. Vessel survey track lines were also recorded on a map.

All individuals found were checked and the sex, age class (adult male, subadult male, juvenile male, female, pup (following McConkey et al. 2002b)), identifying marks (e.g., tag, brand, bleach) and location noted. Pups were identified from their distinctive natal pelage (Walker & Ling 1981). All pups encountered were caught, physically restrained, then sexed, weighed (to nearest 0.1 kg), measured (length, girth to nearest 1 cm) and tagged. All pups were tagged in both pectoral flippers with uniquely numbered blue or pink "coffin" shaped Dalton "Jumbotags" (Dalton ID systems, Oxon RG9 5AA, United Kingdom). Pups removed from their mothers or companions were released back with them or as close to them as possible after handling. Pups were not re-caught after tagging to minimise disturbance but sightings of tagged pups were recorded. Movements of pups were investigated using subsequent resightings of tagged individuals. The location of all dead pups found was recorded and carcases marked to avoid recounting.

Data analysis

Mann-Whitney nonparametric tests were used to investigate differences in pup distribution (e.g., altitude and distance from shore of sightings) as the data had a non-normal distribution. Differences in weights between sexes and trips were investigated using analysis of variance (ANOVA) tests. All tests were completed in SPSS statistical software (v12.0.1; LEAD Technologies, United States) with a significance level of $P < 0.05$. The mean growth rate for each sex was estimated by combining all weights across both trips (i.e., cross-population estimates) and calculating a simple linear regression.

Total pup production was calculated by adding estimates of the number of live and dead pups on the island. The number of dead pups was estimated from a direct count of dead pups seen on the island during both trips. The number of live pups was estimated using Chapman's modification of the Lincoln/Peterson estimator (Seber 1982) for closed populations using Trip 1 as a marking period (e.g., tagging) and Trip 2 as a recapture period (e.g., tagging and resighting). Log (base10) normal 95% CIs were calculated.

RESULTS

A total of 161 pups were tagged (Trip 1 $n = 44$; Trip 2 $n = 117$) and a further 138 dead pups were found (Trip 1 $n = 137$; Trip 2 $n = 1$). The single dead pup found during Trip 2 had not been tagged. The number of pups tagged at each location is shown in Table 1. The following tag numbers were used:

2529–2575, 2601–2643 (pink), and 4579–4650 (blue). The sex ratio of pups tagged (n = 161) was biased towards males in both trips with an overall female : male sex ratio of 1 : 1.5.

The total number of live pups on Campbell Island estimated from the mark-recapture model was 247 (SE = 28; 95% CI 192–302). This was estimated using $n_1 = 44$, $n_2 = 142$ and $m_2 = 25$. This, combined with the number of dead pups estimated from a direct count, gives an estimate of total pup production for Campbell Island as 385 (95% CI 330–440) for the 2003 breeding season (Fig. 2). Using only direct counts (e.g., number of dead pups plus number of pups tagged) provides a minimum estimate for total pup production of 299.

Most (136 out of 138) dead pups were found at Davis Point the first time it was surveyed on 31 January. All but two of these dead pups were found on the coastal rock platform, with the remaining two found in the tussock above the rock platform. It was estimated that the pups had been dead for 2–3 weeks but because of decomposition and scavenging it was not possible to determine the cause of death for any of the carcases. Of the remaining two pups found dead, one was on Menhir with its head wedged tightly in the crook of a tree at ground level and the other was at Duris Point in a mud wallow. Cause of death could not be determined for either pup.

Pups were found over the whole island, with the exception of the northern end (Fig. 1). Most (65%) pups were found in and around Perseverance Harbour which reflects where most of the survey effort occurred. Other locations with significant numbers of pups were various sites in Northwest Bay (n = 35) and Six Foot Lake (n = 12). Most (80%) pups were found within 325 m of the shoreline and at altitudes of less than 60 m a.s.l. The distances from shore of pup locations were significantly greater (Mann-Whitney: U = 1627, Z = –2.350, P = 0.019)

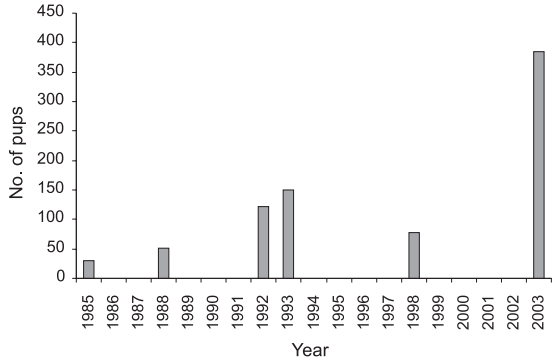

Fig. 2 Estimates of New Zealand sea lion (*Phocarctos hookeri*) pup production at Campbell Island from 1985 to 2003. Estimates are taken from the following sources: 1985 (Taylor & Sadleir 1985), 1988 (Moore & Moffat 1990), 1992 (M. Fraiser pers. comm.), 1993 (Cawthorn 1993), 1998 (McNally et al. (2001), and 2003 (this study). Note: The estimate for 1998 is derived from an incomplete count.

Table 1 Number of New Zealand sea lion (*Phocarctos hookeri*) pups tagged at Campbell Island in 2003 by location and trip (Trip 1: January–February; Trip 2: March–April).

Location	Trip 1	Trip 2	Total
Davis Point	30	0	30
Lookout Bay	3	23	26
Camp Cove	0	23	23
Capstan Cove	0	19	19
Six Foot Lake	*	12	12
Middle Bay	0	11	11
Between De La Vire and Boyack Point	0	11	11
Garden Cove	2	7	9
Beeman Base	4	1	5
Sandy Bay	0	5	5
Menhir	3	0	3
Northeast Harbour	0	3	3
Tucker Cove	2	0	2
Penguin Bay	0	1	1
Southeast Harbour	0	1	1
Total	44	117	161

*This site was not visited during Trip 1.

and altitudes were significantly higher (Mann-Whitney: U = 637, Z = –7.833, $P < 0.001$) in the first trip than the second (Table 2). Pups were found in a variety of vegetation and habitat types including tussock meadows and coastal sward but most were found in the low *Dracophyllum* and *Coprosma* scrub that covers much of the lower reaches of the island. Almost all pups were found in this low scrub during Trip 1 but during Trip 2 many were also found in or near the water along streams and along the coastline.

There were 178 observations of pups released after tagging (e.g., resights) over the period January–April. Sixty-two percent (n = 111) of resightings were of pups at the location where they were tagged. The remainder (n = 67) document the movement of pups around the island. The mean distance of these observed pup movements was 3.5 km (SD = 4.0, range 0.5–19.0), however most (70%) movements were less than 3 km. The longest recorded movements were from Camp Cove and Lookout Bay (in Perseverance Harbour) to the head of Northeast Harbour and another from Perseverance Harbour to Six Foot Lake. There were no observed interchanges between the eastern sites (e.g., Perseverance Harbour, Northeast Harbour) and western sites (e.g., Northwest Bay).

The large number of both live and dead pups found at Davis Point indicate that this was a significant site of colonial breeding in 2003 with a minimum estimate of 166 pups, c. 43% of total pup production for the island. The site is characterised by a large bedrock platform above all tides, giving way to *Dracophyllum* and tussock grasses further inland.

Some (37 of 161) of the pups tagged were unable to be both weighed and sexed (e.g., because of protective mothers) and were excluded from weight analysis. There was a significant difference in mean pup weights between the two trips and both sexes and also a significant interaction effect of trip and sex (two-way ANOVA, total SS = 5341, d.f. = 123; trip: $F_{1,3996} = 287.0$, $P < 0.001$; sex: $F_{1,362} = 26.1$, $P < 0.001$; interaction $F_{1,806} = 12.7$, $P < 0.001$). Male pups were significantly heavier than females in both trips and the mean weights of pups were heavier in the second trip (Table 3). The linear regression equations for growth were $y = 0.2808 \times + 14.977$ ($R^2 = 0.8431$, SE = 0.014) and $y = 0.1816 \times + 14.543$ ($R^2 = 0.6753$, SE = 0.019) for males and females respectively (Fig. 3). These growth equations give an estimated mean growth rate of 0.281 kg/day (or 1.84%/day) for males and 0.182 kg/day (or 1.23%/day) for females over the period January to April (e.g., 90–day period). Male pups had a significantly higher estimated mean growth rate than females over the period January–April (ANOVA : $F_{123,7124} = 10.4$, $P < 0.01$).

Twenty-three sea lions tagged as pups before 2003 were seen, including five sea lions tagged at Campbell Island in 1998, with the remainder being tagged at either Enderby or Dundas Island, in the Auckland Islands. Although most of these were

Table 3 Weights of tagged New Zealand sea lion (*Phocarctos hookeri*) pups by sex and trip (Trip 1: January–February; Trip 2: March–April) at Campbell Island in 2003. Details include count (n) and weight data (mean, standard deviation (SD), minimum and maximum observations). Note: Some (37 of 161) of the pups tagged were unable to be both weighed and sexed and were excluded from this analysis.

	Male		Female	
	Trip 1	Trip 2	Trip 1	Trip 2
n	27	50	16	31
Mean weight (kg)	17.1	32.0	16.0	25.7
SD	3.7	3.6	3.4	4.2
Minimum	11.6	22.8	10.4	14.0
Maximum	24.0	37.8	23.0	33.0

Table 2 Distance from the coast and altitude of locations where New Zealand sea lion (*Phocarctos hookeri*) pups were tagged on Campbell Island in 2003. Details include mean, standard deviation (SD), maximum and the 80th percentile of observations. Sample sizes are n = 44 for Trip 1 (January–February) and n = 117 for Trip 2 (March–April).

	Distance from shore (m)			Altitude above sea level (m)		
	Trip 1	Trip 2	Trips 1 and 2	Trip 1	Trip 2	Trips 1 and 2
Mean	238	172	190	54	11	23
SD	168	184	181	31	14	28
Maximum	800	625	800	160	60	160
80th percentile	225	350	325	60	20	60

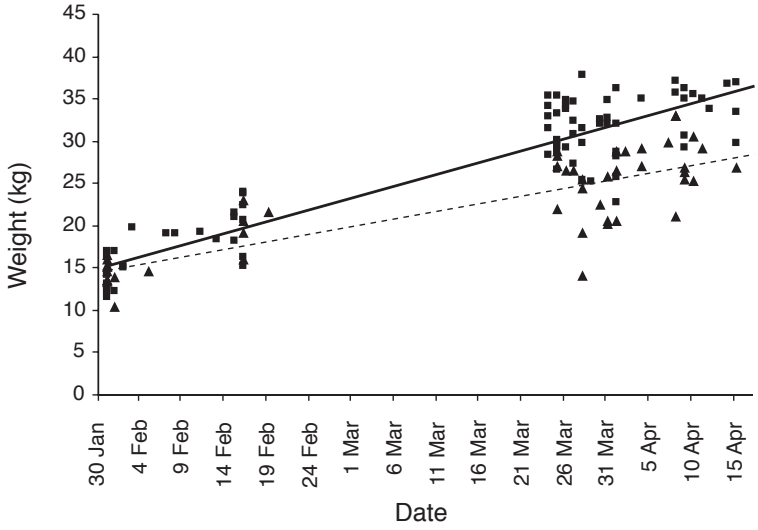

Fig. 3 Relationship between time and weight of tagged male (squares, solid line) and female (triangles, broken line) New Zealand sea lion (*Phocarctos hookeri*) pups at Campbell Island in 2003 (see text for regression statistics).

Table 4 Total number of counts of New Zealand sea lions (*Phocarctos hookeri*) including summary data on counts (number (*n*) and the mean number of individuals at each location including standard deviation (SD) and range), and the mean number of sea lions by age class for each location at Campbell Island in 2003. Age classes (pup, juvenile/subadult male, adult male, female) were determined following McConkey et al. (2002b).

	Summary of sea lion counts				Mean no. of sea lions counted by age class			
Location	*n*	Mean no. individuals	SD	Range	Adult male	Juv/sub-adult male	Female	Pup
Davis Point	2	5	2.1	3–6	0	0	5	0
Camp Cove	8	28	32.5	2–92	2	9	17	1
Six Foot Lake	1	11	–	–	0	0	10	1
Middle Bay	3	7	5.2	1–10	3	2	2	0
Boyack Point	1	3	–	–	0	0	3	0
Garden Cove	7	24	16.4	3–45	2	<1	21	1
Beeman Base	4	71	31.9	40–100	2	38	30	0
Sandy Bay	10	61	34.3	20–107	11	30	20	<1
Northeast Harbour	1	23	–	–	2	5	16	0
Tucker Cove	6	3	2.7	0–6	0	<1	3	<1
Penguin Bay	1	6	–	–	1	0	5	0
Southeast Harbour	1	6	–	–	1	2	3	0
Col Ridge	1	1	–	–	0	0	1	0
Venus Cove	1	2	–	–	0	0	2	0

males, four 4-year-old females were also seen. Of the males seen, most were aged between two and five years, but three 10- and a single 12-year-old were also seen. In addition, 14 adult males that had been bleach marked at Enderby Island in December 2002 or January 2003 by B. Robertson were recorded at Campbell Island.

The highest counts of sea lions (of all ages and sexes) were made at Sandy Bay and Beeman Base (Table 4). Other sites where sea lions were seen in reasonable numbers (e.g., >20) included Camp Cove, Garden Cove, and Northeast Harbour.

DISCUSSION

This project has provided the first robust estimate of pup production for New Zealand sea lions at Campbell Island. Although this estimate is considerably higher than previous estimates, it is not possible to

make direct comparisons with the recent estimate as earlier estimates were generally non systematic and either anecdotal or opportunistic. To quantify any future changes in pup production at Campbell Island it will be necessary to undertake further dedicated surveys using similar methodologies.

The total estimated pup production for New Zealand sea lions for the 2003 season was 2903 pups with 2518 (87%) born at the Auckland Islands (Wilkinson 2003) and 385 (13%) born at Campbell Island. Previous estimates of pup production from Campbell Island have suggested that it comprises <5% of total pup production for the species and this new research has highlighted the importance of this population to the overall production for this species.

The closed population model used to estimate the number of live pups on Campbell Island has a number of assumptions associated with it. The major assumption is of population closure which means that the population is closed to births, deaths, immigration, and emigration. Research at the Auckland Islands has indicated that most pup mortality and births occur before mid January and are negligible after that (Gales & Fletcher 1999). In addition, the movement of young pups to or from Campbell Island seems unlikely as none of the 824 pups tagged at the Auckland Islands in January 2003 (comprising c. 40% of live pups born at the Auckland Islands) were recorded at Campbell Island. Conversely, no pups tagged at Campbell Island were seen at the Auckland Islands. Based on this information it is reasonable to accept the assumption of population closure for sea lion pups during the survey period at Campbell Island.

The high level of pup mortality (36%) at Campbell Island is higher than the 17% reported for the Auckland Islands (Wilkinson unpubl. data) for approximately the same period in 2003 (e.g., December to late January). It is approaching the rate (44%) reported at Campbell Island in 1998 (McNally et al. 2001), although the 1998 survey was incomplete and occurred during an unusual mortality event (Baker 1998). During surveys in 1998 and 2003 almost all of the dead pups were found at Davis Point where pup carcasses are easily seen on the rock platforms. As dead pups are extremely difficult to find in the scrub, these estimates should be considered minimum estimates. They are also much higher than mortality estimates from the Auckland Islands during so-called "normal" years (c. 12% until 6 weeks of age (Gales & Fletcher 1998; Wilkinson unpubl. data)). However, rates up to 53% were recorded at the Auckland Islands during 1998 (Baker 1998) and between 20% and 30% for several years since then (Wilkinson unpubl. data). It was not possible to determine the cause of pup mortality at Campbell Island in either 1998 or 2003 but most dead pups appeared to be in reasonable body condition, which suggests that starvation was unlikely to be the primary factor. Bacterial agents have been implicated in years of higher than normal mortality at the Auckland Islands (Baker 1998; Duignan & Wilkinson unpubl. data).

Resighting of tagged pups indicated movement of pups around the island, and highlights their mobile nature, especially those pups 3 months or older. Pups were found at lower altitudes and closer to the coast during March/April than in January/February. This is consistent with anecdotal observations by previous researchers and confirms that as pups reach 3–4 months of age they become more mobile, move away and/or are led away from birth sites in the scrub by their mothers and congregate along creeks and the coastline.

This difference in behaviour and habitat use between January/February and March/April highlights the importance of careful design for any future surveys. Both periods are required for the generation of any mark-recapture abundance estimate for pup production. Any future surveys should include a January/February survey designed to target colonial breeding and provide a marking period, and a March/April survey to target older, more mobile pups and allow for a recapture period.

The large number of both live and dead pups found at Davis Point indicates that this was a significant site of colonial breeding in 2003 and is in stark contrast to the rest of the island where births appear to be by solitary females in the scrub. The minimum estimate of 166 (43% of total pup production for Campbell Island) pups for the Davis Point Colony is likely to be an underestimate, as by the time the site was surveyed in late January all the live pups found were up in the scrub and there were none on the rock platform where all the dead pups were found. It is probable that many of the live pups born at Davis Point had either moved up into the scrub and were difficult to find or had moved away from Davis Point before our arrival.

Sea lions at Campbell Island exhibit both colonial and non-colonial breeding behaviour (McNally et al. 2001). The high proportion of pups apparently born away from colonies (>50%) at Campbell Island is in contrast to that observed at the Auckland Islands where breeding is almost exclusively colonial (>99%) with breeding restricted to four colonies and

with little breeding occurring outside these colonies (Gales & Fletcher 1999). Although Campbell Island has a much smaller sea lion population than the Auckland Islands, there is no clear explanation for the difference in the proportion of non-colonial breeding.

Weights of individual pups over both trips were pooled to estimate the average growth rate for the study period using cross-sectional data from the population. It was not possible to determine the age of each pup and ideally it would have been preferable to re-weigh the same pups to measure specific individual growth. This was not logistically feasible and instead a random sample taken over the period was used as a representative sample. It is unlikely that the growth rate over this period is a linear function and is more likely to be a curvilinear function, with variable growth rate relative to the age and sex of the pup. However, we used a simple linear function to estimate mean growth over the period as the data would not support more sophisticated analytical methods. Notwithstanding this, a mean growth rate is useful for comparative purposes with other New Zealand sea lion studies (e.g., Auckland Islands, Otago) and other species. As was found in 1998 (McNally et al. 2001), male pups were heavier than females weighed on approximately the same date. It is probable that pups of both sexes were born at similar times, and it is therefore likely that they were of similar age. This is consistent with data for many other otariid species (Mattlin 1981; Georges & Guinet 2000; Luque & Aurioles-Gamboa 2001; Arnould & Hindell 2002). Male pups had a significantly higher growth rate (33% higher) than females which is also common in other otariids (Kovacs & Lavigne 1992; Goldsworthy 1995; Guinet et al. 1999).

The distribution of sightings of sea lions were broadly consistent with those reported from McNally et al. (2001), except that high numbers were reported at Davis Point in 1998, whereas we recorded low numbers for this location. The presence of 136 dead pups in 2003 suggests that this site was more heavily used but was abandoned by most sea lions before our first survey. Furthermore, low numbers of adult females were seen in 1998 compared with 2003. It was likely that both these differences relate to the difference in the timing of surveys (e.g., mid January in 1998 and late January–April in 2003) and also that 1998 is known to be an atypical year owing to a mortality event (Baker 1998). Sandy Bay and Southeast Harbour haul out sites were characterised by sandy beaches whereas all the other sites were boulder beaches or more commonly, open grass and tussock clearings.

The sighting of sea lions that had been tagged and/or bleached at the Auckland Islands indicates that there is some movement between Auckland and Campbell Islands, apparently both within and between seasons. There is only one report of a male sea lion tagged at Campbell Island (in 1992) being seen at the Auckland Islands, but this is likely to reflect the small amount of tagging on Campbell Island, rather than a lack of movement from Campbell Island to the Auckland Islands. During 2003, 18 individuals tagged at the Auckland Islands were seen on Campbell Island. Currently, Auckland and Campbell Island are treated as separate breeding locations for the purposes of management, and sea lions are listed as threatened on the basis of the small number of breeding locations (IUCN 1996). The level of interchange between Campbell and the Auckland Islands needs further investigation to explore whether these two populations constitute independent breeding locations. The independence, or lack of, of these locations has important management implications for the species and requires further consideration, particularly in light of potential mortality events and the transmission of disease between the two locations.

The results of this work provide the first robust estimate of pup production for Campbell Island. Past surveys and the results from Trip 1 and 2 of this study indicate that the timing of surveys can potentially have a large impact on estimates of pup production. For example, if each trip was analysed alone, the estimates from direct counts would be c. 181 (tagged plus dead pups) and 210 pups (tagged or resighted plus dead pups) for Trip 1 and 2 respectively compared with 385 pups from both trips combined. The combination of the two trips allowed for a robust population estimate to be calculated using mark-recapture techniques. Furthermore, Trip 1 served to establish the occurrence of colonial breeding whereas the timing for Trip 2 significantly increased the detection of non-colonial breeders. Because of the changes in sea lion behaviour through the breeding season, it will be useful for the timing of future surveys to be standardised to ensure comparability between estimates.

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