

Aerial survey of New Zealand sea lions – Auckland Islands 2012/13



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Department of Conservation
Barry Baker, Katrina Jensz & Louise Chilvers**

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Aerial Survey of New Zealand Sea Lions at the Auckland Islands 2012/13

1. Introduction

The New Zealand sea lion (NZ sea lion), *Phocarctos hookeri*, is New Zealand's only endemic pinniped. It is classified as Nationally Critical and Geshke and Chilvers (2009) found it to be the world's rarest sea lion. Based on the 2010 pup production estimates from the Auckland Islands and from Campbell Island (Maloney et al. 2012), 76% of all NZ sea lions pups are born at the Auckland Islands. Over the last decade there has been a considerable decline in pup production at the Auckland Islands (Chilvers 2010). This decrease is thought to be aggravated by a combination of incidental bycatch from commercial fishing activity and disease events.

There are four pupping sites at the Auckland Islands; Sandy Bay (50°30'S, 166°17'E) and South East Point (SEP, 50°30'S, 166°19'E) on Enderby Island, Dundas Island (50°35'S, 166°19'E) and Figure of Eight Island (50°46'S, 166°01'E) (Chilvers 2010).

Childerhouse et al (2013) reports on the latest annual survey of the Auckland Island area where one of the objectives was to collect data to allow quantification and estimation of NZ sea lion pup production. NZ sea lion pup production at S.E. Point and Figure of Eight Island was estimated using direct counts, whereas at Sandy Bay and Dundas Island the primary estimation method was a mark-recapture estimate. This work builds on surveys of NZ sea lions at the Auckland Islands since 1995 (Gales & Fletcher 1999; Chilvers et al. 2007; Chilvers 2010) which has allowed estimates of annual sea lion pup production from 1998 to 2010.

In January 2013 we undertook aerial surveys to estimate New Zealand sea lion pup production at the Auckland Islands for the 2012/13 breeding seasons, thus reducing the need to access restricted sites where the sea lion colonies occur and minimising disturbance to the colonies. We used aerial photography to count sea lion pups and establish an archival set of photographs that could potentially be used for future trend analysis. This work was to build on a similar photographic survey undertaken in January 2012 (Baker et al 2012).

Specifically, we were tasked to:

1. estimate the New Zealand sea lion pup production at Enderby and Dundas Islands using aerial survey methods established in 2012;
2. provide a detailed comparison of the pup production estimate obtained by aerial survey with ground counts undertaken by the research team led by Simon Childerhouse; and
3. make recommendations for robust, cost-effective estimates of New Zealand sea lion pup production at the Auckland Islands.

In order to verify counts from aerial photographs with ground truthing, we attempted to carry out the aerial photography at the same time as a ground team collected information on marked animals and conducted counts, to gain some level of understanding of the number of pups present in pup piles, and the proportion of pups that weren't visible from the photographs.

2. Methods

Field Work

We chartered a helicopter from Southern Lakes Helicopters to conduct a photographic survey of sea lions at three of four sites used by this species at the Auckland Islands: Sandy Bay and South East Point on Enderby Island, and Dundas Island. The other site — Figure of Eight Island — was not investigated because it is not suitable to aerial survey as pupping occurs under forest canopy. The aircraft we used was a AS350-B3 Squirrel helicopter, piloted by Mark Deaker, and we flew from Invercargill to Enderby Island on 11 January 2013. On board was Barry Baker (photographer and project coordinator), Mark Holdsworth (additional photographer), Peter McClelland (Department of Conservation Invercargill) and Louise Chilvers (Department of Conservation Wellington). We based ourselves at the DOC research station on Enderby Island for a period of 10 days and undertook flights each day to photograph the sea lion colonies on Enderby and Dundas Islands, or carry out other work (reported elsewhere). We aimed to photograph each sea lion colony at least four times leading up to the commencement of a mark-recapture estimate by a ground-based research team. After completing our assignment, we returned to Invercargill on 21 January 2012.

Flights had been timed to coincide with the time when pupping had finished but before pups have moved away from breeding beaches, and within a few days of when ground counts were undertaken. At this time pups were approximately three weeks old and clearly distinguishable from adults in photographs. Flights were conducted on 12, 14, 15 and 16 January 2012 for the Sandy Bay colony, and on 12, 14, 15 and 18 January for Dundas Island. South East Point on Enderby Island was overflown only once (14 January). Flights were carried out in varying weather conditions, ranging from fine and clear with no wind, to wet and windy with low cloud. The aircraft was flown from the starboard side, requiring the photographers to be seated on the port side. We took photographs through an open door using standard 35mm photographic gear; a Nikon D800 camera with Nikon 70 to 200mm F2.8 zoom lens, and a Nikon 300mm F2.8 telephoto lens. The zoom lens was set on 200mm and used to document entire colonies, while the 300mm lens was initially used to obtain detailed photography of sea lion pup piles. Shutter speeds were kept to $>1/1000$ s, and preferably $>1/2000$ s, to avoid camera shake. The focal length of the zoom lens was not adjusted within each pass sequence over a site to assist in subsequent data analysis.

Our approach was to leave the Enderby Research station and fly slowly along Sandy Bay and South East Point of Enderby Island, and then to fly to Dundas Island. Multiple traverses were made of each site to produce a complete series of overlapping images which could be used to compile a collage of all surfaces of sites where sea lions occur (**Figures 1 and 2**), and to ascertain appropriate flight heights and perspectives to minimise disturbance to sea lions. Consistent with DOC permit requirements, and based on work in 2012, flight heights to photograph sea lions were kept at a minimum elevation of 350m (1000 feet) directly overhead, carefully observing the behaviour of animals on the ground. Photographs were taken as raw or fine scale JPEG digital files of minimum 45 MB size, although file size was determined automatically by the camera, subject to the complexity of the information being recorded. In all cases photography was carried out between 09.00 and 15.00 hours.



Figure 1. Sandy Bay, Enderby Island showing extent of New Zealand sea lion colony



Figure 2. Dundas Island. New Zealand sea lions principally pup and mate on the sandy beach in the foreground. As the breeding season advances, females and pups move into the vegetation and can be found throughout the island.

The entire set of photographs was downloaded and subsequently replicated to ensure that adequate back-up sets were available for storage in at least three different locations. A full collection of photographs have been submitted to the Department of Conservation for archiving.

Counting protocol for aerial photos

We used protocols previously developed for aerial censuses of albatross colonies (Arata et al. 2003; Robertson et al. 2007; Baker et al 2011), fur seals (Baker et al. 2010) and for sea lions in 2012 (Baker et al 2012). Photographic montages of all sea lion colonies were constructed from overlapping photographs using the image editing software package ADOBE PHOTOSHOP (<http://www.adobe.com/>). Counts of all pups and other sea lions on each montage were then made by magnifying the image to view sea lions and using the paintbrush tool in PHOTOSHOP to mark each animal with a coloured circle as they were counted (**Figure 3**). To assist with counting we used a hand held click counter. Once all sea lion pups had been counted on a photo-montage, the file was saved to provide an archival record of the count.

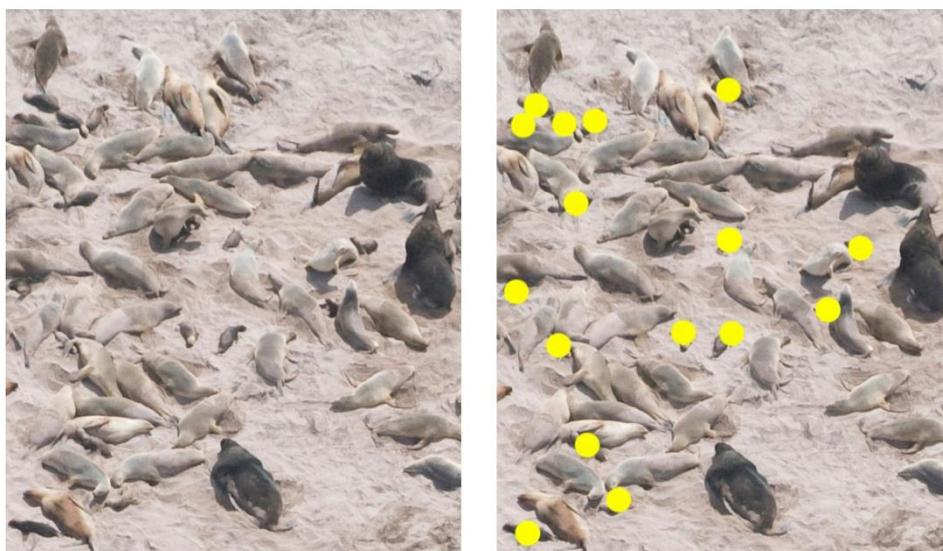


Figure 3. Photomontage of New Zealand sea lion colonies before (left) and after (right) counting. The yellow circles are animals identified as pups.

Detecting sea lions from aerial photos was a function of both the quality of the photos and the terrain encountered. Sea lion pups were easily detected on the sandy beaches preferred for pupping (**Figures 1 and 2**), but were less visible when they moved into the adjoining grass areas. Poorer quality photographs were usually characterised by low contrast between the sea lions and substrate, reducing the ability to determine the age class of animals. The age classes of interest were pups and non-pups. **Pups** were typically small and dark, with a lighter area on the head; **adult females (cows)** were larger and pale with a streamlined shape, while **adult males (bulls)** were larger again and darker than females, and had thick necks and a distinctive shape that was different to other age classes (**Figure 4**).

Counts of photo montages were undertaken by one observer only. To estimate counter variability associated with miscounting and misidentifying objects such as logs and rocks as sea lions, we undertook multiple counts of 15 photographs using three observers. These count data were statistically modelled by Poisson regression, a special case of a Generalised Linear Model (McCullagh and Nelder, 1989), with observer and area as fixed effects. After allowing for both mean observer and mean area differences, there was no evidence to suggest that our model and data were incompatible, based upon regression diagnostics and model checking. There was also no evidence of a difference between observers and hence an observer bias. Thus we present raw counts only and assume the

standard deviation is estimated as the square root of the count, a property of the Poisson model.



Figure 4: Age classes of New Zealand sea lions

Photographic file management

All photographs have been submitted to the Department of Conservation. Photos were provided in one directory (*NZ Sea lions 2013*) with three sub-directories (*Original photos*, *Stitched images*, and *Counted images*). The following information is provided to assist others that may wish to access the photos at some stage in the future.

Extensive photo information is superimposed on all digital images taken with the Nikon D800 and D300 cameras. This includes information on the time and date the photo was taken, the camera and lens used, image quality and size, shooting data (aperture, shutter speed, ISO, exposure correction), and geographic position (latitude and longitude) data where a GPS was connected to the camera. These data can be accessed when the photographic file is opened using Adobe Photoshop or other photographic software, and can be invaluable when analysing photos, building photo montages, or for archival purposes.

Original photographs were saved in the camera with a file name consisting of a prefix 'GBB_' followed by a four-digit number and a three-letter extension 'jpg' or 'NEF' that signified the type of file was either JPEG or raw format, respectively. The initial file number sequence was set to 0001, enabling 9999 photos to be taken before the numbering would be automatically re-set. This was sufficient to ensure each photograph taken during the survey had a unique sequential number. At the completion of field work all files were downloaded to a computer and stored in a separate folder '*Original Photos 2012*', with each photographer's images stored in a sub-directory bearing the photographer's name. Some photos were renamed to indicate the colony number and name, and the start and end point of each photographic run for each colony. The original four-digit number was retained in any subsequent renaming of

files to permit easy tracking of work flows from the original photos to the stitching and development of photomontages, through to counting of images. File numbering protocols may be best explained in Table 1.

Table 1. File numbering protocols for aerial photographs of sea lion colonies on the Auckland Islands taken with Nikon cameras.

File Name/Number	Process	Explanation
GBB_1880.NEF	Original photo	Camera generated file name with unique sequential number.
GBB_1880_Sandy Bay, Enderby Run 1 Start.jpg	File renamed	Some original photos renamed to indicate name of colony and start and end point for the each photographic run at the site. Files stored in directory Original Images
Sandy Bay 11 Jan_1(1881-1890).jpg	Photo montage	Photos GBB_1881 to GBB_1890 have been copied and stitched to create a photomontage of the site. Photomontage files stored in directory Stitched Images
Sandy Bay 11 Jan_1(1881-1890)_count.jpg	Counted image	Stitched image Sandy Bay 11 Jan_1(1881-1890).jpg has been duplicated and counted. Duplicate files showing the sea lions identified and counted stored in directory Counted Images

Ground counts

Ground truthing of aerial counts was carried out to quantify the proportion of sea lions that may be missed from the aerial counts, and to enable the development of correction factors that can be applied to aerial counts to ensure appropriate comparisons could be made with an existing long-term data set for the Auckland Islands (Childerhouse et al 2013). Direct counts were carried out each day on Enderby Island by three people that walked the Sandy Bay Beach once with hand tally counters and counted all live and dead pups located. In addition, mark-recapture experiments were carried out on 16 January on Enderby Island and on 21 January on Dundas Island (Childerhouse et al 2013). Pups were marked with circular, 5 cm-diameter, flexible vinyl discs that were glued to the crown of their heads with a fast-setting cyanoacrylic glue (Loctite 454). The number of pups marked was approximately 40% of previous pup production estimates at Sandy Bay (148 pups marked) and 30% at Dundas Island (398 pups marked). Marking was spread as evenly as possible through the breeding area (based on pup density and distribution). Most discs were shed a few days to weeks after the experiment. Recaptures involved three observers moving systematically through the entire sea lion pupping area counting pups, with each observer conducting three replicate counts. Each pup was classified as either marked or unmarked and a tally of each was maintained by each observer using two hand-tally counters. Results of each recapture were used to calculate a modified Petersen estimate (Chapman 1952; Seber 1982) of pup production.

Numbers of pups found dead at the time of the M-R estimate were then added to produce a figure for total pup production (Childerhouse et al 2013). Dead pup numbers were estimated by counting all visible pup carcasses the day of the pup production estimate. Note that this was in contrast to previous years, where dead pups that died at Sandy Bay were removed on a daily basis.

3. Results

Photography

We were able to photograph both the Sandy Bay and Dundas Island colonies on four occasions prior to the commencement of the mark-recapture estimate. As in 2012, we obtained good images for counting from photographs taken at an elevation of 1000 feet directly over a colony using a 200mm focal length extension. This permitted a practical compromise between providing adequate photographic detail without the need to take an excessive number of photographs to ensure complete documentation of each colony during a photographic run. Use of the 300mm lens provided excellent photographs, although it was more difficult to document entire colonies with this lens, because it required greater concentration by the photographer to ensure they did not become 'lost in the viewfinder'. As in 2012, there was no detectable impact on sea lions when the helicopter was flown directly over colonies at 1000 feet or higher.

As in 2012, the quality of the photos taken was generally excellent. It should be noted that the equipment used this year differed from that used in 2012 when a lower resolution camera (Nikon D300) was used. This produced smaller files 12 MB with a concomitant reduction in detail in the images. While the 2012 images were certainly fit for purpose, the 2013 images represent a considerable improvement in quality, particularly when the camera was combined with the 300mm lens, which facilitated counting even in low-contrast substrates. The D800 camera also produced images that permitted us to determine the presence of dead pups from the photographs, where this was not possible in 2012.

Aerial counts

Aerial counts for both Sandy Bay and Dundas Island are provided in Table 2. For Sandy Bay we estimate that there were 333 (95% CI 297 – 365), 338 (301-367), 343 (306-372) and 349 (312 – 378) pups on the 12, 14, 15 and 16 January, respectively.

For Dundas Island we estimate that there were 1,390 (1,315 – 1,441), 1,410 (1,335-1,448), 1,464 (1,387-1,503) and 1,398 (1,323 – 1,438) pups on the 12, 14, 15 and 18 January, respectively.

These estimates are based on photographs taken principally with the 300mm focal length lens.

No adult sea lions or pups were seen or photographed at the South East Point colony.

Ground counts

The mark-recapture experiment undertaken on 16 January for Sandy Bay estimated 357 ± 4 pups. Eight dead pups were recorded on that date, but to maximise comparability with previous years, the maximum dead pup count of 17 (recorded on 14 Jan) was used to give a total pup production of 374 ± 4 . (Table 1; Childerhouse et al 2013).

The mark recapture estimate at Dundas Island was completed on 21st of January. The mark-recapture estimated 1,364 live pups \pm 46 and 127 dead pups were counted giving a total estimate of 1,491 \pm 46 pups on the island (Table 2; Childerhouse et al 2013).

Table 2. Comparison between Petersen estimates of sea lion pups at the Sandy Bay and Dundas Island colonies and total counts (dead animals included) derived from analysis of aerial photographs of the same sites. Total counts (dead pups included) derived from ground counts are also shown. No pups were located at the South East Point colony.

Area / Date	Mark Recapture			Ground count		Aerial Count		Difference between aerial count & MR estimate	
	Total	\pm	dead pups incl.	Total	Dead pups incl.	Total	dead pups incl.	No	%
Sandy Bay, Enderby Is									
11-Jan				335	7				
12-Jan				332	9	333	4	32	8.8%
13-Jan				346	10				
14-Jan				347	17	338	8	27	7.4%
15-Jan				355	8	343	8	22	6.0%
16-Jan				339	8	349	8	16	4.4%
15/16-Jan	374	4	17						
Dundas Is									
12-Jan				-	-	1390	24	101	6.8%
14-Jan				-	-	1410	37	81	5.4%
15-Jan				-	-	1464	38	27	1.8%
18-Jan				-	-	1398	35	93	6.2%
20-Jan				-	-				
20/21-Jan	1,491	46	127	1,398	127				

Comparison of Aerial and Ground counts

The aerial and mark-recapture counts were highly correlated and varied by less than 9% at any one time (Table 2). The 'best' estimates of pup production differed by 4.4% and 1.8% for the Sandy Bay and Dundas Island colonies, respectively.

4. Discussion

The 2012/13 estimates of pup production using aerial photography confirm that this technique is able to provide robust, cost-effective estimates, with good precision, of New Zealand sea lion pup production at the major pupping sites in the Auckland Islands. As in 2012, aerial and mark-recapture counts were highly correlated and varied by less than 9% at any one time, and by less than 6% in half the counts. The major point of difference between the mark recapture and aerial counts would appear to be in the greater ability of on-ground methods to detect dead pups, many of which would have been partially covered by sand and

other material that obscures detection from 350 metres height. We are confident that aerial techniques can easily detect recently deceased pups, but this becomes difficult once a corpse becomes partially scavenged or buried. However, this issue is unlikely to impact the determination of trend, or comparison with early counts that have been based on mark-recapture methods, particularly if a small correction factor, say 5%, was applied to aerial based counts to account for dead pups.

In our earlier report (Baker et al 2012) we suggested that aerial counts should be undertaken on more than one day to achieve a count that can be incorporated into the existing longitudinal dataset with confidence. Noting the pups and pup piles are not static and large piles that may present counting difficulties on one day are likely to break up over a day or two (Baker et al 2012), we recommend that photographs are taken over three or four days and subsequently analysed, with the maximum count used to estimate pup production for a period of interest. Certainly, the results of both the 2011/12 and 2012/13 counts show that the maximum counts for both Sandy Bay and Dundas Islands were within 4% of the mark-recapture estimates in both years.

It is also important that future aerial surveys are timed to occur as close as possible to the dates historically used for the mark-recapture estimates, to ensure their usefulness in building on the considerable longitudinal data set that exists for the Auckland Island sea lion population and enabling effective monitoring of population trend. Future aerial surveys should also cover the South East Point colony on Enderby Island too. The site is in an area than could be easily checked and photographed annually.

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