

**Research to assess the demographic parameters of
New Zealand sea lions, Auckland Islands 2011/12
Contract Number: POP 2011/01
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Abstract

The New Zealand sea lion (NZ sea lion), *Phocarctos hookeri*, is New Zealand's only endemic pinniped. It is classified as Nationally Critical (Baker et al. 2010) and is estimated to be the world's rarest sea lion (Geschke & Chilvers 2009). This report summarises the annual survey 2011-12 of the Auckland Island area with the objective to estimate pup production and collect data to allow quantification and estimation of demographic parameters of all NZ sea lions from the Auckland Islands.

The pup production estimate for the Auckland Island NZ sea lion population in 2011-12 was 1683 ± 16 , the third lowest pup production ever reported for this species. Field sightings of previously tagged, branded and/or passive integrated transponder (PIT) tagged animals were collected and recorded.

1. Objectives

The objectives of the project were:

1. To estimate New Zealand sea lion pup production on the Auckland Islands.
2. To collect information on marked animals relevant to improving the understanding of population dynamics of New Zealand sea lions at the Auckland Islands.
3. To make available all field data for upload into the New Zealand sea lion database.

2. Logistics

The scientific trip was split into two parts to allow changes in personnel: December 10th - January 10th, and January 10th - February 16th. The first science team comprised of three people: Jo Hiscock (DOC, Southland), Mel Young (Contractor) and Stu Cockburn (DOC, Wellington). The second team comprised of six people: Louise Chilvers (DOC, MCT), Sarah Micheal (Massey University), Jacinda Amey (Contractor), Carlos Olavarria (Contractor), Jack Mace (DOC, Wellington) and Gareth Hopkins (DOC, Taranaki). Transport during the season was aboard the Tiana and Awesome under charter to DOC R&D. All personnel were accommodated in the Sandy Bay and Dundas hut.

3. Methods

3.1 Methods used to estimate NZ sea lion pup production on the Auckland Islands

There are two pupping areas (Northern Auckland Islands and Figure of Eight Island) at the Auckland Islands (Figure 1). Pups were born at Sandy Bay (50°30'S, 166°17'E) and South East Point (SEP) on Enderby Island (50°30'S, 166°19'E), Dundas Island (50°35'S, 166°19'E, Figure 1) and Figure of Eight Island (50°46'S, 166°01'E). Pup production at SEP 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 (M-R) estimate.

3.1.1 Direct counts

Direct counts of all animals were conducted at SEP using surveys during the breeding season (December 4th to January 20th). SEP is a small, open, rocky coastal area which is easily surveyed. All counts were conducted from the rocky beach margin, with hand tally counters and counts recorded. Pup production was based on the counts of live pups and the cumulative total of dead pups (Gales & Fletcher 1999; Chilvers et al. 2007).

The remote location of Figure of Eight Island (over 60 km south of Enderby Island) prevented multiple visits during a season. Pup production was based on the mean of a separate count conducted by three people around the entire island made on a single day on the 10th of January. Adult counts were undertaken by one person on the single day on the 10th of January.

Reports of any pups were sought from albatross researchers based at Adams Island in Carnley Harbour. No pups were sighted.

3.1.2 Mark-recapture experiments

A single M-R experiment was conducted at Sandy Bay on the 16th January 2012 and at Dundas Island on the 21st January 2012. 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). Pups are marked late afternoon on the 15th and 20th January each season (when weather and logistics allows). The number of pups marked was approximately 40% of previous pup production estimate at Sandy Bay (148 pups marked) and 30% at Dundas Island (380 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, and if found picked up and removed from the islands. Recaptures involved three observers moving systematically through the entire sea lion pupping area counting pups the morning after marking, 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. Only pups where the entire head was visible were included in the counts, to minimise the risk associated with undercounting unmarked pups. As the discs were clearly visible on the heads of pups if only part of the head is viewed there is a greater probability that a marked pup would be correctly identified than an unmarked pup. Any greater probability of viewing marked caps would lead to an overestimate of the proportion of marked pups and underestimate of pup production. Consequently, any pups that could not be categorised as marked or unmarked, i.e., where the entire head was not visible, were excluded from the count.

Results of each recapture were used to calculate a modified Petersen estimate (Chapman 1952) of pup production P_i namely

$$(1) P_i = \left[\frac{(M + 1)(C_i + 1)}{(R_i + 1)} \right] - 1$$

where, for replicate i , M is the number of previously marked sea lion pups, C_i is the number of pups examined in the recapture sample, and R_i is the number of marked pups in the recapture sample. The overall estimate of pup production, P , is the mean of the Q individual estimates, i.e.,

$$(2) \bar{P} = \frac{\sum_{i=1}^Q P_i}{Q}$$

The standard error, of P was calculated directly from the individual estimates (Chapman 1952), as:

$$(3) SE = \sqrt{\frac{1}{Q(Q-1)} \sum_{i=1}^Q (P_i - \bar{P})^2}$$

(consistent with previous methodology Gales & Fletcher 1999, Chilvers et al. 2007).

The standard error for the Auckland Island pup production estimate from Sandy Bay, Dundas and Figure of Eight is calculated as:

$$(4) SE_{Total} = \sqrt{(SE_{SandyBay}^2 + SE_{Dundas}^2 + SE_{FigureofEight}^2)}$$

The assumptions for the M-R model were:

- (1) all pups were born by mark-recapture dates;
- (2) all pups were accessible for marking (i.e., capture probability was constant);
- (3) all pups were mobile and mixed well after being marked;
- (4) marks were not lost before M-R counts; and
- (5) mortality was negligible and assumed to be zero in the time between marking and recapturing.

Numbers of pups known to have died up to the date of the M-R estimate were then added to produce a figure for total pup production (Chilvers et al. 2007). All pups that died during the breeding season from Sandy Bay were counted and removed on a daily basis, which resulted in the accurate assessment of numbers of dead pups from this site. Pup carcasses at SEP were removed if possible. For Dundas and Figure of Eight islands, dead pup numbers were estimated by counting all visible pup carcasses the day of pup production estimate. Carcasses were counted by up to four observers systematically covering the islands at the same time calling out and identifying carcasses, so as not to overlap observer search areas, with one observer using a hand counter to tally the total carcass count.

3.2 Methods used to collect information on marked animals

3.2.1 Marking

New Zealand sea lion pups have been tagged at one month of age as part of a demographics study since 1979/80 at Sandy Bay, 1985/86 on Dundas Island and 1992/93 at SEP. Tagging has been intermittent and the numbers of animals tagged annually have varied from 0 to over 500 since 1979/80. Between 1979/80 and 1992/93 flipper tags used were uniquely numbered Alflex laser-marked button tags (Alflex NZ Ltd, Palmerston North, NZ), tagged in the right pectoral flipper only. In the 1997/98 and 1998/99 seasons the same tags were used but animals were tagged in both pectoral flippers. Since 1999/2000, uniquely numbered Dalton DAL 008 Jumbotags® coffin-shaped tags with a different colour each year (Dalton Supplies Ltd, Henley-on-Thames, UK) have been used to tag animals in both pectoral flippers. During the 1999/2000 season 297 pups and 135 adult females from Sandy Bay were also hot-iron branded (Wilkinson et al. 2011). Between 1999 to 2003 and in 2010, 2011 and 2012 pups were also injected with individually identifiable passive integrated transponders (PIT, Trovan, Ltd., Douglas, United Kingdom).

3.2.2 Presence and breeding status of marked animals

Daily counts of pups, females and breeding males were undertaken by one person at 9.30am in the area of Sandy Bay beach and immediate open sward between 13 December to 20 December. Daily tag resightings were conducted at Sandy Bay between 12th December to 14th February. Daily resighting took 2 to 6 people, typically five hours a day to complete.. All other areas around Enderby Island were surveyed at least once a week during December and early January and then surveyed at least once every second day from late January until the end of the field season. Resighting were undertaken at Dundas Island on 20th to 24th of January 2012 when field staff were on the island. Resightings consisted of the date and place of sighting, the animals tag number, colour, shape and number of tags in which flippers, PIT presence (therefore alphanumerical series) or absence, animal sex and breeding status or behaviour. Breeding status of males is determined by location in harem, breeding status for females is recorded in the form of whether they are with pup or not. PIT tag checking was undertaken throughout the season. Given the need for close approach

to scan for PIT tags (~10cm), there was a higher likelihood of getting access to all animals after mid-January, because until then the animals in the harem were packed so tight, with large territorial males defending areas, that many animals could not be accessed. All animals, whether they have tags or not are checked for PIT tags by passing the PIT reader over the hind quarters of a sleeping or otherwise distracted animal.



Figure 1: The Auckland Islands showing areas where sea lions were sighted: Figure of Eight, Dundas, Enderby and Auckland Islands.

3.2.3 Presence and breeding status of marked animals away from known breeding areas

Presence and breeding status data were collected opportunistically from marked animals at all sites outside the breeding sites around the Auckland Islands when researchers were travelling near these areas. This year Rose Island, Ross Harbour, Kekeno and the NE area of the Auckland Islands were visited by the NZ sea lion team.

3.3 Preparation of data for upload to the NZ sea lion database

All sighting field data were verified, entered into the NZ sea lion field spreadsheet and data made available for upload to the NZ sea lion database. Data verification was performed both during the season and at the end of the season. End of season verification involved the following procedures:

- all data is sorted by individual animal (current tag) and duplications (same animal on the same date) deleted,
- number of tags checked and assessed (during the season if animals were still identified as having only one flipper tag seen, notification was given to field staff to try and determine true tag number while the team were still in the field),
- colour and tag number matches checked,
- previous and original tag information entered where necessary for adult females, and
- class, tag year, age, tag location and status entered for all animals.

4. Results

4.1 Estimate of New Zealand sea lion pup production on the Auckland Islands

Estimates of pup production were calculated for each breeding site in the Auckland Islands between the 10th and 21st of January (Tables 1 and 2, Figure 2). Mark recapture estimates have been used as the estimates of pup production from Sandy Bay and Dundas Island, while Figure of Eight Island and South East Point areas were estimated using direct counts. The total pup production estimate was 1683 ± 16 for 2012 (Figure 2).

On the 16th of January, the mark-recapture estimate at Sandy Bay was undertaken. The mark-recapture estimated 343 pups ± 9 , there were 18 dead pups at that date giving a total pup production of 361 ± 9 . 360 pups were tagged by the 17th of January.

The mark recapture estimate at Dundas Island was completed on 21st of January. The mark-recapture estimated 1189 live pups ± 13 and 59 dead pups were counted giving a total estimate of 1248 ± 13 pups on the island. Four hundred pups were tagged on Dundas Islands.

A direct count at Figure of Eight Island was made on the 10th January. 72 pups $\pm 0.3 + 2$ dead pups were counted giving a total of 74 pups.

Direct counts conducted up to and including the 15th of January at South East Point recorded 1 pup (confirmed dead but not removed) giving a total pup production estimate of 1 pup.

Pup mortality during the first 4 weeks of the 20010/11 season from Sandy Bay was 5% as of the 16th January (Table 2), by the 15th of Feb it was 10%.

The estimate of pup production from the Auckland Islands was the third lowest count ever reported for this species at 1683 ± 16 (Figure 2).

4.1.1 Sea lion counts

Daily counts of pups and adults (live and dead) were made from 13th December to 20th January at Sandy Bay at 9.30am each morning (Figure 3). Similarly, counts were made at South East Point every second day from 15th December to 8th January, there after weekly until the 25th January and then back to a minimum of every second day until the 14th of February. Counts were made at approximately one week intervals at East Bay and other areas around Enderby Island. Figure of Eight Island was counted on January 10th. Two researchers studying Albatross were located on Adams Island, Carnley Harbour during the same six week season and reports from this area yielded

two tag resights however no sign of breeding. Sea lion counts at Figure of Eight Island were 59 females, 11 males and 72 live and 2 dead pups on the 10th of January 2012.

4.2 Information on marked animals

4.2.1 Marking

Pups have been tagged to provide a pool of known age individuals for the estimation of parameters such as survival, recruitment and reproductive rate as part of the long-term study. All live pups at Sandy Bay (360 by the 17th January) were tagged with Green ‘coffin’ shaped Dalton ‘Jumbo’ tags with a letter and three-digit number combination and PIT tagged. Four hundred pups were tagged at Dundas Island with Green ‘coffin’ shaped Dalton ‘Jumbo’ tags with a letter and three-digit number combination. Thirty pups were tagged on Figure of Eight Island with Green coffin shaped Dalton ‘Jumbo’ tags.

4.2.2 Resighting of previously marked individuals

Daily counts of all animals and resights of tags and brands on NZ sea lions were undertaken on Enderby Island to understand the composition of animals at this breeding site and to enable the calculation of survivability, recruitment and fecundity of animals. Field sightings of previously tagged, branded and/or passive integrated transponder (PIT) tagged animals were collected and recorded. Over 6914 resights made on 1074 animals previously tagged or branded (including 252 individuals identified from a PIT). One hundred and nineteen resights were collected from Dundas Island and two from Figure of Eight Island. Animals were checked at Kekenoo on the main Auckland Island, however no tagged or branded animals were seen. These records have been made available for uploading into the NZ sea lion database.

5. Discussion

The New Zealand sea lion is New Zealand’s only endemic pinniped. It is classified as Nationally Critical under the NZ threat classification system because of the significant decrease in pup production that has occurred (Baker et al. 2010) and is estimated to be the world’s rarest sea lion. This research shows the pup production at the Auckland Islands overall continues to be significantly lower than during the late 1990s (Figure 2).

5.1 Pup production and early mortality

For pinnipeds, estimates of pup production are the best index of relative population status and when combined with other population parameters provide the best estimate of overall population size and trends (Berkson & DeMaster 1985). Pups represent an estimate for the number of reproductive females within a population, they are relatively easy to handle and represent good experimental animals for M-R experiments to estimate abundance (Gales & Fletcher 1999). Early pup mortality averaged 4.7% overall in the first month and for Sandy Bay averaged 5% at one month and 10% at the end of the season. These are normal early mortality rates in non epidemic years. The consistent yearly monitoring of annual pup production and tagging and resighting data to enable estimation of population parameters at the Auckland Islands is essential for monitoring this declining Nationally Critical species.

Table 1: Pup production estimates for Auckland Islands

Season	Sandy Bay			Dundas Island			Figure of Eight Island			South East Point		
	total	alive	dead	Total	alive	dead	total	alive	dead	Total	alive	dead
94/95	467	421	46	1837	1603	234	143	123	20*	71	59	12
95/96	455	417	38	2017	1810	207	144	113	31	69	49	20
96/97	509	473	36	2260	2083	177	143	134	9	63	39	24
97/98	477	468	9	2373	1748	625	120	97	23	51	37	14
98/99	513	473	40	2186	1957	229	109	100	9	59	42	17
99/00	506	482	24	2163	2039	124	137	131	6	50	37	13
00/01	562	527	35	2148	1802	346	94	92	2	55	47	8
01/02	403	320	83	1756	1395	361	96	90	6	27	21	6
02/03	489	408	80	1891	1555	336	95	89	5	43	26	17
03/04	507	473	34	1869	1749	120	87	86	1	52	39	13
04/05	441	411	30	1587	1513	74	83	79	4	37	31	6
05/06	422	383	39	1581	1349	232	62	55	7	24	20	4
06/07	437	414	23	1693	1587	106	70	67	3	24	19	5
07/08	448 ± 5	425	23	1635 ± 44	1512	123	74 ± 1	72	2	18	13	5
08/09	301 ± 2	289	12	1132 ± 16	1065	67	54 ± 1	48	6	14	8	6
09/10	385 ± 6	364	21	1369 ± 35	1218	151	55 ± 1	48	7	5	1	4
10/11	378 ± 7	359	19	1089 ± 40	952	137	79 ± 2	71	8	4	2	2
11/12	361 ± 9	343	18	1248 ± 13	1189	59	74 ± 0	72	2	1	0	1

* Denotes that the number of dead pups was estimated from mean mortality rates derived from Sandy Bay and Dundas Island

Figure 2. Annual pup production for the Auckland Islands 1995/96 to 2011/12.

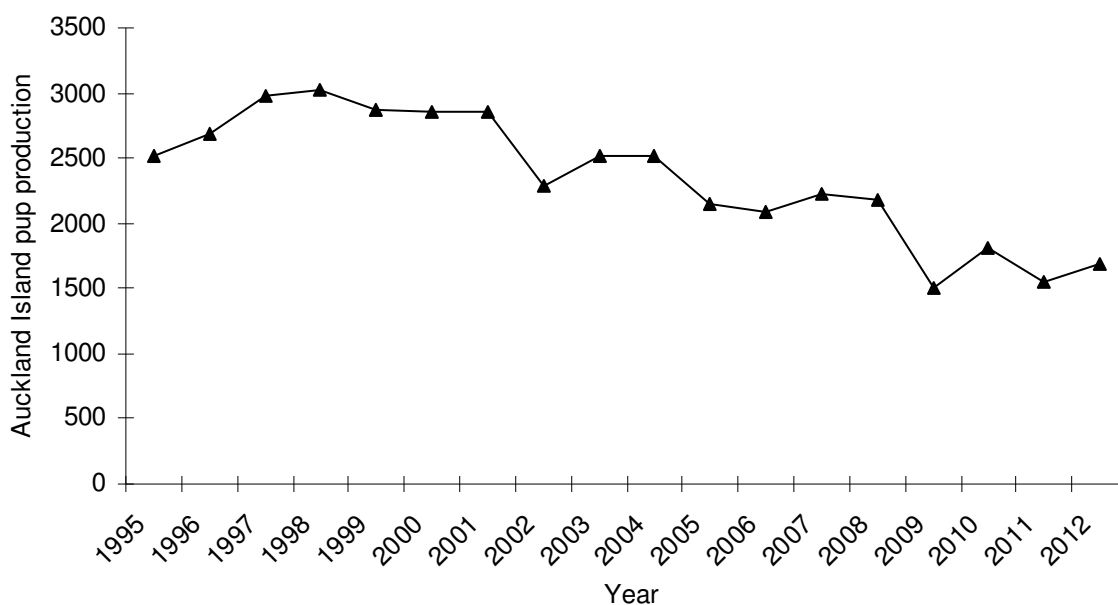
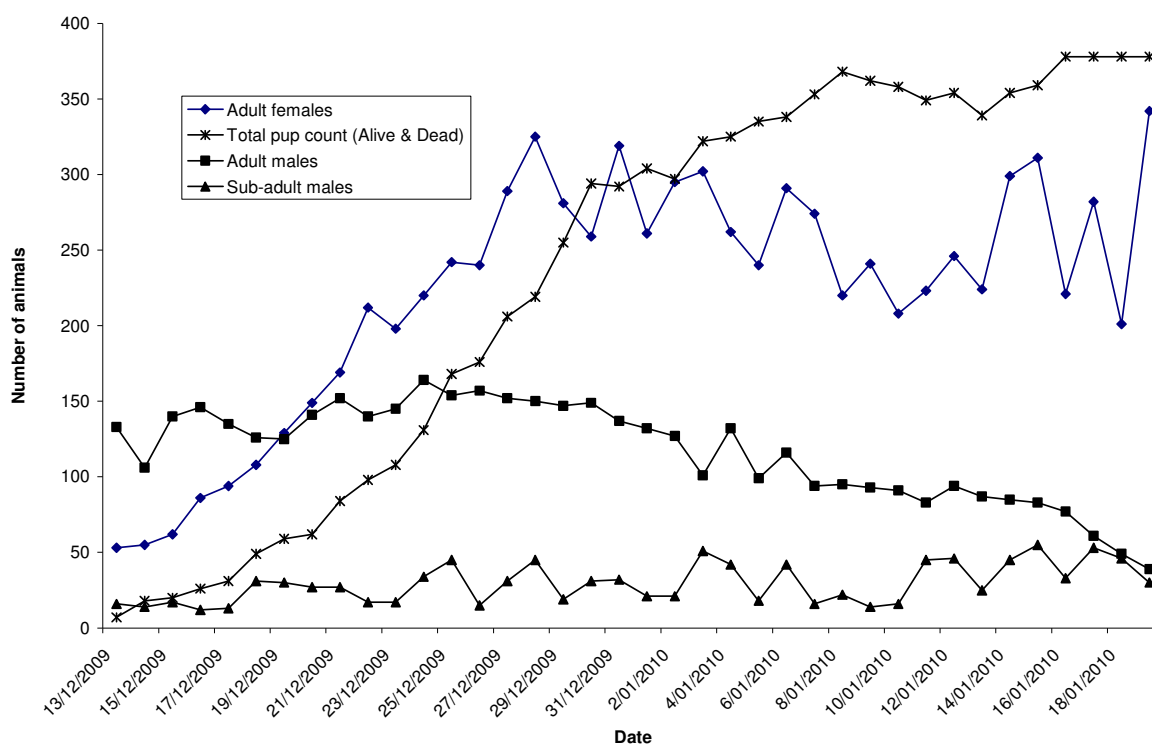


Table 2: Total pup production from the Auckland Islands (NB. These estimates do not include an estimate of pup production from Campbell Island).

Season	Annual pup production			% Annual change in no. pups born	% Mortality at mark recapture estimate date		% Mortality at end of season (SB only)
	Total	Alive	Dead		Total	SB only	
94/95	2518	2206	312		12%	10%	n.a.
95/96	2685	2389	296	6.6%	11%	8%	n.a.
96/97	2975	2729	246	10.8%	8%	7%	n.a.
97/98	3021	2350	671	1.5%	22%	2%	42%
98/99	2867	2572	295	-5.1%	10%	8%	9%
99/00	2856	2689	167	-0.4%	6%	5%	11%
00/01	2859	2468	391	0.1%	14%	6%	10%
01/02	2282	1826	456	-20.2%	20%	21%	33%
02/03	2518	2078	438	10.4%	17%	16%	21%
03/04	2515	2347	168	-0.1%	7%	7%	15%
04/05	2148	2034	114	-14.6%	5%	7%	12%
05/06	2089	1807	282	-2.8%	13%	9%	16%
06/07	2224	2087	137	6.5%	6%	5%	16%
07/08	2175±44	2022	153	-2.3%	7%	5%	14%
08/09	1501±16	1410	91	-31.0%	6%	4%	12%
09/10	1814±36	1631	183	20.9%	10%	5%	15%
10/11	1550±41	1384	166	-14.6%	11%	5%	8%
11/12	1684±16	1604	80	8.6%	4.7%	5%	10%
Actual number of pups recorded as dead 11/12					79	18	35

Figure 3 Daily count data at Sandy Bay, Enderby Island 2011/12 season



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Appendix 1 Raw mark-recapture values (for Sandy Bay and Dundas) and direct counts (for Figure of Eight) for the 2011/12 season

	2011/12	
Sandy Bay	Marked	Unmarked
Pups capped / marked	148	
Counter 1a	95	137
1b	84	124
1c	92	142
Counter 2a	87	126
2b	117	144
2c	105	104
Counter 3a	97	129
3b	109	127
3c	109	137
Dundas		
Pups capped / marked	380	
Counter 1a	180	370
1b	180	380
1c	142	320
Counter 2a	243	507
2b	207	447
2c	247	541
Counter 3a	128	262
3b	131	303
3c	156	312
Figure of Eight	Alive	Dead
Count 1	72	2
Count 2	72	2
Count 3	71	

Appendix 2 NZ sea lion data base information

DESCRIPTION OF FIELDS

Current Tag - This is the **current** identification of the individual

Colour - In addition to a unique number, tags are also colour coded

Tag shape - Either R = Round shaped or C = Coffin shaped

Brand - Refers to the presence or absence of a brand on a specific sea lion

Chip - Refers to the presence or absence of a Passive Integrated Transponder (PIT or CHIP tag) in a specific sea lion

Sex - M (Male), F (Female) or U (Unknown)

N of tag - The number of tags recorded on a specific sea lion, which flippers the tags were in and which flippers were sighted

Original Tag - Refers to the tag number a sea lion was originally tagged with as a pup

Previous Tag - Refers to any tag that is not a sea lion current or original tag

Date - This field records the date on which a marked animal was resighted

Season of Resight - Season in which resights were made expressed as a year. Years run from November in one year to October in the following year.

Location - The location at which the animal was sighted

Island - The island on which the resight location is found

Class - Provides details on the age class of the individual

Nature - The type of resight record in the database i.e. animal tagged, resighted or chip-read

Tag Year - This field identifies the year in which animals were tagged for the first time

Age - The age of the animal in years determined as the difference between the year of resighting and the year of tagging if tagged as a pup

Tag Location - The location at which the animal was originally tagged, as a pup, yearling or adult

Status - This field provides information about the animal, particularly reproductive status, in a numerical coded format

Behaviour Comments - Descriptive comments about the animal at the time of sighting

Pup tag - Tag number of pup which is added to database of female if that female is known to be the pup's mother

Pup tag colour - Tag colour of pup which is added to database of female if that female is known to be the pup's mother

Sight status - Confidence in sighting accuracy