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<b>Plot</b>	<b>Consensus Count</b>	<b>Count</b>	<b>Date Counted</b>	<b>Difference</b>	<b>Percentage difference</b>
13	85	84	May 5	-1	-1.18%
14	76	76	May 5	0	0.00%
15	117	114	May 10	-3	-2.56%
16	65	55	May 12	-10	-15.38%
17	107	108	May 12	1	0.93%
18	84	83	May 16	-1	-1.19%
19	86	85	May 17	-1	-1.16%
20	70	67	May 17	-3	-4.29%
21	104	106	May 17	2	1.92%
22	95	93	May 18	-2	-2.11%
23	102	99	May 24	-3	-2.94%
24	81	82	May 25	1	1.23%
25	94	90	May 26	-4	-4.26%
26	132	127	May 30	-5	-3.79%
27	40	40	May 30	0	0.00%
28	58	58	June 1	0	0.00%
29	76	72	June 7	-4	-5.26%
30	116	113	June 6	-3	-2.59%
<b>Mean (SE)</b>					<b>-2.21% (0.67)</b>

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Table 5. Percentage of pups that died up to 12 January, 2016, at 10 sites on Sable Island.

Area	Live Pups from Imagery	Dead Pup Count	Percentage
North Beach, East Light Dune	76	1	1.32%
No. 4 West	57	0	0.00%
Beck's Cove	64	4	6.25%
Legal Crossing, Inland, North	93	2	2.15%
Blowout	88	7	7.95%
Deadhorse Pass, South	107	8	7.48%
A-Frame, Inland, North	102	8	7.84%
Little Italy, Inland	107	7	6.54%
Tern Colony	112	6	5.36%
West of BIO, North	232	13	5.60%
Mean (SE)			5.05% (1.28)

Table 6. Estimates of stage durations, assuming gamma distribution, from daily records of Sable Island pups followed from birth to stage 5 in 1997 (n=47), 2007 (n=52), and 2010 (n=54), combined. Model and data updated from Bowen et al. 2011.

Stage	Common Shape				Separate Shape			
	Shape	Rate	Mean (d)	Variance	Shape	Rate	Mean (d)	Variance
1	18.78	5.82	3.22	0.55	13.71	4.29	3.20	0.75
2	18.78	5.12	3.67	0.72	17.90	4.89	3.66	0.75
3	18.78	1.59	11.79	7.40	25.21	2.13	11.85	5.57
4	18.78	3.33	5.64	1.69	9.01	1.61	5.58	3.46

Table 7. Comparison of Gamma and Weibull pup distribution models fit to staging transects data from each colony. Both models had two parameters. For all colonies, the preferred model is the Weibull (in bold).

Colony	Model	Shape	Rate	AIC
Sable Whole	Gamma	4.90 (0.43)	0.2 (0.02)	-36200
	<b>Weibull</b>	<b>2.78 (0.11)</b>	<b>25.83 (0.66)</b>	<b>-36184</b>
Hay Island	Gamma	15.24 (0.75)	0.46 (0.01)	-5200
	<b>Weibull</b>	<b>4.15 (0.23)</b>	<b>35.70 (0.89)</b>	<b>-5200</b>
SWNS	Gamma	5.62 (4.05)	0.27 (0.18)	-1607
	<b>Weibull</b>	<b>2.56 (0.53)</b>	<b>23.14 (0.84)</b>	<b>-1591</b>

Distribution	Density Function	Number of Parameters
Gamma	$\rho(\rho t)^{k-1}\exp(-\rho t)$	2
Weibull	$k\rho(\rho t)^{k-1}\exp[-(\rho t)^k]$	2

$\rho$ =scale,  $\kappa$ =shape parameter

Table 8. Estimates of the proportion of pups born based on the 2 models and the date of first birth (Dec 3, 2015). Jackknife standard error is in parentheses. The bolded cells are from AIC selected model.

Colony	Date	Proportion Born	
		Gamma	Weibull
Sable	Jan 12	0.91 (0.02)	<b>0.97 (0.01)</b>
Hay	Jan 12	0.80 (0.02)	<b>0.80 (0.04)</b>
Hay	Jan 15	0.88 (0.01)	0.89 (0.03)
Hay	Jan 28	0.99 (0)	1.00 (0)
SWNS	Jan 8	0.94 (0.03)	<b>0.96 (0.02)</b>

Table 9. Estimate of grey seal pup production on Sable, Hay and Southwest Nova Scotia (SWNS) islands in 2016 with SE in parentheses.

Count	Sable	Hay Island	SWNS
Pup counts	74,899	1,833	1,849
Proportion of pups missed	0.022 (0.0067)	0.022 (0.0067)	0.022 (0.0067)
Dead pup correction	0.051 (0.0128)	0.051 (0.0128)	0.051 (0.0128)
Proportion born	0.965 (0.0108)	0.799 (0.0420)	0.955 (0.0191)
<i>N</i>	83,594 (10,170)	2,471 (380)	2,085 (156)
95% CI	63,600-103,528	1,725-3,217	1,778-2,392

## FIGURES

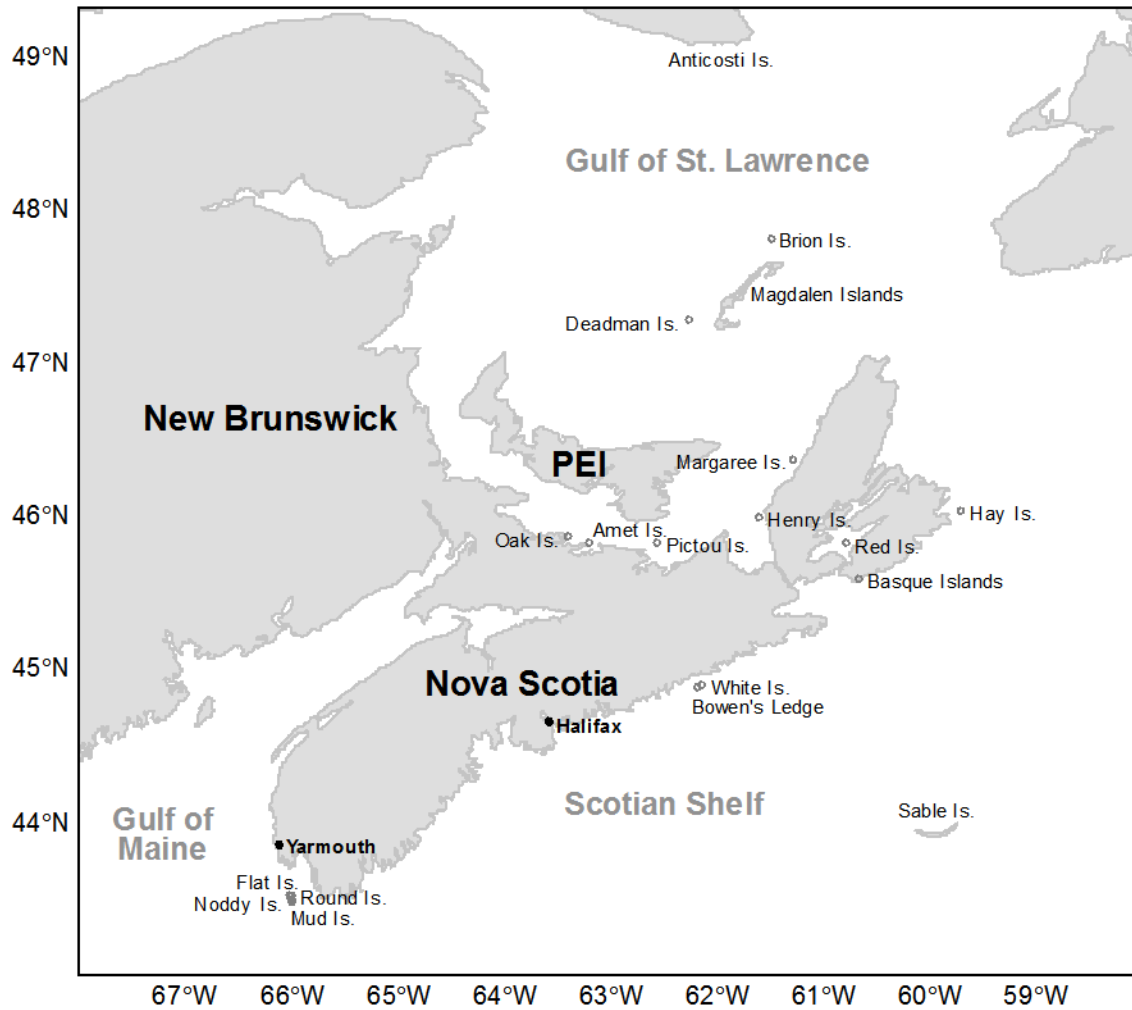


Figure 1. Map of historic and current land-based grey seal breeding colonies (open circles).

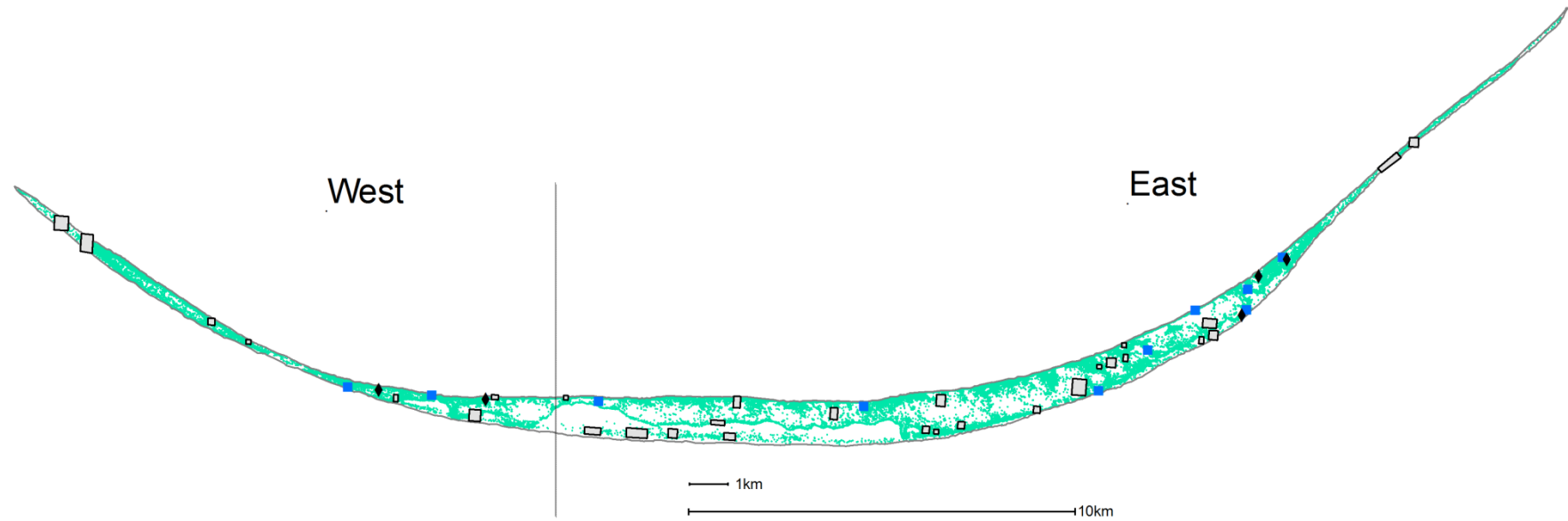


Figure 2. Map of the distribution of grey seal pups on Sable Island (green dots) and the location of mortality plots (blue squares), ground truth plots (black diamonds) and validation plots (black boxes). The horizontal line represents the east and west colony divide used in previous assessments.

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a)



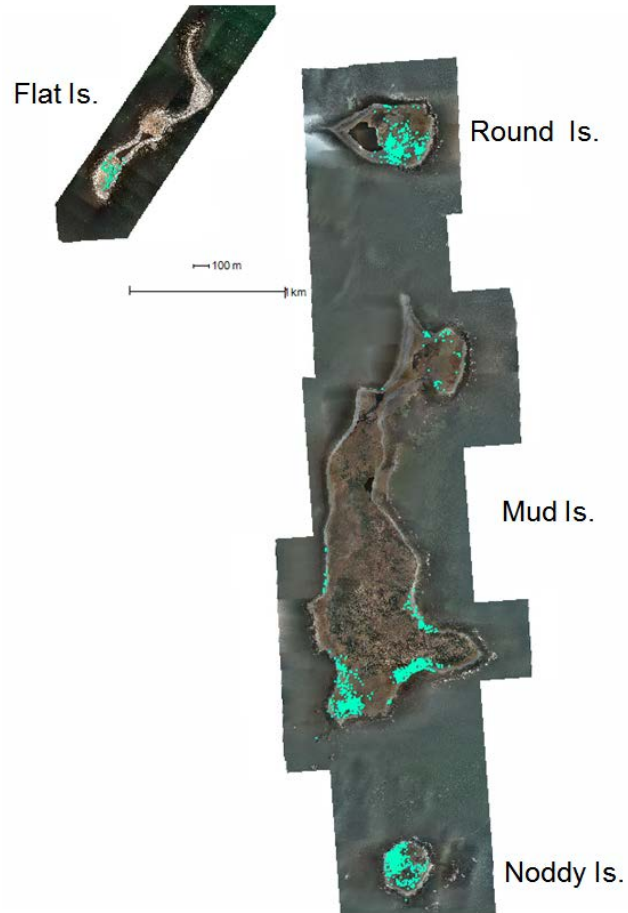
b)



*Figure 3. Example of digital imagery from (a) Sable Island and (b) Hay Island. Scale 1:125*



a)



b)

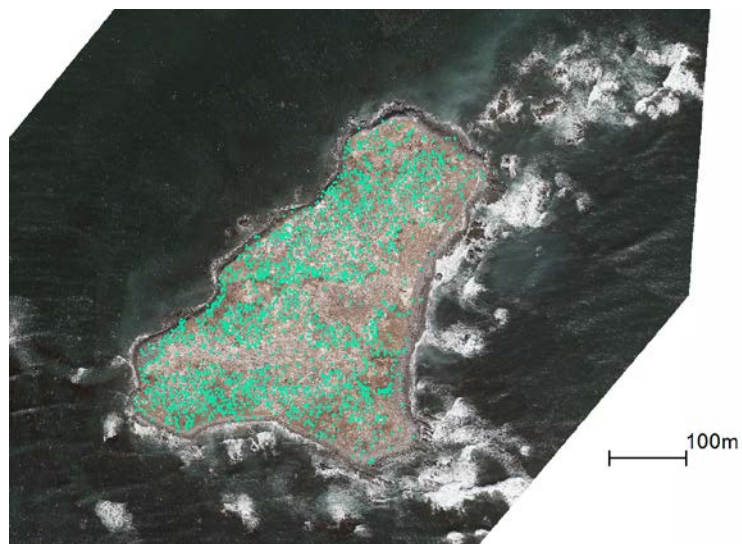


Figure 4. Distribution of pupping (green dots) on (a) Southwest Nova Scotia Islands (scale 1:25,000) and (b) Hay Island (1:3000) in January 2016.

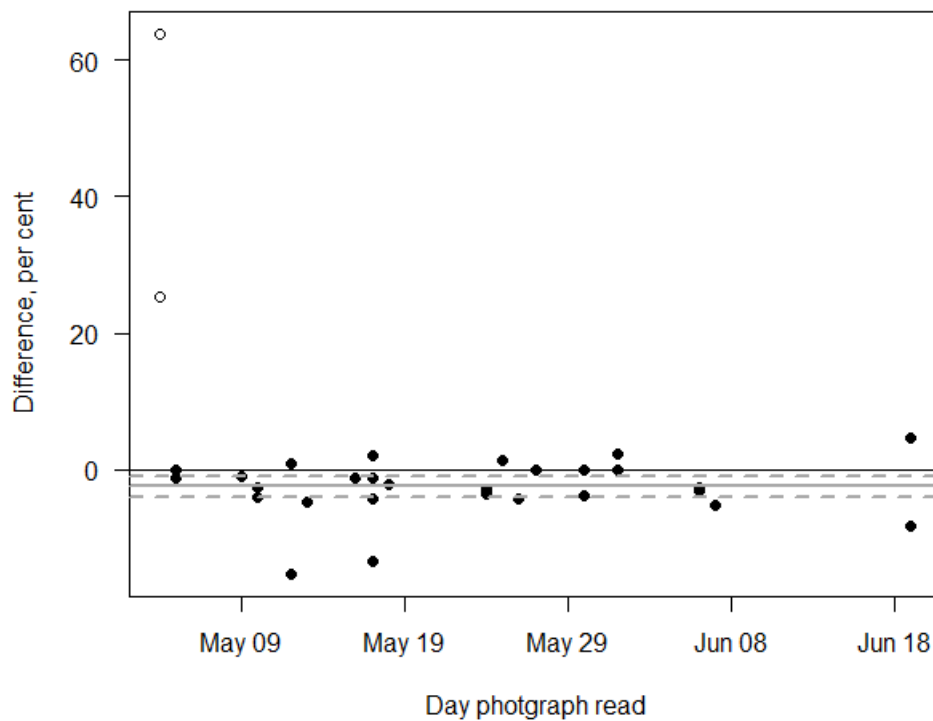


Figure 5. Comparison of the difference between reader pup count and the consensus pup count on validation plots, plotted by date counted by the reader. The solid horizontal line is the origin, the light grey line is mean and 95% confidence intervals are indicated by dashed line. Open circles were recounted by reader and not included in the overall average.

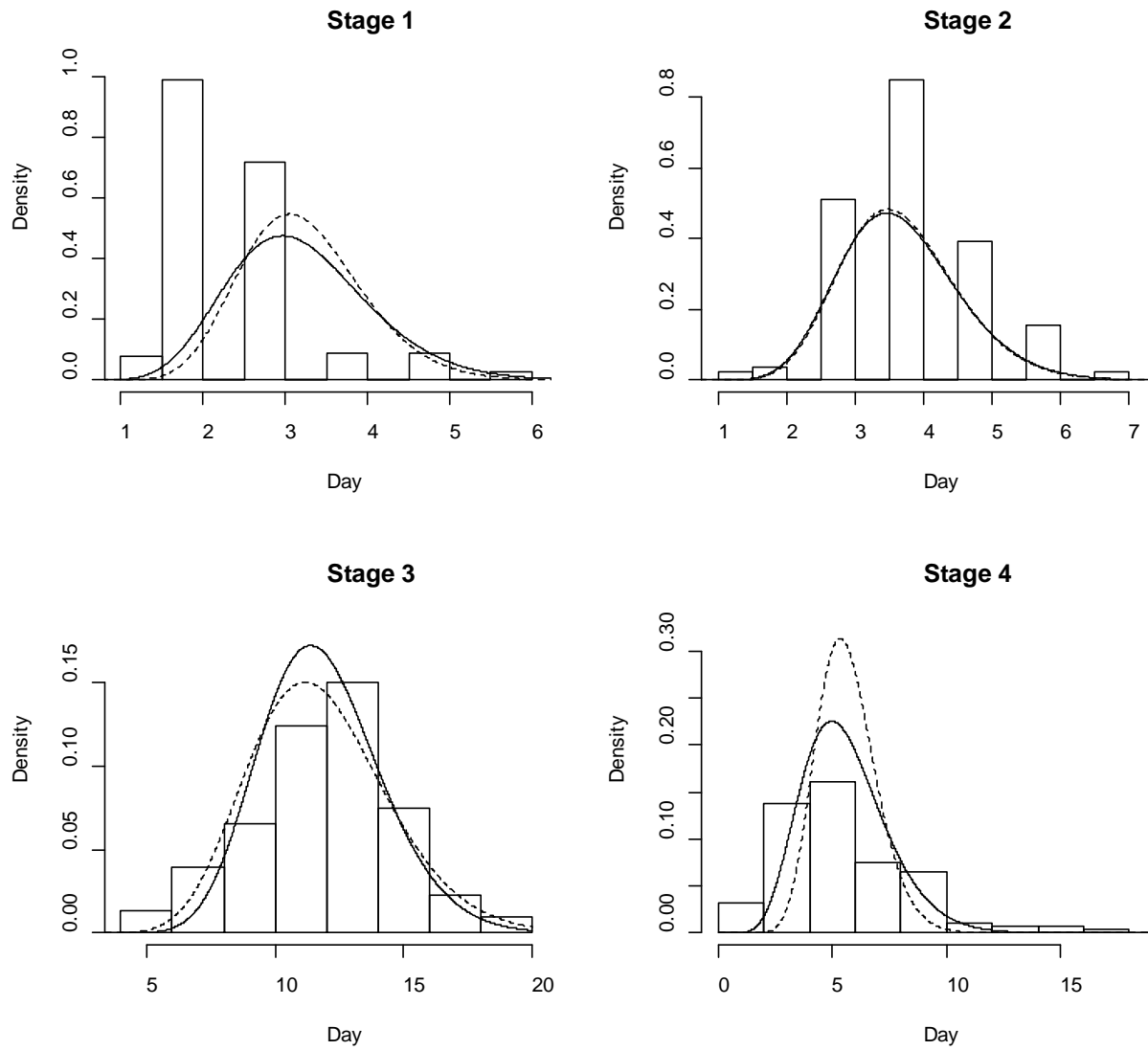


Figure 6. Fit of gamma model to pup stage duration from known aged pups assessed in 1997, 2007 and 2010 ( $n=153$ ). The solid line is a common shape model and the dashed line has a separate shape for each stage.

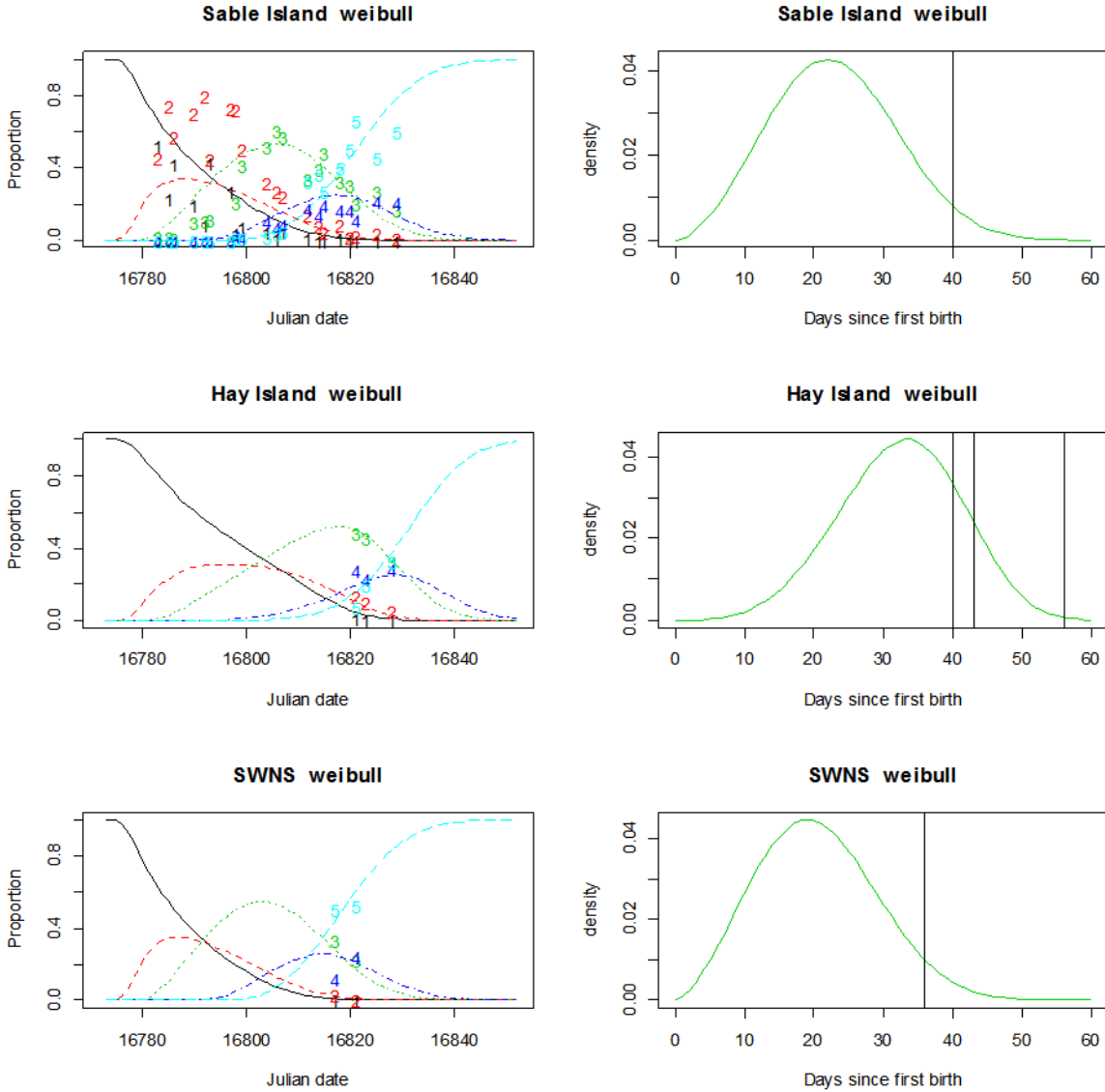


Figure 7. Fit of pupping distribution models to the transect data and the plot of pupping distributions with vertical bars indicating the day of the count. For all models the day of first birth is assumed to be Dec 3, 2015.

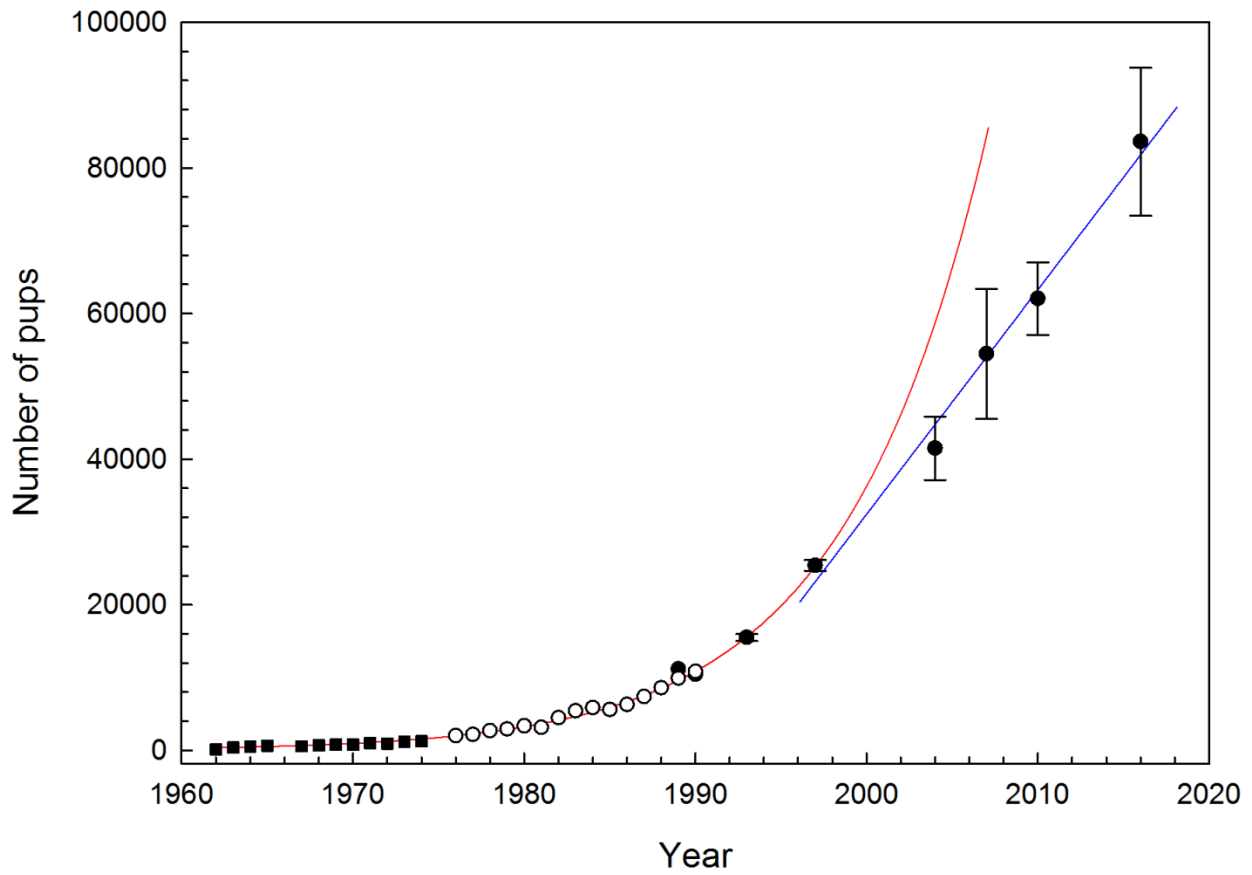
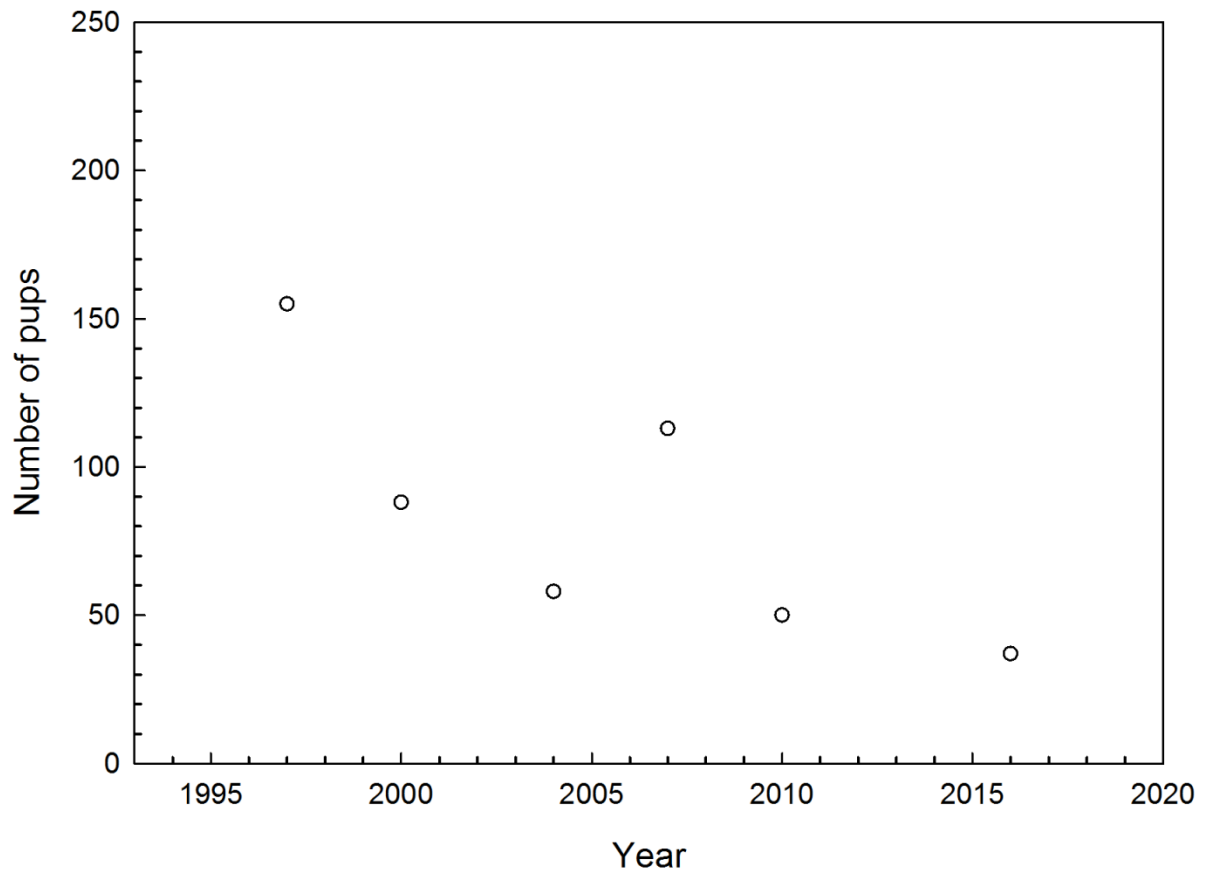


Figure 8. Trend in grey seal pup production on Sable Island, 1962 to 2016, based on incomplete tagging (1962-1974), complete cohort tagging (1976-1990) and aerial photographic surveys (1989-2016). Error bars are SE. The red line represents an exponential curve fit to the 1976 to 1997 estimates. The blue line represents a linear regression fit to the 1997 to 2016 estimates.



*Figure 9. Trend in grey seal pup production for coastal Nova Scotia colonies on White Island and Bowen's Ledge based on aerial survey counts. Counts are uncorrected.*

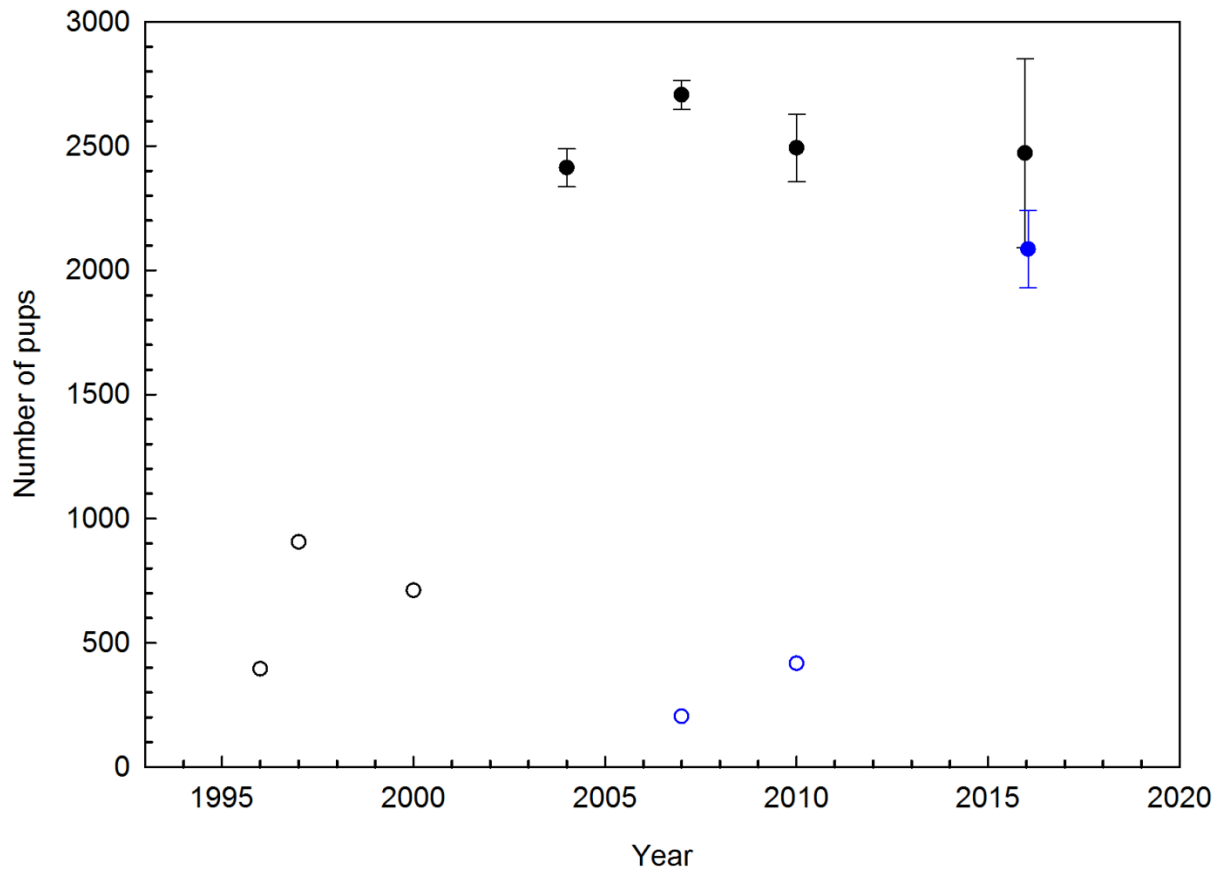


Figure 10. Trends in grey seal pup production for coastal Nova Scotia colonies located on Hay Island (black) and Flat, Mud, Round and Noddy Islands combined (SWNS; blue) based on aerial survey counts. Open circles are uncorrected counts, closed circles are corrected counts. Error bars are SE.

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## APPENDICES

*Appendix 1. The count of the number of pups observed on Sable Island in each developmental stage on each day. Day 1 is the birth day of an individual pup.*

Day	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
1	153	0	0	0	0
2	147	6	0	0	0
3	71	61	0	0	0
4	16	137	0	0	0
5	9	144	0	0	0
6	2	133	18	0	0
7	0	79	74	0	0
8	0	42	111	0	0
9	0	20	133	0	0
10	0	6	147	0	0
11	0	0	153	0	0
12	0	0	152	1	0
13	0	0	152	1	0
14	0	0	150	3	0
15	0	0	147	6	0
16	0	0	140	13	0
17	0	0	135	18	0
18	0	0	115	38	0
19	0	0	94	57	1
20	0	0	66	76	8
21	0	0	47	87	13
22	0	0	26	102	20
23	0	0	17	103	31



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<b>Day</b>	<b>Stage 1</b>	<b>Stage 2</b>	<b>Stage 3</b>	<b>Stage 4</b>	<b>Stage 5</b>
24	0	0	7	98	44
25	0	0	3	83	61
26	0	0	1	67	77
27	0	0	1	52	92
28	0	0	1	43	99
29	0	0	0	24	119
30	0	0	0	15	124
31	0	0	0	8	133
32	0	0	0	2	120
33	0	0	0	1	121
34	0	0	0	0	99
35	0	0	0	0	95
36	0	0	0	0	80
37	0	0	0	0	47
38	0	0	0	0	47
39	0	0	0	0	25
40	0	0	0	0	6

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*Appendix 2. Development stage of pups recorded on transects from southwest Nova Scotia Islands (SWNS; Noddy, Round, Flat and Mud), Eastern Nova Scotia Islands (ENS; Hay, Red and White) and on Sable Island. Pup staging data were recorded on the ground, from helicopter by experienced observers or from photographs taken by hand held cameras or drones. The Red and White Island transects from ENS were not included in the model.*

<b>Colony</b>	<b>Location</b>	<b>Date</b>	<b>Stage 1</b>	<b>Stage 2</b>	<b>Stage 3</b>	<b>Stage 4</b>	<b>Stage 5</b>	<b>Method</b>
SWNS	Noddy	1/17/2016	1	10	94	33	141	ground
SWNS	Noddy	1/21/2016	0	1	23	27	60	helicopter
SWNS	Round	1/21/2016	0	1	22	37	66	helicopter
SWNS	Flat	1/21/2016	0	0	19	5	4	helicopter
SWNS	Mud	1/21/2016	0	0	37	40	106	helicopter
ENS	Hay	1/21/2016	1	9	32	18	5	helicopter
ENS	Hay	1/23/2016	2	27	120	60	52	hand camera
ENS	Hay	1/28/2016	5	95	560	479	560	ground
ENS	Hay	1/28/2016	0	140	1418	593	159	drone flight
ENS	Red	1/23/2016	0	4	33	3	1	helicopter
ENS	White	1/28/2016	0	3	15	6	5	ground
Sable	1	12/14/2015	38	32	0	0	0	ground
Sable	1	12/21/2015	27	153	22	1	0	ground
Sable	1	12/29/2015	7	167	32	9	1	ground
Sable	1	1/4/2016	11	40	114	39	5	ground
Sable	1	1/12/2016	1	23	74	25	100	ground
Sable	1	1/18/2016	0	24	68	35	77	ground
Sable	2	12/14/2015	104	90	4	0	0	ground
Sable	2	12/21/2015	27	154	28	0	0	ground
Sable	2	12/29/2015	7	136	56	2	2	ground
Sable	2	1/4/2016	9	60	110	24	4	ground
Sable	2	1/12/2016	2	34	69	44	57	ground

<b>Colony</b>	<b>Location</b>	<b>Date</b>	<b>Stage 1</b>	<b>Stage 2</b>	<b>Stage 3</b>	<b>Stage 4</b>	<b>Stage 5</b>	<b>Method</b>
Sable	2	1/18/2016	4	19	73	25	107	ground
Sable	3	12/16/2015	55	140	2	0	0	ground
Sable	3	12/23/2015	16	163	20	0	0	ground
Sable	3	12/30/2015	11	149	49	4	2	ground
Sable	3	1/6/2016	2	51	121	21	16	ground
Sable	3	1/14/2016	0	9	74	30	96	ground
Sable	3	1/20/2016	0	5	57	29	115	ground
Sable	4	12/16/2015	43	187	7	0	0	ground
Sable	4	12/23/2015	22	185	28	2	0	ground
Sable	4	12/30/2015	9	161	54	2	1	ground
Sable	4	1/6/2016	2	71	149	9	0	ground
Sable	4	1/14/2016	0	22	106	33	70	ground
Sable	4	1/20/2016	0	2	70	41	88	ground
Sable	10	12/17/2015	36	52	0	0	0	ground
Sable	10	12/24/2015	91	66	6	0	0	ground
Sable	10	12/30/2015	22	70	92	0	0	ground
Sable	10	1/7/2016	16	55	144	14	5	ground
Sable	10	1/15/2016	1	6	116	56	40	ground
Sable	10	1/25/2016	2	4	35	74	90	ground
Sable	11	12/17/2015	37	83	0	0	0	ground
Sable	11	12/24/2015	34	154	30	0	0	ground
Sable	11	12/30/2015	5	150	69	6	0	ground
Sable	11	1/7/2016	3	37	145	24	7	ground
Sable	11	1/14/2016	0	24	74	29	85	ground

<b>Colony</b>	<b>Location</b>	<b>Date</b>	<b>Stage 1</b>	<b>Stage 2</b>	<b>Stage 3</b>	<b>Stage 4</b>	<b>Stage 5</b>	<b>Method</b>
Sable	11	1/21/2016	0	8	50	22	118	ground
Sable	12	12/17/2015	28	112	1	0	0	ground
Sable	12	12/24/2015	34	171	14	0	0	ground
Sable	12	12/30/2015	5	141	48	6	7	ground
Sable	12	1/7/2016	1	29	133	41	23	ground
Sable	12	1/14/2016	4	9	80	28	62	ground
Sable	12	1/21/2016	0	2	32	25	153	ground
Sable	13	12/21/2015	50	69	1	0	0	ground
Sable	13	12/28/2015	52	140	0	0	0	ground
Sable	13	1/4/2016	7	103	109	3	2	ground
Sable	13	1/12/2016	3	36	90	49	61	ground
Sable	13	1/18/2016	0	17	69	52	80	ground
Sable	13	1/29/2016	1	3	35	44	126	ground
Sable	5	12/17/2015	31	53	2	0	0	ground
Sable	5	12/24/2015	134	53	9	0	0	ground
Sable	5	12/30/2015	29	96	106	0	0	ground
Sable	5	1/7/2016	12	83	130	7	2	ground
Sable	5	1/15/2016	0	11	94	42	76	ground
Sable	5	1/25/2016	0	5	29	72	83	ground
Sable	6	12/17/2015	8	2	0	0	0	ground
Sable	6	12/24/2015	122	74	26	0	0	ground
Sable	6	12/30/2015	21	67	112	2	1	ground
Sable	6	1/7/2016	10	55	142	10	2	ground
Sable	6	1/15/2016	0	11	118	43	41	ground

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<b>Colony</b>	<b>Location</b>	<b>Date</b>	<b>Stage 1</b>	<b>Stage 2</b>	<b>Stage 3</b>	<b>Stage 4</b>	<b>Stage 5</b>	<b>Method</b>
Sable	6	1/25/2016	1	10	82	24	93	ground
Sable	7	12/17/2015	40	43	1	0	0	ground
Sable	7	12/24/2015	83	53	33	0	0	ground
Sable	7	12/30/2015	8	72	110	0	0	ground
Sable	7	1/7/2016	10	67	115	19	9	ground
Sable	7	1/15/2016	0	18	120	36	40	ground
Sable	7	1/25/2016	0	9	71	30	96	ground
Sable	8	12/17/2015	62	54	1	0	0	ground
Sable	8	12/24/2015	101	59	27	0	0	ground
Sable	8	12/30/2015	17	78	104	5	1	ground
Sable	8	1/7/2016	13	78	116	27	22	ground
Sable	8	1/15/2016	1	10	100	36	72	ground
Sable	8	1/25/2016	2	15	81	44	70	ground
Sable	9	12/17/2015	89	51	1	0	0	ground
Sable	9	12/24/2015	78	67	35	0	0	ground
Sable	9	12/30/2015	17	56	114	6	1	ground
Sable	9	1/7/2016	10	52	123	14	20	ground
Sable	9	1/15/2016	1	7	85	39	83	ground
Sable	9	1/25/2016	0	7	44	34	139	ground

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Appendix 3. Grey seal pup production on Sable Island, 1962 to 2016, based on incomplete tagging (1962-1974), complete cohort tagging (1976-1990) and aerial photographic surveys (1989-2016). Values in parentheses are SE.

Year	Number of pups
1962	134
1963	400
1964	550
1965	660
1967	580
1968	700
1969	800
1970	800
1971	1000
1972	950
1973	1200
1974	1250
1976	2000
1977	2181
1978	2687
1979	2933
1980	3344
1981	3143
1982	4489
1983	5435
1984	5856
1985	5606
1986	6301
1987	7391
1988	8593
1989	9906 <sup>1</sup> , 11168 <sup>2</sup>
1990	10838 <sup>1</sup> , 10457 <sup>2</sup>
1993	15500 (463)
1997	25400 (750)
2004	41500 (4381)
2007	54482 (8909)
2010	62054 (4973)
2016	83594 (10170)

<sup>1</sup> complete tagging

<sup>2</sup> aerial survey

Appendix 4. Grey seal pup production on for coastal Nova Scotia colonies located on Hay Island, White Island and Bowen's Ledge and on Flat, Mud, Round and Noddy Islands combined (SWNS) based on aerial survey counts. Values in italics are corrected counts. Values in parentheses are SE.

<b>Colony</b>	<b>Year</b>	<b>Number of pups</b>
<b>Hay Island</b>	1996	395
	1997	906
	2000	711
	2004	2413 (76)
	2007	2706 (57)
	2010	2492 (136)
	2016	2471 (380)
<b>White Island/Bowen's Ledge</b>	1997	155
	2000	88
	2004	58
	2007	113
	2010	50
	2016	37
<b>SWNS</b>	2007	204
	2010	417
	2016	2085 (156)