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An Estimate of the Proportion of Recovered Harp Seal Tags not Returned
for Reward: the 1983 Mark-recapture Experiment

by

W. D. Bowen¹

Northwest Atlantic Fisheries Centre, Dept. of Fisheries and Oceans
P. O. Box 5667, St. John's, Newfoundland, Canada A1C 5X1

Estimates of population parameters, such as population size, from mark-recapture methods are based on the assumption that all recaptures of marked animals are known to the investigator. To the extent that this is not the case, estimates of population size will overestimate the true value and assuming other model assumptions are upheld, this bias will be proportional to the proportion of recovered tags not disclosed.

In March 1983, a modified Petersen mark-recapture experiment was conducted to estimate harp seal pup production in the Northwest Atlantic (Bowen and Sergeant 1985). Previous experiments of this nature had indicated that approximately 25% of recovered tags were not returned for the reward (Bowen and Sergeant 1983). The present survey was designed to estimate the total number of recovered harp seal tags that were not returned for the reward during the 1983 hunt for pups off northeastern Newfoundland. This information was used to correct estimates of pup production from the modified Petersen method used by Bowen and Sergeant (1985).

METHODS

The survey was carried out from 8 to 24 September, 1983 approximately 2.5 months after the hunting season had ended. The sample frame was defined as those communities from Bonavista Bay around the northern peninsula of Newfoundland to Bay of Islands on the west coast of Newfoundland in which one or more licenced sealer was known to reside. Lists of the number of licenced sealers per community were obtained from the Operations Branch of the Department of Fisheries and Oceans, St. John's, Newfoundland. In total, there were 211 communities in the population.

¹Present address: Marine Fish Division, Dept. of Fisheries & Oceans,
Bedford Institute of Oceanography, Dartmouth, N.S.

¹ Present address: Marine Fish Division, Dept. of Fisheries and Oceans,
Bedford Institute of Oceanography, Dartmouth, N.S.

Information from previous surveys of this type (Bowen and Sergeant 1983) suggested that increased precision could be obtained by stratifying communities on the basis of reported pup landings. Landing statistics, obtained from Operations Branch, St. John's, were used to define five strata: communities in which the pup catch was 1) >1000 seals, 2) 500-1000 seals, 3) 100-499 seals, 4) 1-99 seals, and 5) no reported catch. Sampling units within each strata were selected using two-stage random sampling. Initially a random sample of communities was selected (Table 1), and then within each community, 75% of licenced sealers were selected (Table 2). In total, 51 communities and 1894 sealers were included in the survey. Sealers were contacted in person or by telephone. If unsuccessful on the first occasion, interviewers made up to four call backs. Between the first and subsequent calls, interviewers obtained information from spouses and/or neighbours to increase the probability of successfully finding the respondent at home. Once contacted, sealers were asked a series of 10 questions (Appendix 2) and were paid a reward of \$12 per tag for any harp seal tags they held.

An estimate of the total number of tags recovered but not returned for the reward was determined as follows:

let $L =$ the total number of strata ($h = 1, \dots, L$)

$N_h =$ the total number of communities in stratum h

$N = \sum_h^L N_h =$ total number of communities

$n_h =$ number of communities sampled in stratum h

$n = \sum_{h=1}^L n_h =$ total number of communities over all strata

$M_{ih} =$ total number of sealers in community i and stratum h

$m_{ih} =$ total number of sealers interviewed in community i and stratum h

$f_{ih} = (M_{ih}/m_{ih}) =$ inverse of the sampling fraction

$y'_{ih} =$ number of tags (double tag counts as one tag) recovered and not returned

$y_{ih} = f_{ih} \cdot y'_{ih} =$ estimated total number of tags not returned in community i and stratum h

$\bar{y}_h = \sum_{i=1}^{n_h} y_{ih}/n_h =$ estimated average number of tags not returned in stratum h

$\bar{y}_{nr} = \frac{\sum_h^L N_h \bar{y}_h}{N} =$ average overall strata

$y_{nr} = N \bar{y}_{nr} =$ estimated total number of tags not returned in population.

The variance of \bar{y}_h within a stratum is given by:

$$s^2(\bar{y}_h) = \frac{\sum_{i=1}^{n_h} (y_{ih} - \bar{y}_h)^2}{(n_h - 1)}$$

and the variance of \bar{y}_{nr} overall strata is

$$s^2(\bar{y}_{nr}) = \frac{1}{N^2} \sum_{h=1}^L N_h (N_h - n_h) \frac{s^2(y_h)}{n_h}$$

The estimated population variance is $N^2 s^2(\bar{y}_{nr})$.

If m = the number of tags actually returned from the population of communities prior to the survey, then an estimate of return rate (r) is given by:

$$r = \frac{m}{m + y_{nr}}$$

and the estimated variance of r following Mood, Grayhill and Boes (1974:181) is given as:

$$\begin{aligned} \text{Var}(r) &\approx \left(\frac{m}{m+y_{nr}} \right)^2 \times \left(\frac{\text{Var}(y_{nr})}{(m+y_{nr})^2} \right) \\ &\approx \left(\frac{m}{m+y_{nr}} \right)^2 \times \left(\frac{N^2 s^2 (\bar{y}_{nr})}{(m+y_{nr})^2} \right) \end{aligned}$$

since $\text{Var}(m) = 0$ and $\text{Var}(m+y_{nr}) = \text{Var}(y_{nr})$ and $\text{Cov}(m, m+y_{nr}) = 0$.

RESULTS

Of the 1,375 sealers selected, 1,012 were interviewed directly (859) or were found to have hunted in partnership (153) with a sealer who was interviewed and hence the appropriate information on the number of tags recovered but not returned was available. Over all 51 communities in the sample, 53.4% of 1,894 sealers were interviewed (Table 2). Of the sealers selected for interviews, 66 (4.8%) had moved, were attending school or were working outside the community, 139 (10.1%) were unable to be located because they did not have a telephone or were relatively unknown in the community and 151 (11%) were available but could not be reached even after four call-backs. Only three hunters refused to provide information during the interview.

The estimated number of recovered beater tags not returned for the reward in each of the 51 communities sampled are given in Table 3. For convenience, only tags from pups marked at the Front in March 1983 were used in the analysis. As expected the largest number of tags came from communities in Stratum 1 (beater catch >1000). However, 3 recoveries were estimated to have come from Shoe Cove a community with 27 licenced sealers but no reported beater landings (Stratum 5). The estimated number of tags not returned from La Scie excludes 42 tags recovered by M. Burton. Immediately after sealing, Mr. Burton went fishing off Labrador and had only just returned when the survey was conducted. Thus although he planned to return the tags (valued at \$504.00) he had not had an opportunity. That he would have returned the tags is supported by the fact that in previous years he had always done so, even when fewer tags were involved. Given the circumstances, Mr. Burton's behaviour is unlikely to be representative of the population and was therefore eliminated from the sample.

The mean and standard deviation of the estimated number of beater tags not returned for the reward by stratum are given in Table 4. The average number of tags not returned per community over all strata is 1.4 ± 0.23 (1sd). Therefore, the estimated total number of beater tags not returned in the population is 295 ± 49 (1sd).

Before the survey, a total of 665 beater tags from pups tagged at the Front in March 1983 had been returned for the reward. Therefore the estimated reporting rate (r) is 0.693 ± 0.0351 (1sd).

DISCUSSION

The results of this study indicate that approximately 31% of beater tags recovered by Newfoundland sealers are not returned for the \$12 reward (i.e. $r = 0.693$). Bowen and Sergeant (1983) conducted similar but less extensive surveys in 1979 and 1980 in Newfoundland and estimated r to be 0.690 and 0.769 respectively. Hence the results from all three surveys indicate a similar level of non-reporting.

The impact of these results on population estimates from a mark-recapture experiment are clear. Without correcting for reporting rate, estimates of harp seal pup production would be overestimated by about 30%. It should be stressed that the results of this study strictly apply only to Newfoundland sealers. Although the reward for harp seal tags is the same in all areas where harp seals

are hunted, cultural and socio-economic factors may well influence the estimated reporting rate. The effect of any regional differences in reporting rate would be greatest for estimates based on pup recoveries, since a greater proportion of the total catch occurs outside Newfoundland at this age. Recoveries of tags from seals age 1 and older are mainly from Newfoundland and thus these estimates of production will be less affected by the lack of information on reporting rate from other areas. It would nevertheless be advisable to conduct studies on reporting rate in areas such as the North Shore of Quebec, Magdalen Islands and Cape Breton to determine if regional differences exist.

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Table 1. Number of communities per stratum in the September 1983 survey in Newfoundland.

Stratum (h)	Number of Communities (N_h)	Number of Communities in sample (n_h)
1	7	5
2	4	2
3	23	11
4	38	19
5	139	14
Total	211	51

Table 2. Communities and number of sealers in the September survey, Newfoundland 1983.

Stratum ¹	Community	Unit area	Total Sealers	No. in Sample	No. Contacted			% Contacted of total
					Directly	Partner	Total	
1	Englee	341	116	83	56	13	69	59.4
	Great Brehat	342	26	19	12	6	18	69.2
	St. Anthony	342	195	139	89	3	92	47.2
	La Scie	340	103	72	39	24	63	61.2
	Twillingate	339	89	66	42	9	51	57.3
	TOTAL			529	379	238	55	293
2	Goose Cove	342	39	30	18	5	23	59.0
	Nippers Hr.	340	36	27	17	6	23	63.9
	TOTAL		75	57	35	11	46	61.3
3	Wild Bight	401	16	12	4	3	7	43.8
	St. Lunaire	342	57	42	19	6	25	43.9
	Fleurs de Lys	340	57	42	26	5	31	54.4
	Summerford	339	61	44	23	0	23	37.7
	Indian Cove	339	14	10	5	2	7	50.0
	Durrells	339	96	72	46	13	59	61.5
	Musgrave Hr.	339	10	6	3	2	5	50.0
	Port-aux-Choix	401	12	9	6	0	6	50.0
	Boat Hr.	401	29	20	8	0	8	27.6
	Cooks Hr.	401	88	62	44	8	52	59.1
	Change Is.	339	45	34	25	1	26	57.8
TOTAL			485	353	209	40	249	51.3
4	Salvage	338	24	16	13	0	13	54.2
	Eastport	338	33	27	15	4	19	57.6
	Hare Bay	338	34	25	13	1	14	41.2
	Greenspond	338	41	31	22	2	24	58.5
	Deadman's Bay	339	15	11	7	0	7	46.7
	Fogo	339	69	49	37	9	46	66.7
	Cottlesville	339	7	5	3	1	4	57.1
	Lushes Bight	340	22	16	8	2	10	45.5
	Beachside	340	26	17	11	0	11	42.3
	Coachman's Cove	340	17	13	10	0	10	58.8
	Wild Cove	341	27	18	12	5	17	62.9
	Seal Cove	341	41	32	23	2	25	61.0
	Sops Arm	341	16	12	7	2	9	56.3
	Straitsview	401	22	15	8	0	8	36.4
	Raleigh	401	45	33	25	3	28	62.2
	Roberts Arm	340	30	22	16	2	18	60.0
	Bale Verte	340	30	20	15	1	16	53.3
Westport	341	66	50	28	4	32	48.5	
Great Hr. Deep	341	53	35	17	4	21	39.6	
TOTAL			618	447	290	42	332	53.7
5	Shoe Cove	340	27	19	14	4	18	66.7
	Botwood	339	13	9	4	0	4	30.8
	Hampden	341	50	38	19	0	19	38.0
	Silverdale	339	1	1	1	0	1	100.0
	Campbellton	339	5	4	4	0	4	80.0
	Main Point	339	1	1	0	0	0	0.0
	Bird Cove	401	7	5	3	0	3	42.9
	Rocky Hr.	402	3	2	2	0	2	66.7
	Green Is. Cove	401	15	11	3	0	3	20.0
	Centerville	338	24	17	11	0	11	64.7
	Templeman	338	4	3	3	0	3	75.0
	Culls Hr.	338	6	5	5	0	5	83.3
	Daniels Hr.	402	14	11	9	0	9	64.3
Brig Bay	401	17	13	9	1	10	58.8	
TOTAL			187	139	87	5	92	49.2
Overall Strata TOTAL			1894	1375	859	153	1012	53.4

¹ Strata based on beater landings as follows: 1 = 1000, 2 = 500-1000, 3 = 100-499, 4 = 1-99, 5 = 0.

Table 3. Estimated number of pup tags not returned for 51 communities in 5 strata in the Newfoundland survey. Only front tagged animals used in analysis.

STRATUM														
1			2			3			4			5		
f_{1h}	y'_{1h}	y_{1h}	f_{1h}	y'_{1h}	y_{1h}	f_{1h}	y'_{1h}	y_{1h}	f_{1h}	y'_{1h}	y_{1h}	f_{1h}	y'_{1h}	y_{1h}
1.68 ¹	6	10	1.69	1	2	2.28	0	0	1.84	0	0	1.50	2	3
1.44	27	39	1.56	0	0	2.28	3	7	1.74	0	0	3.25	0	0
2.12	14	30				1.84	0	0	2.43	0	0	2.63	0	0
1.63	28 ²	46	Total	2		2.65	0	0	1.71	0	0	1.00	0	0
1.75	0	0				2.00	2	4	2.14	0	0	1.25	0	0
						1.63	2	3	1.50	6	9	0.00 ³		
Total	125					2.00	0	0	1.75	0	0	2.33	0	0
						2.00	0	0	2.20	0	0	1.50	0	0
						3.62	1	4	2.36	0	0	5.00	0	0
						1.69	1	2	1.70	0	0	1.55	0	0
						1.73	0	0	1.58	1	2	1.33	0	0
									1.64	1	2	1.20	0	0
						Total	20		1.78	0	0	1.56	0	0
									2.75	0	0	1.70	0	0
									1.61	4	6			
									1.67	0	0	Total	3	
									1.88	0	0			
									2.06	0	0			
									2.53	0	0			
									Total	19				
N_h	7		4			23			38			239		
n_h	5		2			11			19			14 ³		

f_{1h} = inverse of sampling fraction, y'_{1h} = observed no. not returned, y_{1h} = estimated total no. not returned in each community.

¹ communities listed in order as in Table 2.

² excludes one sealer's tags, see text

³ only 1 licenced sealer in the community, but not contacted, thus $N_h = 13$

Table 4. Mean and standard deviation of the estimated number of beater tags¹ not returned by stratum.

Stratum	Mean no. tags per stratum (\bar{y}_h)	Standard Deviation $S(\bar{y}_h)$
1	25.0	19.44
2	1.0	1.41
3	1.8	2.40
4	1.0	2.43
5	0.2	0.83

¹ doubled tags counted as only 1 tag.

Appendix I. Questions used during the September survey, 1983.

SURVEY QUESTIONNAIRE 1983

1. Did you hunt harp seals this year (1982-83)? YES ___ NO ___
2. If "YES", how many days did you hunt?
3. How many harp seals did you kill less than 1 year of age and
how many greater or equal to 1 year of age
4. What method did you use to kill each age group?
1 = net; 2 = small boat, shot; 3 = longliner, shot;
4 = large vessel; 5 = other.
5. How many harp seals did you kill that had a tag on the hind flipper?
 - A. seals less than 1 year old
 - B. seals 1 year old or older
6. Do you know there is a reward for harp seal tags? YES ___ NO ___
7. What is the value of the reward?
8. Did you send your tags to Fisheries for the reward? YES ___ NO ___
9. If "NO", why did you not return the recovered seal tags?
10. When did you discover the tag?
 - A. before the seal was killed
 - ___ on the ice
 - ___ in the water
 - B. after the seal was killed
 - ___ on the ice
 - ___ in the water
 - ___ while the seal was coming aboard the vessel
 - ___ onboard the vessel
 - ___ during sculping
 - ___ after sculping

