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Summary of Female Harp Seal Reproductive Parameters in the Northwest Atlantic

by

B. Sjare, G. B. Stenson, and W. G. Warren

Science Branch, Department of Fisheries and Oceans, Northwest Atlantic Fisheries Centre
St. John's, Newfoundland, Canada A1C 5X1

INTRODUCTION

Significant changes in the population size of many animal species are often accompanied by changes in reproductive parameters. Two of these parameters, pregnancy rate and mean age of maturity, are of particular interest with respect to the management of Northwest Atlantic harp seals because they may be convenient indices of population change.

Although the accuracy of the various population estimates made for the Northwest Atlantic harp seals may be argued, it is generally believed that the numbers declined during the commercial seal hunt from approximately 3 million in 1952 to 1.5 million in the early 1970's. Following the imposition of a quota in 1971, the population increased throughout the 1970's and early 1980's. The demise of the large vessel hunt in 1983 further reduced catches; by 1990 the population had increased to an estimated 3.1 million seals (Sergeant 1991; Stenson et al. 1993). The 1994 estimate places the population at approximately 4.3 million (Shelton et al. 1995).

Biological sampling of female reproductive tracts began in 1951 and has continued to the present. Mean age of maturity declined from 6.2 years in 1952 to 4.5 in 1979. During the same period pregnancy rates increased from 85% to 94% (Bowen et al. 1981). Given that both parameters changed concurrently with the decline in population numbers, it is likely density dependent mechanisms were involved. However, these results were strongly dependant on the scant data from the early 1950's. Convincing empirical evidence of density dependent changes would only be obtained when the population size once again reached a high level. Thus, no new information on female harp seal reproductive parameters has been readily available since 1979. Here we present data on mean age of sexual maturity (1980-1992) and pregnancy rates (1980-1994), as well as, compare our results to the historical data base.

MATERIALS AND METHODS

Since 1980, female reproductive tracts and jaws have been collected from most regions of Newfoundland and southern Labrador during all seasons except summer. The most

consistently sampled area is the northeast coast of Newfoundland between November and May. Historic data presented here are based on samples collected primarily in northeast Newfoundland during the spring (late March-April) or winter (January-February). These data were obtained from Bowen et al.(1981).

We have summarized information on female harp seal reproductive parameters annually from 1954 to 1994. In order to obtain larger sample sizes and smooth some of the variability in the annual samples, we have also combined this information into five periods, 1951-1954, 1964-1970, 1978-1982, 1985-1989, and 1990-1994. The first period represents the historic population high, the second, the decline during the commercial hunt, the third and fourth, the increase in numbers after the imposition of a quota and demise of the large vessel hunt, and the fifth, the recent population high (Figure 1). Although these period designations reflect the long term population trajectory and the availability of data, they are subjective. A more parsimonious and objective representation of age specific pregnancy rates using sequential 2 x 2 contingency table tests is also presented. The initial table compared the proportion of females pregnant or non pregnant in an age class in two successive years. The X^2 statistic (1 d.f.) was calculated and if the null hypothesis of common pregnancy rate was accepted then these data were pooled and a new 2 x 2 table formed by including the next year's data. This procedure was continued as long as the successive X^2 values remained non significant. When a significant x^2 was encountered, the sequence was terminated, and a new sequence begun, starting with the year for which a significant change in pregnancy rate was indicted.

Age was determined to the nearest year by counting dentine annuli. The reproductive condition of females was assessed by sectioning and examining the ovaries. The pregnancy rate is defined as the percentage of mature females pregnant at the time of the sample. Age specific pregnancy rates are presented in two ways, 1) the percentage of mature females pregnant in a particular age class and 2), the percentage of females pregnant in a particular age class regardless of maturity status. Because of delayed implantation, pregnancy rate is easily measured only in fall and winter samples; we used samples collected between September and February (ie. a late term pregnancy rate). Mean age of sexual maturity (MAM) was calculated using the algorithm of Demaster (1978, 1984) from samples obtained throughout the season, excluding March. Possible differences in MAM between sampling periods were tested using t-tests.

RESULTS AND DISCUSSION

The overall pregnancy rate has varied considerably during the five study periods. The rate was 85.5% when the population was at a high level during the mid 1950's, it increased to 95.2% during the commercial hunt period in the mid 1960's, declined to 87.9% during the early 1980's, declined further to 76.4% by the mid 1980's, and finally reached a low of 69.0% in the early 1990's.

Summaries of harp seal reproductive samples are presented annually and as blocked averages in Tables 1 and 2 respectively. Annual, late term age specific pregnancy rates for all females aged 3 to 7+ are shown in Table 3. There is considerable inconsistency in these data due to the small sample sizes in some years. However, there does appear to be a notable drop in 1987 that generally continues to 1993 for most age classes. Age specific pregnancy rates based on blocked averages for mature seals in each age class are presented in Figure 2; rates

based on blocked averages for both immature and mature seals are presented in Figure 3 and Table 4; and, rates for mature and immature seals derived from the sequential contingency table tests are presented in Table 5. When only mature seals were considered there was a marked decline in the proportion of females pregnant during the mid 1980's; this decline continued into the early 1990's. Although it appears that the pregnancy rate of 3 and 4 year old seals may have been influenced to the greatest extent, seals in all age classes showed the same response.

When immature seals were also included in the analysis three tenancies could be noted. For 3 and 4 year old seals the proportion pregnant was lowest in the mid 1950's, increased until the early 1980's and then started to decline into the early 1990's. Seals aged 5 and 6 years exhibited a similar, but less notable trend. The pregnancy rate of 7+ year old seals has declined particularly in the mid 1980's and early 1990's. Results of the age specific sequential contingency table tests showed the same general trends. A comparison of Figures 2 and 3 suggests that in the mid 1950's even though only a small proportion of the young seals were mature - most were pregnant. In more recent years there appears to be a greater proportion of seals that are mature, but not pregnant.

The MAM decreased from 5.8 years in the mid 1950's to a low of 4.6 years in the early 1980's and then increased to 5.4 in the early 1990's (Table 6). The MAM for the mid 1950's and early 1990's were significantly higher than during the early 1980's.

Although we have yet to establish a significant statistical relationship between pregnancy rate and age at maturity and recent changes in the size of the Northwest Atlantic harp seal population, our preliminary results indicate that both these reproductive parameters have behaved in a manner which is consistent with a density dependent response. The mechanisms responsible for changes in these parameters are not known. However, an ongoing study of body condition and morphometrics of harp seals in Newfoundland waters suggests that condition declined significantly for all age and sex classes of seals in 1992. We do not know if this finding was just a short term phenomenon or whether it was part of a more prolonged trend. However, seals collected in southern Labrador during the winter of 1995 appeared to be in poor condition (D. Wakeham pers. comm.). The body condition of harp seals sampled in the Gulf of St. Lawrence, Quebec also declined between 1988 and 1992 (Hammill pers. comm.). Body condition is likely coupled with foraging efficiency and prey availability; both of these factors may have changed significantly due to the wide spread environmental perturbations in the Northwestern Atlantic during recent years.

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Table 1 Annual sample sizes for determining late term pregnancy rates of females aged 3 to 7+ years (using 1978 and 1979 data from Bowen et al. 1981)

Year	3	4	5	6	7+
1954	4	3	3	16	33
1965	30	44	37	38	109
1966	7	9	17	11	49
1967	10	19	33	29	123
1968	27	19	20	12	55
1969	25	25	16	28	165
1970	13	13	12	10	107
1978	40	38	20	9	41
1979	9	9	3	4	11
1980	2	2	1	-	12
1981	5	4	2	7	18
1982	4	5	1	4	3
1985	4	3	5	3	1
1986	1	-	2	1	7
1987	12	8	9	4	24
1988	16	6	3	-	19
1989	8	9	6	3	22
1990	8	7	3	1	10
1991	11	11	7	3	28
1992	10	11	9	8	32
1993	8	17	4	8	23
1994	20	14	13	6	30

Table 2 Summary of female harp seal reproductive samples blocked into year periods (I=Immature; P=Pregnant; MNP=Mature, Not Pregnant).

Period	3 Year Olds	4 Year Olds	5 Year Olds	6 Year Olds	7+ Year Olds
	I/P/MNP	I/P/MNP	I/P/MNP	I/P/MNP	I/P/MNP
1951-1954	4/0/0	2/1/0	1/2/0	1/12/3	0/29/4
1965-1970	110/2/0	106/23/0	61/73/1	22/106/0	42/534/32
1978-1982	55/5/0	23/33/2	2/24/1	3/18/3	1/70/14
1985-1989	34/4/3	13/5/8	6/15/4	1/9/1	2/58/13
1990-1992 *(Table 6)	24/3/2	19/6/4	5/9/5	3/7/2	8/44/17
1990-1994	-/53/4	-/10/50	-/15/21	-/16/10	-/78/45

* The maturity status of females collected in 1993 and 1994 are unknown and not included in Table 6 or Figure 2.

Table 3 Annual, late term age specific preganancy rates for females aged 3 to 7+ years (using 1978 and 1979 data from Bowen et al 1981).

Year	3	4	5	6	7+
1954	0.0000	0.3333	0.6667	0.7500	0.8788
1965	0.0333	0.1136	0.5405	0.7105	0.8807
1966	0.0000	0.1111	0.3529	0.7273	0.8776
1967	0.0000	0.2105	0.6061	0.9655	0.8862
1968	0.0000	0.3158	0.7000	0.9167	0.8727
1969	0.0400	0.1600	0.4375	0.8214	0.8848
1970	0.0000	0.2308	0.5000	0.9000	0.8598
1978	0.0250	0.6053	0.9000	0.6667	0.8537
1979	0.3333	0.5556	1.0000	0.7500	0.9091
1980	0.0000	0.5000	1.0000	-	0.8333
1981	0.2000	0.5000	0.5000	0.8571	0.7778
1982	0.0000	0.4000	1.0000	0.7500	0.3333
1985	0.0000	0.3333	0.4000	1.0000	1.0000
1986	1.000	-	0.5000	0.0000	1.0000
1987	0.1667	0.3750	0.7778	1.0000	0.6250
1988	0.0625	0.1667	1.0000	-	0.7368
1989	0.0000	0.0000	0.3333	0.6667	0.9545
1990	0.0000	0.1429	0.3333	0.0000	0.6000
1991	0.0909	0.1818	0.5714	0.3333	0.6071
1992	0.2000	0.2727	0.4444	0.7500	0.6563
1993	0.0000	0.1176	0.0000	0.7500	0.3913
1994	0.0500	0.1429	0.4615	0.5000	0.8333

Table 4 Blocked averages of late term, age specific pregnancy rates for females aged 3 to 7+ years

Year	3	4	5	6	7+
1954	0.0000	0.3333	0.6667	0.7500	0.8788
1965-70	0.0179	0.1783	0.5407	0.8281	0.8783
1978-82	0.0833	0.5690	0.8889	0.7500	0.8235
1985-89	0.0976	0.1923	0.6000	0.8182	0.7945
1990-94	0.0702	0.1667	0.4167	0.6154	0.6341

Note: pregnancy rates from 1954 - 94 also shown in Figure 3

Table 5 Late term, age specific pregnancy rates based on sequential contingency table tests

Age	Time Periods	Pregnancy Rate
Age 3	1954-70	0.0172
	1978-88	0.0968
	1989-94	0.0615
Age 4	1054-70	0.1818
	1978-87	0.5507
	1988-94	0.1467
Age 5	1954-70	0.5435
	1978-88	0.8043
	1989-94	0.4048
Age 6	1954-66	0.7231
	1967-89	0.8684
	1990-94	0.6154
Age 7	1954-89	0.8648
	1990-94	0.6341

Table 6 Mean Age of Sexual Maturity (MAM)

Year	MAM	Variance	95% C.I.	
			Lower	Upper
1951-1954	5.8	0.066	5.3	6.3
1964-1970	5.3	0.005	5.2	5.4
1978-1982	4.6	0.005	4.5	4.7
1985-1989	4.9	0.035	4.5	5.3
1990-1992	5.4	0.022	5.1	5.7

Figure 1 Comparison of Winters (1978) VPA estimates of total population ('000s) with those from the current population model

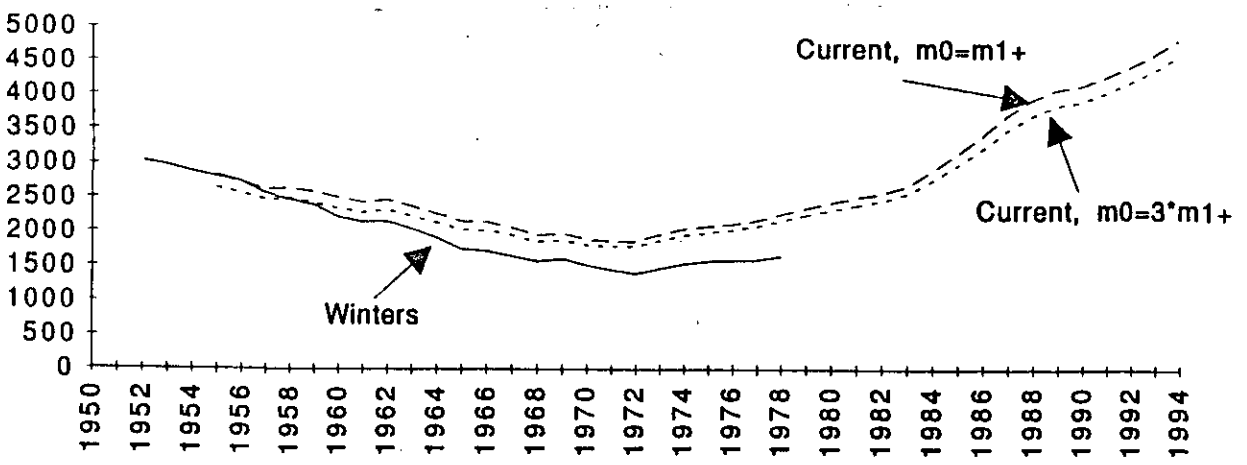

Fig. 2. Age Specific Pregnancy Rates
Including Mature Females Only

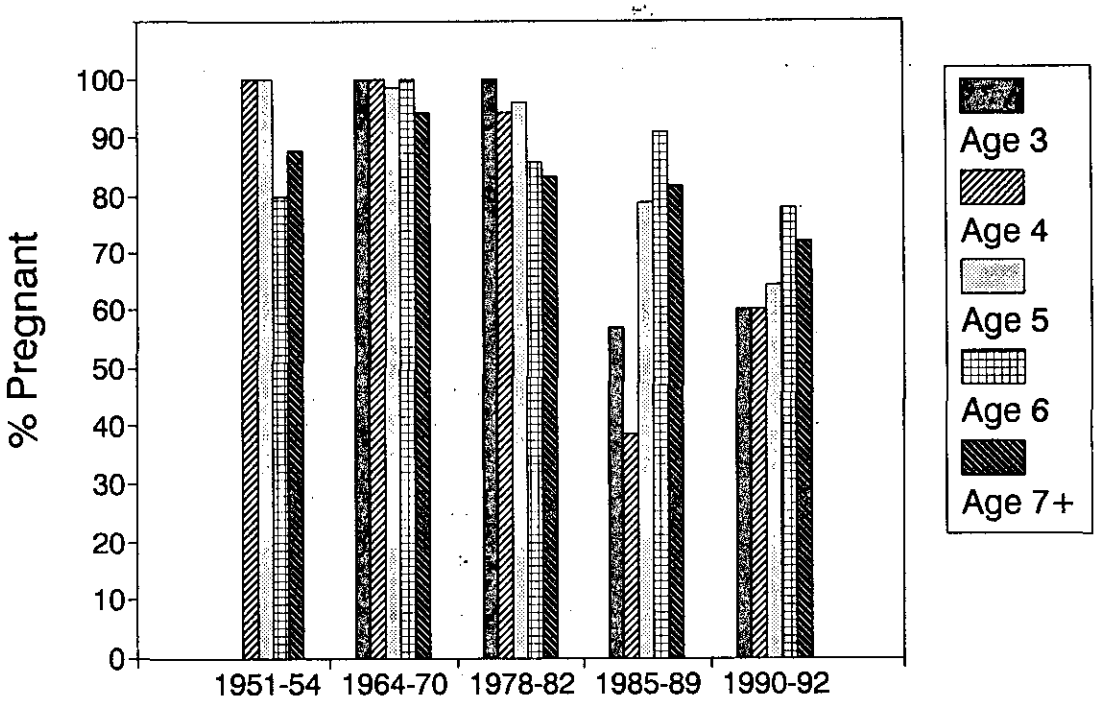

Fig. 3. Age Specific Pregnancy Rates
Including Mature and Immature Females