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Mortality and Productivity of the Newfoundland Hooded Seal Stock

by

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Introduction

The quota level for hooded seals in the "Front" area off Newfoundland has been set at 15,000 animals since 1972. However, annual kills since then have averaged about 11,500 animals and only in one year (1975) was the TAC fully utilized. This has prompted some concern by the Canadian Industry that quota levels for the Newfoundland herd may be optimistic. This is contrasted by several analyses which have suggested that sustainable yields may be as high as 22,000 (ICNAF, 1978) to 24,000 animals (Øritsland and Benjaminsen, 1975a). Sergeant (1976, 1977) however, considers that recent average kills approximate very closely the surplus production of the present herd.

The intent of this paper is to examine the available data as a basis for evaluating the validity of present management strategies.

Estimation of Pup Production

The survival index, measured as the ratio of frequency in individual samples to the average frequency was used by Øritsland and Benjaminsen (1975a) to estimate pup production of hooded seals from Norwegian samples collected during 1971-74. Unlike harp seals, however, adult hunting mortality in hooded seals is substantially larger to the extent that the accumulated hunting mortality during the first 2-3 breeding age-groups may have as great an effect on the survival index (measured at age-groups 7, for example) as the pup catch. This may lead to significant errors in estimates of pup production when survival indices from older age-groups are used. In this paper survival indices refer only to 5 year-old female hooded seals as calculated from Norwegian sampling data for the period 1971-76. The results of functional regression analyses (Fig. 1) suggest an average pup production of 27,100 animals for the year-classes 1966-71. This compares with an estimate of 25,000 pups by Sergeant (1977) from Canadian sampling data for the year-classes 1966-72 and nearly 32,000 animals by Øritsland and Benjaminsen (1975a) for the 1966-70 year-classes.

Mortality Estimation

Catch curve analyses can provide reasonably accurate estimates of mortality characteristics of a population providing that both recruitment and hunting mortality have fluctuated without trend over the period under consideration. Catch curves of adult breeding females (age-groups 5-15) for the period 1971-76 are shown in Fig. 2. They suggest that total mortality (Z) during the period 1960-75 has fluctuated between 0.19 to 0.35 with an average estimate of 0.27.

If, as Sergeant (1976) points out, the hooded seal population has been relatively stable during the past decade or so, then estimates of Z from catch curve analyses should be linearly related to the average kill during the period represented by the catch curve. This relationship is shown in Fig. 3 and suggests that the Newfoundland hooded seal population may indeed have been relatively stable during the past 10-15 years.

The average number of adult females during the period 1966-71 may be calculated by multiplying the average pup production (estimated from survival indices) by the inverse of the fertility rate (0.97, Øritsland, 1973). The average kill of adult females during this period was about 3,400 animals representing an average hunting mortality of 0.135. Accepting the mean Z (0.27) from catch curve analyses as representative of this period suggests a natural mortality rate of 0.135. This value agrees well with that determined by Øritsland and Benjaminsen (1975a) of 0.13 for females from the West Ice herd.

Sequential Population Analyses

Annual kills of female hooded seals for the years 1971-76 have been decomposed into age-specific catches from age composition data for that period (unpublished data). Since the catch is taken during a brief seasonal fishery, it is assumed to precede natural mortality. Sequential population analyses were therefore calculated from the following equation:

$$N_t = N_{t+1}e^M + C_t$$

where N_{t+1} in the terminal year is estimated as follows:

$$N_{t+1} = \frac{C_{t+1}}{1-e^{-F}}$$

Two approaches were used to estimate terminal hunting mortality in 1976. Initially, pup production in 1971 was assumed to be equal to the average production level as estimated by survival indices for the year-classes 1966-71 (27,100 animals). From age-composition, partial recruitment rates (equal to productive maturity rate) and fertility rate data the number of breeding females was computed for 1971. These cohorts were then projected forward to 1976 using age-specific catches and a natural mortality rate of 0.135, thereby providing an estimate of $F_T = 0.16$. The final value of $F_T = 0.17$ was selected such that the average pup production estimated by sequential population analyses for the years 1966-71 was equal to that estimated from survival indices. The results are shown in Table 1.

Since 1971 pup production has fluctuated around 26,000 animals but is projected to increase in the late 1970's as a result of restrictions imposed in 1977 on the killing of breeding females. The number of 1+ females has fluctuated from a high of 51,000 animals in 1971 to slightly less than 48,000 animals in 1977, more or less in response to substantial changes in hunting mortality from year to year.

Annual age-specific kills of female hooded seals prior to 1971 have been derived from a decomposition of total kills using the mean age composition for the period 1971-76 and a female sex ratio of 60% (Øritsland, 1973). Population size and pup productions have thus been back-calculated from 1971 cohort levels by sequential computation. The results (Fig. 4) indicate that since the early 1960's pup production has fluctuated within a narrow range from a high of 30,000 animals in 1966 to a low of 24,000 animals in 1962. The 1+ population has also been relatively stable, fluctuating in the range of 48,000 to 55,000 animals. The resurgence in population levels during the early to mid 1960's is undoubtedly a result of the closure of the Denmark Strait fishery in 1960 and the relatively low kills in the Newfoundland herd up to 1964. Since then annual kills have been substantially higher resulting in greater population stability at a somewhat reduced level.

Sustainable Yield

Under equilibrium conditions the sustainable yield of pups may be calculated from the following relationship (Winters, 1978).

$$SY = \frac{FR-A}{FR}$$

where F = fertility rate
R = ratio of adult female recruits to pup survivors

$$= \frac{e^{-Zt}}{2}$$

and A = annual adult mortality $(1-e^{-Z})$

Thus for F = 0.97 (Øritsland, 1973), R = 0.291 (calculated from M = 0.135 and a mean whelping age of 4.0 years (unpublished data)) and Z(adult females) = 0.175 the sustainable yield rate for pups is computed to be 43.3%. Under equilibrium conditions, therefore, a pup production equivalent to the 1979 level (28,500 animals) could sustain annual kills of 12,500 pups plus 1,100 adult females under the sex ratio restrictions imposed in 1978 (adult females = 7.5% of the TAC).

Since the early 1960's annual kills of adult females in the "Front" area have averaged about 3000 animals implying (from an average adult population of 28,000 females) a sustainable yield rate of 6,000 pups (22%) from a mean pup production of 27,000 animals. The actual pup kill averaged 6,200 animals which suggests that the Newfoundland population of hooded seals has been exploited at approximately the sustainable yield level since then and accounts for the relative stability of the population during the period. This view has also been expressed by Sergeant (1976).

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Table 1. Number of female hooded seals at age as estimated by sequential population analyses from catch-at-age data for the period 1971-76. Pup productions are male and females and were calculated from a productive maturity ogive (Lett, MS 1977) and a fertility rate of 97%.

	Year								
Age	1971	1972	1973	1974	1975	1976	1977	1978	1979
0	26925	26550	25860	26920	26950	25850	25320	27320	28550
1	8727	8078	8490	9180	9145	8345	8332	7080	8380
2	6785	7627	7060	7420	8025	7995	7295	7280	6188
3	8959	5930	6667	6170	6485	7015	6988	6374	6360
4	6193	7778	5167	5827	5392	5605	6130	6106	5570
5	3320	4909	6254	4399	4799	3967	4277	5166	5162
6	3727	2545	3886	5260	3483	3460	2906	3605	4367
7	3357	2225	1953	3270	4152	2743	2577	2450	3048
8	2480	2336	1678	1612	2635	3081	2043	2172	2071
9	1361	1822	1790	1368	1262	1864	2294	1722	1836
10	1066	875	1351	1504	1041	993	1388	1933	1456
11	1202	711	590	1096	1208	811	740	1170	1634
12	694	851	483	464	884	946	604	624	990
13	524	480	651	393	326	696	704	510	528
14	647	353	338	554	283	230	518	593	431
15+	2240	2157	1693	1626	1613	1332	1163	1419	1700
Total 1+	51282	48677	48051	50143	50733	49083	47959	48204	49721
F_4+	.189	.140	.047	.102	.195	.170	.035	.030	

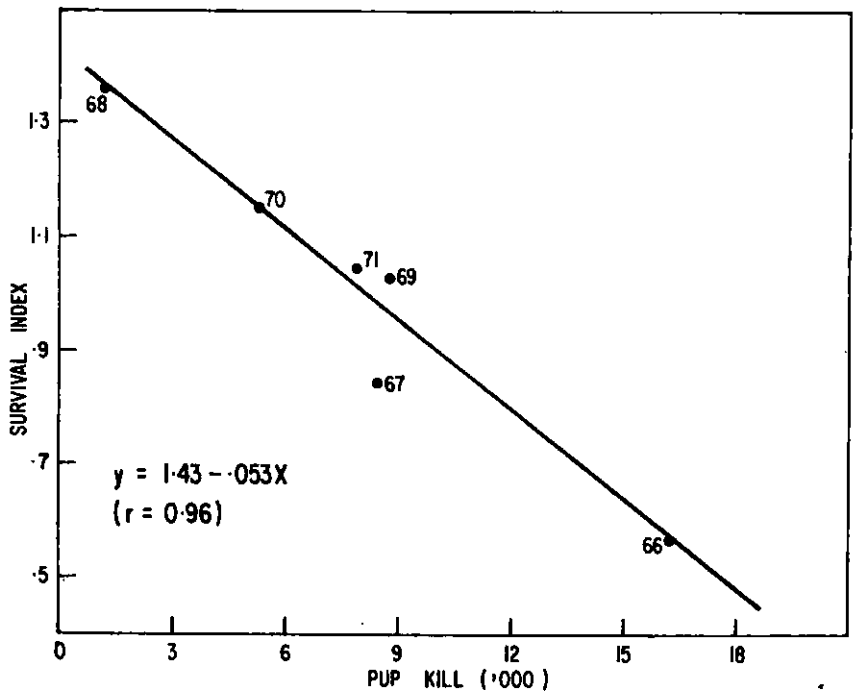

Fig. 1. Relationship between pup kill and survival index as measured from samples of 5-year-old female hooded seals.

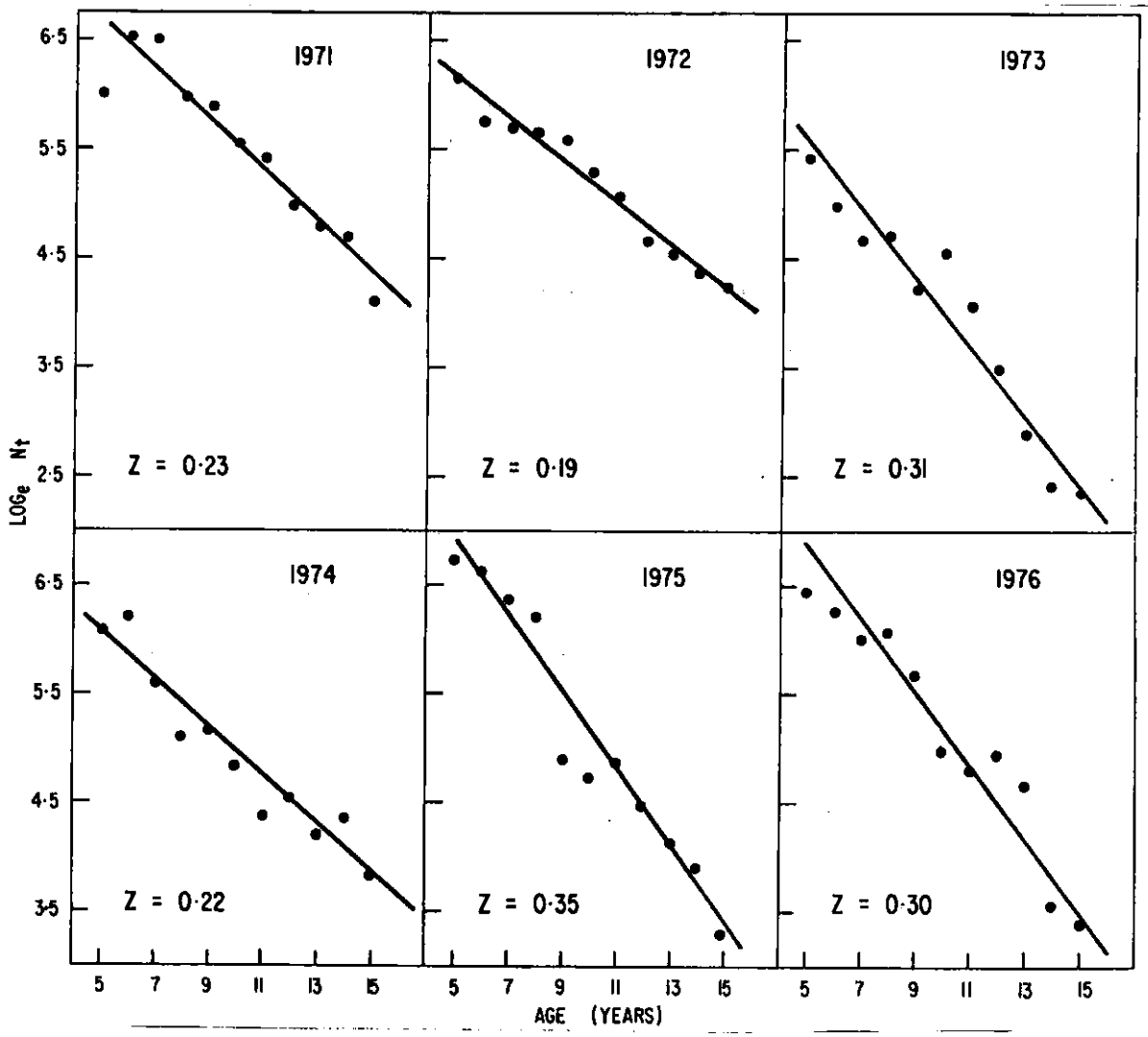

Fig. 2. Catch curves of female hooded seals sampled during the period 1971-76.

A 6

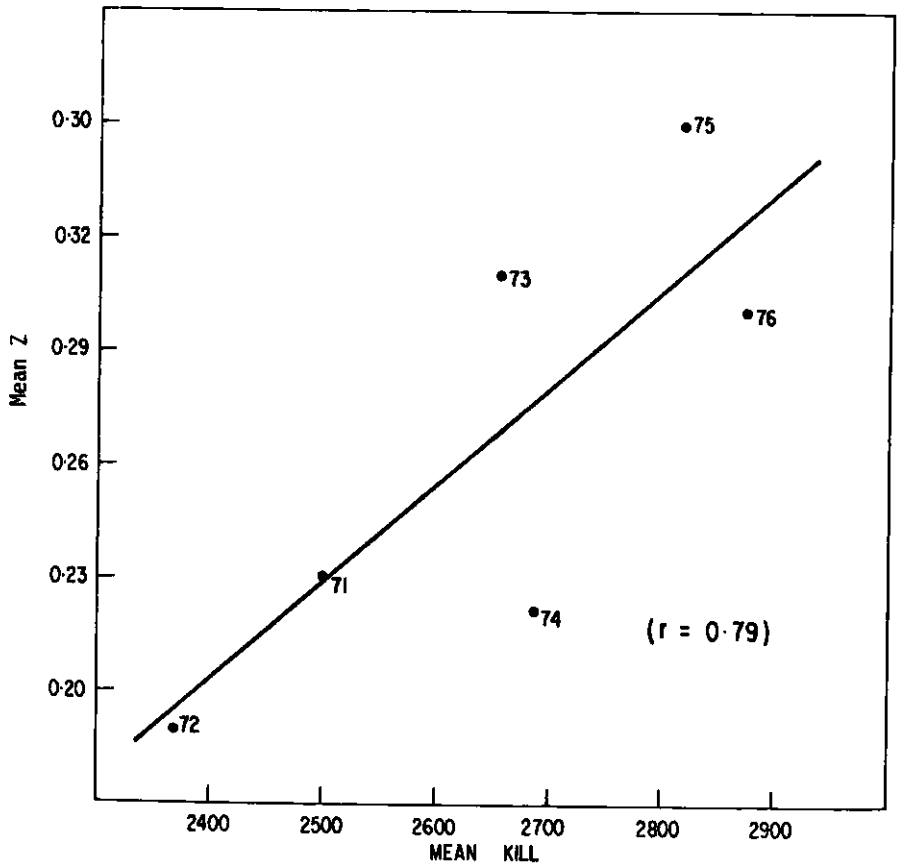

Fig. 3. Relationship between total mortality ($\bar{Z}$) estimated from catch curve analyses and average kill of female hooded seals.

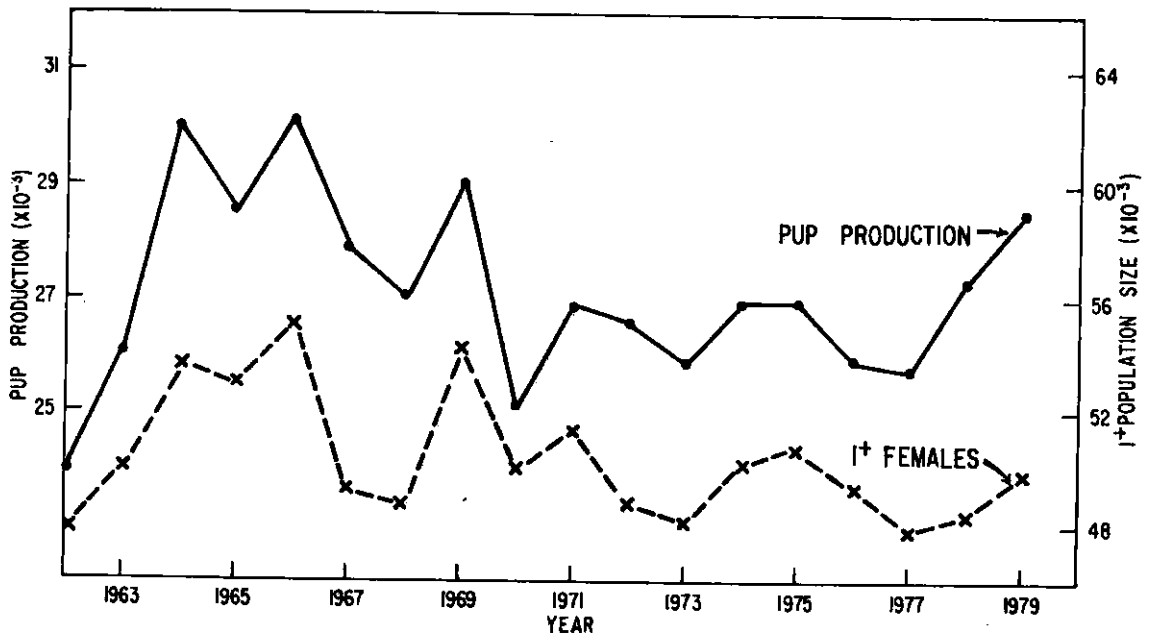

Fig. 4. Trends in pup production and abundance of hooded seals (1+ females) during the period 1962-79.