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Use of Catch and Effort Data to Estimate the Pup Production of Hooded Seals (Cystophora cristata) at Newfoundland

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INTRODUCTION

A current estimate of pup production of hooded seals (Cystophora cristata) at the Front area off northeastern Newfoundland is required in order to determine the effects of present catches and to predict population trajectories given different catch levels and values for other population parameters. This paper attempts to estimate pup production of hooded seals at the Front using catch-effort data for the large vessels taking part in the seal fishery for the years 1977 to 1982.

MATERIALS AND METHODS

Prior to 1977 and the establishment of the 200-mile economic zone off the Canadian coast, good detailed catch and effort data for the seal hunt at Newfoundland do not seem to be readily available. Beginning in about 1977, Fisheries Officers have been assigned to each Canadian and Norwegian large vessel prosecuting the seal fishery at the Front and they have recorded catches of newborn (bluebacks), adult male and adult female hooded seals in logbooks or diaries on a daily basis. For the most part, we have extracted catch and effort information from these original diaries, supplemented by catch logs submitted by the Masters of the various vessels and the seal hunt reports prepared by the Conservation and Protection Branch of the Department of Fisheries and Oceans. The information that we extracted includes (for each large vessel): daily kill of pups, adult males, and adult females; daily position; and daily information on vessel activities, hunting methods, ice conditions, and weather; plus interesting biological and other observations.

The removal method of Leslie (as described in Caughley 1977) was used to estimate pup production as follows. First, daily positions of all large vessels were plotted on maps in order to determine hunting patterns. On the basis of these maps, we made a decision as to the number and location of the different seal patches that were being hunted. We usually decided that only one main patch was being exploited with scattered seals being picked up elsewhere. The unit of effort is defined as one full day devoted to hunting hooded seals. For each patch, catch per unit effort was calculated as the daily mean catch of pups of those vessels which took part in the hooded seal hunt as a first priority, generally those powerful and highly maneuverable vessels from Norway but often including Canadian vessels recently acquired from Norway. We excluded those days when catches were obviously reduced as a result of bad weather and we also excluded those days when vessels were steaming (not hunting) or stuck in the ice. This detailed information was generally available from the Fisheries Officers' diaries.

The daily mean catch rate of hooded seal pups was then plotted against the cumulative catch and least squares linear regression was performed on these data. The x-intercept is then taken as an estimate of pup production (Fig. 2). In 1978 a second patch was considered to have been exploited and the catch-effort data have been treated in a similar fashion as above. For each year, the catch of pups by landsmen is added to the Leslie estimate derived from the analysis of large vessel catch-effort data and other adjustments are made, especially the addition of catches taken outside the main patch(es) where such catches could not be analyzed by the Leslie method. It is, therefore, clear that the final estimates of pup production will be negatively-blased.

RESULTS AND DISCUSSION

Assumptions

The Leslie method has three assumptions. These are (from Caughley 1977):

Probability of being caught is constant for all animals on each catching occasion.
 The population is not so dense that the catching of one individual interferes with the catching of another.

3. No births, deaths, immigration or emigration occur during the experiment.

Each of these assumptions can be examined in turn by reference to Fig. 2, which is a plot of catch per unit effort against cumulative catch for 1979 large vessel data. Catch/effort is calculated as the daily mean catch of pups by (1) the Norwegian vessels along with the 'Arctic Explorer' and 'Carino' (the 6 "highliners") and (2) all vessels (including the 6 "highliners"). Table 1 indicates the data sets used for each year and Table 2 gives a list of individual vessels referred to in Table 1. Catch/effort is initially low, on 22-23 March, but then increases suddenly on 24 March (Fig. 1 and 2). Thereafter, catch rate declines more or less linearly and quickly with cumulative catch and date. One can interpret the peak on 24 March as a sudden increase in recruitment (the majority of pups have now been born) and the linear decrease as a reduction in catch per unit effort as pup numbers are reduced by hunting. The trend is fairly linear from 24-26 March, after which catch rates decline even faster (Fig. 2). Thus, assumption 1 can be met if the data used fit a linear trend. For the 1979 data, two time periods were selected for the regression, 24-26 March and 24-28 March (Table 1). As catchability seems to be failing off after the 26 March. It is possible that catchability is declining after 26 March as a result of increasing numbers of pups being weaned and entering the water. For all of the analyses reported here, we have carried out regressions over time series such that the trend of data appeared to be linear and we have based the production estimates on these regressions.

The very nature of the hooded seal hunt is such that assumption 2 must be correct.

Assumption 3 is very difficult to test. The hooded seal hunt occurs during the peak of the pupping season. The lactation period is short, reportedly only one week or less. Thus, over the course of the hunt, many pups may be born while many others may be weaned and likely to enter the water. Thus, the "system" is not closed; ideally, we would like to have all the pups born initially and then remaining on the ice for the duration of the hunt. With some pups being born and others weaned during the course of the hunt, a bias may occur in the resulting production estimate. It is likely that the bias will be negative, ie. pup production will be underestimated, since the hunt begins at the peak of pupping or even slightly later and then increasing numbers of pups will be entering the water and will be unavailable for catching. Therefore, this possible mechanism for the violation of assumption 3 means changing (decreasing) catchability of pups, ie., in essence, a violation of then only 3 or 4 points may be finally available and the regression may have a very large variance (ie., confidence intervals about the x-intercept and the slope may be very large; these have not been calculated in this report).

In every year analyzed, there is a secondary smaller peak of pup catches around the end of March and into early April (Fig. 1). These catches usually comprise weaned solitary pups but may be from regions of the icefields where late-pupping families gather.

Pup Catches

The catches of hooded seal pups and adults at the Front for the years 1977-82 are given in Table 3. These figures are, for the most part, based on daily catches recorded in Fisheries Officers' diaries.

Estimates of Pup Production

Leslie estimates of pup production, corresponding to the various data sets used, are listed in Table 4. Table 5 presents "best" estimates of pup production which are based on the values in Table 4 to which have been added the landsmen's kill of pups from Table 3. In some cases there have been additions of seals killed outside of the main patch (see footnotes at the bottom of Table 5). The estimate for 1981 is certainly on the low side, as the total catch exceeded the estimate for this year. This was the year of little offshore ice and the catch-effort data present an extremely confused picture.

Pup production estimates and pup catches (for large vessels and landsmen separately) are graphed in Fig. 3.

Trends in Catch Per Unit Effort

Tables 6 and 7 give peak (maximum) daily catches of hooded seal pups by each Canadian and Norwegian vessel during each year from 1977-82 and these have been plotted in Fig. 4 for vessels for which a significant time series of data exists. The trend for most vessels and for the means ((A) Norwegian vessels only and (B) Norwegian vessels plus selected Canadian vessels) is a relatively constant feature: catch rates peaked in 1979-80 and declined in 1981-82. The total catch of pups has correspondingly declined over the same time period, especially for the large vessels (Fig. 3).

CONCLUSIONS

Based on considerations in the foregoing, it is very likely that these estimates of pup production are negatively-biased but the magnitude of the bias cannot be determined. Therefore, the exploitation rates in Taple 5 are likely over-estimated.

The trends in catch per unit effort (Fig. 4) and pup production (Fig. 3) match each other very closely. One can conclude that either the abundance or the availability of hooded seals at the Front has fluctuated in recent years, reaching an apparent maximum around 1979 (Fig. 3 and 4). It is impossible to conclude, however, that the fluctuations in pup production are real; fluctuations in catch and catch per unit effort of hooded seals at the Front could equally well be ascribed to changing availability as a result of climatic changes (Sergeant 1974). The interrelationships of hooded seals which pup in Davis Strait and at the Front are not yet understood.

On the other hand, fluctuations in catch rates (Fig. 4) could be a function of annual variations in spatial distribution patterns of hooded seals at the Front (ie., in some years the seals may be more concentrated while in other years they may be more dispersed and widespread). If such were the case, fluctuations in pup production (Fig. 3) would be more imaginary than real.

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Sergeant, D.E. 1974. A rediscovered whelping population of hooded seals Cystophora cristata Erxleben and its possible relationship to other populations. Polarforschung 44: 1-7.

| Table 1. | Sources of | data for | analyses of | catch-effort | data | for hooded | seals at |
|------------|------------|----------|-------------|--------------|------|------------|----------|
| the Front, | , 1977-82. | | | | | | |

| Year | Vessels and time period used for regression |
|--------------|--|
| 1977 | A - Norwegian vessels only, 22-26 March B - Norwegian vessels only, 22-30 March C - All vessels, 22-26 March D - All vessels, 22-30 March |
| 1978 | A - All vessels, main patch, 22-27 March (excl. 23 March) B - All vessels, main patch, 22-30 March (excl. 23 March) C - All vessels, secondary patch, 30 March - 1 April D - All vessels, secondary patch, 30 March - 2 April |
| 1979 | A - Norwegian vessels, Arctic Explorer, Carino, 24-26 March B - Norwegian vessels, Arctic Explorer, Carino, 24-28 March C - All vessels, 24-26 March D - All vessels, 24-28 March |
| 1980 | A - All vessels, 24 March - 3 April |
| 1981 1982 | A – All vessels, 22–25 March A – Norwegian vessels, 21–25 March |

Table 2. Vessels used for catch-effort analyses.

| Year | Vessels Used |
|------|---|
| 1977 | Norway - Veslekari, Norvarg, Polar Star, Kvitbjorn, Polarhav Canada - Martin Karlsen, Arctic Explorer, Carino, Lady Johnson II, Theron |
| 1978 | Norway - Polarsirkel, Polar Star, Norvarg, Polarhav Canada - Arctic Explorer, Carino, Lady Johnson II |
| 1979 | Norway - Lance, Norvarg, Polar Star, Veslemari Canada - Arctic Explorer, Carino, Martin Karlsen, Lady Johnson II |
| 1980 | Norway – Polar Star, Veslemari, Norvarg Canada – Arctic Explorer, Fogo Isle (= Carino) |
| 1981 | Norway - Veslekari, Polar Star, Norvarg Canada - Polaris V, Lady Johnson II, Chester (= Polarhav), Fogo Isle |
| 1982 | Norway - Polar Star, Veslemari, Melshorn |

| | | | Pup catch | |
|--|--|--|--|---|
| Year | Norwegian large vessels | Canadian large vessels | Total large vessels Landsme | n Total |
| 1977 1978 1979 1980 1981 1982 | 4343 5082 6592 5019 4096 3193 | 3605 2786 5013 4721 3354 1541 | 7948696786820011605131974013277450328647342858 | 8644 8068 11736 11067 10736 7592 |
| | 1+ catch (lar | ge vessels) | | |
| | Male | Female | 1+ catch (landsmen) | |
| 1977 1978 1979 1980 1981 1982 | 1607 1137 2212 1102 1655 1436 | 1204 795 652 427 248 222 | 165 270 301 404 1118 649 | |
| | | | | |

Table 3. Catches of hooded seals at the Front, 1977-82.

Table 4. Leslie estimates of pup production of hooded seals at the Front, 1977-82.

| • • | | P | up produ | ction ^a | |
|-------|-----------------------------------|------------------------------|-----------|----------------------------------|-----------------------------------|
| · · · | A | В | | C | D |
| 1977 | 10,274 (r ² = 0.90) | 8,22 (r ² = 0 |) .92) | 10,399 ($r^2 = 0.90$) | 8,316 ($r^2 = 0.92$) |
| 1978 | 10,482 ($r^2 = 0.99$) | 7,29 (r ² = 0 | 5 •92) | 2,961 (r ² = 0.97) | 1,678 ($r^2 = 0.90$) |
| 1979 | 14,022 ($r^2 = 0.99$) | 11,54 (r ² = 0 | 6 .97) | 14,412 ($r^2 = 0.99$) | 11,445 (r ² = 0.97) |
| 1980 | 9,631 ($r^2 = 0.92$) | | | | |
| 1981 | 6,331 (r ² = 0.98) | | | | |
| 1982 | 3,627 (r ² = 0.99) | | | | |

^a see Table 1 for meaning of letter designations A-D

| Year | Pup production ^a | Pup catch | Percent caught |
|------|-----------------------------|-----------|----------------|
| 1977 | 11,033 | 8,644 | 78 |
| 1978 | 13,643 | 8,068 | 59 |
| 1979 | 16,197 ^b | 11,736 | 72 |
| 1980 | 12,193 ^C | 11,067 | 91 |
| 1981 | 9,617 ^d | 10,736 | |
| 1982 | 7,690 ^e | 7,592 | 99 |

Table 5. Best estimates of pup production of hooded seals at the Front and total pup kill, 1977-82.

a Leslie analysis plus the known pup kill by landsmen.

b Includes catches of 1725 on 19-21 March and 124 on 28 March-3 April taken outside the main patch.

c Includes 1235 pups caught on 21-22 March outside the main patch.

d Partial estimate (only one patch; see text).

e Includes Norwegian catches of 1152 after 25 March outside the main patch.

Peak daily catch rates of hooded seal pups by Norwegian vessels at the Front, 1977-82. Table 6.

| Year | Veslekari | Veslemari | Norvarg | Polar Star | Kvitbjorn | Polarhav | Polarsirkel | Lance | Melshorn | Mean |
|------|-------------------------------------|-----------|---------|------------|-----------|----------|-------------|--|-----------------|------|
| | | | | | | | | | | |
| 1977 | 190 | | 360 | 202 | 232 | 220 | 1 | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | ні. І н т | 241 |
| 1978 | بر المراجع المراجع المراجع | 1 | 313 | 298 | | 143 | 190 | • | 1 1 | 236 |
| 1979 | 1 1 1 | 312 | 398 | 483 | | 1 | • | 361 | 1 1 | 389 |
| 1980 | | 502 | 470 | 352 | I | a 193 | | 1 | 1 | 441 |
| 1981 | 338 | | 388 | 233 | 1 | 351 | | н В 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | ì | 320 |
| 1982 | | 349 | 1 | 210 | • | ł | 1 | 1 | 298 | 286 |
| | | | | | | | | | | |

b excluding Polarhav, 1980-81

Peak daily catch rates of hooded seal pups by Canadian vessels at the Front, 1977-82. Table 7.

| Year | Martin Karlsen | Arctic Explorer | Carino | Arctic Endeavour | Theron | Terra Nova | Polaris V | Clayton M. Johnson | Lady Johnson II |
|---------|---|--------------------|--------------|---------------------|------------|---------------|-----------|-----------------------|--------------------|
| 1977 | 177 | 286 | 226 | 129 | 140 | | | | 153 |
| 1978 | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 372 | 157 | | | | | | 144 |
| 1979 | 254 | 572 | 333 | | | | I. | | 305 |
| 1980 | | 529 | a 346 | 108 | | 265 | | 1 | 337 |
| 1981 | | | 221 | | 48 b | | 370 | | 344 |
| 1982 | | • | 153 | | 7 | 72 | | 201 | 231 |
| | | | | | | | | | |
| a owner | ship of the Ca | arino changed | in 1980 when | i it was rename | ed "Fogo I | sle" | | | |

ownership of the Theron changed in 1981 when it was renamed "Polar Explorer"

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Fig. 4. Variations in peak daily catches of hooded seal pups by Norwegian and Canadian large vessels, 1977-82.

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