Canadian Atlantic Fisheries Scientific Advisory Committee

Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CAFSAC Research Document 86/103

CSCPCA Document de recherche 86/103

# Identification of Developmental Stages in Hooded Seal (*Cystophora cristata*) Pups

by

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## Abstract

The errors and biases involved in classifying development stages of hooded seal (*Cystophora cristata*) pups were examined. Results indicate that pups can be classified into developmental stages from an altitude of 30 m although the techniques used previously should be modified. A training period involving the examination of pups under field conditions should be undertaken before classifications begin. Stage 1 pups were difficult to identify from the helicopter and this stage should not be used unless surveys are conducted from ground level. Error rates for stage 2 and 3 pups were consistent among observers, averaging 15%. Transitional stages were difficult to classify and biased estimates of the number of stage 2 and 3 pups present can occur when the proportion of transitional stages is high. A method for incorporating these results into the current model for correcting population estimates is given.



## Résumé

Une évaluation a été faite des erreurs et des écarts observés au cours du classement des divers stades de développement des jeunes phoques à capuchon (*Cystophora cristata*). Les résultats indiquent qu'il est possible de classer les stades de développement des jeunes phoques à partir d'une altitude de 30 m, bien que les techniques utilisées jusqu'ici devraient être modifiées. Il faudrait prévoir une période de familiarisation comportant l'examen des jeunes phoques sur le terrain, avant que le travail de classification ne commence. Les jeunes phoques du stade 1 sont difficiles à identifier à partir d'un hélicoptère et ce stade ne devrait pas être utilisé, à moins que les relevés soient réalisés au sol. Les taux d'erreurs (15 % en moyenne) dans le cas des jeunes phoques des stades 2 et 3 étaient uniformes d'un observateur à l'autre. Les stades transitionnels étant difficiles à classer, on peut obtenir des estimations biaisées du nombre de jeunes phoques des stades 2 et 3 lorsque la proportion des phoques dans un stade transitionnel est élevée. On donne une méthode pour incorporer ces résultats dans le modèle actuel afin de corriger les estimations de population.

## Introduction

Recently pup production of hooded seals, Cystophora cristata, in the northwest Atlantic has been estimated by the use of aerial survey techniques (Hay et al. 1985; Bowen et al. 1987). However, the use of aerial surveys for hooded seals pose many difficulties. The foremost among these is the problem of conducting a survey on a species in which the length of time individual pups are available on the ice is shorter than the period during which births occur. Therefore, in any one survey some pups may be missed because they have yet to be born or they have already left the ice. One method to account for this variation in availability of pups is to correct the survey results by estimating for the distribution of births over the whelping season. This is based on the identification of distinct developmental stages among the pups and a knowledge of the duration of each stage (Radford et al. 1978; Myers and Bowen 1986; Bowen et al. 1987).

Pup developmental stages were used to correct estimates of pup production of hooded seals in the Front region in 1984 (Bowen et al. 1987). By determining the proportion of pups in each stage over the course of the whelping period from helicopter surveys at 30 m (100 ft) and estimating duration of each stage from tagging experiments and personal observations, Bowen et al. (1987) were able to apply a correction factor to the aerial survey results which increased the pup production estimate by 56%. These results indicate how important it is to correct for the distribution of births for hooded seals.

Recently, controversy has arisen concerning this technique. Questions have been raised concerning the ability of an observer to distinguish the stages and to recognize developmental stages from the air. The results of a 1985 hooded seal survey were not corrected for the distribution of births because of difficulties in identifying developmental stages (Hay et al. 1985). In addition, the degree of error involved in classifying pups into stages has not been determined.

This study was undertaken in an effort to answer some of these questions. For a classification scheme to be useful stages should be discrete and easily recognizable. The first objective of this study, therefore, was to determine if hooded seal pups can be consistently classified into discrete developmental stages. The second objective was to estimate the degree of error involved in such classifications under the survey conditions used. Finally, accepting that such errors will always occur, we identified some refinements to the survey technique which should improve the accuracy of classifications.

## Materials and Methods

### Experimental design

To determine the extent of errors and the biases involved in classifying developmental stages of hooded seal pups, a series of experiments were conducted in the Gulf of St. Lawrence during March 1986. Experiments were conducted by three observers, two (B, C) having previous field experience with hooded seals and one (A) without. Each of the observers examined photographs and slides of pups in the laboratory to familiarize themselves with the different developmental stages as described by Bowen et al. (1987). The criteria used are as follows:

Stage 1: Newborn
- skin in loose folds along flanks, fur saturated to wet, entire pelage with yellowish hue, awkward body movements. mother present.

Stage 2: Thin blueback
- ventrum white, neck well defined, trunk conical in shape. Mother present.

Stage 3: Fat blueback
- ventrum white, neck not clearly distinquishable, trunk fusiform in shape. Mother present.

Stage 4: Solitary blueback
- as in fat blueback but mother not present.

On March 16, a small concentration of whelping hooded seals was located at 46°40'N 62°12'W, approximately 40 n mi south of the Magdalen Islands. Prior to the start of the experiments a series of pups were examined to standardize the observers. Pups were examined from the air and at ice level and the criteria to be used for classifying developmental stages was agreed upon.

Aerial observations were conducted from a Bell 206B helicopter at a flying altitude of 30 m (approximately 100 ft) and at a speed of approximately 65 km/hr. Marks were made on each window using tape corresponding to a strip width of 100 m at an altitude of 30 m. All pups classified were observed within this range.

The first study consisted of identifying individual pups from an altitude of 30 m and again at ice level to determine the amount of error present. Stage 4 pups were excluded from this experiment as only pups with attending mothers were examined. Pups were chosen randomly by the pilot who flew past the pup so that it was visible within the strip width of each observer. The pilot presented the pup to the two observers on the one side of the helicopter (A, B) first and then to the third (C). After each observer independently classified the pup, it was then observed from the helicopter while hovering just above ice level and classified a second time. Only after these two classifications were completed was the developmental stage of the pup discussed between the observers and a consensus ('true stage') reached. To obtain a variety of developmental stages this experiment was conducted over the three day period from 16-18 March.

To determine the variability between observers under actual survey conditions a second experiment was conducted on March 17. Using a Loran C navigational system, a series of 10 east-west transects were flown across the entire whelping patch at an altitude of 30 m. The start and end points of each transect were recorded and upon completion, the transect was reflown in the opposite direction to allow the observer(s) on the opposite side of the helicopter an opportunity to examine the study area. Observers A and B examined the transect on the same pass while Observer C viewed it on the return trip.

## Statistical analysis

In the first experiment the percentage of pups incorrectly identified was determined for each observer. Due to the small sample size and high error rate for stage 1 pups, the possibility of biases in classification was examined for stage 2 and stage 3 pups only. With one exception, the probability of misidentifying stage 2 and 3 pups were determined using a binomial distribution assuming that the proportion of pups misidentified in each stage was equal to the proportion of the total pups identified as being in that stage. In one instance, (total days) the sample size was large enough for a Chi-squared test for goodness of fit to be used. Values given as mean   standard deviation.

# Results

## Classification criteria

Initial attempts to classify pups based on the criteria of Bowen et al. (1987) resulted in a large amount of variation in classifications. Of seven pups which were examined by all three observers 48% were incorrectly classified. Only one pup was correctly classified by all the observers. Therefore, the criteria used for stage classifications were redefined prior to the start of experiment 1. The criteria we used for the experiments were modified from those of Bowen et al. (1987) and were based on the identification of primary criteria for each stage which would allow unambiguous identification of stage from an altitude of 30 m. The primary criteria used were:

Stage 1 - pup still wet with amniotic fluid, mother present
Stage 2 - pup dry and outline of neck present, mother present
Stage 3 - pup larger, no neck outline visible, mother present
Stage 4 - as in Stage 3 but no mother present

## Experiment 1

The total number of pups examined by each observer was 109. Although the percentage of pups in each of the three stages varied by day, in total 1.8% were in stage 1, 69.6% in stage 2 and 28.5% in stage 3.

When examined at ice level the majority of pups were identified consistently by all observers (Table 1). On average, only 2.1% of the pups present were misidentified and error rates for stages 2 and 3 were similar. The errors occurred primarily in pups which were considered to be transitional between the two stages. Both stage 1 pups were correctly identified by all observers.

The percentage of pups incorrectly identified from an altitude of 30 m varied greatly (Table 2). Although only a few stage 1 pups were encountered, only one classification was correct, resulting in a 83.3% error rate. Among stage 2 and stage 3 pups the error rated varied with observer and date. Generally error rates for stage 2 and 3 pups ranged between 6% and 30% and averaged 15.9% and 12.9% respectively.

Potential biases in identifying stage 2 and stage 3 pups were examined for individual days (Table 3) and among observers (Table 4). A bias was observed on March 18 only when the number of stage 3 pups present was significantly overestimated.

## Experiment 2

The total number of pups in each developmental stage observed by individual observers on the ten survey transects were similar (Table 5). The greatest variability was in the number of pups which could not be identified as belonging to a specific developmental stage. In particular, Observer A recorded fewer pups as unidentified while a greater number of pups were classified as stage 2. Considerable differences were found among observers in the number of pups in each stage on individual transects but the number of pups seen on each transect was small.

The three observers were comparable when the percentage of pups identified as belonging to a recognizable stage was examined (Table 6). The results of Observer A showed the greatest deviation with a greater percentage of stage 2 pups recorded.

# Discussion

## Classification criteria:

The most important feature of any classification method is to use criteria that are objective in nature and which can be easily recognized. The classification criteria used previously (Bowen et al. 1987) were found to be ambiguous and difficult to use from a moving helicopter at an altitude of 30 m. The variety of criteria for each stage resulted in some confusion among the observers concerning the basis for each classification. Each observer used different cues which resulted in widely varying classifications. Also, there was a great deal of variation among pups with regards to the combinations of characteristics present. Because these stages identify points on a continum of growth, it was particularly difficult classifying pups which could be considered transitional between stages. Finally, the time available for viewing a pup does not allow consideration of multiple characteristics. Therefore, to minimize the errors involved in classifying pups and to improve consistency among observers, we reduced the criteria for each stage to one or two primary characteristics. The full array of characteristics outlined by Bowen et al. 1987 were used only if there was some difficulty in classifying a particular pup. Using the new criteria we found that identifications were easier, the time necessary for each classification was decreased and there was less variation among observers. Because the classification criteria was changed slightly the stage duration experiments performed by Bowen et al. should be reexamined using the new criteria to determine if stage durations change.

Because initial classifications were not consistent among the observers, an initial period of training was needed to standardize the observers before the experiments began. It was necessary to view approximately two dozen pups of various developmental stages from the air and at ice level before reasonably consistent classifications could be made. The viewing cues used were discussed and agreed upon by all of the observers. After this training period was completed all three observers had similar error rates (experiment 1). This indicates that even inexperienced observers can learn quickly and effectively with the proper period of training. A similar standardization period during which pups are examined under field conditions should be incorporated in any future survey design.

Prior experience did not appear to increase the accuracy of the initial classifications. Before the training period, the variability in classifications between experienced observers was as great as between the experienced and inexperienced observers. A similar problem was recognized by LeResche and Rausch (1974) who found that experienced observers with current experience identified significantly more moose during an aerial survey than experienced observers without current experience. Observers without current experience did not have a greater accuracy than inexperienced observers. Therefore, both experienced and inexperienced observers should be included in any training program implemented.

Experiment 1

Extremely accurate classifications of developmental stages were made from the helicopter hovering near ice level. By descending upon a random series of pups without actually landing, accurate classifications of the developmental pup stages of a number of pups can be made reasonably quickly. However, classifications from a greater altitude provide some advantages over those at ice level. Firstly, a larger sample size can be obtained. Also, systematic transects can be conducted and data collected can be used for a population estimate with lower confidence limits than the aerial survey (see

Bowen et al. 1987). Finally, the mother pup pair are not subjected to the stress which may occur due to the close approach of the helicopter. Therefore, aerial transects are preferable provided the degree of error involved in the classifications is acceptable.

The difficulties which occur in trying to identify developmental stages from a distance are indicated by the greater error rates which occurred at an altitude of 30 m. In particular, stage 1 pups were found to be extremely difficult to identify; newborn pups were correctly identified only once during six observations. The primary sighting cue for newborn pups is their wet coat but because of blowing snow or the angle of the sun, this may be difficult to observe. The other criteria (yellowish hue, awkward movements, etc.) are subjective and were observed occasionally among pups which were considered to be in stage 2. Given the difficulties involved in identifying this stage and the short duration of this stage (approximately three hours) estimated by Bowen et al. (1987), this stage is of questionable value.

Stage 2 and stage 3 pups could be identified from a distance although the error rates varied greatly. It was particularly difficult to distinguish so called 'transitional' pups where the distinction between the stages was minor. The criteria of presence or absence of a neck was chosen in an attempt to make the division objective and was found to be useful although the positioning of the pups body often obscured this feature. As the proportion of 'transitional' stages increased, the error rates rose accordingly. The largest error rates occurred on March 18 when the number of stage 3 pups was the greatest and the proportion of pups considered to be transitional was high (pers. obs.). A significant bias towards identifying pups as belonging to stage 3 was also observed on March 18, reflecting the difficulty associated with identifying pups late in the stage 2 period. This was the only date on which a statistically significant bias was observed. Thus, the factor used to correct for errors in stage identifications should be weighted to allow for a bias towards stage 3 pups as the mean age of stage 2 pups increases.

Stage 4 pups were not included in this part of the study because they could be readily identified due to the absence of an attending female. Bowen et al. (1985) found that pups with milk in their stomachs were always accompanied by females and therefore, felt that the absence of a female was a reliable indicator of stage 4 pups. However, future studies are necessary to confirm that the female does not leave the pup during lactation.

Errors in identifying stage 4 pups may occur in areas with high densities of seals due to the possibility of mistaking a wandering solitary as the attending stage 3 pup of a nearby adult. Because twining is assessed to not occur, two pups associated with a single female would not result in an error; one pup would be considered a solitary while the other classified as the attending pup. If however, the solitary pup was in close proximity to an unattended female (i.e. before birth or after weaning), it may result in a bias towards stage 3 pups. This bias would be small and would not likely affect the results significantly. A similar bias would occur if the solitary pup was associated with a male that was mistaken for being female. This possibility can be reduced by conducting the surveys slow enough to check the sex of all attending adults.

## Experiment 2

We have shown that under the favourable conditions of experiment 1, stage 2 and 3 pups can be identified, with reasonably consistent error rates, even if observers are inexperienced. However, under actual survey conditions, more variability occurred among observers. This variability is accounted for primarily by pups which could not be classified. The results of individual transects were quite variable but the sample sizes were small and the totals for the entire experiment were reasonably similar. The two experienced observers (B and C) were very similar in all of their classifications while the inexperienced observer (A) tended to identify a greater number of stage 2 pups but a smaller number of unknowns. This may reflect his lack of previous experience in flying transects and identifying hooded seals.

The variability seen among observers may be reduced by improving the survey design. One improvement would be to decrease the strip width. The greater the strip width, the greater the mean distance between the animal and the observer and the lower the sightability (Caughley 1974, Caughley et al. 1976; Briggs et al. 1985; Estes and Gilbert 1978). With the 100 m strip width used in this experiment, the angle of view of the outer edge was low and pups along this edge could not be identified easily. Pups in this outer area accounted for many of the unclassified animals and thus for much of the variability among observers. A smaller strip width, for example 50 m, would improve the angle of viewing thereby reducing the number of unidentified pups and improving the accuracy of the classifications made.

A smaller strip width also results in a greater length of time in which to view the pups. The time available for counting has been found to exert the greatest influence on sightability during aerial surveys (Caughley 1974; Wartzok and Ray 1975). Although it did not appear to be a problem in this study, the time available for scanning individual pups may be a limiting factor in areas where pups occur in greater density such as the Front. The results of this experiment may not be directly applicable to surveys conducted at the Front and a similar series of experiments should be performed there to determine error rates and inter-observer consistency in an area of high density.

Altering the method used in this study to delimit strip width may also result in improved survey results. Because the viewing area was indicated by marks on the window only, a slight movement of the observer's head resulted in a dramatic change in effective strip width. This change in viewing area may account for differences between Observers A and B who were viewing the same strip. A second set of marks, perhaps on a bar attached to the bottom of the helicopter, would ensure that the strip width remained constant during the transects.

## Effect on Estimates of Population Size

There are two effects of pup misclassification that are of concern: bias and variance. There was little bias in the estimates of proportions of pups in stages 2 and 3 from helicopter transects; overall, this bias was not statistically significant and on the order of 2%. Nevertheless, this bias should be considered in future estimates of pup production.

The second effect of misclassification is to increase variance in the estimates of pup production. This "unbiased" misclassification can have serious effects on the estimates of the proportion of pups present. If an observer mistakes stage 2's and stage 3's at an equal rate of 20% then he will estimate that a population consisting only of stage 2 pups will contain 20% of stage 3 pups. Thus, unbiased misclassifications may result in biased estimated of the proportions of pups present. However, this effect will be largely mitigated since the majority of the errors occur near the transition between stages 2 and 3.

There are two approaches to modify the model to account for errors in classification. First, the transition function of pups from one stage to the next can be modified. The second approach is to incorporate errors in stage determination in the manner that Fourier and Archibald (1982) suggested for age misclassification. Let $a_{jk}$ be the probability than an individual within the age range assumed for stage class k will be judged to lie in stage class j. Equation (5) of Bowen et al. (1987) then becomes

$$L(\Theta) \propto \prod_{ij} \left(\sum_k a_{jk} \quad P_{ij}\right)^{\alpha_i S_{ij}} \prod_{\ell} \frac{1}{\sqrt{2 \pi \sigma}} \exp\left(- \frac{1}{2} \left( \frac{O_\ell - C_\ell}{\sigma_\ell}\right)^2\right).$$

We prefer the first approach because it can more realistically describe the observed patterns of misclassification. That is, errors in classification seemed to take place close to the transition from stage 2 to stage 3. The second (matrix) approach assumes that errors take place with the same probability independent of the age of the pup. The observed bias in misclassification could be accounted for be reducing the mean duration of stage 2 by 2% and increasing the mean duration of stage 3 by 2%.

A more subtle question is the inclusion of the unbiased portion of the misclassification of pups. This effect to a large extent is already built into the model because the time pups spend in each stage is assumed to be stochastic. Furthermore, the stochastic duration pups spend in each stage was estimated from data in which the pup age was estimated with some error. This effect will somewhat balance the qreater rate of misclassifying pups from helicopter surveys.

In conclusion, the low bias observed in misclassifying pups should have only a slight effect on previous estimates of pup production (Bowen et al.

1987), however, the known bias in misclassifying pups should be considered in future surveys.

In summary, the results of this study indicate that hooded seal pups can be classified into distinct developmental stages and that after a period of training involving an examination of pups under field conditions, these stages can be readily identified and recognized consistently by observers. We also found that developmental stages can be recognized during aerial transects flown at an altitude of 30 m. However, the techniques used previously should be modified slightly and the classification error rates should be incorporated into any correction to the population estimate.

## Acknowledgements

We would like to thank the D. Wakeham and W. Hoek, for their assistance in determining the classification and their help in conducting the experiments. We would like thank our pilot Kim Miller for his skill and cooperation.

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Table 1. Error rates in classification of hooded seal pup developmental stages by observers at ice level. N = total numbered pups classified, n = number of pups classified incorrectly.

| | | Stage 1 | | | Stage 2 | | | Stage 3 | | | All stages | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Obs. | N | n | % | N | n | % | N | n | % | N | n | % |
| Mar. 16 | A | | | | 12 | - | - | 12 | 1 | 8.3 | 24 | 1 | 4.2 |
| | B | | | | 12 | 1 | 8.3 | 12 | 1 | 8.3 | 24 | 2 | 8.3 |
| | C | | | | 12 | - | - | 12 | - | - | 24 | - | - |
| | A-C | | | | 36 | 1 | 2.8 | 36 | 2 | 5.6 | 72 | 3 | 4.2 |
| Mar. 17 | A | 2 | - | - | 41 | - | - | 5 | - | - | 48 | - | - |
| | B | 2 | - | - | 41 | 1 | 2.4 | 5 | - | - | 48 | 1 | 2.1 |
| | C | 2 | - | - | 41 | 1 | 2.4 | 5 | - | - | 48 | 1 | 2.1 |
| | A-C | 6 | - | - | 123 | 2 | 1.6 | 15 | - | - | 144 | 2 | 1.4 |
| Mar. 18 | A | | | | 23 | 1 | 4.3 | 14 | - | - | 37 | 1 | 2.7 |
| | B | | | | 23 | 1 | 4.3 | 14 | - | - | 37 | 1 | 2.7 |
| | C | | | | 23 | - | - | 14 | - | - | 37 | - | - |
| | A-C | | | | 69 | 2 | 2.9 | 42 | - | - | 111 | 2 | 1.8 |
| Total | A | 2 | - | - | 76 | 1 | 1.3 | 31 | 1 | 3.2 | 109 | 2 | 1.8 |
| | B | 2 | - | - | 76 | 3 | 3.9 | 31 | 1 | 3.2 | 109 | 4 | 3.7 |
| | C | 2 | - | - | 76 | 1 | 1.3 | 31 | - | - | 109 | 1 | 0.9 |
| | A-C | 6 | - | - | 228 | 5 | 2.2 | 93 | 2 | 2.2 | 327 | 7 | 2.1 |

Table 2. Error rates in classification of hooded seal pup developmental stages from an altitude of 30 m. Flying velocity = 65 km/hr, N = total number of pups classified, n = number of pups classified incorrectly.

| | | Stage 1 | | | Stage 2 | | | Stage 3 | | | All stages | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Obs. | N | n | % | N | n | % | N | n | % | N | n | % |
| Mar. 16 | A | | | | 12 | 1 | 8.3 | 12 | 3 | 25.0 | 24 | 4 | 16.7 |
| | B | | | | 12 | 2 | 16.7 | 12 | 3 | 25.0 | 24 | 5 | 28.8 |
| | C | | | | 12 | 1 | 8.3 | 12 | 1 | 8.3 | 24 | 2 | 8.3 |
| | A-C | | | | 36 | 4 | 11.1 | 36 | 7 | 19.4 | 72 | 11 | 15.3 |
| Mar. 17 | A | 2 | 2 | 100 | 41 | 3 | 7.3 | 5 | 1 | 20.0 | 48 | 6 | 12.5 |
| | B | 2 | 1 | 50 | 41 | 8 | 19.5 | 5 | 1 | 20.0 | 48 | 10 | 20.8 |
| | C | 2 | 2 | 100 | 40 | 2 | 5.0 | 5 | 1 | 20.0 | 47 | 5 | 10.6 |
| | A-C | 6 | 5 | 83.3 | 122 | 13 | 10.6 | 15 | 3 | 20.0 | 143 | 21 | 14.7 |
| Mar. 18 | A | | | | 23 | 7 | 30.4 | 14 | 1 | 7.1 | 37 | 8 | 21.6 |
| | B | | | | 23 | 6 | 26.1 | 14 | 1 | 7.1 | 37 | 7 | 18.9 |
| | C | | | | 23 | 6 | 26.1 | 14 | - | - | 37 | 6 | 16.2 |
| | A-C | | | | 69 | 19 | 27.5 | 42 | 2 | 4.8 | 111 | 21 | 18.9 |
| Total | A | 2 | 2 | 100 | 76 | 11 | 14.5 | 31 | 5 | 16.1 | 109 | 18 | 16.5 |
| | B | 2 | 1 | 50 | 76 | 16 | 21.0 | 31 | 5 | 16.1 | 109 | 22 | 20.2 |
| | C | 2 | 2 | 100 | 75 | 9 | 12.0 | 31 | 2 | 6.4 | 108 | 13 | 12.0 |
| | A-C | 6 | 5 | 83.3 | 227 | 36 | 15.9 | 93 | 12 | 12.9 | 326 | 53 | 16.2 |

Table 3. Determination of potential biases in identifying stage 2 and stage 3 hooded seal pups from an altitude of 30 m. Probability levels may be overestimated since the same seals were examined by three observers and there was a moderate tendency to misidentify the same seal.

| Date | Numbers of pups/stages: True stage[a] | Observed stage 2 | Observed stage 3 | p[b] | q[c] | Probability p = q |
|---|---|---|---|---|---|---|
| Mar. 16 | 2 | 32 | 4 | .11 | .19 | .27 |
| | 3 | 7 | 29 | | | |
| Mar. 17 | 2 | 109 | 12 | .10 | .20 | .22 |
| | 3 | 3 | 12 | | | |
| Mar. 18 | 2 | 50 | 19 | .28 | .05 | .004[d] |
| | 3 | 2 | 40 | | | |
| TOTAL | 2 | 191 | 35 | .15 | .13 | >.5 |
| | 3 | 12 | 81 | | | |

[a]Determined at ice level.

[b]Where p = probability of classifying a stage 2 animal as stage 3.

[c]Where q = probability of classifying a stage 3 animal as stage 2.

[d]Indicates significant bias.

Table 4. Determination of potential biases in individual observers identifying stage 2 and stage 3 hooded seal pups from an altitude of 30 m. Probability levels may be overestimated since the same seals were examined by three observers and there was a moderate tendency to misidentify the same seal.

| | Numbers of pups/stages | | | | | |
|---|---|---|---|---|---|---|
| | | Observed stage | | | | |
| Obs. | True stage[a] | 2 | 3 | p[b] | q[c] | Probability p = q |
| A | 2 | 65 | 10 | .13 | .16 | .46 |
| | 3 | 5 | 26 | | | |
| B | 2 | 60 | 16 | .20 | .16 | .40 |
| | 3 | 5 | 26 | | | |
| C | 2 | 66 | 9 | .12 | .06 | .33 |
| | 3 | 2 | 29 | | | |

[a]Determined at ice level.

[b]Where p = probability of classifying a stage 2 animal as stage 3.

[c]Where q = probability of classifying a stage 3 animal as stage 2.

Table 5. Comparison between observers in classifying developmental stages of hooded seal pups. Flying altitude = 30 m, flying velocity 65 km/hr.

| | Observer A | | | | | Observer B | | | | | Observer C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Stages | | | | | Stages | | | | | Stages | | | | |
| Trans. | 2 | 3 | 4 | 5[a] | Total | 2 | 3 | 4 | 5[a] | Total | 2 | 3 | 4 | 5[a] | Total |
| 1 | 5 | 6 | - | 2 | 13 | 10 | 2 | - | - | 12 | 8 | 2 | - | 1 | 11 |
| 2 | 14 | 1 | - | 2 | 17 | 8 | 3 | - | 5 | 16 | 11 | 2 | - | 1 | 14 |
| 3 | 12 | 2 | - | 3 | 17 | 10 | 4 | 1 | 3 | 18 | 11 | 3 | 1 | 2 | 17 |
| 4 | 13 | - | - | 1 | 14 | 15 | 1 | - | 5 | 21 | 7 | 2 | - | - | 9 |
| 5 | 16 | 2 | - | 3 | 21 | 10 | 2 | - | 9 | 21 | 15 | 1 | 1 | 4 | 21 |
| 6 | 5 | 1 | - | - | 6 | 4 | 4 | - | 1 | 9 | 5 | 2 | - | 3 | 10 |
| 7 | 15 | 1 | 1 | - | 17 | 13 | 1 | 1 | 2 | 17 | 13 | 3 | 1 | 6 | 23 |
| 8 | 4 | 1 | - | - | 5 | 3 | - | - | 3 | 6 | 6 | 2 | - | 2 | 10 |
| 9 | 2 | 2 | - | - | 4 | 1 | 1 | - | 4 | 6 | 2 | 1 | - | 4 | 7 |
| 10 | 1 | 1 | - | - | 2 | 1 | 1 | - | - | 2 | 3 | 1 | - | 1 | 5 |
| TOTAL | 87 | 17 | 1 | 11 | 116 | 75 | 19 | 2 | 32 | 128 | 81 | 19 | 3 | 24 | 127 |

[a]Stage 5 pups = unknown.

Table 6. Inter observer comparisons: percentage of identifiable pups in each developmental stage. Total number of transects equal to 10.

| Observer | Stage 2 | 3 | 4 |
|---|---|---|---|
| A | 82.8 | 16.2 | 1.0 |
| B | 78.1 | 19.8 | 2.1 |
| C | 78.6 | 18.4 | 2.9 |