RESTRICTED

International Commission for the Northwest Atlantic Fisheries

Serial No. 3717
(D.c.11)

ICNAF Res.Doc. 75/XII/144

SPECIAL MEETING OF PANEL A (SEALS) - DECEMBER 1975

An aerial census of western Atlantic harp seals (*Pagophilus groenlandicus*) using ultraviolet photography[1]

by

D.M. Lavigne, S. Innes, K. Kalpakis and K. Ronald
Department of Zoology, University of Guelph
Guelph, Ontario, Canada

ABSTRACT

Harp seal production in the western Atlantic was estimated by an aerial census, using ultraviolet photography for low altitude sampling, at between 126,000 and 158,000 seals. Of these approximately one-third were produced in the Gulf of St. Lawrence and two-thirds on the Front off the east coast of Newfoundland. This suggests that western Atlantic stocks of harp seals have continued to decline in recent years to between 630,000 and 790,000 animals in 1975.

INTRODUCTION

Ultraviolet photography has been introduced as a new technique for detecting certain white animals, including the white-coated offspring of harp seals, Pagophilus groenlandicus, against a white background of ice or snow (Lavigne and Øritsland 1974a, b). Extensive field experiments conducted in the Gulf of St. Lawrence in March 1974 suggested that the use of this sensor might significantly improve population estimates, specifically estimates of annual production, based on aerial surveys of harp seals on their whelping grounds (Lavigne et al. 1974).

[1] Presented to the FAO/ACMRR Working Party on Marine Mammals, *ad hoc* Group III, 1-6 September 1975, Seattle, Washington, USA, as Doc. 31.

In March 1975, further research was conducted on whelping harp seals, both in the Gulf of St. Lawrence and on the Front, off the coast of Labrador. The primary objective was to design a useful, feasable, and precise sampling technique for routine use in aerial surveys of harp seals. A preliminary outline of this research has been prepared (Lavigne and Ronald 1975) and a detailed report will be available in the near future (Lavigne et al. 1975). The present paper briefly summarizes only those results relevant to obtaining the best available estimate, from our aerial survey data, for production of western Atlantic harp seals in March 1975.

METHODS

Four experimental remote sensing flights were conducted, two over the whelping herd in the Gulf of St. Lawrence west of the Magdalen Islands on the 10 and 17 March, 1975, and two over harp seals whelping on the Front off the east coast of Newfoundland on the 11 and 15 March, 1975. The latter group was divided into a northern patch and a smaller southern patch. Attempts were made to obtain total coverage of these areas by flying parallel grid lines over the herd at an altitude of 1220 m (4000 ft) guided by an inertial navigational system on board the remote sensing aircraft. A 9" x 9" (22.9 cm x 22.9 cm) aerial survey camera and black and white photography (Kodak 2402 aerial film) were used, since ultraviolet photography in this large format is not presently available. Subsequent sampling was conducted at random areas over the herd at an altitude of 305 m (1000 ft) using ultraviolet photography in 70 mm format (Lavigne and Øritsland 1974a). The rationale was that the 1220 m imagery should provide a second estimate of herd area, the first being made by observers in the field, as well as a direct count of the number of adult seals on the ice at the time of the flight. The sample obtained with ultraviolet photography at a lower altitude would give numbers of adults and pups which could then be extrapolated to the area of the

herd. The estimate of adults would then be compared with the direct count of adults to evaluate the accuracy of the sampling technique. If satisfactory, the samples could then be used to estimate the numbers of white-coated pups on the ice (annual production), and in turn lead to a direct extrapolation of the number of breeding females in the population.

The data obtained from the 1975 imagery were analyzed using a variety of independent sampling techniques (Lavigne and Ronald 1975, Lavigne et al. 1975). These included simple random sampling (Mendenhall et al. 1971; Som 1973) and ratio estimation (Snedecor and Cockran 1967), the latter utilizing adult/pup ratios obtained from the 305 m imagery.

RESULTS

Analysis of the imagery revealed that total coverage at 1220 m was not obtained for the Front herd on either day. Herd area determinations made in the field (T. Curran, pers. comm., Bergflødt 1975) were thus used in calculations. Also, replicate coverage of Front and Gulf herds was not in fact obtained, primarily because atmospheric conditions causing backscattering, rendered some of the ultraviolet imagery at 305 m unusable. Somewhat fortuitously, however, satisfactory single coverage was obtained for each herd. Our calculations are thus based on aerial survey data from the Gulf of St. Lawrence on 10 March, approximately three days after pupping had been completed, from the north patch on the Front on 11 March when pupping was about 80% completed (T. Curran, pers. comm.), and from the south patch, on 15 March, again when pupping was virtually complete (T. Curran, pers. comm.). These data were used in estimating annual production in 1975. The results of estimates obtained using ratio estimation techniques, and considered to be best estimates available from our data (Lavigne et al. 1975) are summarized in Table 1. The mean estimate for annual production of harp seals in the western Atlantic in March 1975 was 125,958 with 37 percent of these being born in the Gulf of St. Lawrence west of the Magdalen

Islands. The upper confidence limit ($p < 0.05$) on this estimate was 197,233. These calculations (Table 1) were based on the herd area estimates obtained from the aerial imagery from the Gulf on 10 March, from the mean herd area estimated by T. Curran (pers. comm.) and Bergflødt (1975) for the north patch on 11 March, and from the single estimate of herd area for the south patch on 15 March (T. Curran, pers. comm.).

The largest estimate of production provided by our data, using the area estimate of Bergflødt (1975) for the north patch on 11 March, was 157,900 (Table 1).

DISCUSSION

Harp seals and their pups are distributed in a clumped or contagious manner on their whelping grounds (Lavigne et al. 1975). This causes certain difficulties when conducting an aerial census, since there are large areas of ice within the area of the herd which are devoid of seals, and other areas where the seals are located in dense concentrations. Such a nonrandom distribution is quite typical for gregarious species (Woolf 1968), and the harp seal is gregarious (Mansfield 1967) especially during the whelping and breeding seasons. In addition, habitat heterogeneity may also contribute to such distributions of animals (Poole 1974) and this undoubtedly applies to the harp seal, which may actively seek out certain ice conditions for whelping, and which tends to congregate along the edge of open leads, and around breathing holes in the ice.

The problems associated with sampling a population distributed in this manner became readily apparent during initial calculations of production for the Gulf of St. Lawrence (Lavigne and Ronald 1975). For example, in the Gulf of St. Lawrence on 10 March 1975, 35,418 adult harp seals were counted on the ice at the time of the flight on the 1220 m imagery. This provided a reference for extrapolations from the samples obtained at 305 m using ultraviolet photography. On the basis of a simple random sample (Mendenhall et al. 1971) the number of adults on the ice, predicted from 69 samples was about 38,000 or

within about 8% of the direct count (Lavigne and Ronald 1975).

However, 95% confidence limits on this estimate ranged from 12,727-63,934. These wide confidence limits are due in part to the fact that the 69 samples were not sufficient, because of the distribution of seals on the ice, to obtain a normal distribution of sample means (Remington and Schork 1970, Snedecor and Cochran 1967). It has been shown that the means become normally distributed and the variances are greatly reduced simply by increasing the sample size (Lavigne and Ronald 1975).

An alternative method which may prove to be more satisfactory is that of ratio estimation (Snedecor and Cochran 1967). It has recently been observed that adult/pup ratios in our samples are rather normally distributed. This means that smaller sample sizes may be used to obtain precise estimates of production as long as an accurate estimate of the total number of adults on the ice, such as that provided by our 1220 m imagery, is available. Ratio estimation was selected as the appropriate analysis to provide our best estimate of annual production of western Atlantic harp seals because it provided the tightest confidence limits on the estimates. Estimates from the Front still have wide confidence limits (Table 1), primarily because of the small number of samples obtained at 305 m (Lavigne et al. 1975). This emphasizes the need for larger samples in future aerial surveys. With more accurate estimates of herd area, a relatively minor problem to overcome, it would appear that aerial censusing, encorporating ultraviolet photography as the primary sensor for low altitude sampling, can provide very precise estimates of production for whelping harp seals, overcoming most of the difficulties encountered in the past (Sergeant 1975a).

The estimated number of harp seals produced in the western Atlantic in March 1975, between 126,000 and 158,000, is considerably lower than recent predictions of annual production made by other investigators. Using Sergeant's (1975a) suggestion that the population other than young is between 4 to 5 times

the number of young born, it follows that the number of harp seals in the western Atlantic may now total between about 630,000 and 790,000 animals. The distribution of 37 percent of western Atlantic harp seals breeding in the Gulf and 63 percent on the Front, is in general agreement with the 1:2 ratio observed in the past (Sergeant 1975a).

It might be suggested that the photographic census did not cover all the whelping harp seals in the western Atlantic. However, this is not considered to be a large source of error in our estimates. The two concentrated patches located on the Front by Canadian (T. Curran pers. comm.) and Norwegian (Bergflødt 1975) observers, and Canadian and Norwegian sealers, were surveyed. Harp seals in the Gulf of St. Lawrence near the Magdalen Islands were located in one concentrated area at the time of our surveys and were thoroughly covered in our census. Only two small groups of seals were not included in our coverage or our estimates, to the best of our knowledge. The so-called Meccatina patch comprising some 3000-4000 seals, and a second group of old harps and bedlamers without pups were located by T. Curran (pers. comm.). Dispite many searches by various experienced observers over wide areas, no other concentrations of whelping harp seals were reported to us.

Previous estimates of annual production are summarized in Fig. 1. In the early 1950's Fisher (1955) estimated that western Atlantic stocks of harp seals numbered about 3.3 million animals and estimated annual production to be in excess of 600,000 animals. Between 1951 and 1960, Mansfield (1967) estimated that the stocks declined from more than 3 million to about 1.25 million seals. In 1970, it was suggested that western Atlantic harp seals numbered about 2.5 million (Mansfield 1970), although no comment was made on the apparent increase in numbers during the 1960's. Best estimates for annual production during the late 1960's are between 270,000 (Sergeant 1975a) and 390,000 (Benjaminsen and Øritsland 1975). Most recent estimates seem to suggest that harp seals now number some 1.10 to 1.35 million based on estimates of annual production of between

220,000 and 270,000 seals (Sergeant 1975b). Our results indicate that production has continued to decline in recent years (Fig. 1), despite the reduced quota of 150,000 harp seals per year, and restricted sealing in the Gulf of St. Lawrence since 1972 (Anon. 1972). Extrapolation of the present trend in annual production (Fig. 1) suggests that if current management policies are continued production will continue to decline, and the population will be severely threatened before the end of the twentieth century.

ACKNOWLEDGEMENTS

We thank Major E.J. McLaren, Head, Airborne Operations Section, Canada Centre for Remote Sensing, Energy, Mines and Resources Canada, and the officers and men of CF-ASU who, for the second consecutive year, participated in the field work, and carried out the experimental aerial survey flights.

Mr. Tom Curran continually supplied us with up to date information on the location of harp seals on the Front, and assisted our operations in the field. Mr. Wybrand Hoek, Arctic Biological Station, Fisheries and Marine Service, Ste. Anne de Bellevue provided us with information resulting from his survey flights, both in the Gulf of St. Lawrence and on the Front. Similarily, Mr. Stan Dudka assisted with our field operations in the Gulf of St. Lawrence.

We also thank Mr. C. Levelton, Director General, Operations Directorate, Fisheries and Marine Service, Environment Canada; and Dr. G.A. Jarvis, Department of Mathematics and Statistics, University of Guelph, for his advice on the analysis of data.

Financial support was obtained through the Special Advisory Committee on Seals and Sealing to the Minister of State for Fisheries, and from grants to D.M.L. and K.R. from the National Research Council of Canada.

REFERENCES

Anon. 1972. Canadian-Norwegian agreement on sealing. Polar Rec. 16:268-271.

Allen, R.L. 1975. A life table for harp seals in the northwest Atlantic. Rapp. P.-v. Cons. int. Explor. Mer. 169:in press. Proceedings of a Symposium on the biology of the seal. Sug. 1972. University of Guelph, Ontario, Canada.

Benjaminsen, T., and T. Øritsland. 1975. The survival of year-classes and estimates of production and sustainable yield of northwest Atlantic harp seals. Int. Comm. Northwest Atl. Fish. Res. Doc. 75/121.

Bergflødt, B. 1975. Report on the sealing season and Norwegian seal investigations off Newfoundland-Labrador in 1975. Int. Comm. Northwest Atl. Fish. Res. Doc. 75/120.

Fisher, H.D. 1955. Utilization of Atlantic harp seal populations. Trans. Twentieth North Amer. Wildlife Conf., 507-518.

Lavigne, D.M. and N.A. Øritsland. 1974a. Ultraviolet photography: A new method for remote sensing of mammals. Can. J. Zool. 52:939-941.

Lavigne, D.M. and N.A. Øritsland. 1974b. Black polar bears. Nature (Lond.) 251:218-219.

Lavigne, D.M., N.A. Øritsland, P. Watts, and K. Ronald. 1974. Harp seal remote sensing. A report prepared for the Committee on Seals and Sealing, the Canada Centre for Remote Sensing, and the Arctic Biological Station, Fisheries and Marine Service, Environment Canada. MS.

Lavigne, D.M. and K. Ronald. 1975. Improved remote sensing techniques for evaluating seal populations. ICES C.M. 1975/N:12.

Lavigne, D.M., S. Innes, K. Kalpakis, and K. Ronald. 1975. Harp seal aerial censusing. A report prepared for the Committee on Seals and Sealing, and Canada Centre for Remote Sensing. MS.

Mansfield, A.W. 1967. Seals of arctic and eastern Canada. Fish. Res. Bd. Can. Bull. 137 (second edition, revised).

Mendenhall, W., L. Ott, and R.L. Scheaffer. 1971. Elementary survey sampling. Wadsworth Publishing Co., Inc., Belmont, California.

Poole, R.W. 1974. An introduction to quantitative ecology. McGraw-Hill Book Co., New York.

Remington, R.D. and M.A. Schork. 1970. Statistics with applications to the biological and health sciences. Prentice-Hall Inc., Englewood Cliffs, New Jersey.

Sergeant, D.E. 1975a. Estimating numbers of harp seals. Rapp. P.-v. Cons. int. Explor. Mer. 169:in press. Proceedings of a symposium on the biology of the seal. Aug. 1972. University of Guelph, Ontario, Canada.

Sergeant, D.E. 1975b. Interrelations of the Gulf and Front herds of harp seals, Pagophilus groenlandicus. Canadian Government-Industry Sealing Meeting, 25 Feb. 1975 Doc. No. R/1.

Snedecor, G.W. and W.G. Cochran. 1967. Statistical methods, 6th edition. The Iowa State University Press, Ames, Iowa.

Som, R.K. 1973. A manual of sampling techniques. Heinemann Educational Books Ltd., London.

Woolf, C.M. 1968. Principles of Biometry. D. Van Nostrand Co., Inc., New Jersey.

TABLE 1

Estimate of production of harp seals, Pagophilus groenlandicus, in the western Atlantic in March, 1975.

Location	Date	Herd Area Km^2	Pup production $\hat{t}$ ± 95% CI
Gulf	10 March	519[a]	46,300 ± 5,158
Front (N)	11 March	208[b]	53,583 ± 47,648
Front (S)	15 March	52[c]	26,075 ± 18,469
		Total	125,958 ± 71,275

[a] Herd area estimated from aerial imagery obtained at 1220 m.

[b] Mean estimate of herd area based on estimates of T. Curran (pers. comm.) and Bergfløydt (1975).

[c] Estimated herd area (T. Curran, pers. comm.)

Note: If Bergfløydt's (1975) estimate for herd area for the north patch on the Front on 11 March (332 km^2) is used in calculations the estimate of production becomes 157,900 ± 99,702.

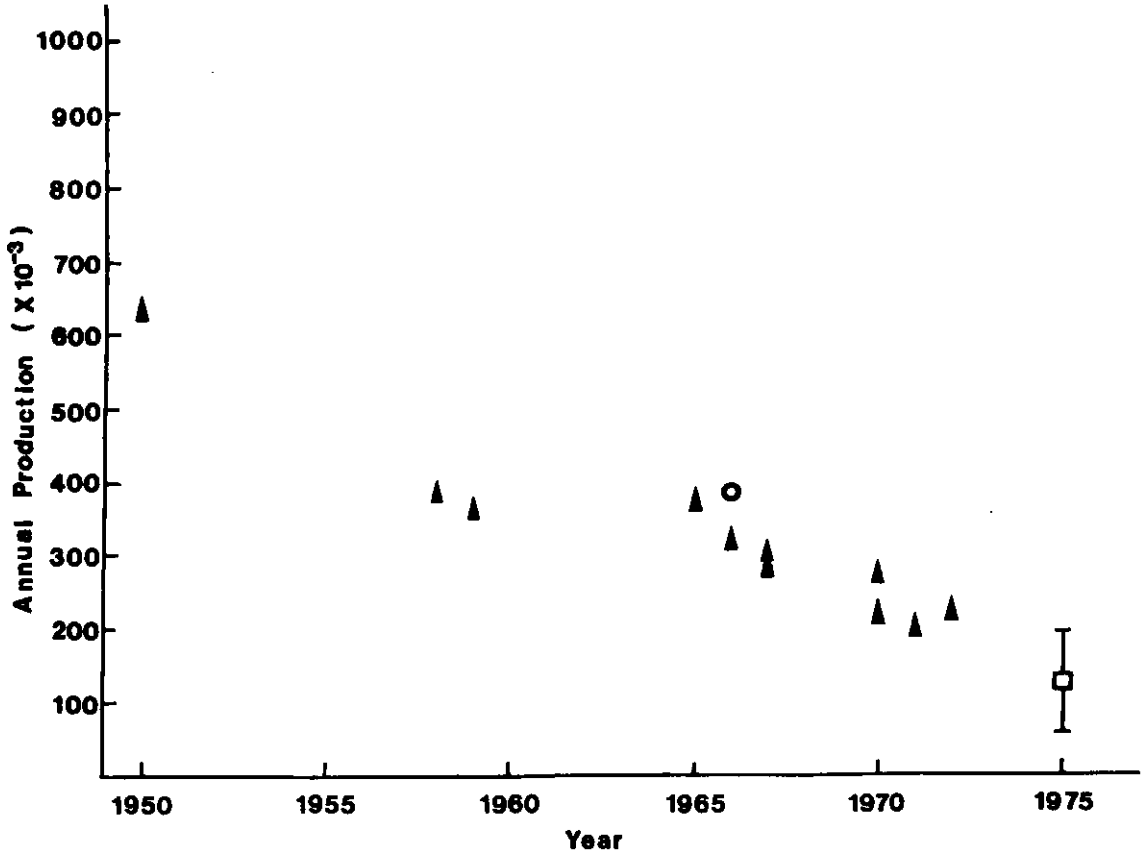

Fig. 1. Annual production of western Atlantic harp seals, Pagophilus groenlandicus, estimated by aerial survey, capture-recapture experiments, greatest catch, and catch and survival estimates (Sergeant 1975a) ▲, by survival estimates (Benjaminsen and Øritsland 1975) ○, and by aerial censusing using ultraviolet photography □, with error bars designating 95% confidence intervals.