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Whales, seals, fish and man

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Increased accuracy in the estimation of harp seal (*Phoca groenlandica*) abundance in whelping patches

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Abstract. The course and results of experimental aerial surveys of harp seal whelping patches conducted in March 1993–1994 in the White Sea using an MI-8 helicopter are presented. Recommendations concerning improvements of the on-board equipment, the method of aerial survey and possible automation of the aerial counting work are given.

Key words: seal, white coat pup, air survey, infrared, transect

Introduction

Aerial surveys of harp seal whelping patches are part of the complex research which also includes the distribution and migration analysis (geographical aspects) and biological aspects, and which leads to a rational use of the stocks of this animal. Aerial surveys have been used to estimate the number of harp seals in the White Sea since the middle 1920s. Since the early 1960s scientists have surveyed only suckling females, while estimations of the number of pups themselves, the main indication of the seals' stock condition, have not been made.

While suckling their pups the females need to feed themselves and must occasionally leave their pups. According to observations made by Popov [1] in early March (when the patches are formed and the suckling begins) 70–80% of females are in the water in the early morning hours on bright sunny days. During the second part of the day no more than 30–40% stay in the water. After 1 or 2 weeks of suckling, the time the females spend in the water increases greatly. This may cause aerial surveys when only females are counted to err by 50% or more. The number of females on the ice also decreases during snow-storms, or when the ice breaks up [1], but increases during ice compressions.

Taking into account that the number of suckling females varies greatly both during a 24-h daily cycle and during the whelping period, the harp seal researchers in the White Sea have introduced a correction factor [2]. Thus it is assumed that 80% of females are on the ice and 20% are in the water during aerial surveys conducted in early March. The validity of the correction factor has not yet been confirmed.

Estimates based on aerial surveys of harp seal whelping patches during the first days of suckling have some advantages compared to estimates made at other periods of their life (e.g. when the suckling period is over or on the moulting grounds). Then

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the density of the seals' patch is at its highest; furthermore, the age and sex structures of the patch are stable for a long time (females + pups + males). After approximately 3 weeks the whelping patches break up leaving only the pups on the ice. Because of the ice drift, however, the density of pups in the patch greatly decreases, thus resulting in increases in the cost of flights designed to survey them. For that reason we set out to improve the method of aerial surveys of seals in the suckling period.

The main point of the work was to improve the accuracy in the methods used to estimate harp seal pup numbers. The means was a survey where the seals were synchronously recorded visually and in the IR part of the spectrum.

The stages of the work were:

- data collection;
- determination of optimal survey conditions by considering the technical specifications of the on-board equipment;
- improving the methods for a synchronous survey using the visual and IR part of the spectrum;
- simultaneous processing of the shots and images obtained from the two parts of spectrum.

Methods and Equipment

In March 1993 and 1994 experimental aerial surveys of harp seal whelping patches were carried out using an MI-8 helicopter in the entrance of the White Sea.

Technical facilities used in 1993 included (see Table 1):

- "Vulkan" thermovision set;
- aerial photo camera AFA TES 10;
- video set JVC GF-500.

It is necessary to emphasize that, unlike photo and video cameras, the thermovision set surveys the space by linear scanning with a narrow momentary sighting angle perpendicular to the flight direction. Therefore the given combined survey may be considered as a "quasisynchronous" one.

Table 1. Specifications of the equipment used in the 1993 survey

Sensor	Sight angle	Track width	Ground resolution (m)[b]	
	(°)	(km)	Across	Along
Thermovision[a]	80	1.29	0.40	0.4
Video	40	0.72	0.33	0.4
Photo	84	1.34	0.15	0.2

[a]Thermovision-scanner with scanning frequency of 180 lines/s, sensitivity 0.5°C.
[b]Ground resolutions are given for a flight altitude of 200 m.

Table 2. Specifications of the equipment used in the 1994 survey.

Sensor	Sight angle	Track width	Ground resolution (m)[b]	
	(°)	(km)	Across	Along
Thermovision[a]	20	0.35	0.26	0.3
Video	40	0.72	0.33	0.4
Photo	44	0.80	0.08	0.1

[a]Thermovision sensitivity is 0.2°C.
[b]Ground resolutions are given for a flight altitude of 200 m.

Technical facilities used in 1994 included (see Table 2):

- "Insight 80" series thermal imager;
- video camera JVC TK-880;
- videocassette recorders JVC;
- aerial photo camera PA-39;
- lap-top computer Toshiba;
- GPS positioning system Raytheon R-900.

To determine the number of whitecoats reliably, the survey should be conducted when the majority of the females have whelped. The experiments were conducted when the number of whelped females exceeded 95%.

The experiments both in 1993 and in 1994 were carried out using the following design:

- *1st flight:* searching for the whelping patch and choosing the optimum flight parameters (height and speed; synchronous surveys were carried out successively from 400, 200 and 100 m height, speeds ranging between 100 and 180 km/h).
- *2nd flight:* surveying the seal patch along a net of transects at a predetermined height and speed. In 1993 the flights were carried out on 6 and 7 March, and in 1994 on 8 and 9 March.

With the equipment used in 1993, the optimum height and speed was 100 m and 180 km/h. The corresponding values in 1994 were 200 m and 130 km/h.

The essence of the method is synchronous surveying of the harp seal whelping patches in the visual and IR parts of the spectrum followed by joint processing of the images, when the number of whitecoat pups lying on the ice is determined.

Interpretation of the visual images was unproblematic because this information is the same as obtained through the human eye.

Thermal images were formed by three main objects: snow-and-ice cover, water and seals. Snow-and-ice cover and water were hardly distinguishable on IR images and served as background for the surveyed seals. These objects had a temperature close to that of the air which at the beginning of March is usually −3 to −5°C. It is known that the temperature of adult seals and whitecoat pups substantially exceeds 0°C. Such thermal contrast is quite enough to image them distinctly by means of thermovision techniques (Fig. 1).

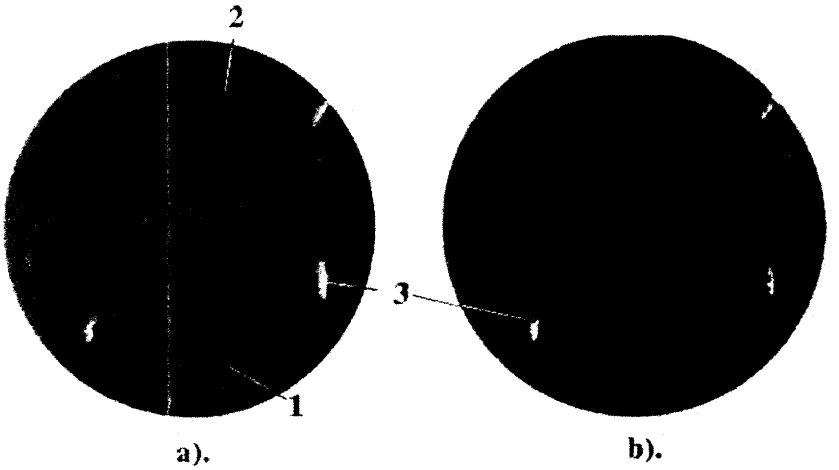

Fig. 1. Computer image processing of an IR frame (there are 3 harp seals on the frame) (a) incoming IF frame; (b) IR frame (a) after image processing. 1, Water; 2, ice; 3, harp seals.

The succession of analyses of the photographs obtained was as follows:

- general analysis of images, sorting of the films according to tracks and heights;
- selection of image areas and ice-floes surveyed in both the visual and IR parts of the spectrum;
- identification and calculation of seals on the photos in the visual part of the spectrum;
- joint analysis and calculation of seals in both the visual and IR parts of the spectrum (Fig. 2);

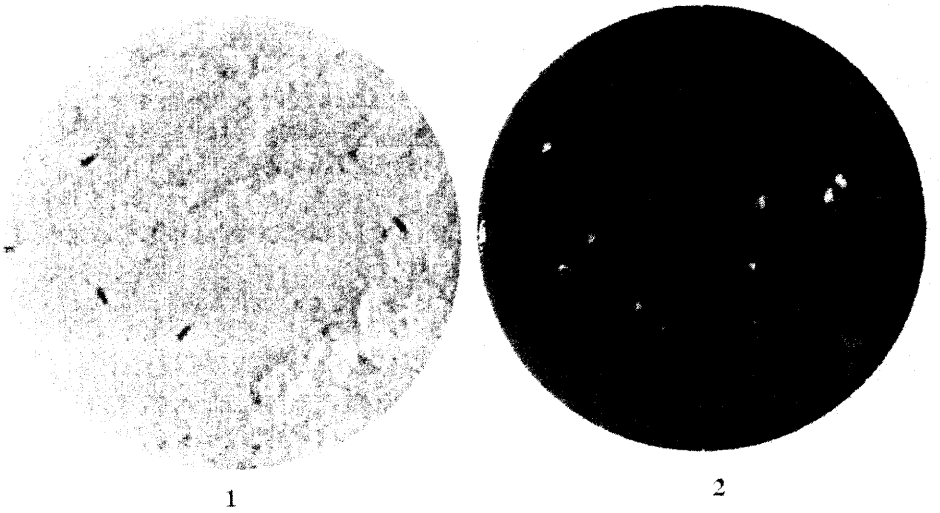

Fig. 2. (1) Video image; (2) processed IR image; bright (warm) spots on IR image are seals; dark (cold) background is ice and water.

– studies of spatial distribution and determination of errors in seal calculations;

In the 1993 experiment, the number of seals was determined by counting the animals on the same ice floes on visual and IR images.

The seal count was made in the following order:

– counts of adult seals on the photos;
– counts of total number of seals on the IR images;
– counts of adult seals and whitecoat pups while analysing both photo and IR images.

To ensure the reliability of the survey results, video films were also used.

The 1994 results have not yet been analysed, so that the following only presents the 1993 results.

Results

In Table 3 the results of aerial survey of seals on three tracks from a height of 100 m are presented. On these tracks some ice-floes with clearly visible edges were selected and on these ice-floes seals were counted on photos and IR images. A total 272 females and 60 males (332 in total) were counted on the three tracks. According to presently used methods of estimation of seal numbers in aerial surveys, these data correspond to 272 whitecoat pups, 272 females and 60 males (totally 604 seals).

Use of a correction factor of 20% [2] yields a corrected number of seals of 340 females, 60 males and 340 pups; in total 740 animals. On IR images 522 seals were counted.

Thus the results obtained by one method alone may include large errors. Combination of the two methods, however, may help to increase the accuracy.

As can be seen from Table 4, the number of adults remained the same, 332, but the distribution among males and females was altered when the photos and IR images were analysed in combination. In particular, two new groups of seals appeared: single ones (without pups), which were classified as "females with pups" according to Table 3, and dead ones (no spots on IR image). The number of females with pups decreased from 272 to 188 (by 31%), the number of males increased from 60 to 72 (by 20%). In the combined analysis of the images, 69 pups lying on ice-floes without

Table 3. Number of harp seals detected during photo and IR surveys on whelping patches in the White Sea, 6.03.93, 100 m height (corrected numbers include a surplus of 20% [2])

No. of track	Visual survey			IR survey total no. of seals
	Females	Males	Total	
10	96	9	105	194
11	109	27	136	194
12	67	24	91	134
Total	272	60	332 (604)	522
Corrected	340	60	400 (740)	

Table 4. Results of harp seal numbers estimated on whelping patches in the White Sea obtained by combined analysis of the photo and IR images obtained 6.03.93, 100 m height

No. of track	Adults			Pups			Total number
	Females with pups	Single seals	Males	Dead or ice-floes	With mothers	Single	
10	88	6	9	2	88	28	221
11	62	47	27	–	62	28	226
12	38	17	36	–	38	13	142
Total	188	70	72	2	188	69	589

mothers were detected. The total number of pups established by the visual and IR method of survey on the three tracks equalled 257 which was 6.5% less than in Table 3 (or 32% less if the correction factor is taken into consideration).

The data of Table 4 also let one determine the number of females in the water, which is equal to the number of single pups. On track 10 they amount to 24.1%, on track 11, 31.1% and on track 12, 25.5%.

Discussion

When conducting such surveys, the spatial resolution of the survey equipment is of utmost importance. The ground resolution depends on the angle of view, the equipment's angular resolution and the altitude of the flight. Due to some technical problems the resolution of the thermovision equipment obtained during the present survey was less than that of the video camera and included 200–250 lines in the frame. The technical characteristics of the infrared imager are determined when conducting the survey (video + IR). An infrared imager temperature sensitivity of 0.1°, a spatial resolution of 300–400 elements in the line, and an angle of view of 15–20° are desirable.

The following errors appear in processing of the infrared images:

- a seal scared away from the ice in the patch can be seen as a luminous spot (heated ice), which may be erroneously interpreted as a second seal;
- a seal only observed in the water has a very weak infrared contrast and may be not detected in the infrared image, but may be observed in the video image;
- pup and female lying together may be seen as a large spot;
- pups lying under standing ice-floes are not observed in the infrared still pictures.

The main shortcoming of the infrared equipment (infrared imager "Vulkan") used in 1993 was that the film recording the infrared information was not suitable for operational analysis and correction of the survey results in situ. Furthermore, its sensitivity was insufficient. The infrared equipment used in 1994 had better sensitivity, with an output signal of television standard, making it possible to observe the results

of the survey during the flight at once. Additionally, the use of a satellite navigational system made it possible to have a precise spatial attachment of all the data from the survey and to show the route of the flight on the monitor screen. The 1994 results will be published at a later stage.

Synchronous video and IR surveys of harp seals whelping patches allow the determination of the number of seals on the ice. A combined image analysis in the visible and IR parts of spectrum increases the accuracy of the number of adult seals determined. Using this method, the pupless females (sterile and non-pregnant), separate males, females moving inside the patch, dead animals (or spots resembling animals) and pups separated from their mothers may be detected on the photos.

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