Automated Thermal Detection of Seals on Ice
Bering Okhotsk Seal Surveys (BOSS): Finding a needle in a haystack

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Abstract

Joint U.S.-Russian aerial surveys of the Bering Sea and the Sea of Okhotsk for ice-associated seals were completed in the spring of 2012 and 2013. These surveys mark the most comprehensive effort to enumerate bearded, ringed, ribbon and spotted seals occupying these waters and a shift in methodology from observer to instrument-based data recording. Both U.S. and Russian teams relied on thermal imagery to detect warm seal bodies on cold ice. An automated seal detection system was tested during these surveys. Custom software (Skeyes 2.0, MoviMED) processes thermal data and identifies outliers in temperature histograms to extract frames that may contain seals. Results from the automated approach were compared to a manual evaluation of digital color photos and a manual evaluation of thermal data. Detection rates and time investment are presented.

Detection Methods

A subset of survey data were used to compare seal detection approaches. Ten tracks were selected from the 2012 U.S. survey effort and data from one set of paired thermal and digital cameras were analyzed using the three methods described below.

Manual evaluation of photos (Manual Visual method)

Traditional image analysis requires a technician to look though all of the photos collected for the presence of seals. For BOSS 2012 and 2013 data, this would require evaluating 1.8 million photos. For the Manual Visual, a technician looked through 10% of the photos selected from a 10 flight subsample (11,724 images), and found 70 seal groups (A seal group is generally one, though occasionally two seals).

Manual evaluation of thermal data (Manual Thermal method)

A graph of the maximum pixel temperature per thermal video frame is evaluated to identify temperature spikes corresponding to hot spots in the video that are likely to be seals. A temperature threshold is applied to reduce background noise and video frames corresponding to peaks exceeding the threshold are reviewed for hot spots. Corresponding photos are then referenced to identify the source of the hot spot. We also looked at peaks below the threshold that seemed to stand out from the background noise.

Automated detection using custom software (Automated Thermal method)

Custom software (Skeyes 2.0) evaluates the temperature histogram from each video frame and identifies outliers. Hot spot detection relies on anomalous temperature shifts rather than specific, absolute, temperature thresholds. The software extracts thermal frames from video for further hot spot evaluation. Corresponding photos are reviewed to identify the source of the hot spot.

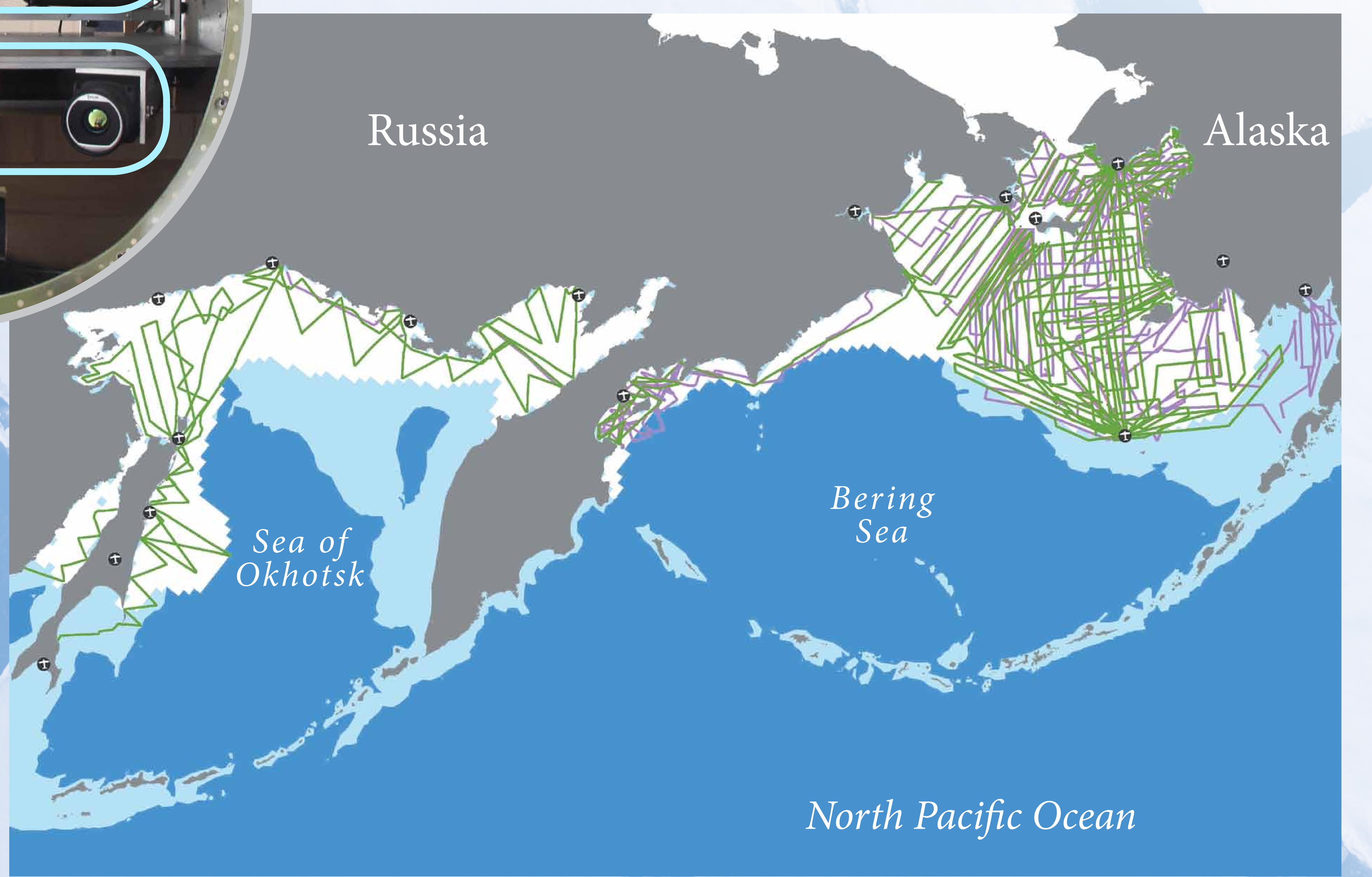

Figure 1. BOSS 2012 (pink) and 2013 (green) survey track lines in the Bering and Okhotsk seas covering more than 90,000 km completed during the joint U.S. – Russian survey effort. Data were collected in the central and eastern Bering Sea using paired thermal (FLIR SC645) and digital single-lens reflex cameras (Canon 1Ds and Nikon D3X) mounted in the belly ports of a NOAA Twin Otter and a chartered Aero Commander. Ten U.S. flights from the 2012 survey were used for seal detection method comparison.

Results

Both manual and automated thermal data analysis are an immense improvement over traditional review of photos alone, both in the rate of detection and the time expended.

Table 1. Seal detection probability comparison between manual and automated thermal detection approaches applied to all of the data from a single-camera pair from ten flights.

Thermal Method	Seal Group Count	Missed Seals	Detection
Manual	740	32	95.6%
Automated (Skeyes 2.0)	732	41	94.5%

Every tenth color photo from the 10 flight subsample was reviewed by a technician for the presence of seals. Of the 70 seal groups found in 11,724 images examined, the manual thermal detection approach detected 94%. In contrast, the technician examining photos located just 66 of 82 seal groups found by thermal detection, indicating a detection probability of 80.5%. Automated detections fall between these two probabilities, finding a total of 75 seal groups. Skeyes 2.0 detected 98.6% of seal groups found by the technician and 85.4% of seal groups found using the manual thermal detection method.

Table 2. Detection probabilities of each method as compared to the other two methods. These results are from each analysis applied only to the 10% of photos used in the manual visual method. Detection probabilities are calculated as the percent of seal groups identified in one method by a second method. As an example, the manual thermal method found 82 seal groups but only found 66 of the 70 seal groups (94.3%) identified using the manual visual approach.

	Manual		Automated
Detection Method	Visual	Thermal	Thermal
Seal Group Count	70	82	75
Visual finds missed by thermal methods	—	4	1
Thermal detection compared to Visual	—	94.3%	98.6%
Manual thermal finds missed by other methods	16	—	12
Detection compared to Manual Thermal	80.5%	—	85.4%
Automated thermal finds missed by other methods	7	4	—
Detection compared to Automated Thermal	90.7%	94.7%	—

Table 3. Workflow and estimated data processing time required for three seal detection methods on a single camera pair. Estimates assume one person working on detection fulltime.

	Manual		Automated
Processing Step	Visual	Thermal	Thermal
Thermal data preparation	—	3.5 hrs	—
Hot spot detection	—	12 hrs	1.2 hrs
Hot spot evaluation	—	—	1.7 hrs
Locate seal in photo and ID species	121 hrs	6.3 hrs	6.5 hrs
Total detection/ID time for single flight camera	121 hrs	22 hrs	9.5 hrs
Total processing time for all of BOSS data	12 yrs	2 yrs	1 yr

Support

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