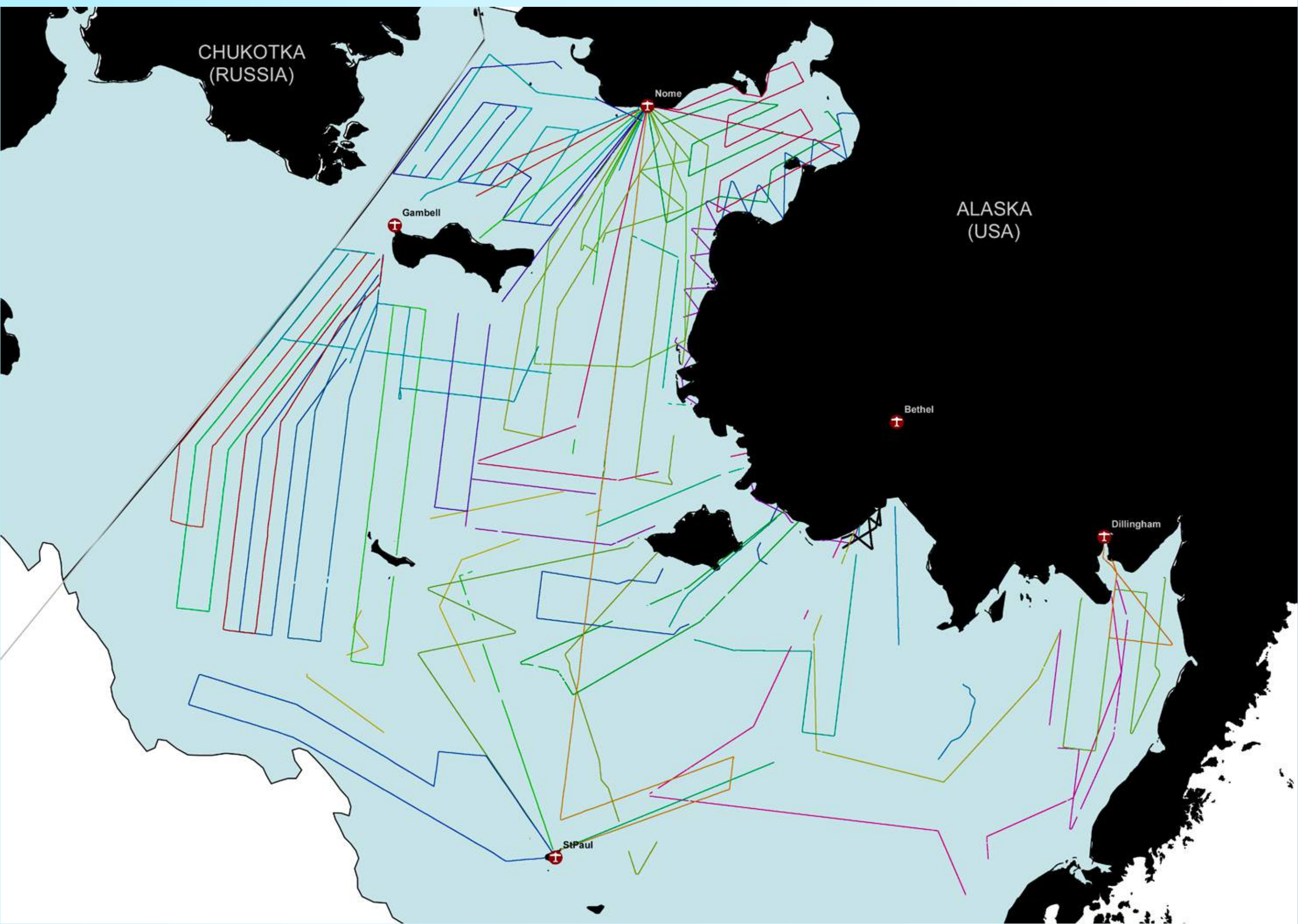# Ice-Associated Seal Detection and Identification from the 2012 Bering-Okhotsk Seal Surveys (BOSS)

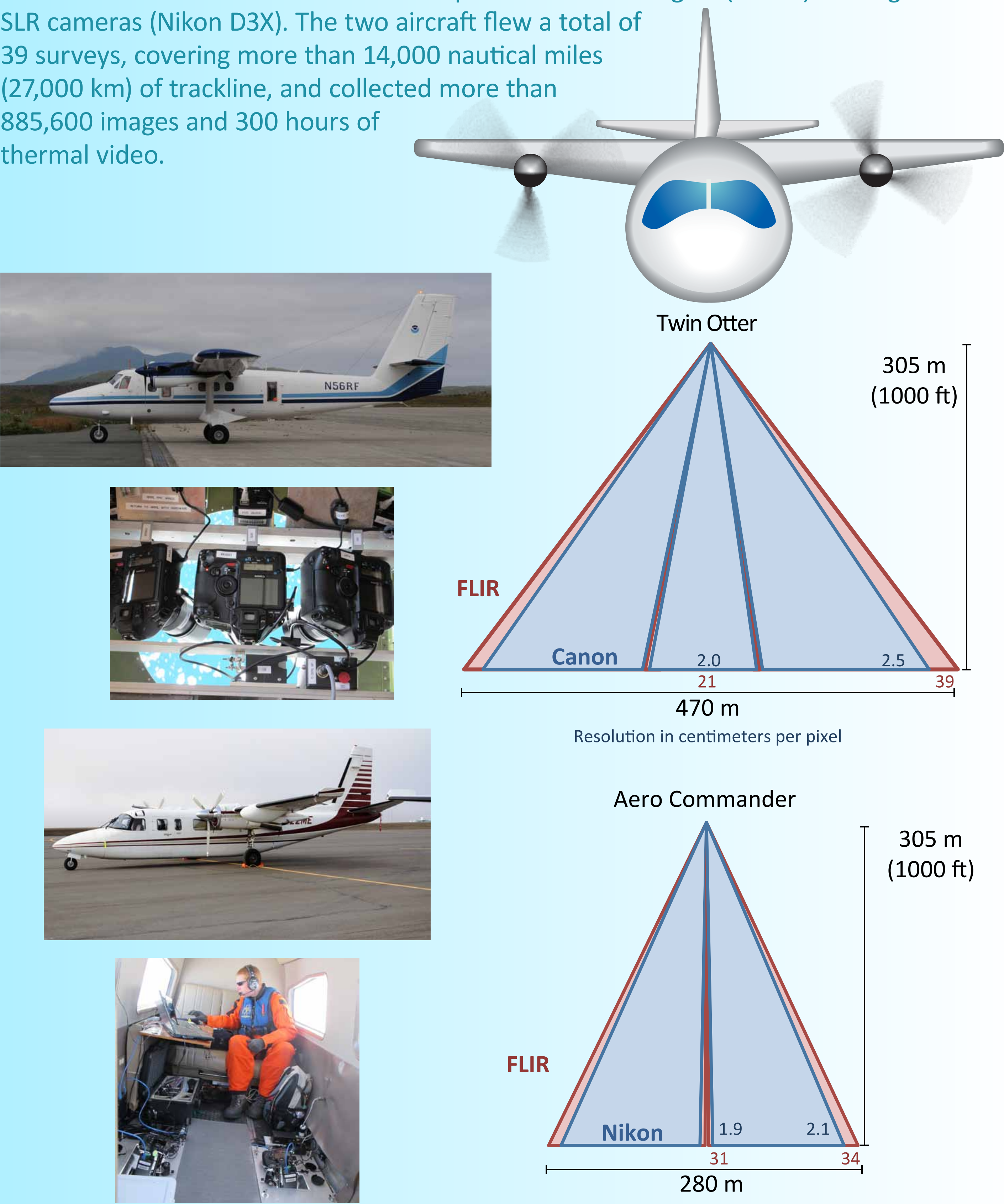Erin Moreland, Brett McClintock, Michael Cameron and Peter Boveng

National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, Seattle, WA 98115

Introduction and Methods

Researchers from the National Marine Mammal Laboratory's (NMML) Polar Ecosystems Program (PEP), in collaboration with Russian colleagues, conducted abundance and distribution surveys for the four species of ice-associated seals (bearded, spotted, ribbon, and ringed seals) that are known to occupy the Bering Sea during the spring and summer. The fieldwork was conducted using digital cameras and thermal imagers mounted in the belly ports of two US and one Russian fixed-wing aircraft in April and May 2012.

A NOAA Twin Otter carried three FLIR SC645 thermal imagers that recorded continuous data in the 7.5-13.0 µm wavelength. Each thermal imager was paired with a Canon 1Ds Mark III digital single-lens reflex (SLR) camera with a 100-mm Zeiss lens. All six instruments were mounted in an open-air belly port. A chartered Aero Commander aircraft carried two sets of paired thermal imagers (SC645) and digital SLR cameras (Nikon D3X). The two aircraft flew a total of 39 surveys, covering more than 14,000 nautical miles (27,000 km) of trackline, and collected more than 885,600 images and 300 hours of thermal video.

Twin Otter

305 m (1000 ft)

FLIR

Canon   2.0   2.5
         21   39
         470 m
Resolution in centimeters per pixel

Aero Commander

305 m (1000 ft)

FLIR

Nikon   1.9   2.1
         31   34
         280 m
Resolution in centimeters per pixel

Thermal Detection

Thermal video is analyzed using temperature profiles. We graph the maximum pixel temperature per frame, apply a temperature threshold and review video frames corresponding to peaks crossing that threshold. We also look at peaks below the threshold that stand out from the background noise. After visually evaluating and accepting a "hot spot" (congregation of pixels warmer than their surroundings) we assign a hot spot ID and export the frame from the video. Using the time of the frame capture to find the corresponding image, we match ice to confirm we identified the appropriate image and finally locate the source of the hot spot in the visual image. Seal species, anomalies (e.g., melt pool or dirty ice) and additional image characteristics are recorded.
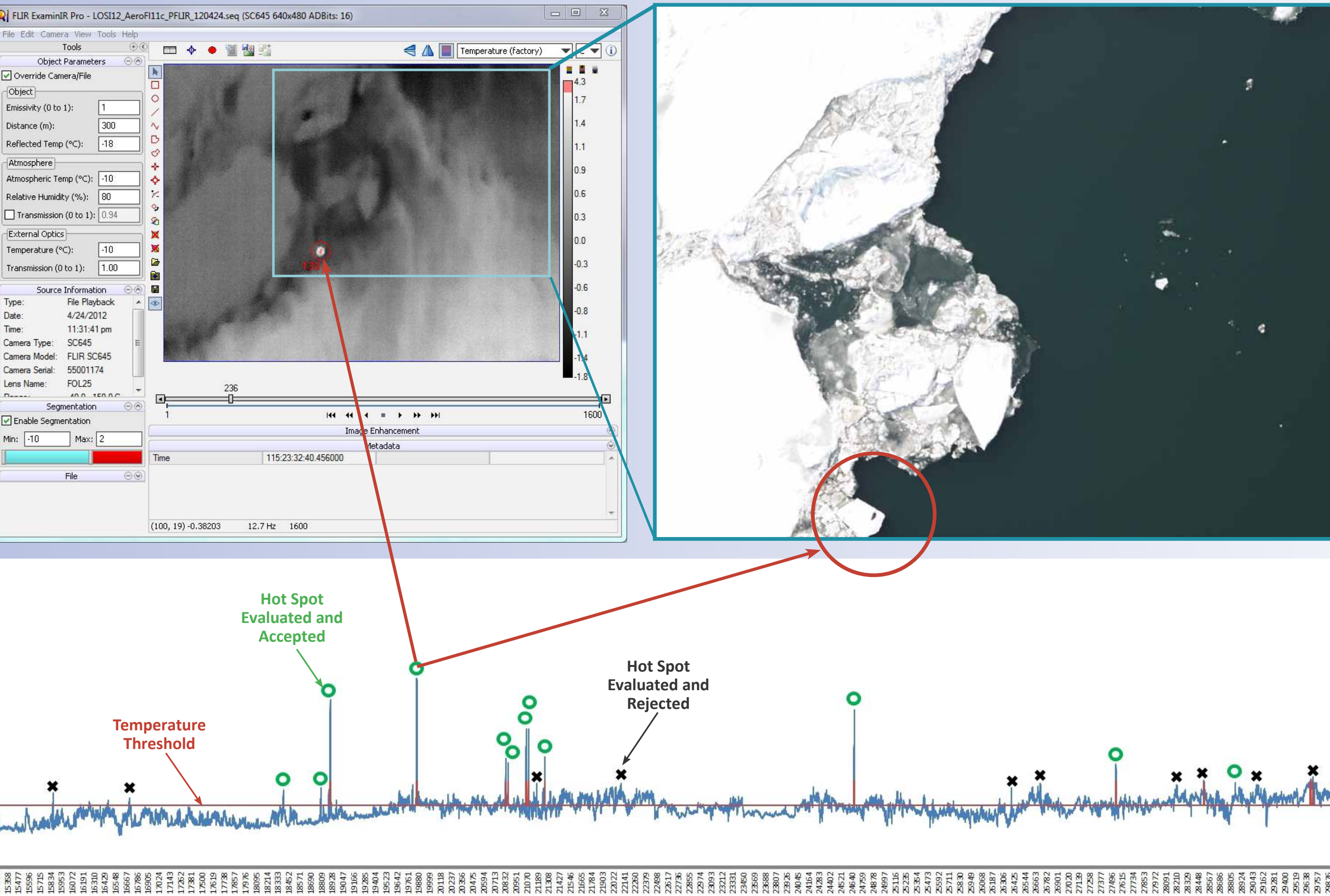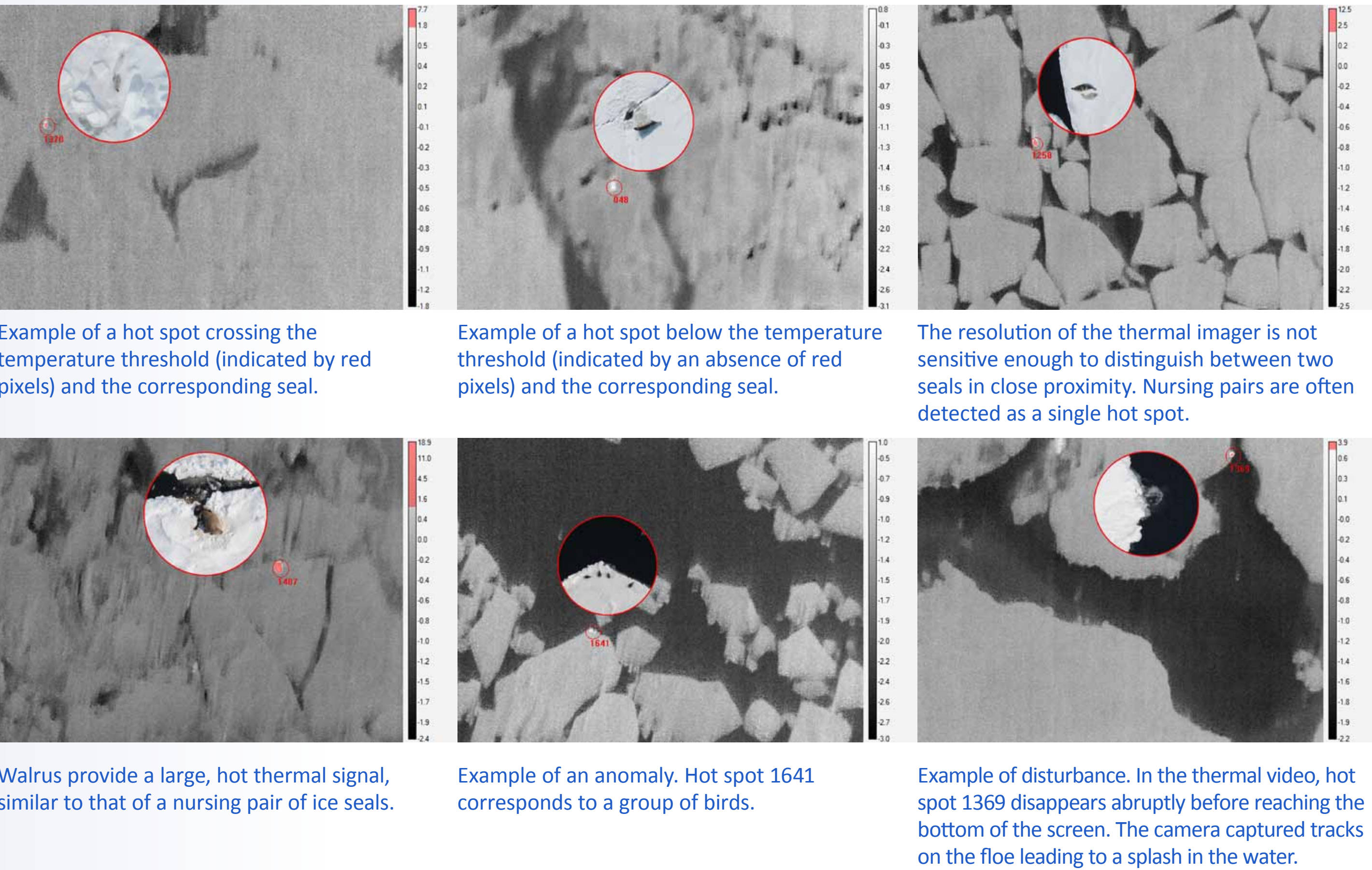
Of the hot spots detected in the preliminary data set, 85% were seals while the remaining 15% were anomalies. Of 113 hot spots corresponding to peaks that did not cross the temperature threshold, only 35% were seals.

Detection Error

In order to estimate detection error, every tenth photo was examined for seals independently of using temperature data to identify hot spots. This systematic sample served as a trial set to test the thermal method for finding seals. Of the 70 seal groups found in 11,724 images examined manually, the thermal detection approach detected 66, indicating an error rate of 6%. When total seals detected using both visual and thermal detections are considered, the thermal detection method finds 95% of all seals while the visual detection method finds 81%.

Hot Spot Evaluated and Accepted

Temperature Threshold

Hot Spot Evaluated and Rejected

Example of a hot spot crossing the temperature threshold (indicated by red pixels) and the corresponding seal.

Example of a hot spot below the temperature threshold (indicated by an absence of red pixels) and the corresponding seal.

The resolution of the thermal imager is not sensitive enough to distinguish between two seals in close proximity. Nursing pairs are often detected as a single hot spot.

Walrus provide a large, hot thermal signal, similar to that of a nursing pair of ice seals.

Example of an anomaly. Hot spot 1641 corresponds to a group of birds.

Example of disturbance. In the thermal video, hot spot 1369 disappears abruptly before reaching the bottom of the screen. The camera captured tracks on the floe leading to a splash in the water.

Species Misclassification

We are accounting for species misidentification in our abundance model by estimating misclassification probabilities for species identified in the images. Several experts are identifying the species of each seal in each image. To learn more about the factors driving the species identification process, our experts are also recording the specific morphological characteristics that are visible in each image. In addition, experts rank their confidence in each species identification as "positive," "likely," or "guess," where it is assumed that positive species identification is the correct species. Replicating the species identification process with multiple observers for each seal allows the probabilities of correct (and incorrect) species identification to be estimated and accounted for in our final estimates of population abundance for each species.
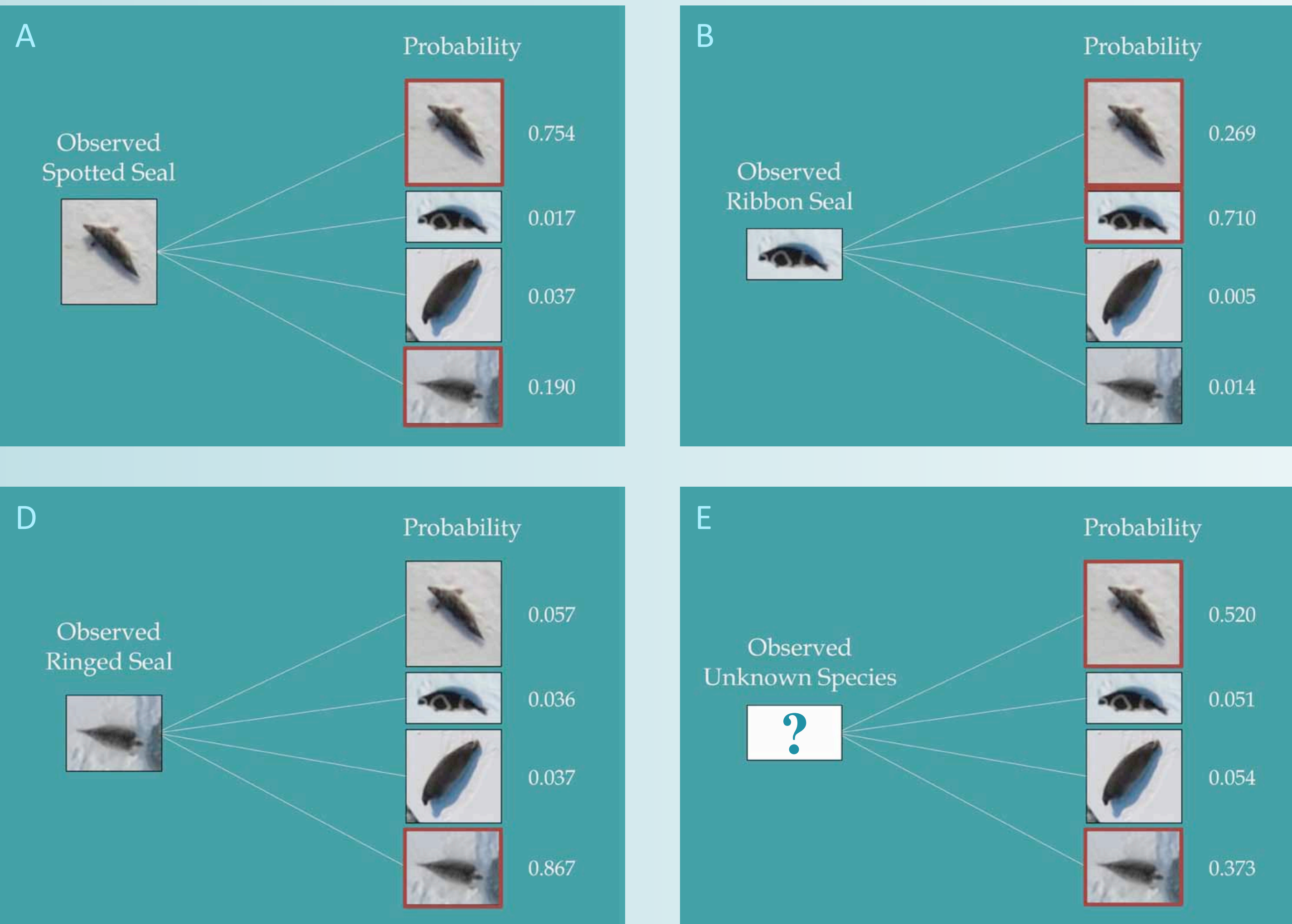
Example of species identification trials for six expert seal observers and four species of ice seals (SD= spotted, RN=ribbon, BD=bearded, RD=ringed, UK=unknown). Observers rank their confidence in the species they identify as positive (red), likely (green), or guess (purple). Statistical models estimate the different species misclassification probabilities and assign species identities to images that are not known with certainty (e.g., seals 4 and 5).

Image ID	Obs. 1	Obs. 2	Obs. 3	Obs. 4	Obs. 5	Obs. 6	Species
1	RN	RN	RN	RN	RN	RN	RN
2	SD	SD	RD	SD	SD	RD	SD
3	BD	BD	RN	BD	RN	BD	BD
4	SD	SD	SD	SD	SD	SD	?
5	RN	UK	UK	BD	RD	UK	?

A

Observed Spotted Seal

Probability
0.754
0.017
0.037
0.190

B

Observed Ribbon Seal

Probability
0.269
0.710
0.005
0.014

C

Observed Bearded Seal

Probability
0.073
0.019
0.835
0.072

D

Observed Ringed Seal

Probability
0.057
0.036
0.037
0.867

E

Observed Unknown Species

?

Probability
0.520
0.051
0.054
0.373

Figures A-E. For any given species identified in an image, our model estimates the probability of the observed species actually being any one of the possible species of ice-associated seals found in the Bering Sea. Using Figure A as an example, if a seal is observed to be a spotted seal in an image, there is a 75% probability that it is a spotted seal and a 19% probability it's a ringed seal.

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