Quantitative Assessment of Species Identification in Aerial Transect Surveys for Ice-Associated Seals

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Abstract

Technological advances have facilitated collection of vast quantities of photographic data from aerial surveys of marine mammals. However, when it is difficult to distinguish species from a distance, reliable identification from aerial images can often be challenging. This is the case for ice-associated seals, species for which global climate change has motivated intensive monitoring efforts in recent years. We assess species and age class identification from aerial images of four ice seal species (bearded seals, *Erignathus barbatus*; ribbon seals, *Histriophoca fasciata*; ringed seals, *Pusa hispida*; spotted seals, *Phoca largha*) in the Bering Sea. We also investigate the specific phenomenological and behavioral traits commonly associated with species identification and observer confidence. We generally found species and age class misidentification occurred at relatively low levels, but only 83% of spotted seals tended to be correctly identified (with 11% mistaken as ribbon seals). We also found certain traits were strong predictors for observed species, age class, or observer confidence. Our findings add to the growing body of evidence that species misidentification is pervasive in passive sampling of animal populations. Even low levels of misidentification have been demonstrated to induce substantial biases in estimators of species distribution and abundance, and it is important that statistical models account for such errors.

Methods

Image collection

- Aerial transect surveys of ice-associated seal species
- April and May in 2012 and 2013
- Eastern Bering Sea
- Target altitude of 300 m, Canon 1Ds Mark III (21 MP) and Nikon D3X (24 MP) fitted with a 100 mm Zeiss lens. Target ground resolution for species identification (2 cm per pixel). Images were collected continuously at a rate of approximately one frame per second with minimal or no overlap.

Species ID data

We randomly selected 716 images containing seals from 10 flights during a one week period from 20-27 April 2012 that provided representative spatial coverage of the study area. These 716 images included 759 distinct seals for species and age class identification.

Four seal biologists assigned species to 600 photographed individuals, and only one of two observers assigned species to the remaining 159 individuals.

For each trial, observers assigned a species, species identification confidence level (guess: < 50%, likely: 51-99%, or positive: 100%), age class (pup, non-pup, unknown), and age class confidence for pup or non-pup classifications (guess, likely, positive).

Characteristics

Prior to commencing the trials, a comprehensive list of potential characteristics was compiled from extensive discussions with ice seal biologists. This included traits as seen specifically in aerial imagery, which were not necessarily consistent with traits seen on the ground (e.g. white band around neck and serpentine body position).

Assumptions

- Any positive species or age observation is the true species or age class.
- Non-pups cannot be positively misclassified as pups.
- Positive species or age class confidence levels are correct, and conflicting positive classifications are therefore not permitted.

Analysis

We are able to estimate misidentification probabilities by repeated sampling of multiple observers and treating observations with positive confidence levels as truth. We performed our analysis in R using the rjags package, compared observer effects, and performed an additional analysis assuming no observer effects.

For each observed species and age class, we performed logistic regressions to identify the traits that best predicted the observed species and species confidence levels. To identify the traits that best explained the observed species, we first ignored observer confidence levels and treated the response as binary (e.g., SDP or not SDP; Fig. 1). To identify the traits that best predicted positive species identifications, we performed logistic regressions using only the observations in which each particular species and age class was identified (i.e., only those observations with guess, likely, or positive confidence levels for both the particular species and age class). For this second set of analyses, we ignored age class confidence levels and again treated the response as binary (e.g., positive SDP or non-positive SDP; Fig. 2). For both sets of analyses, the predictors were binary indicators for the presence or absence of each trait (below).

Characteristics used to identify four species of ice-associated seal from aerial survey images.

Behavior
- Within 1 body length of edge on non-small ice floe
- On small ice floe (<2 body lengths)
- Close proximity to a maintained hole in ice floe
- 3 or more associated non-pups
- Two non-pups associated with one pup
- "Associated" with another seal within 6 body lengths
- >1 body length from edge on non-small ice floe
- On non-small ice floe (>3 body lengths)

Body shape or position
- Short broad square fore flippers
- Tubular or "cigar-like" body shape
- Approximately 2/3 the length of an associated seal
- "American football" or "comma" shape
- Long, slender neck
- Long hindflippers
- Long slender fore flippers
- Serpentine body position
- Slender posterior
- "Torpedo-like" or "elongated teardrop" shape
- Other fore flipper characteristics (not lsff or sbsff)
- Other body shape

Head
- Beard-like vibrissae
- Reddish coloration on face
- Small blunt head relative to body size
- "T"-shaped pattern on forehead
- "Cat-like" face; compact features, short muzzle
- Other face type (not catlike or doglike)
- "Dog-like" face; wide skull, long muzzle

Pelage
- Light, uniform coat
- White band around neck
- 1 or more distinct ribbons
- Dark coat with no spots
- 1 faint ribbon
- 2-3 faint ribbons
- White lanugo
- Off-white lanugo
- Mottled coat; spots or rings

Track
- Alternating flipper pattern in tracks
- Serpentine track pattern
- Paired flipper pattern in tracks
- Straight track pattern

Results

Examples of the top predictive characteristics for each species

Spotted seals:
- Triad (two adults with one pup)
- Dog-like snout
- Long slender foreflippers
- Offwhite and white lanugo

Ribbon seals:
- One distinct ribbon
- Two faint ribbons
- Serpentine body position

Bearded seals:
- Within one body length of the ice edge
- Red face
- Small head
- Tubular body
- Pup: 2/3 length of associated adult

Ringed seals:
- Close to breathing hole
- Football shaped body
- Neckband*

**effect only seen in aerial imagery*

Correct Species Identification Probabilities (95% CI)

Species	Probability of being identified correctly	Most often misidentified as:
Spotted	0.83 (0.80-0.86)	Ribbon 0.11 (0.09-0.14)
Ribbon	0.97 (0.93-0.99)	Ringed 0.01 (0.00-0.03)
Bearded	0.96 (0.93-0.98)	Spotted 0.03 (0.02-0.04)
Ringed	0.94 (0.92-0.96)	Spotted 0.03 (0.02-0.04)

All species had a 1-2% chance of being assigned to the unknown species category.

Figure 1. Species and Age Class Identification Probabilities

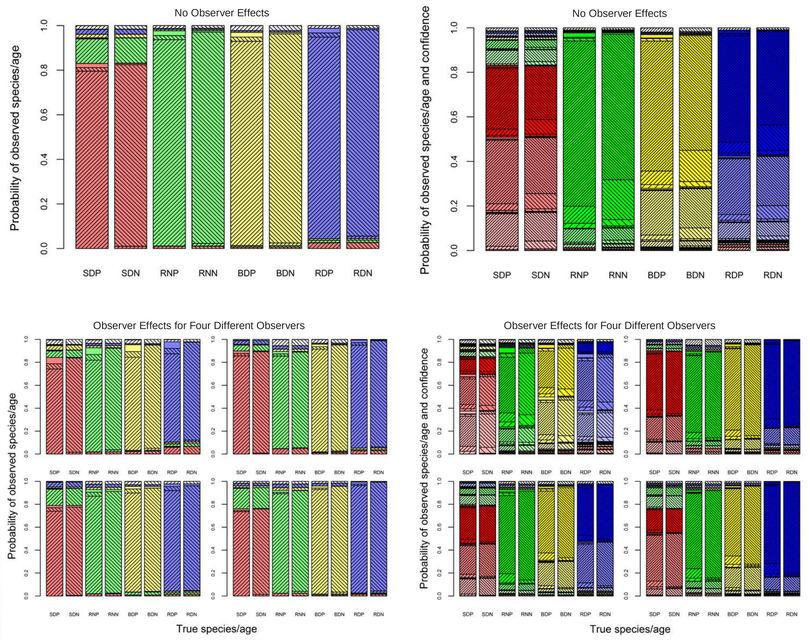

Figure 2. Species, Age Class, and Confidence Level Probabilities

Discussion

We generally found species and age class misidentification to occur across all species and observers. While species misidentification rates appear to be low for ribbon, bearded, and ringed seals, we found spotted seals were frequently mistaken for other species, and ribbon seals in particular. We attribute this to observers generally being less confident about spotted seal observations and a tendency for spotted seals to resemble ribbon seals when their distinctive pelage patterns are obscured or absent. Age class misidentification rates were similarly low across species, although we found evidence that pups may be slightly more likely to be mistaken for non-pups.

Variation in both misidentification rates and confidence levels among our observers suggest it may be important to include observer effects in species distribution and abundance models that account for these sources of uncertainty.

Our observers had differing levels of field and photo-identification experience, and while experience is expected to affect observer performance, we did not attempt to incorporate individual covariates as predictors in our model. We instead included generic effects for each observer and found strong evidence of differences among our observers. These differences could be attributable to many factors, including (but not limited to) experience, personality, age, vision, and health. This remains an interesting avenue for future research.

Our methodology can be used to assess the identification process for a wide variety of species from aerial or satellite imagery and provides a mechanism for accounting for misidentification in models of species distribution and abundance.

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BOEM Bureau of Ocean Energy Management

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