Mammalian Biology

Ways Forward in Sea Otter Photo-identification

--Manuscript Draft--

Manuscript Number:	
Full Title:	Ways Forward in Sea Otter Photo-identification
Article Type:	Short Communication
Funding Information:	Earthwatch Institute — Dr. Heidi C Pearson
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Ways Forward in Sea Otter Photo-identification

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Acknowledgements

The studies presented in this paper were funded by the Earthwatch Institute. We thank the numerous volunteers and research assistants that helped with data collection and analysis. We thank Ryan Wolt for providing comments on the manuscript. Data were collected under Letter of Confirmation No. MA-043219 from the U.S. Fish & Wildlife Service.

Abstract

Many sea otters can be recognized by distinct nose scars, which are acquired by females during mating and males during conspecific fighting. We used photo-identification in a long-term study of sea otters in Simpson Bay, Prince William Sound, Alaska. Here, we review our: 1) findings pertaining to mark rate, sighting rate, and rate of mark change; 2) application of photo-identification to our studies of territorial males; 3) methodological accomplishments and challenges; and 4) suggestions for future work. Mark rate was 45%, and average resighting rate for individuals within a season was 8 (range = 2-26), demonstrating suitability of photo-identification for sea otters. We had few inter-annual resightings, indicating a high rate of mark change or low inter-annual site fidelity. We used photo-identification to study territorial males, which enabled us to conduct focal animal sampling of 23 males during a 3-year period to assess territory fidelity and territory quality. We matched digital images of sea otters through a manual method and a semi-automated matching program, which used a blotch-pattern recognition algorithm to match individuals. However, the time-intensive nature of both methods prohibited application of photo-identification in our study beyond the first five years. Automated facial recognition technology holds promise for overcoming these challenges. Sea otters could be identified according to morphological attributes that are more stable than nose scars (e.g., nose shape, eye to nose distance ratio, septum length, vibrissae patterns).

Keywords: sea otter, *Enhydra lutris*, nose scar, individual recognition, photo-identification, Alaska

Individual identification has long been an important component in studies of ecology and evolution (e.g., Würsig and Würsig 1977; Katona and Whitehead 1981; Goodall 1986; Clutton Brock and Sheldon 2010; Moss et al. 2011). As natural selection occurs at the level of the individual, it is through study of individuals and their behaviors that we can more fully comprehend evolutionary drivers (Williams 1966). Further, tracking individuals through time allows for more accurate representations of life history strategies; foraging, mating, and social behaviors; habitat use; and movement patterns, all factors that are fundamental in conservation and management strategies (Würsig and Jefferson 1990; Clutton-Brock and Sheldon 2010; Mann and Karninski 2017).

Photo-identification is a non-invasive method for individual identification that relies on images of individually distinct, naturally occurring external marks (i.e., a small area having a different color from its surroundings) or features (Würsig and Jefferson 1990). For the method to be reliable, these marks must also be stable through time or sampling must occur at a high enough frequency to track changes through time. Further, images should meet inclusion criteria based on photographic quality (e.g., based on lighting, focus, distance to the subject, angle of the subject to the camera) and mark distinctiveness (Würsig and Jefferson 1990; Friday et al. 2000; Read et al. 2003; Gilkinson et al. 2007).

Sea otters are a good species for photo-identification because they are reliably visible on the sea surface (i.e., they spend the majority of their time floating at the surface or swimming on their backs), have relatively short dive times (average *ca*. 2 min, maximum *ca*. 4 min; Wolt et al. 2012), and inhabit the nearshore environment (Bodkin et al. 2004), which facilitates access. In addition, many individuals exhibit distinct nose scar patterns obtained through mating (for females; Foott 1970) or agonistic interactions (for males; Pearson and Davis 2005) (Fig. 1).

We used photo-identification to study a stable sub-population of approximately 138 sea otters (includes all age-sex classes; Gilkinson et al. 2007; Finerty et al. 2010) in Prince William Sound, Alaska that has been the focus of long-term research since 2001. Our study site was Simpson Bay, which is used primarily by female-pup pairs and dominant males that maintain aquatic breeding territories containing resources attractive to females (Pearson et al. 2006; Finerty et al. 2010). A systematic photo-identification study occurred during the summers of 2002-2003 (Gilkinson et al. 2007), with targeted effort on territorial males from 2003 to 2006 (Pearson and Davis 2005; Pearson et al. 2006; Finerty et al. 2010). Below, we: 1) summarize our findings pertaining to mark rate, sighting rate, and rate of mark change; 2) describe how we applied photo-identification to our studies of territorial males; 3) discuss methodological accomplishments and challenges; and 4) offer suggestions for future work.

Mark rate, or the proportion that had distinctive nose scars, was 45% (Table 1; Gilkinson et al. 2007). This is similar to the occurrence of distinctive marks in other marine mammal species (summarized in Gilkinson et al. 2007), demonstrating suitability of sea otters for photo-identification.

Over a two-year period, sighting rate (i.e., the rate at which an individual was re-identified photographically using distinctiveness criteria; see Gilkinson et al. 2007) averaged 3.3 sightings individual^{-1} (range = 1-26; Table 1). Considering only those individuals re-identified more than once (n = 54, 47%), average resighting rate was 8.1 sightings individual^{-1}. Of all individuals photo-identified during the first year of the study, 19% (n = 8) were seen in the second year.

Intra-annual resighting rate was 2-fold higher than inter-annual resighting, indicating that photo-identification is a reliable method for annual tracking. While we did not record specific data on the rate of mark change, our low inter-annual resighting rate indicates that it may be substantial. However, an alternative explanation is low site fidelity of sea otters to Simpson Bay as documented by Monnett and Rotterman (1988). Females obtain nose scars while mating, during which the male bites the female's nose to obtain the copulatory hold (Foott 1970). As females can mate every 1-2 years (Riedman and Estes 1990; Jameson and Johnson 1993), it is possible for female nose scars to change with each successive mating season. However, mating does not always result in a nose scar, as we have observed females with pups without nose scars (Gilkinson et al. 2007).

Male nose scars also may change through time. In one example, we photographed changes in the nose scar of a territorial male over a 74-d period (Fig. 2). While the cause of this change is unknown, it is likely to be a result of pigmentation changes in the scar tissue rather than a wound incurred during an agonistic encounter. Over this period, we conducted 25 h of focal animal observations (Altmann 1974; Mann 1999) and did not observe any agonistic interactions or any evidence of a fresh nose wound (e.g., blood; H. Pearson, unpubl. data).

Our primary application of photo-identification was to study the territoriality of males. As males are typically more approachable than females and reliably found within their territories (H.

Pearson, pers. obsv.), photo-identification can be used in conjunction with detailed behavioral observation (e.g., focal animal sampling; Altmann 1974; Mann 1999; Pearson and Davis 2005; Pearson et al. 2006). During 2003-06, we used nose scars to identify 23 territorial males for which we assessed behavior and territory quality. Most (*n* = 18, 78%) males maintained a territory for only one year, while 22% (*n* = 5) maintained a territory for two years. Photo-identification allowed creation of a catalogue of territorial males that was used to answer questions related to site fidelity and inter-annual changes in territory quality (Finerty et al. 2010).

We used two methods to match the nose images obtained with a digital camera and 80-400 mm image-stabilized lens (Nikon D1H). In the first method, the best image of each individual was selected and digitally cropped (Adobe Photoshop 7.0, Adobe Systems, San Jose, CA) to isolate the face (Fig. 1). Two experienced observers independently matched all images that met inclusion criteria for photographic quality and scar distinctiveness (Finerty et al. 2007).

We later used a custom, semi-automated matching program (Sea Otter Nose Matching Program or SONMaP). SONMaP used a blotch-pattern recognition algorithm to identify individual sea otters based on their nose scars. After isolating the nose from the face (Adobe Photoshop 7.0, Adobe Systems, San Jose, CA), each image was uploaded to SONMaP and a computer cursor was used to interactively mark the location of the scar(s) on each nose. A matching algorithm in SONMaP compared each image with those already catalogued. An ordinal list of best possible matches was then generated which the user visually checked to make the final matching decision. While SONMaP reduced matching effort by 67% as compared to the manual method, it was still labor intensive, requiring 0.9-2.7 h to make a single match (*vs*. 3.4-6.8 h using the strictly manual method). In addition, there was the possibility for bias because of inter-user variability in designating scars (Finerty et al. 2007).

Based on our research, we identified four limitations to applying photo-identification to sea otters. First, it is not possible to approach all sea otters at the distance required to obtain high quality photographs, leading to unequal re-identification, which may bias results (Gilkinson et al. 2007). In general, males are more approachable than females with pups. Further, it is challenging to closely approach sea otters in regions where subsistence sea otter hunting occurs (e.g., Southeast Alaska; H. Pearson, pers. obsv., Raymond et al. 2019). Second, as discussed above, the rate of mark change may prevent long-term tracking of individuals. Third, there is currently no method for identifying sea otters with unscarred noses, which in our study constituted 55% of individuals sampled (Gilkinson et al. 2007). Finally, the currently available image-matching methods are prohibitively time-consuming for practical use.

While the first two limitations are unlikely to be overcome, the latter two issues could be solved with automated facial recognition technology. This method has been successfully applied to brown bears (*Ursus arctos*; Clapham et al. 2020), giant pandas (*Ailuropoda melanoleuca*; Chen et al. 2020), chimpanzees (*Pan troglodytes*; Loos and Ernst 2013; Schofield et al. 2019), rhesus macaques (*Macaca mulatta*; Witham 2018), red-bellied lemurs (*Eulemur rubriventer*; Crouse et al. 2017), and domestic dogs (*Canis familiaris*; Moreira et al. 2017). In sea otters, facial recognition could be used to recognize individuals based on unique morphological attributes that are more stable than nose scars such as nose shape, eye to nose distance ratio, septum length, and vibrissae patterns.

A potential limitation of using facial recognition for wild populations is that automatic detection and extraction of features via deep learning techniques requires a large number of images of already identified individuals for training and testing (Clapham et al. 2020). Our image catalogue, which contains > 1,600 images of nearly 200 individuals, would expedite development of this method. If successful, automated facial recognition would facilitate non-invasive study of sea otters at the individual level across a larger temporal scale than is currently possible.

Our research showed that it is possible to recognize and track individual sea otters over a scale of 1-2 years using photo-identification. However, the software available for facial recognition in 2003 was not fully automated and remained time-intensive. The advent of new, commercially available facial recognition software, which has been developed for identifying and tracking humans (e.g., Fuentes-Hurtado et al. 2019; Roussi 2020), may be applicable to other species which will enhance long-term study of sea otter behavior at the individual level.

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Figure Captions

Fig. 1 Sea otters may be identified by individually distinct nose scar patterns. For initial classification prior to manual matching, scars were categorized as: a) single small, b-d) two or more small, or e-f) large. Photos by Heidi Pearson taken under Letter of Confirmation No. MA-043219 from the U.S. Fish & Wildlife Service.

Fig. 2 Changes in the nose scar of a territorial male documented during 2003 on: a) Jun 18, b) Jul 3, c) Jul 21, d) Jul 28, e) Aug 1, f) Aug 11, g) Aug 17, h) Aug 27, and i) Aug 31. Photos by Heidi Pearson taken under Letter of Confirmation No. MA-043219 from the U.S. Fish & Wildlife Service.

Caption for photo of study animal: An adult male sea otter (*Enhydra lutris*) grooming in his territory in Simpson Bay, Prince William Sound, AK. Photo by Heidi Pearson taken under Letter of Confirmation No. MA-043219 from the U.S. Fish & Wildlife Service.

Table 1. Mark rate and sighting rate (no. sightings/individual) by sex for sea otters in Simpson Bay, Prince William Sound, AK (Gilkinson et al. 2007).

	Male	Female	Unknown Sex
Mark rate	63% (*n* = 19)	45% (*n* = 45)	40% (*n* = 49)
Sighting rate	6.1	3.4	2.3

Figure 1

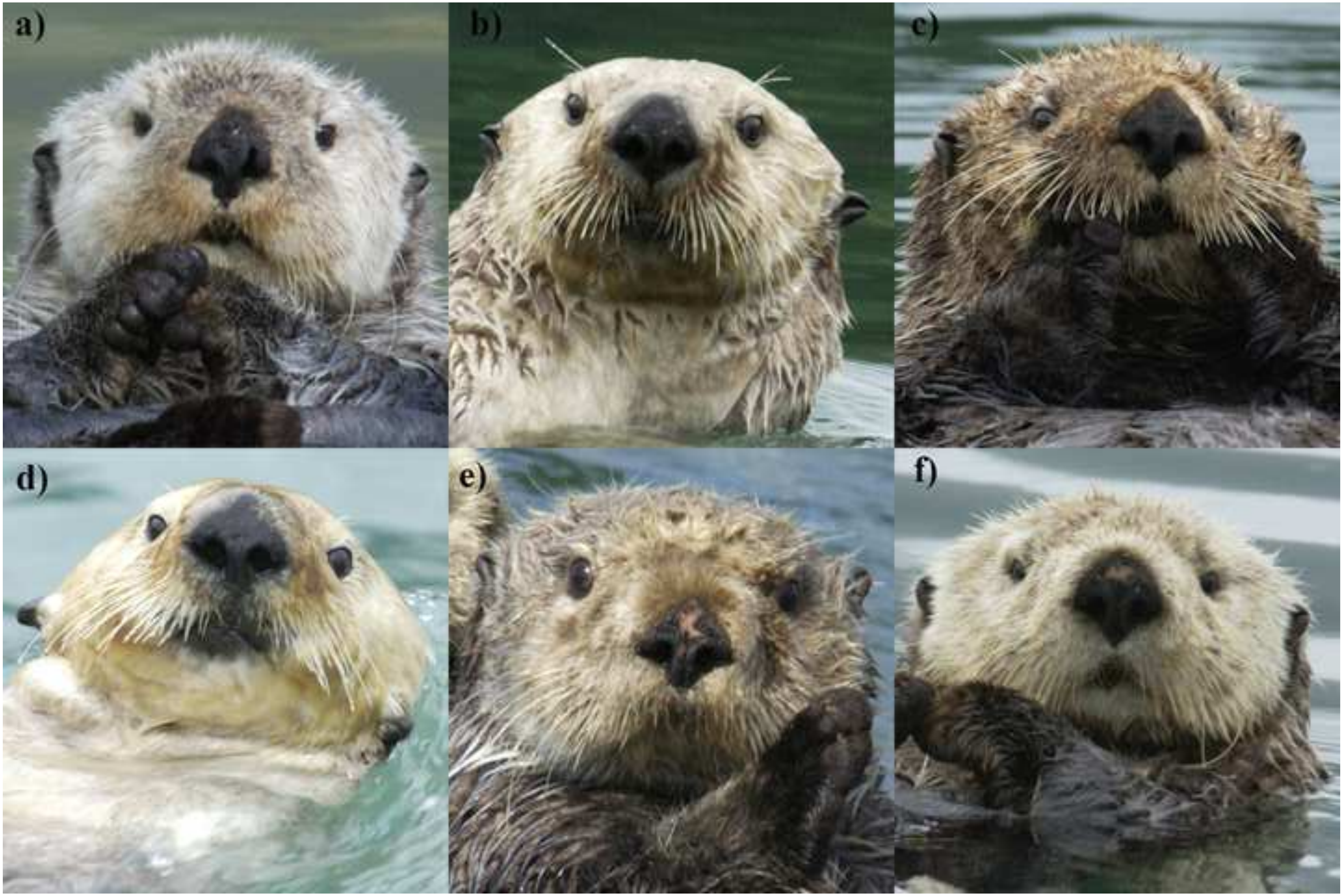

Figure 2