Photo-Identification of Sea Otters Using Nose Scars

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ABSTRACT We evaluated the use of naturally occurring nose scars to identify individual sea otters (*Enhydra lutris*) in Simpson Bay, Prince William Sound, Alaska, USA. We spent 520 hours over 103 days conducting photo-identification surveys from June to August 2002 and 2003. Altogether, we identified 114 individuals. The number of sightings per individual ranged from 1 to 26, with an average of 3.3. The maximum number of sightings of an individual within a single year was 19. We saw 54 otters (47%) on >1 day, with an average of 8.1 sightings per individual for those seen more than once. We identified 8 individuals (19% of those identified in 2002) in both years. Males and otters of undetermined sex that we first sighted in June had the highest re-sighting rates. We considered 45% of all individuals encountered identifiable from nose scars. Nose scars were present in 63% ($n = 19$) of males, 45% ($n = 45$) of females, and 40% ($n = 49$) of otters of undetermined sex. Our results are similar to the results of photo-identification studies of other marine mammals, suggesting that this technique may be a useful tool for the individual identification of sea otters as well. (JOURNAL OF WILDLIFE MANAGEMENT 71(6):2045–2051; 2007)

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The importance of individual recognition for the understanding of species' ecology and behavior has long been acknowledged (Würsig and Jefferson 1990, McGregor and Peake 1998). It allows for detailed studies of survival, movement patterns, reproduction, foraging, and life histories, and it enables an understanding of individual variation within a population. Many systems of artificial marks have been used to identify individual animals, including both invertebrates and vertebrates from many taxonomic groups. These systems include notching of the ear, toe, fin, or scale; tattooing, dyeing, or branding; tagging; and attaching satellite and radioiotransmitters (McGregor and Peake 1998). However, applying artificial marks, tags, or transmitters to an animal requires that it be captured, which may injure the animal or handler and alter the animal's behavior or relationship with other individuals (McGregor and Peake 1998, Markowitz et al. 2003). To reduce these risks, some researchers have taken advantage of naturally occurring variation in physical appearance to recognize individuals. Individual phenotypic variation in color patterns (e.g., zebras [*Equus* sp.], giraffes [*Giraffa* sp.], cheetahs [*Acinonyx jubatus*]), facial characteristics (e.g., Bewick's swans [*Cygnus columbianus*], chimpanzees [*Pan troglodytes*]), and even wrinkle patterns (e.g., black rhinos [*Diceros bicornis*], ostriches [*Struthio camelus*]) have been used. Some researchers also have made use of marks created by natural injury (e.g., ear nicks in elephants; Pennycuick 1978, Slooten et al. 1992, McGregor and Peake 1998, Evans and Yablokov 2004).

Using natural marks to identify individuals has become a widespread practice in the study of marine mammals during the past 20 years. The use of photographs or digital images to identify individuals has revealed a high degree of variation in either pigmentation or scar patterns in many species. Photo-identification has been used in studies of cetaceans (reviewed by International Whaling Commission 1990) including both toothed whales (Arnbom 1987, Würsig and Jefferson 1990, Whitehead et al. 1997) and baleen whales (Rugh 1990, Calambokidis and Barlow 2004), sirenians (Reid et al. 1991, Langtimm et al. 1998), and even some pinnipeds (Forcada and Aguilar 2000, Abt et al. 2002). Applications of this technique include mark–recapture population estimates (Karczmarski et al. 1999) and studies of short- and long-distance movements (Rugh 1990, Neumann et al. 2002), residency patterns (Bejder and Dawson 2001), reproduction (Thayer et al. 2003), social relationships (Shane and McSweeney 1990), survival rates (Langtimm et al. 1998), and disease patterns (Wilson et al. 2000).

One of the few marine mammals with which photo-identification has not been attempted is the sea otter (*Enhydra lutris*), even though it has long been acknowledged that some individuals are recognizable. Foott (1970) first noted that female nose scars incurred during copulation could be used as a natural feature for identification. Since then, several other studies have used this method of identification to a limited extent (Calkins and Lent 1975, Loughlin 1980, Garshelis 1983), but no study has systematically explored the prevalence of scarring in sea otters or the degree to which nose scars may be used for identification. The purpose of this study was to assess the prevalence of nose scars and their potential use for individual recognition.

STUDY AREA

We conducted this study in Simpson Bay (approx. 60.6°N, 145.9°W), located in northeastern Prince William Sound, Alaska, USA (Fig. 1), because of the reliable presence of sea otters and protection from rough seas. It was approximately 21 km^2 in area; 7.5 km in length in the northwestern arm, 5 km in length in the southeastern arm, and 2.5 km across at the widest point. Maximum water depth was 125 m, with an average depth of about 30 m. Bottom sediments consisted of glacial clay, silt, and gravel, with some rocky hard reefs.

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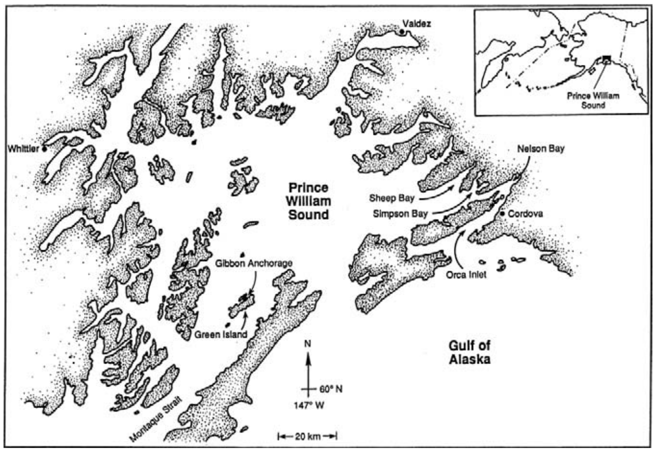

Figure 1. Prince William Sound, Alaska, USA (from Riedman and Estes 1990). We studied sea otters in Simpson Bay, Alaska, from June to August 2002 and 2003.

There were no large-bodied kelps (e.g., *Nereocystis* spp.) that form surface canopies. The bay was recolonized by male sea otters in 1977, and females moved into the area between 1983 and 1985 (Garshelis 1983, Rotterman and Simon-Jackson 1988, VanBlaricom 1988). It is currently used during the summer by 100–150 sea otters, including adults, subadults, and pups (R. W. Davis, Texas A&M University, unpublished data).

METHODS

Photo-Identification Surveys

We took digital images of sea otters from June to August 2002 and 2003. We divided the study area into 3 survey sections (Fig. 2) for logistical purposes. A single survey consisted of identifying the otters in 1 of the 3 sections. We surveyed the sections of the bay in a systematic rotation, which allowed us to cover the entire bay every 1.5–2 days depending on weather. Dividing the study area into sections and surveying them in rotation also ensured more uniform coverage of the entire area.

The research team, composed of a driver, photographer, recorder, and spotter, conducted surveys from a 5-m skiff between 0900 hours and 1700 hours local time. To maximize otter encounters, we did not follow a systematic vessel track. We opportunistically approached as many otters as possible in the boat, but we avoided approaching any individual more than once during a survey. We took digital images with a Nikon D1H digital camera (Nikon, Tokyo, Japan) with an 80–400-mm image-stabilized telephoto lens.

When we sighted an otter, the skiff operator approached the animal slowly while the photographer attempted to obtain an image of the otter's face, usually at a distance of about 30 m. We recorded time, location (using a Global Positioning System), behavior before disturbance, sex, and presence of a pup. We determined sex when possible by noting the presence of a penile ridge or testicular bulge for males or the presence of abdominal mammae or a pup for females (Kenyon 1975, Estes 1980, Rotterman and Simon-Jackson 1988, Reidman and Estes 1990). This research was conducted under Letter of Confirmation Number MA-043219 from the United States Fish and Wildlife Service.

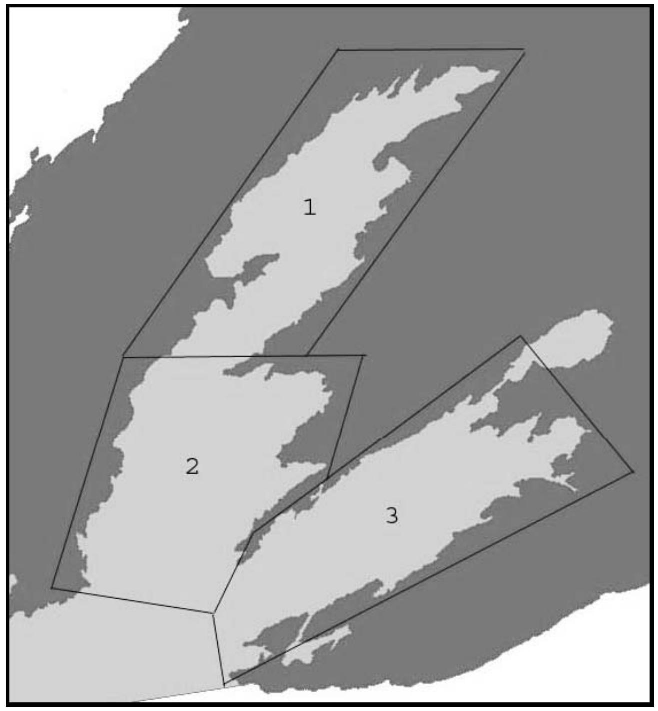

Figure 2. Photo-identification survey sections for sea otters at Simpson Bay, Alaska, USA, from June to August 2002 and 2003.

Photo-Identification Analysis

We sorted the images from each survey, and we selected the best images of each individual and then cropped them to isolate the face using Adobe Photoshop 7.0 (Adobe Systems, San Jose, CA). We used only those selected images for subsequent analysis. We adapted our rating system for image quality and individual distinctiveness from Arnbom (1987), Chilvers and Corkerson (2003), and Read et al. (2003). We rated each image for photographic quality (Q) based on focus, angle of the nose to the camera, lighting and contrast, and image size on a scale of 1–4 (Table 1). We then rated all images of quality rating Q2 or above for individual distinctiveness (D) according to the size, shape, and placement of the nose scar on a scale of 1–5 (Table 1; Fig. 3). We considered images rated Q1 too poor to accurately assess distinctiveness (Friday et al. 2000), and we did not use them for further analysis. We considered images rated Q3 and D3 or higher suitable for individual identification. In addition, we also used those ranked Q2–D5. In addition to nose scars, we used supporting information such as sex, pelage color around the head, and the presence of discolored or broken teeth to confirm a match.

Two experienced observers performed image matching independently (A. Gilkinson and H. Pearson), and only those pairings that both observers agreed on were considered matches. During the first year, we compared each image with every other image to determine the number of individuals and number of matches for each individual. We then assigned each identifiable otter a number and entered it into

Table 1. Rating systems for picture quality and individual distinctiveness for sea otters digitally imaged in Simpson Bay, Alaska, USA, from June to August 2002 and 2003.

Rating	Criteria
Q1	Very poor quality image. Displays ≥2 of the flaws listed in Q2 or >3 flaws listed in Q3
Q2	Poor quality image. Displays 1 of the following flaws or 2–3 of the flaws listed in Q3: image out of focus; all of nose is not visible or exact location of scars is questionable; image is very light or very dark; visibility of nose distorted by water or glare; nose is small in the frame
Q3	Good quality image. May have 1–2 of the following minor flaws: image slightly out of focus; head is turned slightly to the side or tilted slightly forward or backward; image exposure somewhat light or dark; nose appears of medium size in the frame
Q4	Excellent quality image. Image is clear; otter is directly facing camera; good contrast; nose is clearly visible and appears large in frame
D1	No nose scars or other identifying features
D2	Nose has some scars, but they are indistinct
D3	Nose has 1 small scar or identifying feature of distinctive location or shape or ≥2 very small scars forming a distinctive pattern
D4	Nose has ≥1 distinctive medium-sized scar or has ≥2 small or less distinctive scar or identifying features that form a distinctive pattern
D5	Nose scars are highly distinctive, including a large scar or scar pattern that is evident or distinctive even in a poor quality image

an image catalog. After we established the catalog, we compared new images to those in the catalog. If we could not match an image, we entered it as a new individual.

Prevalence and Demographics of Scarring

We estimated the percentage of otters in the study area with distinctive scars by comparing the number of unscarred individuals (rated D1 and D2) to the number of individuals in the catalog (rated D $\geq$ 3). We used all images of acceptable quality rating (Q3–4 images for D1–4 individuals, Q2–5 images for D5 individuals). To estimate the number of individuals seen without scars, we calculated sex-specific re-sighting frequencies of scarred otters and divided the number of individuals within each category (M, F, unknown) without scars by these frequencies, because we assumed that scarring has a minimal affect on sighting frequency. For example, there were 65 sightings of unscarred males, and the average number of sightings per scarred male was 6.1; so, the estimated number of unscarred males in the study area was 11 (65 divided by 6.1). We determined prevalence of scarring for both the population as a whole and for each sex.

RESULTS

We spent approximately 520 hours during 103 days over the 2 years in conducting photo-identification surveys: 278 hours over 54 days in 2002 and 239 hours over 49 days in 2003. We surveyed the bay during 14 periods of about 1 week each (7 periods spread equally each summer from Jun to Aug), and we covered the entire study area approximately 3 times for every survey week. We encountered otters during every survey with a total of 1,765 encounters: 824 in 2002 and 941 in 2003. We conducted a census of otters in the study area from 2 skiffs during each survey week in 2002 and 2003. The average numbers of adult otters and pups in the study area were 93 $\pm$ 15.2 (SD) and the 29 $\pm$ 8.7 (SD), respectively, and there were no significant ($P < 0.05$) differences between years (R. W. Davis, Texas A&M University, unpublished data).

Overall, we obtained 816 good quality (Q $\geq$ 3) images, with 380 (47%) containing distinctively scarred individuals (D $\geq$ 3). From these images, we were able to identify 114 individual sea otters: 19 adult males, 45 adult females, and 49 adults of undetermined sex. The number of individuals identified increased continuously throughout the sampling period (Fig. 4). The number of sightings per individual ranged from 1 to 26, with an average of 3.3. The maximum number of sightings of an individual within a single year was 19 (Fig. 5). We saw 54 otters (47%) on >1 day with an average of 8.1 sightings per individual for those seen more

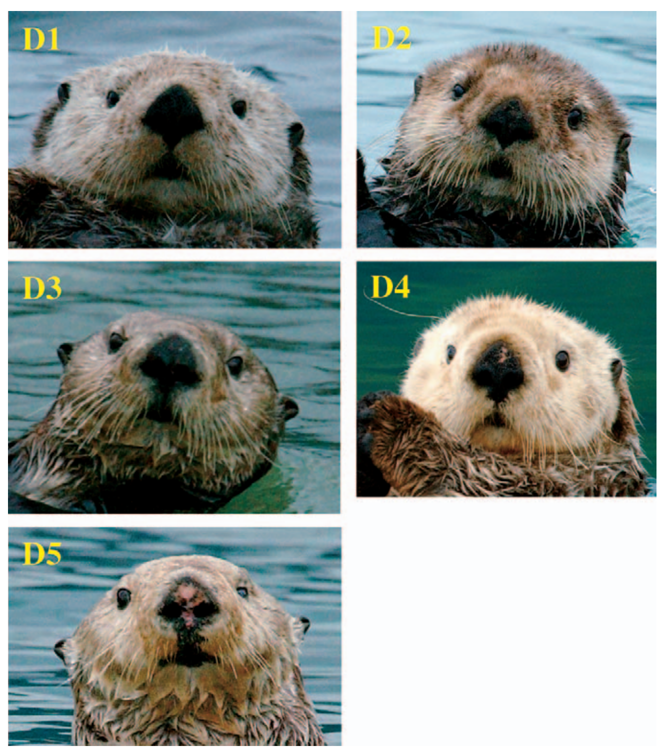

Figure 3. Sea otters with scars of different degrees of distinctiveness ranging from D1 to D5 (see Table 1 for distinctiveness classification criteria). Otters were imaged in Simpson Bay, Alaska, USA, from June to August of 2002 and 2003.

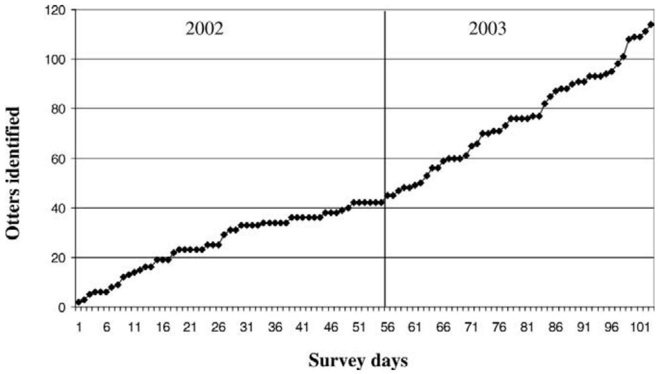

Figure 4. Discovery curve for sea otters identified in Simpson Bay, Alaska, USA, from June to August 2002 and 2003.

than once. We identified 8 individuals (19% of those identified in 2002) in both years.

There was a difference between years in both the number of good quality ($\geq$ Q3) images and the number of individuals identified. In 2002, only 298 (36%) encounters produced good quality images, and we identified 42 individuals (Table 2). In 2003, 518 encounters (55%) produced good quality images, and we identified 80 individuals. The discovery curve started to plateau toward the end of 2002 as the number of new individuals identified decreased with each month. However, the 2003 curve showed no signs of flattening by the end of the season, with approximately equal numbers of new individuals identified during each month (Fig. 4; Table 2). The average number of sightings for all identifiable otters was approximately 3 sightings per individual in both years, but the average number of sightings for re-sighted animals (those seen $\geq$2 times) increased slightly from 4.6 sightings per individual in 2002 to 5.5 sightings per individual in 2003.

Analysis of sighting patterns by sex for both 2002 and 2003 showed that males had the highest average sighting frequency (6.1 sightings/individual), followed by females (3.4 sightings/individual) and otters of unknown sex (2.3 sightings/individual). Analysis of sighting patterns by

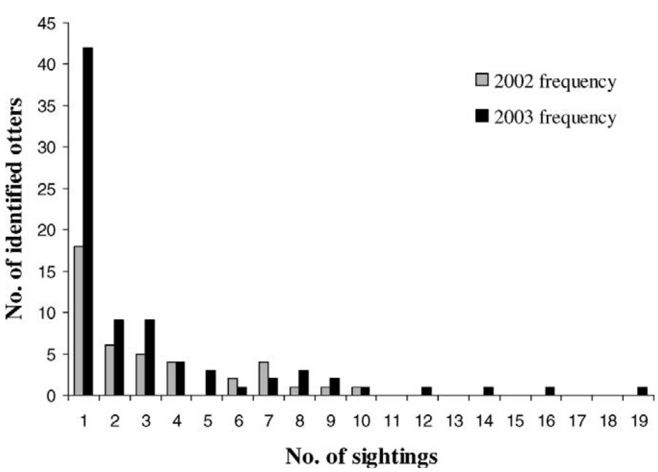

Figure 5. Sighting frequencies of identified sea otters in Simpson Bay, Alaska, USA, from June to August 2002 and 2003.

Table 2. Number of new sea otters identified each month in Simpson Bay, Alaska, USA, from June to August 2002 and 2003.

Month and yr	No. of new sea otters identified
Jun 2002	19
Jul 2002	15
Aug 2002	8
Jun 2003	23
Jul 2003	28
Aug 2003	29

month-first-sighted showed that individuals first sighted in June had the highest average sighting frequency (4.3 sightings/individual), followed by July (3.3 sightings/individual), and August (1.5 sightings/individual).

We analyzed monthly sighting rates to obtain a general pattern of site fidelity among individuals (Weller et al. 1999). Monthly sighting patterns for both 2002 and 2003 showed that 68% ($n = 42$) of individuals that we sighted more than once were sighted in >1 month, and 93% ($n = 39$) of those individuals re-sighted in >1 month were seen in consecutive months (i.e., Jun–Jul, Jul–Aug, Jun–Aug; Table 3).

Overall, approximately 45% of the population had scars that we could use for identification, and this percentage was consistent between years. Analysis of scarring by sex revealed that 63% of males, 45% of females, and 40% of adults of undetermined sex had identifiable nose scars (Table 4).

DISCUSSION

This study showed that nose scars can be used to identify individual sea otters. Almost half of the animals in the study area had recognizable scars, which is within the range reported for other species of marine mammals for which photo-identification has been used (Table 5). In addition, the results are in agreement with what is known about the movement and residency patterns of sea otters in Simpson Bay, indicating that photo-identification can be used to study these patterns. Simpson Bay otters do not form a closed population. Monnett and Rotterman (1988) showed that females with pups traveled throughout large areas of eastern Prince William Sound, generally using areas west of Sheep Bay (the adjacent bay to Simpson Bay) during late spring and early summer, moving into the area of Sheep and Simpson Bays during August and September, and staying until about November when they move further east (Fig. 1).

Table 3. Number and percentage of sea otters re-sighted in each monthly combination in Simpson Bay, Alaska, USA, from June to August 2002 and 2003.

Month(s)	No. of sea otters	%
Jun	4	6.5
Jul	4	6.5
Aug	12	19.4
Jun and Jul	3	4.8
Jul and Aug	21	33.9
Jun and Aug	3	4.8
Jun–Aug	15	21.4
Total	62	100

Table 4. Number of scarred and unscarred sea otters by sex in Simpson Bay, Alaska, USA, from June to August 2002 and 2003.

Sex	No. with scars	% with scars	No. without scars	% without scars
M	19	63	11	37
F	45	45	55	55
Unknown	49	40	72	60

Our 2003 discovery curve, which did not plateau, suggests that new individuals were entering the study area throughout, and probably beyond, the study period. In addition, the high number of re-sightings for animals identified in June and the tendency for animals to be seen in consecutive months after their first sighting also fit this pattern, because otters often stay in the area until late fall. When staying within the general area of Sheep and Simpson bays, many females with and without pups will travel between the 2 bays (Siniff and Monnett 1985, Monnett and Rotterman 1988). Territorial males have smaller seasonal ranges than females (Loughlin 1980, Ribic 1982, Ralls et al. 1988, Jameson 1989), and they are more likely to stay within the boundaries of Simpson Bay. This may explain the higher number of re-sightings for males compared with females.

The difference in the number of individuals identified in 2002 and 2003 is most likely due, at least in part, to a difference in image quality between the 2 years. Image quality improved significantly between years, with images of Q3 and Q4 increasing from 36% of the total images in 2002 to 55% in 2003. This probably resulted from improved techniques for approaching otters and more experience in using the camera. Our census data indicated that both the number of otters and the percentage with nose scars remained approximately the same between the 2 years. However, the number of identifiable individuals seen only once doubled in 2003, whereas the average number of re-sighted individuals increased only slightly. Better image quality alone would not likely produce these different rates of increase. However, real demographic changes, such as an increase in the turnover of individuals in the study area, may have contributed to the increase in the number of individuals identified in 2003.

Most nose scars in adult female otters are thought to result from injuries received during copulation, when the male grasps the female by the nose and upper lip with its teeth (Foott 1970, Estes and Bodkin 2002). There is little published information on nose scars in adult males, although they have been used to identify a small number of untagged males (Calkins and Lent 1975, Loughlin 1980). The results from this study indicate that nose scars are just as prevalent, or more prevalent, among males as among females. The source of scars among males is most likely the result of antagonistic interactions with other males (R. W. Davis, personal observation). The fact that a higher percentage of males had scars than females was unexpected. The proportion of females with scars was lower in our study than in the study by Foott (1970), who reported that 65% of females had nose scars. Because no other studies have reported the prevalence of nose scars, it is not known which number is more typical of sea otter populations.

A high degree of stability of natural marks is desirable if they are to be used for identification (Pennycuick 1978). We did not investigate the stability of nose scars in sea otters in this study, and it is thus unknown. We identified 8 individuals in both years, so some scars are stable for ≥ 1 year. Since females may mate every year (Riedman and Estes 1990, Jameson and Johnson 1993), there is potential for scars to change annually. However, because we saw several females without scars with pups in this study, indicating that not all copulations result in scarring, there is also potential for scars to remain stable >1 year. In general, we hypothesize that the larger and more distinctive the scar, the longer it can be used to identify an individual. However, the duration will probably vary among individuals.

Another potential limitation of sea otter photo-identification is that not all individuals have equal capture probability. Certain otters are more easily approached than others (A. K. Gilkinson, Texas A&M University, personal observation), which produces better quality images for those individuals (International Whaling Commission 1990). Generally, males are the easiest to approach, whereas females with pups are the most difficult. In addition, individuals with a distinctiveness rating of D4 or D5 are more reliably identified than those of distinctiveness rating D3 (Pennycuick 1978). However, unequal capture probability is a potential problem in all photo-identification

Table 5. Estimated percentage of population identifiable from natural markings for various marine mammal species.

Species	Latin name	% identifiable	Source
Sea otter	*Enhydra lutis*	45	This study
Dusky dolphin	*Lagenorhynchus obscurus*	50	Markowitz et al. 2003
Atlantic bottlenose dolphin	*Tursiops truncatus*	54	Read et al. 2003
Indo-Pacific bottlenose dolphin	*Tursiops aduncas*	57	Chilvers and Corkerson 2003
Hector's dolphin	*Cephalorhynchus hectori*	37	Bedjer and Dawson 2001
Pilot whale	*Globicephala macrorhynchus*	33.5–45.3	Shane and McSweeney 1990
Spinner dolphin	*Stenella longirostris*	15–20	Shane and McSweeney 1990, Würsig and Jefferson 1990
Indo-Pacific humpback dolphin	*Sousa plumbea*	92	Karczmarski et al. 1999
Sperm whale	*Physeter macrocephalus*	91	Arnbom 1987
Killer whale	*Orcinus orca*	100	Bigg 1982
Fin whale	*Balaenoptera physalus*	74	Agler et al. 1990
Humpback whale	*Megaptera novaeangliae*	92	Shane and McSweeney 1990

studies and is not unique to sea otters (Pennycuick 1978, Arnbom 1987, Friday et al. 2000, Whitehead 2001).

Identifying individual sea otters based on artificial marks also has limitations. In general, sea otters are very difficult to mark because they often manipulate, remove, or destroy a tag placed anywhere on their body, and marks that interfere with their fur may affect their ability to thermoregulate (Thomas et al. 1987). One of the most commonly used marks is a colored plastic tag attached to the hind flipper. These tags are relatively inexpensive, but they require capture and restraint for attachment, which may cause injury to the animal (Thomas et al. 1987). Many animals bite and manipulate the tags causing their loss (Siniff and Ralls 1991), and they are difficult to read. Radio transmitters have been attached to the neck (Estes and Smith 1973, Loughlin 1980, Garshelis and Siniff 1983), ankle (Garshelis and Siniff 1983), hind flipper (Ribic 1982, Garshelis and Siniff 1983, Garshelis and Garshelis 1984), and implanted both subcutaneously and intraperitoneally (Garshelis and Siniff 1983, Garshelis and Garshelis 1984, Ralls et al. 1989). Neck and ankle attachments were unsuccessful (Estes and Smith 1973, Garshelis and Siniff 1983), and hind flipper attachments were typically removed within 3 months, may have altered the animals' behavior, and frequently caused injury to the hind flipper (Garshelis and Siniff 1983). Intraperitoneal radiotransmitter implants have been very successful (Garshelis and Siniff 1983, Ralls et al. 1989). The more recent transmitter design has allowed otters to be tracked over 526 days (Ralls et al. 1989), and almost no complications have been reported. Intraperitoneal implants as a marking method may be superior to photo-identification in terms of stability and potentially can provide more information on individuals because they can be located over longer distances. However, implantation is a very invasive procedure that requires capture, chemical immobilization, surgical implantation, and release after only a short recovery, all of which are stressful. In addition, the transmitters and the procedures associated with them can be costly (Ralls et al. 1989), reducing the number of individuals that may be monitored.

MANAGEMENT IMPLICATIONS

Photo-identification of sea otters using nose scars appears to be a promising, new, noninvasive method for identifying individual animals for periods of 1–2 years, and possibly longer. It may allow half of all adults in a population to be recognized, and it may be useful for studies of short-distance movements and habitat use, breeding and other social interactions, female reproduction, pup dependency, and other life history parameters. However, to identify large numbers of animals, computer-assisted matching will be necessary.

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