

THE IMPACT OF SEA KAYAK TOURISM AND RECREATION ON HARBOR
SEAL BEHAVIOR IN KENAI FJORDS NATIONAL PARK: INTEGRATING
RESEARCH WITH OUTREACH, EDUCATION, AND TOURISM

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A
THESIS

Presented to the Faculty
of the University of Alaska Fairbanks

in Partial Fulfillment of the Requirements
for the Degree of

MASTER OF SCIENCE

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Fairbanks, Alaska

December 2009

ABSTRACT

Increasing numbers of sea kayakers in Kenai Fjords National Park, Alaska prompted a study to evaluate human disturbance on harbor seals. Harbor seal behavior recorded during the molt from 2004-2006 via remotely controlled cameras and direct field observations were used to evaluate effects of human activities. Behaviors of the seals observed in the presence and absence of kayakers/walkers were contrasted by method of collection, year, presence of humans, presence of a guide, and guide training. Results demonstrated that harbor seals abandoned the ice and were more alert when kayakers were present than when humans were absent. Harbor seals became progressively sensitive to the presence of walkers. Sea kayak guides were advised to observe seal behavior and minimize contact by avoiding areas with high concentrations of hauled-out seals. Educational training provided to sea kayak guides effectively reduced the impact of human disturbance on harbor seals.

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Acknowledgements

My graduate education has been a journey guided by the knowledge and expertise of many individuals. My committee members, Brenda Norcross, Anne Hoover-Miller, Kate Wynne, and Lori Polasek, each provided valuable insights into my project. Their varied expertise helped expand my education to include aspects of marine biology, physiology, and oceanography, beyond the scope of my project. I am grateful to have had the opportunity to work with devoted and passionate scientists and educators. I am particularly grateful to Anne Hoover-Miller who provided the resources and local expertise needed to complete this project and Brenda Norcross, my advisor, who continually urged me to challenge myself.

This project was completed with the help of several individuals from the Alaska SeaLife Center (ASLC), my base of operations during most of this project. I am grateful to the ASLC interns, Kristi Heffron, Morgan Sternberg, and Rebecca Pearce who assisted with recording harbor seal behaviors with the remotely operated camera system. I was fortunate to have two great field volunteers, Sarah Schoen and Jacob Knight, who braved the rain, cold, and bear-bin diets to help me gather my field data. ASLC staff, Greg Spencer, Justin Jenniges, and Jamie Thomson, safely navigated me to my field site and back. I am grateful to Russ Andrews who lent me expedition tents able to withstand weeks of rain. I also thank the staff at SeeMore Wildlife Systems for their assistance with the camera systems.

I was extremely lucky to conduct my research in the beautiful Kenai Fjords National Park (KEFJ) and to have had the support of park personnel. The KEFJ Resource Management Team and the Ocean Alaska Science and Learning Center (OASLC) staff were integral to the safe and successful completion of this project. During our pre-trip meetings I was inspired by their dedication to the conservation of the

parks resources. In particular, I would like to thank Mike Tetreau, Ian Martin, Shelley Hall, Meg Hahr, and Jim Pfeifferberger for their guidance on bear safety, expected field practices, and site-specific information. I would also like to thank Peter Armato of OASLC for generously providing camping gear and funding needed to complete this project. Lastly, I owe CJ Rea a thank you for hiring a great Student Conservation Association volunteer and sharing him with me as my field volunteer in 2006.

Several University of Alaska employees aided me in my journey. Christina Neumann and Madeline Scholl, School of Fisheries and Ocean Sciences staff, were always only a phone call away and armed with helpful advice. The staff at the Seward Marine Center, Linda Lasota, Jennifer Elhard, Nici Murawsky, Steven Hartz, and Daniel Oliver, have helped me stay connected to the University and have provided a great support network.

I am indebted to the sea kayak companies in Seward who shared their knowledge and feedback during this project. I especially want to thank Dave and Wendy of Kayak Adventures Worldwide for their willingness to share information and their commitment to low-impact adventure.

Lastly, I would like to thank my parents, Pat and Ken, and my sisters, Anne Marie, Donna, Julie, and Sara for their continual support. Their kind words of encouragement have sustained me during the roughest times. I would also like to thank all my friends who helped provide healthy distractions and motivation to complete this project.

INTRODUCTION

Ecotourism is rapidly increasing in popularity in Alaska (Colt et al. 2002). Kayaking and wildlife viewing, activities that fall into these categories, are projected to increase nearly 30% between 2000 and 2020 (Bowker 2001). Ecotourism has been perceived as a valuable economic alternative to resource consumptive activities such as logging and hard rock mining (Ehrenfeld 1992). It is internationally recognized as a concept in travel grounded in conservation and sustainable development ideals (Miller 1993). As the ecotourism industry has grown, concerns have increased about how non-consumptive ecotourism is and how effective education programs are as management tools (Orams 1995; Bookbinder et al. 1998; Corkeron 2004). One form of ecotourism involves guided non-consumptive recreational activities. In a review of 73 studies on the impact of non-consumptive recreational activities (i.e., hiking, camping, and boating) on mammals, 70% indicated that wildlife was negatively impacted by recreationists (Boyle & Samson 1985). To help minimize the impacts of recreation and tourism on wildlife, assessments of site-specific responses of wildlife to recreationists and effective mitigation measures are needed.

The harbor seal (*Phoca vitulina*) is a widely distributed pinniped, ranging throughout the coastal areas of the North Atlantic and North Pacific Oceans (Reeves et al. 2002). Because harbor seals haul out on rocks, beaches, reefs, and ice to rest, give birth to pups, and molt, they may be exposed to a variety of coastal recreationists. Starting in late summer, harbor seals undergo an annual molt, or shedding and regeneration of hair (Pitcher & Calkins 1979). During this time, harbor seals haul out more frequently and for

longer periods of time due to the higher energy demands of hair regrowth and benefits of increasing body temperature in facilitating this process (Thompson et al. 1989). When glacial ice is available, ice appears to be preferred over terrestrial haulouts (Calambokidis et al. 1987) potentially due to a reduced terrestrial predator risk (Nordstrom 2002) and reduced effects of large tidal ranges on the limited haulout substrate available.

Disturbance by humans can elicit the same response in wildlife as true predators (Beale & Monaghan 2004). Previous harbor seal disturbance studies showed diverse regionally-specific responses. In Bolinas Bay, California the primary response of harbor seals was to the proximity of the disturbance, not whether the vessel causing a disturbance was motorized or not (Allen et. al 1984). Other studies have found that vessel type, not distance, was more important in causing a disturbance. Sea kayakers caused harbor seals to abandon their haulout at nearly twice the distance of other vessels in Woodard Bay, Washington (Calambokidis & Jeffries 1991) and five times more frequently than other vessels within one kilometer of the haulout in the San Juan Islands, Washington (Suryan & Harvey 1999). Conversely, the distance at which harbor seals became alert to vessel presence was greater for motor boats than kayaks in Metis Bay, Québec (Henry & Hammill 2001). Over 71% of the time, a greater percentage of seals abandoned their haulouts when kayakers were present compared to when motor boats were present (Henry & Hammill 2001). People walking along the shore at McBride Glacier, Alaska were found to disturb a greater proportion of harbor seals than sea kayakers and small motorized vessels (Lewis & Mathews 2000). Thus, it is imperative to

conduct site-specific studies of harbor seal responses to various disturbances within areas of concern.

Kenai Fjords National Park, a coastal park located outside of Seward, Alaska on the Kenai Peninsula was established in 1980 to protect temperate rainforests, terrestrial and marine wildlife, historical and archaeological remains, and the unique glacial fjord ecosystems associated with the Harding Icefield. Visitation to the park increased nearly 300% from the early 1980s to the late 1990s (Colt et al. 2002) and continued to increase into the 2000s (Tetreau 2004). Visitor access to the park is either via road to the Exit Glacier area or via boat or aircraft into the fjords. Several tour operators offer day-trips into the park onboard motorized vessels ranging from 30 - 130 feet in length and carrying 6 to more than 100 passengers. Other visitors explore the fjords by sea kayak, small non-motorized vessels marketed as a low-impact and an eco-friendly method of travel. Several commercial sea kayaking companies offer fjord “paddling packages” ranging from kayak rentals to fully guided trips. Water taxi service has increased the accessibility of the fjords by shuttling sea kayaks, paddlers and guides from Seward into the fjords for one or multiple day camping and paddling adventures. The local expertise and training level of sea kayakers ranges from novice to well-trained guide.

While tourist activities including boating and hiking increased within Aialik Bay following the establishment of Kenai Fjords National Park in 1980, the number of harbor seals using the area declined precipitously. Between 1980 and 1989, the number of harbor seals hauled out on ice in front of Aialik Glacier in Kenai Fjords National Park declined by more than 80% (Hoover-Miller 1994). Declining trends were also found near

Kodiak Island in the Gulf of Alaska between 1976 and 1988 (Pitcher 1990) and Prince William Sound, Alaska between 1984 and 1997 (Frost et al. 1999), indicating widespread ecological stress during the same time period. Kenai Fjords National Park and local conservationists were concerned that sea kayaker and hiker activities might be disturbing harbor seals. The current study used a network of remotely operated cameras established in 2002 to study the ecology of seals using glacial ice environments and direct field observation to examine the potential impact of sea kayakers on harbor seal behavior in Pedersen Lake. The project's objectives were to: 1) document harbor seal behavior and human interactions, 2) assess human-wildlife disturbance monitoring techniques, and 3) develop and evaluate measures to mitigate disturbance. To meet these objectives, the following hypotheses were tested: 1) harbor seal behavior do not vary interannually, but is altered in the presence of kayakers and walkers 2) a remotely operated camera system and field observations are equally effective tools to assess behavior and disturbance, and 3) mitigation training can effectively reduce disturbance to harbor seals.

Study Area

Aialik Bay (59°52'N, 149°39'W) is located in Kenai Fjords National Park (Figure 1). Two tidewater glaciers, Aialik and Pedersen, calve ice that is regularly used as a haulout substrate by harbor seals. In the past, ice calved from Aialik Glacier was the primary haulout for harbor seals in Aialik Bay throughout the summer season (Hoover 1983). Ice calved from Pedersen Glacier into Pedersen Lake was identified as a haulout substrate for harbor seals in the early-1990s (personal communication with Jim

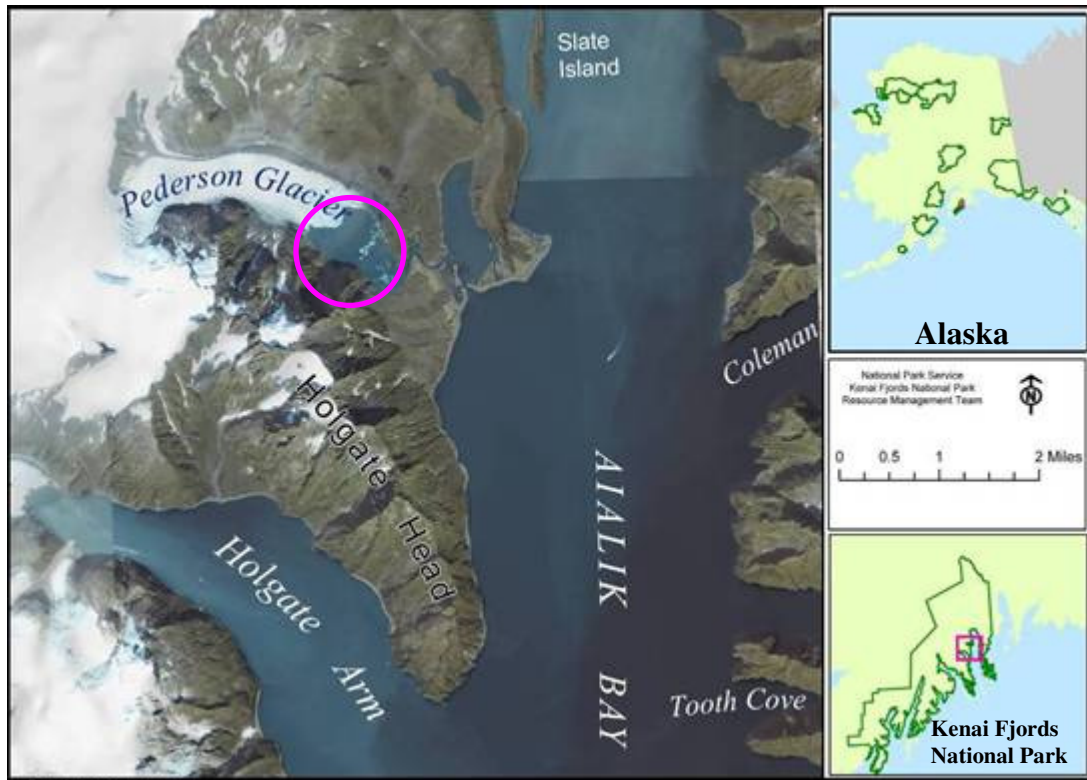


Figure 1. Location of Pedersen Lake (circled) in Kenai Fjords National Park, Alaska. Map compliments of the National Park Service.

Pfeiffenberger, National Park Service ranger) and it has become the preferred haulout area for harbor seals during their molt (Hoover-Miller 2004). A small, shallow inlet stream connects Pedersen Lake via Pedersen Lagoon to Aialik Bay (Figure 2). This stream is tidally influenced and allows for seawater exchange at high tides but is a navigational challenge for motorized vessels; the lake is accessed for recreation primarily by sea kayakers at high tide. Ice calved from Pedersen Glacier tends to be larger than ice from Aialik Glacier. Due to the relatively shallow recessional moraines located

throughout the lake, these large icebergs are often grounded for extended periods of time. In addition, the geomorphology of the outlet stream impedes the exodus of large ice from the lake. Therefore, the ice in Pedersen Lake tends to persist longer than it would in an open fjord providing valuable haulout substrate for harbor seals and a unique paddling experience for kayakers. Once sea kayakers enter the lake, they can either approach Pedersen Glacier in their boats or by walking along the northeastern shore.

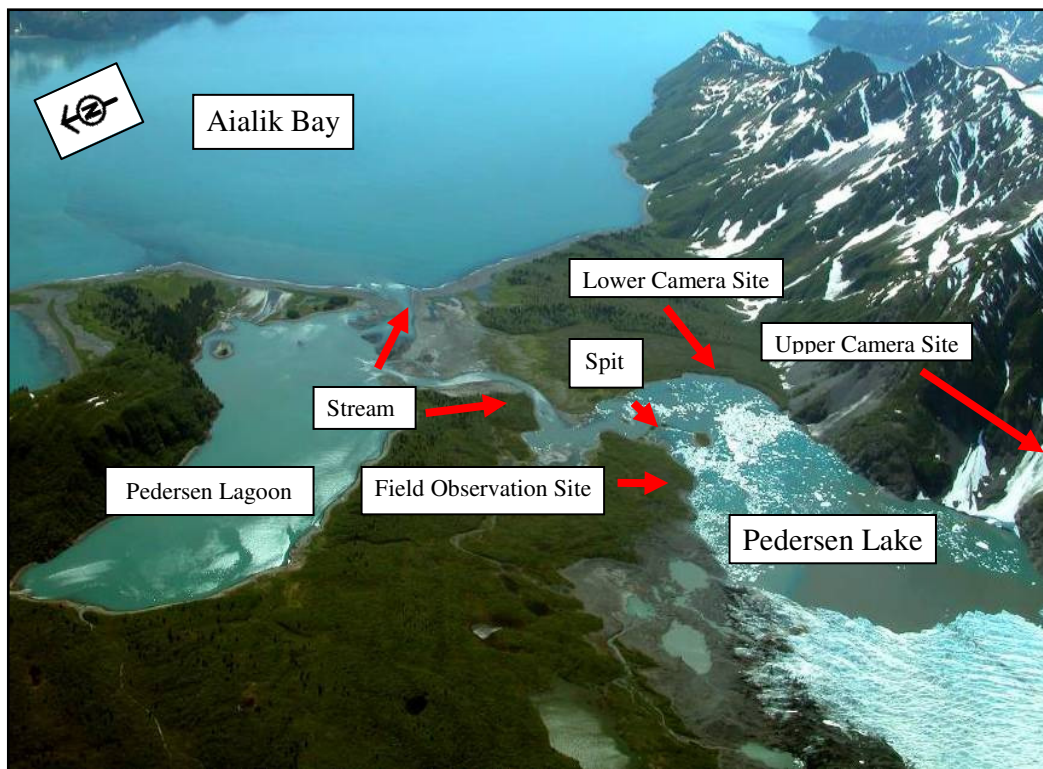


Figure 2. Aerial view of Pedersen Lake. Pedersen Glacier, on right, calves ice into Pedersen Lake. The stream connects to Pedersen Lagoon on the left and then to Aialik Bay on the top. Locations of the spit, cameras, and field observation site are noted.

METHODS

Behavioral Observations

Harbor seal behaviors and human recreational activity were monitored in Pedersen Lake during the harbor seal molt, mid-July to mid-September, 2004-2006, using a network of remotely operated video cameras or by direct field observation. For sampling purposes, the lake was divided into six sections based on topographic features (the big island, the small gravel island, an avalanche chute to the north of the glacier, and an avalanche chute south of the glacier) (Figure 3, Appendix B). To assess harbor seal

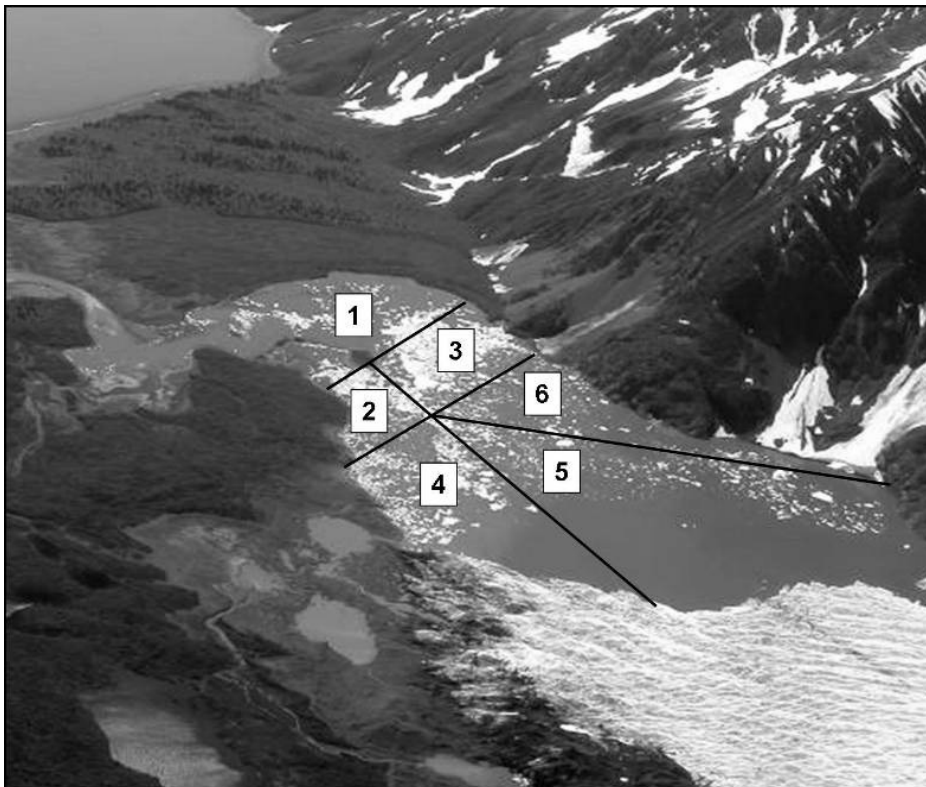


Figure 3. Sampling sections within Pedersen Lake.

behaviors, a focal group of seals was selected based on two conditions: relative distribution of seals in the lake and visibility at the time of sampling. The focal group consisted of a set of seals hauled out together on one iceberg or cluster of icebergs in close proximity to one another (based on Altmann 1974). Due to the circulation of ice, seals were not uniformly distributed throughout the lake. Visibility was affected by weather conditions and distribution of large ice bergs that obstructed the view of harbor seals on other icebergs. When multiple assessments were made during a day, focal groups were selected from different sections of the lake, as conditions allowed.

Behaviors were recorded every ten seconds for ten minutes for each individual harbor seal in a focal group. Thus a total of 60 behaviors were recorded for each seal per observation session. Each seal was assigned a unique identifier consisting of the method of collection (F- field, R- remote camera), year (04, 05, 06), human presence (A- absent, K- kayaker, W- walker), and a number. For each observation, the behavior of each harbor seal was categorized as resting, alert, or abandon. Resting was defined as a seal lying down or exhibiting comfort movements including grooming. A harbor seal was identified as alert when its head was up with its neck extended, eyes open, and it was either actively scanning or showing a fixed stare. If a seal entered the water, it was classified as abandoning the ice. If the seal abandoned the ice and was not observed immediately hauling out again, it was assumed that the harbor seal remained in the water and was classified as abandoned for the remainder of the observation session. No seals were observed returning to the ice after abandoning. In addition to the behaviors, breaks in the observations or times when seals were temporarily out of view were noted.

Harbor seal behaviors were recorded both when kayakers and/or walkers were absent and present to determine whether sea kayakers or walkers were altering harbor seal behavior. When kayakers or walkers passed the spit (Figure 2), they were recorded as present in the lake; the activity of the kayakers and walkers and harbor seal behavior were monitored concurrently.

Camera Observations

A network of remotely operated cameras designed by SeeMore Wildlife Systems Inc. and operated at the Alaska SeaLife Center in Seward, Alaska, was used to collect data in 2004-2006. Two camera sites were located on the southwestern side of Pedersen Lake, one on the shore above the high tide line in the lower lake and one on a ridge by the face of the Pedersen Glacier (Figure 2). The cameras were controlled in real-time from the Alaska SeaLife Center, were capable of pan, tilt, and zoom, and had 12-18 power optical and digital zoom. The cameras were housed in weatherproof cases with windshield wipers. Harbor seal behaviors and human disturbances were recorded on time-lapsed tapes (six frames per ten seconds) from 15 July to 17 September 2004, 11 July to 11 September 2005, and 13 July to 22 September 2006, and were later reviewed. For 2004, camera activity logs were reviewed to locate video recordings with fixed camera observations of harbor seal behaviors when humans were absent. Recorded kayak interactions also were reviewed to determine whether harbor seal behavior had been documented.

Behavioral observations were collected by focusing the camera on a focal group of seals, thereby recording their activities on time-lapsed tape. Operators repositioned the camera to ensure the seals on drifting ice stayed within the camera frame. Due to the ability to review second-by-second freeze-frame viewing of all clearly visible seals, the number of seals concurrently observed was limited only by how many seals could be accurately viewed in the frame. For all years, video-taped behavioral observations were classified as poor, fair, good, or excellent based on the visibility of the seals throughout the observation. Poor observational sessions were disregarded; fair observational sessions were re-reviewed and often times disregarded due to their suboptimal quality. Good and excellent observations were selected for detailed review and data collection.

Field Observations

Data were collected directly by observers in the field 20 to 28 July 2005 and 16 July to 8 August 2006. Daily behavioral observations began between 0800 and 1200 hrs and ended between 1700 and 2000 hrs. This time frame was chosen to include the mid-day hours when the highest number of harbor seals was hauled out on glacial ice and times when kayakers were most likely to be present in the lake (Hoover 1983, Calambokidis et al. 1987; Boveng et al. 2003). If visibility was compromised by weather, observations were canceled until viewing conditions improved. Harbor seal behaviors and human disturbances were observed with a spotting scope (Leupold® Sequoia® 15-45x60mm) mounted on a tri-pod. Experimental trials conducted early in

the 2005 field season determined that a maximum of six seals could be effectively monitored as part of a focal group based on the ten-second interval of direct observations.

Mitigation Training

Mitigation training was provided to sea kayak guides in May 2006. Four companies based in Seward, Alaska offered guided sea kayak tours in Kenai Fjords National Park during the study and all companies were represented at the training. During the training, preliminary results from the 2005 season were presented to illustrate how kayakers and walkers impacted harbor seal behavior. Kayaking techniques for mitigating seal disturbance were recommended: 1) choose a path with least number of seals hauled out, 2) maximize distance from the seals, 3) position icebergs between kayakers and seals, 4) paddle parallel to instead of pointing kayaks directly at seals, 5) observe harbor seal behavior, and 6) minimize unnecessary movements and noise. Harbor seal resting, alert, and abandoning behaviors were described so guides could recognize these behaviors and adjust their paddle route if they observed changes in harbor seal behavior. During the 2006 field season, the effectiveness of this training was tested. As each group of recreationists (kayakers or walkers) entered the lake, the group was classified based upon the recognition of the guide, as a guided versus unguided group, a group receiving the training versus not receiving the training, or a group of unknown/mixed training level.

Analysis

Harbor seal behavioral observations were used to test project hypotheses. To determine whether a remotely operated camera system and field observations were equally effective tools to study behavior and disturbance, seal behaviors recorded during the 2005 and 2006 camera and field observations were compared. Seal behaviors recorded each year by camera or field observers were contrasted to determine the significance of interannual variability. To determine whether kayakers and walkers were altering seal behavior, behaviors recorded when humans were absent were compared to behaviors recorded when kayakers or walkers were present for each year and method of collection. Seal behaviors in the presence of kayakers were compared to behaviors in the presence of walkers to determine if one form of activity was less disruptive. To determine the effectiveness of guide training, seal behaviors recorded in the presence of kayak groups with and without mitigation trained guides and groups with and without guides (regardless of whether they attended the mitigation training or not) were compared using 2006 field observations. To determine if a group was able to minimize their disturbance through their chosen activities, all observations of seal behaviors when kayakers and walkers were present were used for these analyses. Observations of groups with unknown/mixed training level were not included in the analyses.

Harbor seal behaviors were assessed using two measures. The *Abandoning Ratio* was calculated as the ratio of the number of observation sessions in which seals were observed abandoning the ice to the number of observation sessions in which seals were not observed abandoning the ice. A Chi-square test was used to detect differences in the

Abandoning Ratio between groups of observation sessions (see list above). However, a Fisher Exact test was used if over 20% of the expected values being used for comparison were less than five. The *Resting Score* reflected finer-scale behavior. A numeric value was assigned for every behavior recorded during the 10-minute behavioral observation session. Resting was given a value of 2, alert a value of 1, and abandoning a value of 0. The mean *Resting Score* of every seal was calculated by summing the assigned behavior values and dividing this sum by 60, the number of behaviors recorded during the observation session. A higher *Resting Score* reflected more time resting and less time alert; a lower *Resting Score* represented a seal that is more alert and/or abandoned the ice. The mean *Resting Scores* of all individual seals in a group of observations were used to determine the median *Resting Score* for that group. A Mann-Whitney U Rank Sum test was used to test differences between median *Resting Scores* of two groups of observations (see list above) using SigmaStat (SYSTAT, SSI., Inc. San Jose, CA). A Bonferroni adjustment performed on all comparisons minimized statistical errors associated with multiple tests performed on one dataset. For each combination of observations compared, the number of statistical tests run on each dataset was determined and was multiplied with the p -value obtained from the statistical test (Chi-square, Fisher Exact or Mann-Whitney U Rank) to obtain the Bonferroni-adjusted p -value. If a Bonferroni-adjusted p -value was greater than one, it was revalued as one (SAS Institute Inc. 1999). For all statistical tests, a significance level of $\alpha = 0.05$ was used.

RESULTS

A total of 1,857 behavioral observations were recorded of harbor seals hauled out on ice in Pedersen Lake (Table 1). Of those observations, 68% were when humans were absent, 25% when kayakers were present, and 7% percent when walkers were present. Eleven percent of the observations were recorded in 2004, 42% in 2005, and 46% in 2006.

Table 1. Number and percentage of behavioral observations recorded per year, by method of collection, and with varying human presence.

Year	Method of Collection	Absent	Kayaker	Walker	Total	Percentage
2004	Camera	160	29	20	209	11.25
2005	Camera	438	130	12	580	31.23
2005	Field	175	33	0	208	11.20
2006	Camera	88	79	14	181	9.75
2006	Field	408	194	77	679	36.56
Total		1269	465	123	1857	
Percentage		68.34	25.04	6.62		

Groups of recreationists were observed in the lake on 86 of 108 days the lake was monitored (Table 2) and data were collected for 148 groups of recreationists (Table 3). A single group of recreationists was observed in Pedersen Lake in 32% of the camera and field observations combined; the remaining 68% of the observations included multiple groups (Table 3). The number of kayaks within groups ranged from one to nine with a mean kayak group size of three. The number of people per kayak group ranged from one

to sixteen with an average of four people per group (Figure 4). The greatest number of people observed in the lake on one day was 21.

Table 2. Number of days that groups of recreationists were observed by year and method of collection.

Year	Method of Collection	Number of Days Groups Present
2004	Camera	16
2005	Camera	34
2005	Field	3
2006	Camera	16
2006	Field	17
Total		86

Table 3. Number of groups of recreationists using Pedersen Lake simultaneously and total number of groups observed per year and by method of collection. The percentage of time one or more group was observed in the lake is listed.

Year	Method of Collection	One	Two	Three	Four	Five	Total
2004	Camera	7	6	0	2	1	32
2005	Camera	19	12	4	0	0	55
2005	Field	3	1	1	0	0	8
2006	Camera	11	3	1	1	0	24
2006	Field	7	6	2	1	0	29
Total		47	28	8	4	1	148
%		31.8	18.9	5.4	2.7	0.7	

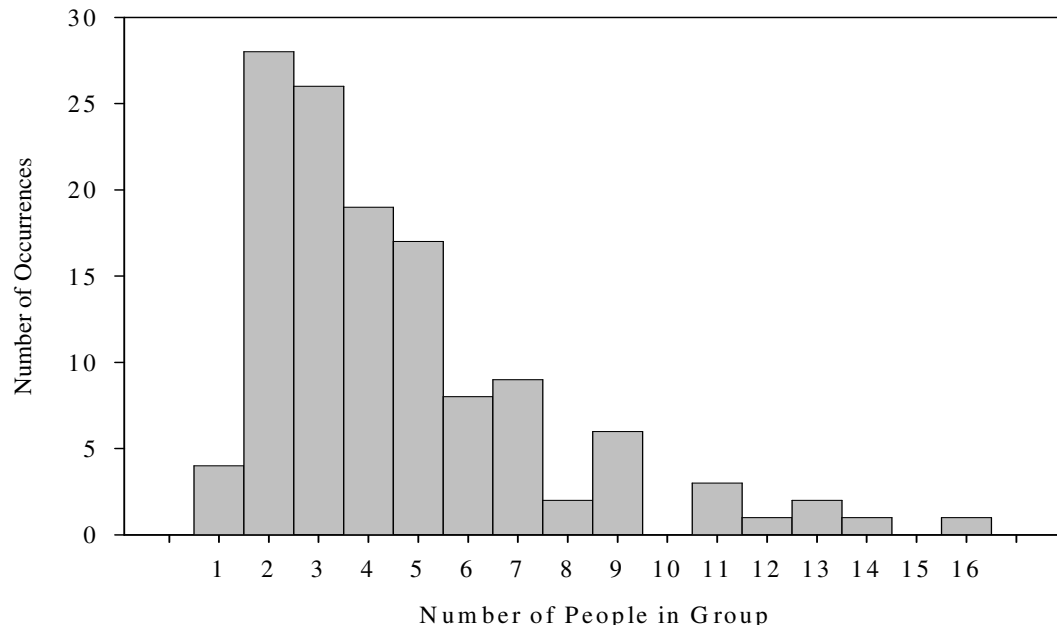


Figure 4. Distribution of group size of recreationists observed in Pedersen Lake.

Comparison of Collection Method: Camera vs. Field Observations

Harbor seal behaviors recorded via a remotely operated camera system and through direct field observations were comparable when walkers were present and for most of the comparisons when humans were absent. The one exception when humans were absent was the *Resting Score* of the harbor seals, which was significantly higher during 2006 camera observations than observed in the field (Table 4). Results gathered using these techniques differed however when kayakers were present in the lake. In 2005, when kayakers were present, a significantly higher abandoning rate was observed with the cameras than in the field (Table 4). In addition, when kayakers were present in 2005, the *Resting Score* of the harbor seals was significantly higher for the field than

camera observations (Table 4). In contrast, when kayakers were present in 2006, seals abandoned the ice at a significantly higher rate and an increased level of alertness was observed during field observations than was observed using the camera system (Table 4).

Table 4. Comparison of collection method. Comparison of harbor seals *Abandoning Ratio* and *Resting Score* derived from camera and field observations when humans were absent and in the presence of kayakers and walkers. Significant results are marked with an asterisk (*).

Absent	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
2005 Camera vs. Field	16, 422 vs. 1, 174	$X^2 = 3.335$	0.340
2006 Camera vs. Field	3, 85 vs. 51, 357	$X^2 = 5.265$	0.132
<i>Resting Score</i>			
2005 Camera vs. Field	438 vs. 175	U = 55482.0	1.000
2006 Camera vs. Field	88 vs. 408	U = 25700.0	0.012*
Kayaker	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
2005 Camera vs. Field	98, 32 vs. 7, 26	$X^2 = 31.375$	$\leq 0.005^*$
2006 Camera vs. Field	21,58 vs. 95,99	$X^2 = 10.616$	0.006*
<i>Resting Score</i>			
2005 Camera vs. Field	130 vs. 33	U = 4159.5	$\leq 0.005^*$
2006 Camera vs. Field	79 vs. 194	U = 13247.5	$\leq 0.006^*$
Walker	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
2006 Camera vs. Field	4, 10 vs. 13, 64	Fisher Exact	1.000
<i>Resting Score</i>			
2006 Camera vs. Field	14 vs. 77	U = 591.500	1.000

^a *Abandoning Ratio* (*a, s vs. a, s*): the number of observations of seals abandoning (a) vs. number staying (s) for each variable tested. *Resting Score*: the number of observations being compared for each category. ^b Values for Chi- square (χ^2) and Mann-Whitney Rank Sum (U) tests. Degrees of freedom for all tests are one.

Interannual Variability

Interannual variability in seal behavior was most marked when kayakers or walkers were present. When humans were absent, interannual variability was not discernible except during 2006 field observations when a significant increase in *Abandoning Ratio* was observed compared to 2005 (Table 5). Between 2005 and 2006, when kayakers were present, there was a significant decrease in *Abandoning Ratio* observed with the cameras and a significant increase in *Abandoning Ratio* observed in the field (Table 5). When kayakers were present during 2005, there was a significantly lower *Resting Score* observed than in 2004 and 2006 during both camera and field observations (Table 5). When walkers were present, seals demonstrated an increased level of alertness and abandoning the ice throughout all study years. No walkers were observed during the 2005 field season; all results in 2005 are from camera observations. The *Abandoning Ratio* of the harbor seals was significantly higher in 2005 than 2004 (Table 5). The *Resting Score* was also significantly lower during 2005 than 2004 indicating an increased level of alertness in 2005 (Table 5). Observations indicate that harbor seals were less alert and abandoned the ice less frequently when walkers were present in 2004 than in 2005 and 2006.

Table 5. Interannual variability. Comparison of interannual variability in harbor seal *Abandoning Ratios* and *Resting Scores* derived from camera and field observations when humans were absent and in presence of kayakers and walkers. Significant results are marked with an asterisk (*).

Absent	Number	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i> ^a		
Camera 2004 vs. 2005	6, 154 vs. 16, 422	$X^2 = 0.0359$	1.000
Camera 2005 vs. 2006	16, 422 vs. 3, 85	$X^2 = 0.0405$	1.000
Field 2005 vs. 2006	1,174 vs. 51, 357	$X^2 = 20.008$	$\leq 0.006^*$
<i>Resting Score</i>			
Camera 2004 vs. 2005	160 vs. 438	U = 49330.0	1.000
Camera 2005 vs. 2006	438 vs. 88	U = 26374.5	0.070
Field 2005 vs. 2006	175 vs. 408	U = 54484.0	1.000
Kayaker	Number	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i> ^a		
Camera 2004 vs. 2005	18, 11 vs. 98, 32	$X^2 = 1.509$	1.000
Camera 2005 vs. 2006	98, 32 vs. 21, 58	$X^2 = 45.762$	$\leq 0.005^*$
Field 2005 vs. 2006	7, 26 vs. 95, 99	$X^2 = 7.696$	0.036^*
<i>Resting Score</i>			
Camera 2004 vs. 2005	29 vs. 130	U = 2995.5	0.015^*
Camera 2005 vs. 2006	130 vs. 79	U = 11638.5	$\leq 0.005^*$
Field 2005 vs. 2006	33 vs. 194	U = 4924.0	$\leq 0.006^*$
Walker	Number	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i> ^a		
Camera 2004 vs. 2005	0, 20 vs. 9, 3	Fisher Exact	$\leq 0.005^*$
Camera 2005 vs. 2006	9, 3 vs. 4, 10	$X^2 = 3.869$	1.000
<i>Resting Score</i>			
Camera 2004 vs. 2005	20 vs. 12	U = 88.5	$\leq 0.005^*$
Camera 2005 vs. 2006	12 vs. 14	U = 124.0	0.270

^a *Abandoning Ratio* (*a, s vs. a, s*): the number of observations of seals abandoning (a) vs. number staying (s) for each variable tested. *Resting Score*: the number of observations being compared for each category. ^b Values for Chi- square (χ^2) and Mann-Whitney Rank Sum (U) tests. Degrees of freedom for all tests are one.

Human Disturbance Recorded by Cameras

Observations recorded via the cameras documented seal disturbance when kayakers and walkers were present in the lake. In 2004, 2005 and 2006, when kayakers were present, harbor seals abandoned the ice at a significantly higher rate than when humans were absent (Table 6, Figure 5). Similarly, the *Resting Scores* were significantly lower for all years indicating an increased level of alertness when kayakers were present (Table 6, Figure 6). The sensitivity of harbor seals to the presence of walkers appeared to increase throughout the study. When walkers were present in 2005 and 2006, there was a significant increase in the *Abandoning Ratio* of harbor seals compared to when humans were absent (Table 6, Figure 5) and the *Resting Scores* were significantly lower when walkers were present (Table 6, Figure 6).

Harbor seal disturbance by kayakers and walkers was found to be comparable during some years of the study. During 2004, however, when kayakers were present, the harbor seals abandoned the ice at a significantly higher rate and were more alert than when walkers were present (Table 6, Figures 5 & 6). In 2005, the *Resting Score* of harbor seals was significantly higher when walkers were present than when kayakers were present (Table 6, Figure 6).

Table 6. Human disturbance recorded by cameras. Comparison of harbor seal *Abandoning Ratios* and *Resting Scores* derived from camera observations when humans were absent and in presence of kayakers and walkers. Significant results are marked with an asterisk (*).

2004 Camera Results	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
Absent vs. Kayaker	6, 154 vs. 18, 11	$\chi^2 = 70.150$	$\leq 0.003^*$
Absent vs. Walker	6, 154 vs. 0, 20	$\chi^2 = 0.0485$	1.000
Kayaker vs. Walker	18, 11 vs. 0, 20	$\chi^2 = 17.042$	$\leq 0.003^*$
<i>Resting Score</i>			
Absent vs. Kayaker	160 vs. 29	U = 907.0	$\leq 0.003^*$
Absent vs. Walker	160 vs. 20	U = 2010.5	1.000
Kayaker vs. Walker	29 vs. 20	U = 754.0	$\leq 0.003^*$
2005 Camera Results	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
Absent vs. Kayaker	16, 422 vs. 98, 32	$\chi^2 = 317.078$	$\leq 0.005^*$
Absent vs. Walker	16, 422 vs. 9, 3	$\chi^2 = 100.126$	$\leq 0.005^*$
Kayaker vs. Walker	98, 32 vs. 9, 3	$\chi^2 = 0.103$	1.000
<i>Resting Score</i>			
Absent vs. Kayaker	438 vs. 130	U = 14203.0	$\leq 0.005^*$
Absent vs. Walker	438 vs. 12	U = 526.0	$\leq 0.005^*$
Kayaker vs. Walker	130 vs. 12	U = 1211.0	0.040*
2006 Camera Results	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
Absent vs. Kayaker	3, 85 vs. 21, 58	$\chi^2 = 16.331$	$\leq 0.004^*$
Absent vs. Walker	3, 85 vs. 4, 10	$\chi^2 = 8.352$	0.016*
Kayaker vs. Walker	21, 58 vs. 4, 10	Fisher Exact Test	1.000
<i>Resting Score</i>			
Absent vs. Kayaker	88 vs. 79	U = 4653.5	$\leq 0.004^*$
Absent vs. Walker	88 vs. 14	U = 279.5	$\leq 0.004^*$
Kayaker vs. Walker	79 vs. 14	U = 570.0	1.000

^a *Abandoning Ratio* (*a, s vs. a, s*): the number of observations of seals abandoning (a) vs. number staying (s) for each variable tested. *Resting Score*: the number of observations being compared for each category. ^b Values for Chi-square (χ^2) and Mann-Whitney Rank Sum (U) tests. Degrees of freedom for all tests are one.

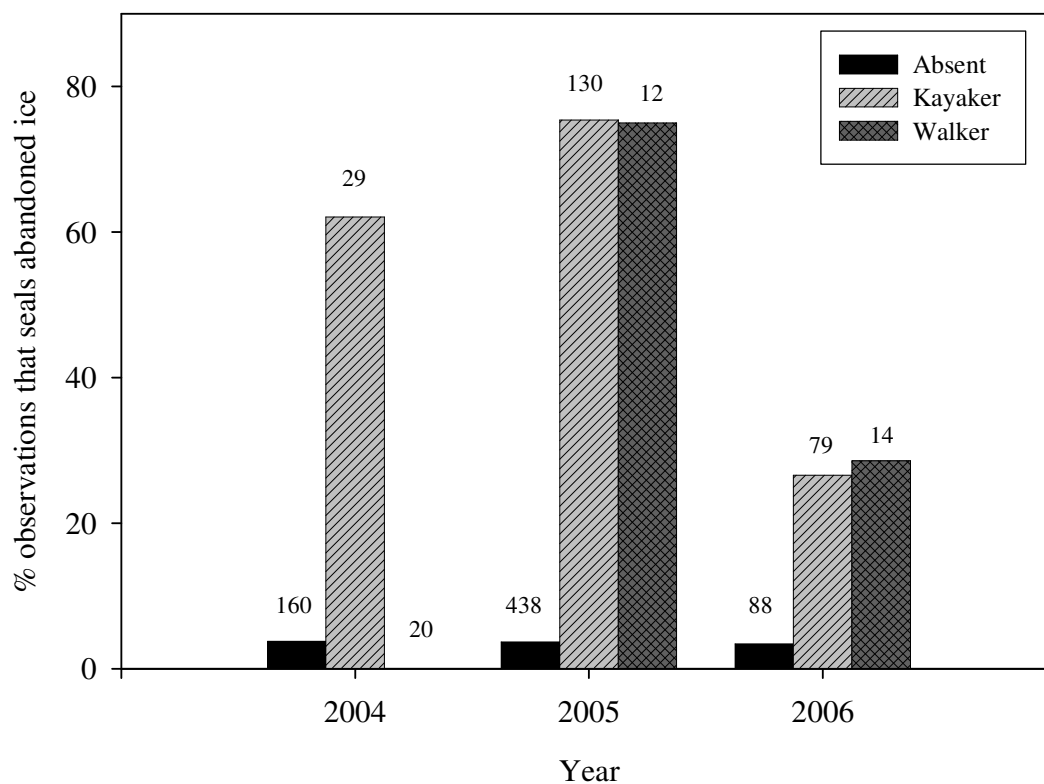


Figure 5. Human disturbance: *Abandoning Ratio* camera results. Percentage of observation sessions in which harbor seals abandoned the ice by year and human presence. Sample sizes are shown above bars. Data were recorded via camera.

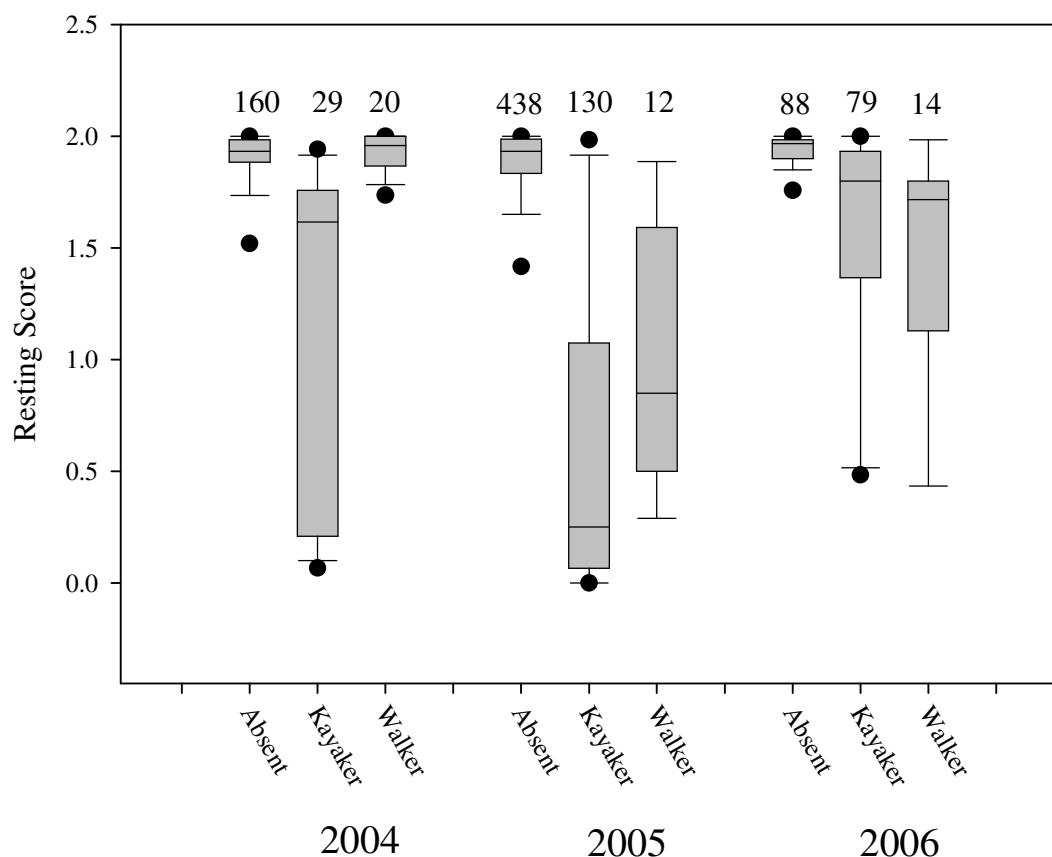


Figure 6. Human disturbance: *Resting Score* camera results. Harbor seal *Resting Score* for year and human activity recorded via camera. The ends of the boxes define the 25th and 75th percentiles, with a center line at the median and error bars defining the 10th and 90th percentiles. Black dots represent the 5th and 95th percentiles. Sample sizes are shown above the boxes.

Human Disturbance Recorded by Field Observers

Field observations indicated that when kayakers were present in the lake, harbor seal behavior was altered. In 2005 and 2006, when kayakers were present, harbor seals abandoned the ice at a significantly higher rate than when humans were absent (Table 7,

Figure 7). When kayakers were present during 2005 and 2006, the harbor seal *Resting Score* was significantly lower than when humans were absent (Table 7, Figure 8). The *Resting Score* when humans were absent was significantly higher than when walkers were present (Table 7, Figure 8). Seals abandoned the ice at significantly higher rates when kayakers were present than when walkers were present, but there was no significant difference in *Resting Scores* when kayakers and walkers were present (Table 7, Figure 8).

Table 7. Human disturbance recorded by field observers. Comparison of harbor seal *Abandoning Ratios* and *Resting Scores* derived from field observations when humans were absent and in presence of kayakers and walkers. Significant results are marked with an asterisk (*).

2005 Field Results	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
Absent vs. Kayaker	1, 174 vs. 7, 26	$\chi^2 = 26.647$	$\leq 0.003^*$
<i>Resting Score</i>			
Absent vs. Kayaker	175 vs. 33	U = 2300.5	$\leq 0.003^*$
2006 Field Results	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
Absent vs. Kayaker	51, 357 vs. 95, 99	$\chi^2 = 93.215$	$\leq 0.006^*$
Absent vs. Walker	51, 357 vs. 13, 64	$\chi^2 = 0.737$	1.000
Kayaker vs. Walker	95, 99 vs. 13, 64	$\chi^2 = 22.355$	$\leq 0.006^*$
<i>Resting Score</i>			
Absent vs. Kayaker	408 vs. 194	U = 35904.0	$\leq 0.006^*$
Absent vs. Walker	408 vs. 77	U = 12583.5	$\leq 0.006^*$
Kayaker vs. Walker	194 vs. 77	U = 12294.0	0.060

^a *Abandoning Ratio* (*a, s vs. a, s*): the number of observations of seals abandoning (a) vs. number staying (s) for each variable tested. *Resting Score*: the number of observations being compared for each category. ^b Values for Chi-square (χ^2) and Mann-Whitney Rank Sum (U) tests. Degrees of freedom for all tests are one.

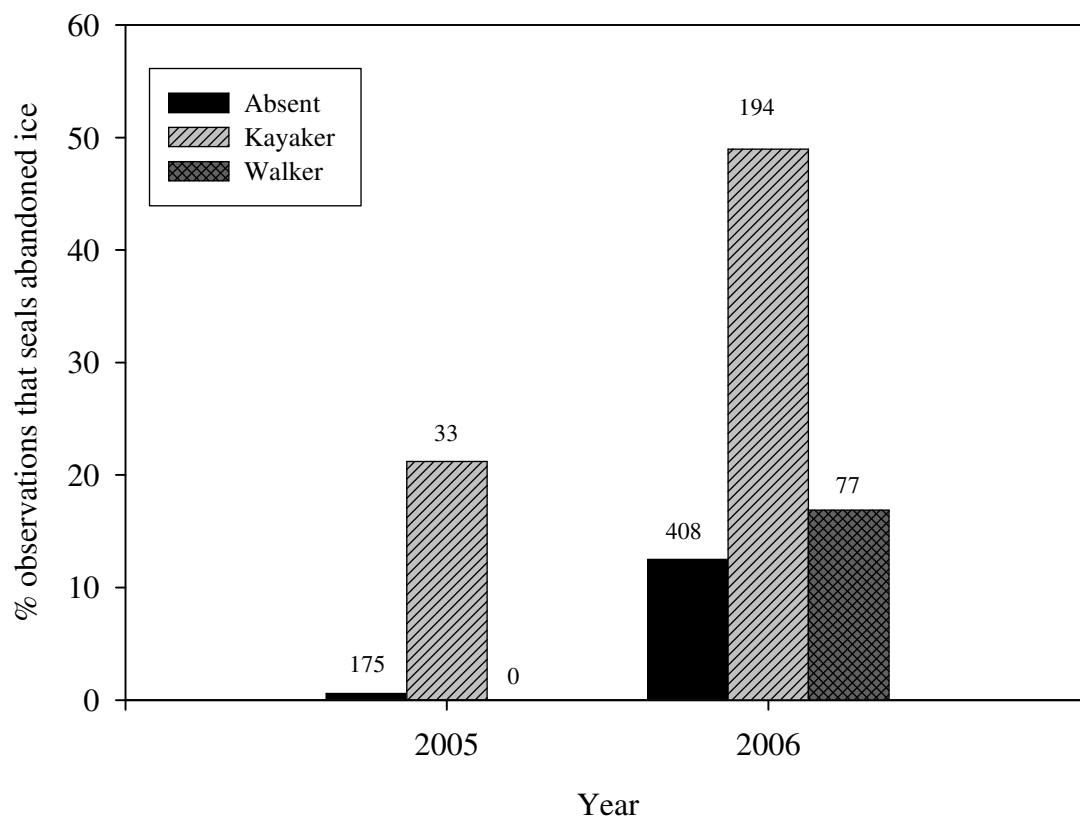


Figure 7. Human disturbance: *Abandoning Ratio* field results. Percentage of field observation sessions in which harbor seals abandoned the ice by year and human presence. Sample sizes are shown above bars.

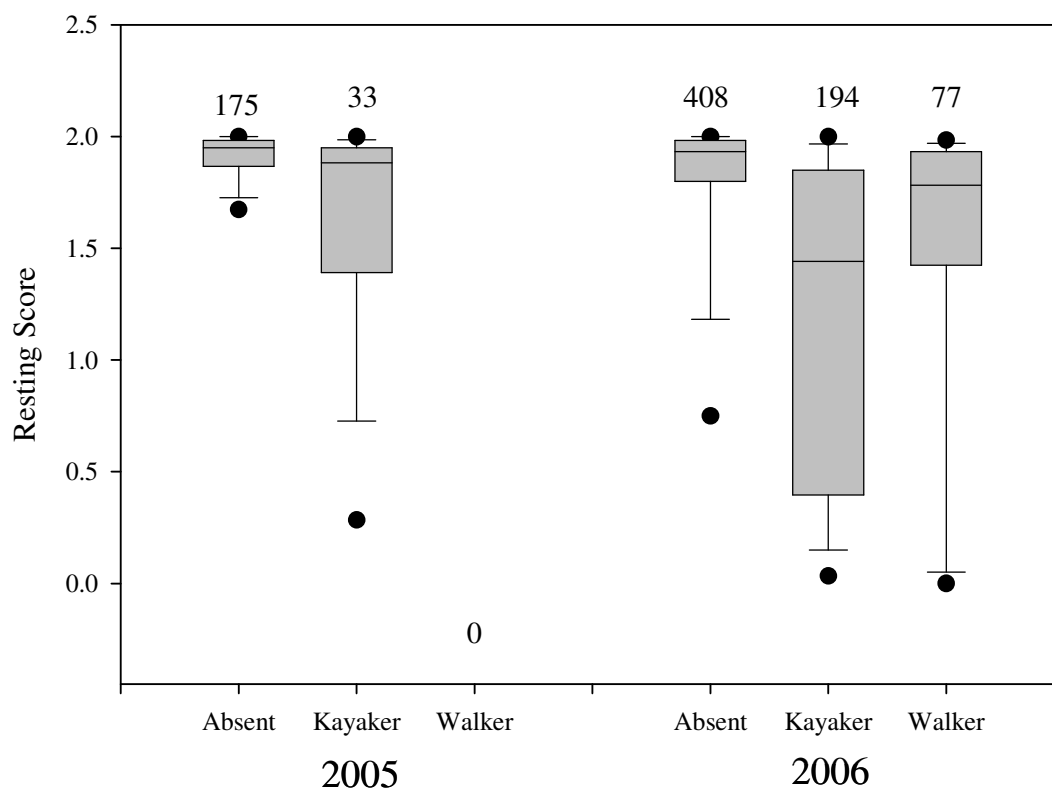


Figure 8. Human disturbance: *Resting Score* field results. Harbor seal *Resting Score* recorded in the field by year and human presence. The ends of the boxes define the 25th and 75th percentiles, with a center line at the median and error bars defining the 10th and 90th percentiles. Black dots represent the 5th and 95th percentiles. Sample sizes are shown above boxes.

Effectiveness of Guide Training

Significant differences in the degree of disturbance were observed in the field in 2006 between groups of recreationists (Table 8). When guided groups were present the *Abandoning Ratio* of the harbor seals was significantly lower than when unguided groups were present (Table 8, Figure 9). When groups were led by guides who had attended the

training, the harbor seal *Abandoning Ratio* was significantly lower than when other groups (unguided or untrained) were present in the lake (Table 8, Figure 9). In addition, the *Resting Scores* of harbor seals were higher when trained groups were present than when unguided or untrained groups were present (Table 8, Figure 10).

Guided and trained groups were effective at reducing seal disturbance. No significant differences were found when *Abandoning Ratios* associated with guided and trained groups were compared to observations when humans were absent (Table 8, Figure 9). The seals' *Resting Scores*, however, were significantly lower when guided groups were present compared to when humans were absent (Table 8, Figure 10). Although the harbor seals were more active when any guided groups (with guides who had attended the mitigation training or not) were present than when humans were absent, fewer seals abandoned the ice in the presence of guided groups than unguided groups. Guides who had attended the training reduced their impact to a greater degree than other guides; seals had a higher median *Resting Score* when guides who had attended the training were present compared to other guides (Figure 10).

Table 8. Effectiveness of guide training. Comparison of harbor seal *Abandoning Ratios* and *Resting Scores* for guided versus unguided, mitigation training versus no mitigation training, and mitigation training versus when humans are absent. Significant results are marked with an asterisk (*).

Training Results	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
Guided vs. Unguided	23, 98 vs. 43, 41	$\chi^2 = 22.072$	$\leq 0.006^*$
Trained vs. Untrained	10, 48 vs. 84, 85	$\chi^2 = 17.442$	$\leq 0.006^*$
Absent vs. Guided	51, 357 vs. 23, 98	$\chi^2 = 2.767$	0.576
Absent vs. Trained	51, 357 vs. 10, 48	$\chi^2 = 0.630$	1.000
<i>Resting Score</i>			
Guided vs. Unguided	121 vs. 84	U = 7801.5	0.108
Trained vs. Untrained	58 vs. 170	U = 8458.0	$\leq 0.006^*$
Absent vs. Guided	408 vs. 121	U = 21153.5	$\leq 0.006^*$
Absent vs. Trained	408 vs. 58	U = 9529.5	$\leq 0.006^*$

^a *Abandoning Ratio* (*a, s vs. a, s*): the number of observations of seals abandoning (a) vs. number staying (s) for each variable tested. *Resting Score*: the number of observations being compared for each category. ^b Values for Chi- square (χ^2) and Mann-Whitney Rank Sum (U) tests. Degrees of freedom for all tests are one.

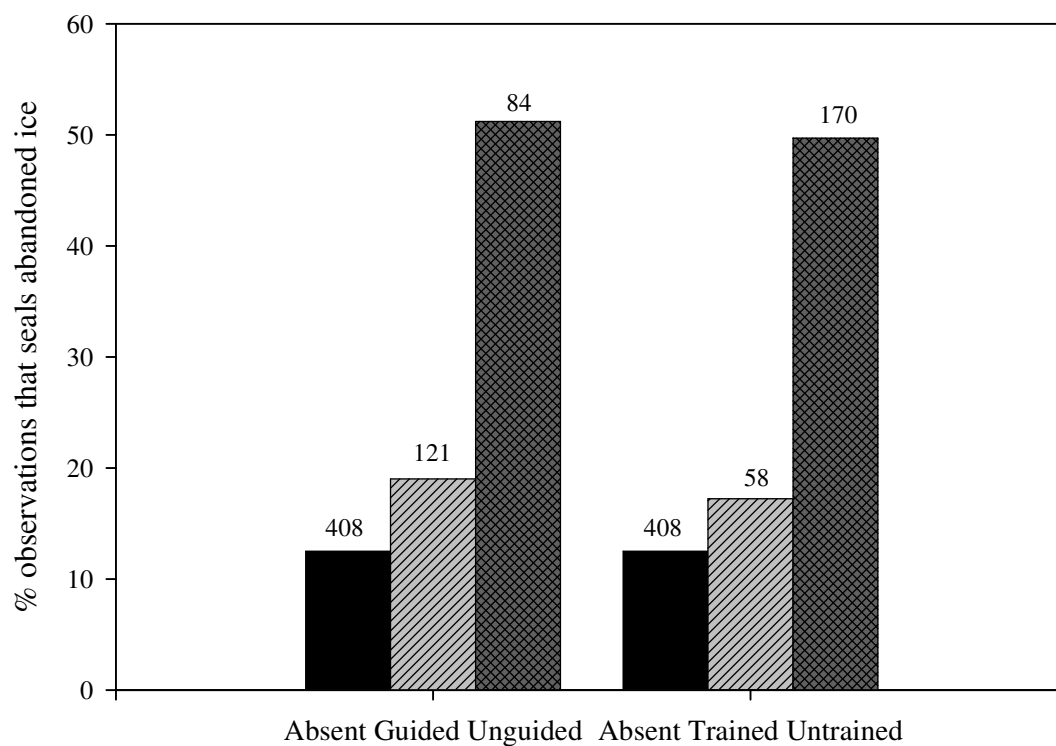


Figure 9. Guide training: *Abandoning Ratio* results. Percentage of observation sessions in which harbor seals abandoned the ice are displayed comparing when humans were absent to when guided and unguided groups were present and when humans were absent to when trained and untrained groups were present. Sample sizes are shown above the bars.

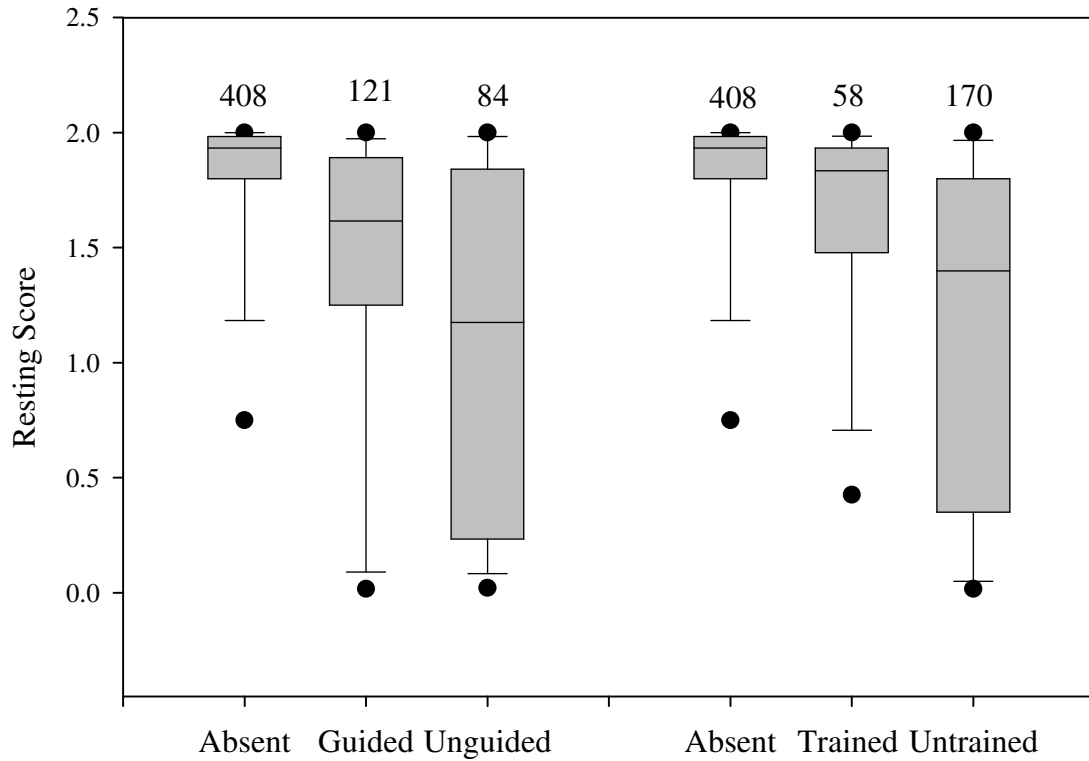


Figure 10. Guide training: *Resting Score* results. Harbor seal *Resting Scores* observed in the absence of humans are compared to group type and guide training level. The ends of the boxes define the 25th and 75th percentiles, with a center line at the median and error bars defining the 10th and 90th percentiles. Black dots represent the 5th and 95th percentiles. Sample sizes are shown above boxes.

DISCUSSION

Harbor seals abandon the ice at higher rates and are more alert when kayakers and walkers are present than when humans are absent. Harbor seals spend time alert and scanning to observe alarm signals and detect danger (Terhune 1985; Da Silva & Terhune 1988). These behaviors are considered the orienting response and precede the defense response if a danger is identified (Gabrielsen & Smith 1995). For harbor seals, the

defense response is to flee the haulout and enter the water. Therefore, by increasing the time spent scanning/alert and the frequency of haulout abandonment, harbor seals are responding to the presence of recreationists in a manner similar to that of the presence of a predator or other perceived danger.

Changes in harbor seal behavior during the molt could be energetically costly for seals. Harbor seals experimentally deprived of a haulout substrate were later found to compensate for the deprivation time by increasing their time hauled out to compensate for the time lost (Brasseur et al. 1996). This is particularly important during the molt when it is energetically beneficial for harbor seals to be hauled out of the water. In order for the epithelial tissues of harbor seals to metabolize efficiently during the molt, harbor seals must maintain a minimum skin temperature of 17° C (Feltz & Fay 1966) and the minimum water temperatures they require are 10 to 14° C (Boily 1995). In a glacial fjord or lake, water temperatures during the molt may be near or below those thresholds (Hoover-Miller & Pinchuk 2008). The cost of thermoregulation varies with animal size (Harding et al. 2005); therefore, the smaller the animal, the more energy it uses to stay warm. If these seals were repeatedly disturbed from their haulout, their molting process may be slowed, increasing the amount of time required for the seals to complete their molt (Boily 1995). Minimizing disturbance from walkers and kayakers can help minimize the energetic cost of response for the seals.

Another potential impact of disturbance could be displacement of the harbor seals from their preferred haulout location, Pedersen Lake, to a less desirable location. The consequences of such displacement have been dramatic for some populations of animals.

Hawaiian monk seals were repeatedly disturbed from their beaches during the 1950s and 1960s and consequently deserted their preferred haulout areas (Kenyon 1972). Survival of the pups at the suboptimal locations was low and the population of Hawaiian monk seals declined because “apparently benign human activities caused small behavioral changes that had large population effects” (Gerrodette & Gilmartin 1990). The harbor seals in our study area have chosen the ice calved from Pedersen Glacier into Pedersen Lake as their preferred haulout location during the molt. Unlike the other tidewater glaciers in the area, Pedersen Glacier does not calve ice into an open fjord, but into a lake. This lake is connected to the main fjord by a shallow stream making it only accessible to water-based recreationists at high tide and inaccessible to orcas.

Additionally, glacial ice, as a haulout substrate, limits exposure to terrestrial predators and the stream entrance prevents motorized tour vessel disturbance. If harbor seals were displaced from Pedersen Lake, they may experience increased likelihood of motor vessel disturbance, or being killed or injured by predators.

After repeated disturbance, animals can become habituated or sensitized to human presence (Wyers et al. 1973). A habituated animal shows a decrease in response to the presence of the disturbance. A sensitized animal exhibits a heightened response to the presence of the disturbance. The behavior of the seals when humans were not present during this study did not change over time, nor did their response to kayakers. When walkers were present, there was an increasing trend of seal disturbance observed with the cameras, as measured by the *Abandoning Ratio* and *Resting Score*. The number of people walking along the shore increased during the study and may account for the

increased sensitivity of the harbor seals to their presence. Another potential explanation for an increased sensitivity of harbor seals to walkers may be a shift in harbor seal haulout distribution caused by an alteration in ice circulation in 2006 that forced larger quantities of ice onshore in the upper portion of the lake closer to human pathways (Table B-2).

The timing of the harbor seal molt differs among age-sex classes (Thompson et al. 1989; Härkönen et al. 1999; Daniel et al. 2003). In general, yearlings molt first followed by subadults, adult females, and adult males. Harbor seals hauled out from late July through mid- August (2006 field dates) had a greater tendency to abandon the ice than harbor seals hauled out in mid-July (2005 field dates). Because seal molt timing and behavioral response to disturbance vary through the summer, data should be collected at the same time each season to allow direct comparisons and minimize within-season variability.

Photography has been used by researchers to study the ecology of wildlife species for over a century (Cutler & Swann 1999). Fixed-position still-frame photography and time-lapsed video photography have been used extensively to estimate population size (Karanth & Nichols 1998; Wallace et al. 2003; Soisalo & Cavalcanti 2006), monitor behavior (Booms & Fuller 2003; Morgart et al. 2005) and identify predation events (Thompson et al. 1999; Stake & Cimprich 2003; Stake et al. 2004). In a review of the use of remote photography in wildlife ecology, the primary objective in 12% of the studies was to record the activity pattern of animals (Cutler & Swann 1999). Less than a third of the studies were on mammals, and human disturbance was not mentioned as a

part of any of the 107 studies reviewed. For most of these studies, a camera system was used due to the remoteness of the location, the desire to monitor multiple sites for extended hours, and to minimize researcher impact on animal behavior.

Using a remotely operated camera system to study human disturbance to wildlife is a potential alternative to collecting data by direct field observation. One advantage to using a camera is that it provides a permanent visual record of animal behavior and human disturbance that can be reviewed at a later time and by multiple researchers. The recorded images can also be used for educational purposes. During this study, images of seals being disturbed by kayakers were used in sea kayak guide trainings. Observing disturbances recorded on video provided guides with insight into the progression of seal behavior leading up to ice abandonment. An additional advantage to using a remotely operated camera system is that the potential for researcher impact on animal behavior is reduced.

There are some disadvantages of using a remotely operated camera system to monitor disturbance. Due to unpredictable routes of travel, it was more difficult to use a camera to observe the effect of kayaks on seals than when humans were absent or when walkers were present. Although there are multiple cameras around the lake and in Aialik Bay, the system transmits data from only one camera at a time to the observation computers. This presented difficulties when measuring disturbance. In addition to monitoring human disturbance for this project, the camera system was concurrently used to document harbor seal haulout patterns through counts conducted throughout the day. If the camera was being utilized for counts or another project, the kayaker and walker

activity in Pedersen Lake could not be observed. Therefore, groups of recreationists may have been present on days or times not monitored. Additional challenges occurred when kayakers were present in the lake. To observe both seals and kayakers, it was necessary to zoom out from the seals or change the position of the camera. Occasionally, it was possible to have both the seals and the kayakers in view at once, but generally, one or the other was in the distance and difficult to see. On occasion, large icebergs would temporarily block the kayakers from the camera view; a scan of the lake was required to re-locate the kayakers. Another challenge when using the cameras was related to the researchers' depth perception and its impact on distance estimations and assessment of kayak interactions. It was rare to encounter similar difficulties during field observations of kayak interactions. In addition, field observations benefited from sounds that could be heard from seals and kayakers. Even given these differences, human disturbance to harbor seals was documented with camera and direct field observations. The use of emerging camera technology to observe and quantify human and animal behavior has proved to be a valuable tool for research and outreach.

Guides that are aware of seal behavior can be more effective at choosing and establishing routes that minimize their disturbance of seals and enhance opportunities for seals to habituate to their presence. There are several factors that influence wildlife's response to disturbance including type, timing, frequency, magnitude, location, and predictability of the activity and the recreationist's behavior (Knight & Cole 1995). In this study, the predictability of recreationist's behavior and training level affected the *Abandoning Ratio* and *Resting Score* of the harbor seals. Animals have a greater

response to humans moving unpredictably so a predictable path helps to minimize disturbance (Gabrielsen & Smith 1995). People walking along the shore have a more predictable path than kayakers. This may account for the decreased *Abandoning Ratio* observed (in 2004 camera and 2006 field observations) when walkers were present compared to when kayakers were present. Local kayak guides are invited to attend a training prior to conducting trips into Kenai Fjords National Park during which they gain an awareness of the area and the wildlife they may encounter. Different tour companies as well as guides within the tour companies have preferred paddle routes within the lake that vary depending on ice distribution. Pedersen Lake is a dynamic environment that continues to grow due to the retreat of Pedersen Glacier. Ice abundance varies throughout the season and between years, thus, the ideal kayaking route frequently changes. Guides that are trained to evaluate seal behavior will be better equipped to modify walking and kayaking routes as needed to reduce disturbance of seals as ice conditions change.

CONCLUSIONS

Humans can recreate in the same area as harbor seals without causing significant disturbance if they monitor changes in seal behavior and are willing to modify their activities. Harbor seal behavior and disturbance by recreationists were documented by a remotely operated camera system and field observations. When humans were absent, seal behaviors recorded via camera and field observers were comparable and there was little interannual variability observed. Seal behavior is more variable when humans are

present; therefore, the method of data collection and years collected should be considered when conducting disturbance studies. Education has been found to be effective in reducing human disturbance on other species of wildlife (Gerrodette & Gilmartin 1990; Calambokidis & Jefferies 1991; Fagen & Fagen 1994). Studies have found that many tourists appreciate receiving more detailed information about the areas they are visiting and animals they are viewing (Lück 2003); this is one of the reasons guided tours are popular for nature-based trips. During this study, sea kayak guides increasingly requested information about harbor seals, Pedersen Lake, and current research findings. Guides that are aware of seal behavior can be more effective at reducing adverse impacts on the seals. Coexistence of recreationists and wildlife may require mitigation measures. These are best developed through site-specific wildlife disturbance research and collaboration with the people that interact with animals in the wild.

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APPENDIX A

Statistical Analysis of Environmental Variables

Tide, time of day, and rain are environmental variables that can impact the haulout behavior of harbor seals (Pauli & Terhune 1987; Boveng et al. 2003). For each behavioral observation recorded when humans were absent, a category of each variable was assigned (Table A-1). High tide included slack high ± 3 hours; low tide included slack low ± 3 hours. Observations were statistically analyzed following procedures outlined in the Methods section of the thesis.

Table A-1. Variables collected and categories applied to statistical analysis of environmental variables.

Variable	Collection Method	Category
Tide	Southcentral Alaska tide table, Resurrection Bay	high or low tide
Time of day	Hour/minutes	morning (0800-10:59), noon (1100-1459), or afternoon (1500-2000)
Precipitation	Weather log from remotely operated camera system	rain or no rain

Table A-2. Environmental variables: camera results. *Abandoning Ratio* and *Resting Score* of harbor seals when humans were absent for categories of environmental variables from data collected via the remotely operated camera 2004 – 2006. Significant results are marked with an asterisk (*).

2004 Camera Results	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
High vs. Low Tide	0, 41 vs. 6, 113	$\chi^2 = 0.978$	1.000
Morning vs. Noon	5, 58 vs. 1, 61	$\chi^2 = 1.526$	1.000
Noon vs. Afternoon	1, 61 vs. 0, 35	Fisher Exact Test	1.000
Rain vs. No Rain	5, 48 vs. 1, 106	$\chi^2 = 4.934$	0.338
<i>Resting Score</i>			
High vs. Low Tide	41 vs. 119	U = 3106.5	1.000
Morning vs. Noon	63 vs. 62	U = 3844.0	1.000
Noon vs. Afternoon	62 vs. 35	U = 1855.0	1.000
Rain vs. No Rain	53 vs. 107	U = 2925.0	$\leq 0.013^*$

2005 Camera Results	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
High vs. Low Tide	2, 190 vs. 14, 232	$\chi^2 = 5.368$	0.315
Morning vs. Noon	6, 117 vs. 4, 129	$\chi^2 = 0.202$	1.000
Noon vs. Afternoon	4, 129 vs. 6, 176	$\chi^2 = 0.0327$	1.000
Rain vs. No Rain	8, 62 vs. 8, 360	$\chi^2 = 11.804$	$\leq 0.015^*$
<i>Resting Score</i>			
High vs. Low Tide	192 vs. 246	U = 42029.0	1.000
Morning vs. Noon	123 vs. 133	U = 15702.0	1.000
Noon vs. Afternoon	133 vs. 182	U = 20116.0	1.000
Rain vs. No Rain	70 vs. 368	U = 13892.5	1.000

Table A-2. (continued)

2006 Camera Results	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i> ^a		
High vs. Low Tide	0, 66 vs. 3, 19	Fisher Exact Test	0.196
Morning vs. Noon	0, 2 vs. 3, 63	Fisher Exact Test	1.000
Noon vs. Afternoon	3, 63 vs. 0, 20	Fisher Exact Test	1.000
Rain vs. No Rain	3, 5 vs. 0, 80	Fisher Exact Test	$\leq 0.014^*$
<i>Resting Score</i>			
High vs. Low Tide	66 vs. 22	U = 695.5	0.084
Morning vs. Noon	2 vs. 66	U = 38.0	1.000
Noon vs. Afternoon	66 vs. 20	U = 731.5	1.000
Rain vs. No Rain	8 vs. 80	U = 230.0	0.952

^a *Abandoning Ratio* (*a, s vs. a, s*): the number of observations of seals abandoning (a) vs. number staying (s) for each variable tested. *Resting Score*: the number of observations being compared for each category. ^b Values for Chi- square (χ^2) and Mann-Whitney Rank Sum (U) tests. Degrees of freedom for all tests are one.

Table A-3. Environmental variables: field results. Comparison of harbor seal *Abandoning Ratio* and *Resting Score* when humans were absent for categories of environmental variables from data collected by field observers for 2005-2006. Significant results are marked with an asterisk (*).

2005 Field Results	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
High vs. Low Tide	0, 70 vs. 1, 104	$\chi^2 = 0.0419$	1.000
Morning vs. Noon	0, 27 vs. 1, 85	$\chi^2 = 0.378$	1.000
Noon vs. Afternoon	1, 85 vs. 0, 62	$\chi^2 = 0.0272$	1.000
Rain vs. No Rain	1, 32 vs. 0, 142	$\chi^2 = 0.637$	1.000
<i>Resting Score</i>			
High vs. Low Tide	70 vs. 105	U = 7394.0	≤ 0.011*
Morning vs. Noon	27 vs. 86	U = 1680.5	1.000
Noon vs. Afternoon	86 vs. 62	U = 5588.0	≤ 0.011*
Rain vs. No Rain	33 vs. 142	U = 2132.5	0.033*
2006 Field Results	Number ^a	Test Statistic ^b	Bonferroni P-Value
<i>Abandoning Ratio</i>	<i>a, s vs. a, s</i>		
High vs. Low Tide	31, 216 vs. 21, 140	$\chi^2 = 0.0000355$	1.000
Morning vs. Noon	5, 57 vs. 29, 226	$\chi^2 = 0.277$	1.000
Noon vs. Afternoon	29, 226 vs. 17, 74	$\chi^2 = 2.506$	1.000
Rain vs. No Rain	29, 165 vs. 22, 192	$\chi^2 = 1.623$	1.000
<i>Resting Score</i>			
High vs. Low Tide	247 vs. 151	U = 31570.5	1.000
Morning vs. Noon	62 vs. 255	U = 10406.5	1.000
Noon vs. Afternoon	255 vs. 91	U = 14922.5	1.000
Rain vs. No Rain	194 vs. 214	U = 36803.5	0.224

^a *Abandoning Ratio* (*a, s vs. a, s*): the number of observations of seals abandoning (a) vs. number staying (s) for each variable tested. *Resting Score*: the number of observations being compared for each category. ^b Values for Chi- square (χ^2) and Mann-Whitney Rank Sum (U) tests. Degrees of freedom for all tests are one.

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APPENDIX B

Harbor Seal Counts, Distribution, and Recommendations for Recreationists

The distribution of harbor seals in Pedersen Lake was determined by counting the number of seals in each section of the lake. Daily harbor seal counts were collected in the field 20-28 July 2005 and 16 July to 8 August 2006 and began between 08:00 and 12:00 and ended between 17:00 and 20:00. Counts were conducted on the odd hours of the day with either binoculars (Nikon 10x25mm) or a spotting scope (Leupold® Sequoia® 15-45x60mm) mounted on a tripod. The number of seals per ice berg was recorded and assigned to a section of the lake based on topographic features (Figure 3). Section 1 included the entire lower lake from the west side of the big island. The dividing line between sections 2 and 3 was from the middle of the west small gravel island to the middle of the west side of the big island. Sections 4, 5 and 6 were all in the upper lake, west of the small gravel island. The dividing line between sections 4 and 5 was a snow chute in the mountain above Pedersen Glacier. Section 5 ended at the westernmost side of the snow/avalanche chute on the south side of the glacier. The area in front of the cliffs was in section 6. Any seals hauled out on the small gravel island were included in the counts of Section 2 for analysis. If the visibility was compromised by weather, observations were canceled until viewing conditions improved.

One-hundred and six counts of seals were conducted in the field: 36 in 2005 and 70 in 2006 (Table B-2). Number of counts per day ranged from two to six with an average of three counts per day. The number of seals observed hauled out on the ice ranged from 0 to 340. The distribution of seals throughout the lake was determined for

each count by dividing the number of seals counted per section by the total number of seals observed during the count and then multiplied by 100. The percentage of seals observed in each section was averaged for 2005 and 2006. For both years, 85% of the seals were counted in the upper portion of Pedersen Lake (sections 4-6); 15% were counted in the lower portion of the lake (sections 1-3) (Figure B-1).

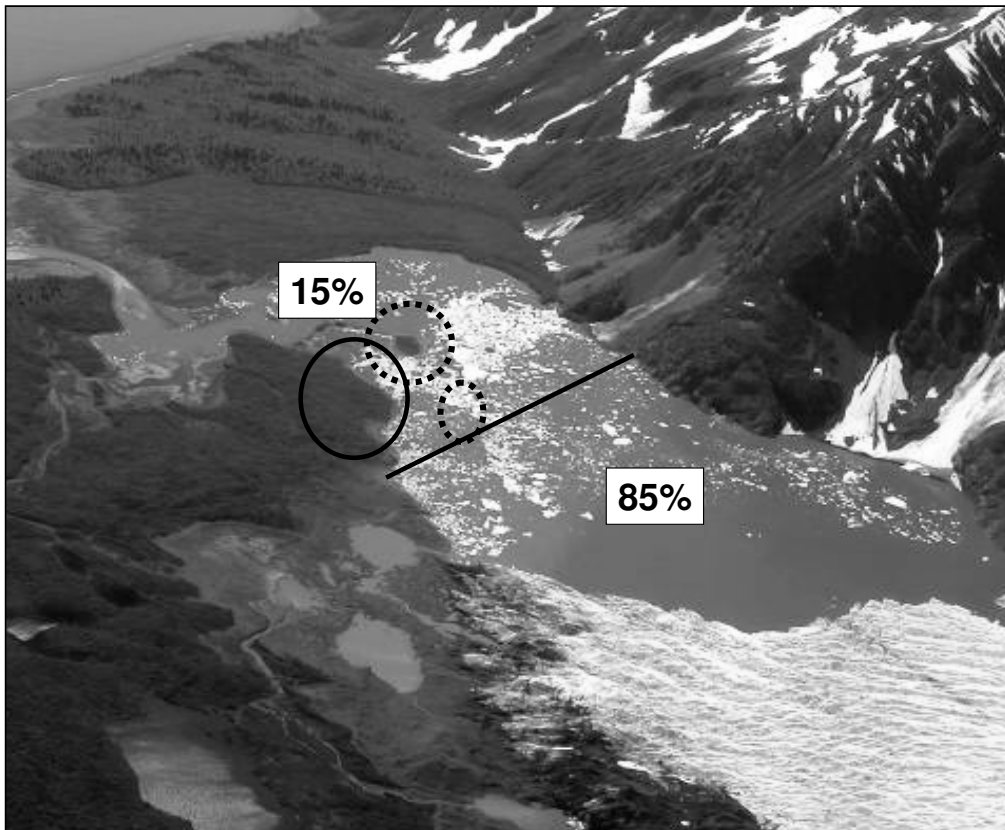


Figure B-1. Distribution of percentage of harbor seals hauled out on ice in Pedersen Lake. Distribution based on counts conducted in the field during 2005 and 2006. Noteworthy landmarks for recreationists are highlighted. The large dashed circle is a vegetated island. The small dashed oval is a gravel island. The open black circle is a knoll along the northeast shore.

Although the distribution of seals in the upper and lower sections of the lake remained constant during the two years, the distribution of seals within the sections varied, potentially due to a shift in water circulation and ice distribution (Table B-1).

Table B-1. Percentage of seals hauled out in each section based on count data.

	2005	2006
Section 1	4.47	0.13
Section 2	2.56	0.28
Section 3	8.51	14.90
Section 4	12.41	45.76
Section 5	31.83	17.59
Section 6	40.21	21.33
Total	100.00	100.00

The results on the distribution of seals determined from the counts and insights acquired from watching kayak interactions were used to develop additional site-specific recommendations for Pedersen Lake. The recommendations were tiered based on risk of disturbance. The lowest risk of disturbance was to paddle a sea kayak into the lower lake, paddle past the big island (Figure B-1) and land on the shore, just past the spit. From there, walk along the shore to the knoll (Figure B-1) and observe the harbor seals and Pedersen Glacier with binoculars. If a recreationists walks past the knoll, their risk of disturbing seals increases. Likewise, if someone paddles into the lower lake towards the small gravel island (Figure B-1), they risk encountering at least 15% of the hauled out seals and potentially many more hauled out in the upper lake. A recreationist that paddles into the upper lake risks the greatest disturbance. All recreationists should observe the behavior of the seals they approach, regardless of what route they take. These recommendations were provided to sea kayak guides at trainings in 2007 and 2008. In addition, they were provided to the Resource Management Team at Kenai Fjords National Park (KEFJ) in 2007; the recommendations were used by KEFJ to direct the activities of the guided trips from eco-lodge built in Pedersen Lagoon in 2008.

Table B-2. Harbor seal count data collected during field observations, 2005 and 2006.

Date	Start Time	End Time	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Island	Total
7/22/05	9:08		8	0	6	13	27	189		243
7/22/05	11:00	11:15	0	0	8	0	24	229		261
7/22/05	13:00	13:12	2	0	2	0	9	252		265
7/22/05	16:04	16:14	0	0	63	0	13	180		256
7/22/05	17:16	17:26	8	0	78	0	12	161		259
7/23/05	9:02	9:17	0	0	7	12	70	58		147
7/23/05	11:03	11:19	0	0	7	23	79	87		196
7/23/05	13:10	13:20	0	0	18	33	92	76		219
7/23/05	15:05	15:17	0	0	15	26	73	87		201
7/23/05	16:33	16:39	0	0	0	0	21	0		21
7/23/05	18:10	18:15	0	0	0	1	3	0		4
7/24/05	11:05	11:15	0	0	0	46	13	0	35	94
7/24/05	13:03	13:07	0	0	0	55	7	0		62
7/24/05	14:55	14:57	0	0	0	3	7	0		10
7/24/05	16:30		0	0	0	3	6	0		9
7/25/05	10:10		0	0	1	16	170	19		206
7/25/05	11:05	11:13	0	0	0	0	165	27		192
7/25/05	13:03	13:08	0	0	1	0	47	27		75
7/25/05	15:00		0	0	0	0	25	55		80
7/25/05	17:03	17:08	0	0	0	0	1	3		4
7/26/05	11:46	11:56	15	4	85	0	77	76	27	284
7/26/05	13:06	13:16	1	1	86	2	69	105	31	295
7/26/05	15:02	15:11	0	3	65	23	70	71	31	263
7/26/05	16:57	17:05	12	9	65	26	94	65	35	306
7/26/05	19:45		0	0	37	0	65	0		102
7/27/05	13:01	13:13	24	0	7	23	85	29		168

Table B-2 (continued)

Date	Start Time	End Time	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Island	Total
7/27/05	15:08	15:15	20	0	26	23	51	117		237
7/27/05	17:06	17:16	22	6	5	64	37	120		254
7/27/05	19:07	19:14	18	0	14	35	4	146		217
7/27/05	20:30	6:37	18	0	0	52	0	138		208
7/28/05	11:03	11:14	44	0	71	8	75	100		298
7/28/05	13:04	13:11	67	0	13	14	34	204		332
7/28/05	15:12	15:19	59	3	39	21	0	205		327
7/28/05	17:07	17:10	56	9	14	32	0	229		340
7/28/05	19:00	19:07	39	0	17	34	22	218		330
7/28/05	20:57	21:03	38	0	15	50	52	105		260
7/16/06	11:10	11:23	0	0	0	6	9	3		18
7/16/06	13:10	13:18	0	0	4	48	0	3		55
7/16/06	15:05	15:12	0	0	0	42	18	0		60
7/16/06	16:45	16:52	0	0	0	46	4	67		117
7/17/06	10:43	10:51	0	0	0	86	4	3		93
7/17/06	13:18	13:26	0	0	0	21	0	40		61
7/17/06	14:56	15:04	0	0	0	37	0	22		59
7/18/06	10:49	10:57	0	0	0	54	0	0		54
7/18/06	13:05		0	0	0	46	8	4		58
7/18/06	20:02	20:08	0	0	0	57	0	0		57
7/18/06	20:57	21:01	0	0	0	44	0	8		52
7/19/06	9:25		0	0	5	92	0	5		102
7/19/06	10:52	11:17	0	0	6	119	16	5		146
7/19/06	14:28	14:33	0	0	1	49	0	0		50
7/20/06	11:06	11:12	0	0	19	128	8	16		171

Table B-2 (continued).

Date	Start Time	End Time	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Island	Total
7/20/06	13:14	13:20	0	0	4	97	9	9		119
7/21/06	10:05	10:14	0	0	10	139	0	0		149
7/21/06	15:26	15:30	0	0	0	97	0	0		97
7/23/06	9:50		0	0	0	44	9	0		53
7/23/06	13:00	13:03	0	0	0	45	7	0		52
7/24/06	10:43		0	0	0	2	17	0		19
7/24/06	13:49	13:55	0	0	4	50	46	6		106
7/24/06	15:07		0	0	4	21	43	1		69
7/25/06	11:27		0	0	2	49	12	0		63
7/25/06	14:15	14:21	0	0	13	83	16	13		125
7/26/06	10:49		0	13	147	46	56	24		286
7/26/06	12:40		0	0	151	15	45	62		273
7/26/06	14:58	15:05	0	6	57	28	48	51		190
7/26/06	17:40		0	0	61	69	75	70		275
7/27/06	10:50		0	0	26	100	23	90		239
7/27/06	14:03	14:15	0	0	76	86	49	50		261
7/27/06	15:05		0	0	107	104	39	31		281
7/27/06	15:59		0	0	21	116	7	28		172
7/28/06	10:42		0	0	81	52	73	35		241
7/28/06	15:02	15:09	0	0	48	46	58	45		197
7/28/06	17:34	17:40	0	0	0	68	7	23		98
7/29/06	11:22	11:37	0	0	31	95	79	27		232
7/29/06	15:24	15:32	0	0	27	161	42	89		319
7/30/06	11:04	11:10	0	2	3	128	38	80		251
7/30/06	12:32	12:45	0	2	4	69	53	91		219

Table B-2 (continued).

Date	Start Time	End Time	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Island	Total
7/30/06	15:07	15:17	0	2	6	94	48	40		190
7/30/06	18:10		0	0	0	0	12	10		22
7/31/06	16:09	16:15	0	0	162	21	25	13		221
7/31/06	18:30		0	1	7	2	0	5		15
8/1/06	15:41	15:48	0	1	55	8	36	50		150
8/1/06	17:22	17:31	0	1	67	28	25	66		187
8/1/06	19:45	19:52	0	1	61	0	27	27		116
8/2/06	17:29	17:34	0	0	18	36	0	59		113
8/2/06	20:20		0	0	25	38	0	43		106
8/3/06	7:36		0	0	5	9	11	6		31
8/3/06	8:45		0	0	0	1	8	26		35
8/4/06	9:58		0	0	70	37	54	13		174
8/4/06	11:03		16	0	49	33	100	0		198
8/4/06	12:52		0	0	52	13	7	61		133
8/4/06	14:40		0	0	50	49	52	29		180
8/5/06	10:08		1	0	26	112	15	80		234
8/5/06	12:00		1	1	22	118	47	43		232
8/5/06	13:26		0	0	10	19	21	53		103
8/5/06	14:35		0	0	1	24	45	56		126
8/5/06	16:45		0	0	12	22	12	75		121
8/6/06	10:03	10:09	0	0	120	90	22	78		310
8/6/06	12:27		0	0	66	42	33	91		232
8/6/06	13:35		0	0	56	22	45	69		192
8/6/06	15:10		0	0	27	29	60	49		165
8/6/06	16:28	16:31	0	0	13	47	13	56		129

Table B-2 (continued).

Date	Start Time	End Time	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Island	Total
8/7/06	14:32		0	0	0	64	17	54		135
8/7/06	16:01		0	0	44	52	8	8		112
8/8/06	11:50		0	0	18	158	0	6		182
8/8/06	14:09	14:13	0	0	0	196	19	0		215
8/8/06	15:36		0	0	0	128	45	27		200

APPENDIX C

Outreach and Education

Table C-1. Selected outreach and education events.

Date	Audience	Event Name	Product
Jan-06	scientific	Alaska Marine Science Symposium	Poster
Mar-06	general public	Alaska Seas & Coasts: Volume 2, March 2006	Informational document
Mar-06	general public	Sea Extreme Episode 2: Sea Kayaking around Harbor Seals	Exhibit video
May-06	sea kayak guides	Local Guide Training	Presentation
May-06	recreational kayakers	Alaska Sea Kayakers Symposium	Presentation
Aug-06	general public	Elderhostel	Presentation
Sep-06	scientific	Wildlife Society Conference: National	Poster
Oct-06	teachers	Ocean Alaska Science and Learning Center Teacher Workshop	Presentation
Jan-07	scientific	Alaska Marine Science Symposium	Presentation
Mar-07	sea kayak guides and recreational kayakers	National Park Service Wildlife Viewing Guidelines and Map	Laminated handout
Apr-07	scientific	Wildlife Society Conference: Alaska Chapter	Presentation
May-07	general public	KTOO radio interview	Radio broadcast/podcast
May-07	sea kayak guides	Local Guide Training	Presentation
Nov-07	general public and scientific	Sitka Whalefest	Presentation
Jan-08	scientific	Alaska Marine Science Symposium	Poster
May-08	sea kayak guides	Local Guide Training	Presentation
Dec-08	general public	Alaska Park Science: Scientific Studies in Marine Environments	Peer-reviewed article

APPENDIX D

Integration of tourism into the marine ecosystem

Published: Jezierski, C.M., A. Hoover-Miller, and B. Norcross. 2008. Integration of tourism into the marine ecosystem. pp. 18-21. *In* M. Shaw (ed.). Scientific studies in Marine Environments, vol. 7. Alaska Park Science. National Park Service. Anchorage AK 7 47pp.

Marine and eco-tourism are among the fastest growing industries in Alaska and worldwide. With increased human presence in remote locations, there is growing concern about the potential impact of tourist activities on wildlife and the ecosystems in which they live. Kenai Fjords National Park (Figure 1) is a coastal park located outside of Seward, Alaska on the Kenai Peninsula. Visitation to the Park increased nearly 300% from the early 1980s to the late 1990s (Colt et al. 2002). Sea kayaking is a popular recreational activity within the Park. Sea kayakers have the ability to paddle close to shore and among floating glacial ice near tidewater glaciers. It is here that they may encounter harbor seals.

Harbor seals (*Phoca vitulina*) are the most widely distributed pinniped ranging throughout the coastal areas of the North Atlantic and North Pacific Oceans. On the west coast of North America, harbor seals are found from Baja California through the Aleutian Islands. Harbor seals in southeast and southcentral Alaska have the unique opportunity to haul out on ice calved by tidewater glaciers to rest, give birth to their pups, and molt. In summer, the seals undergo an annual molt when they shed and regenerate new hair.

During this time, seals bask on the haulout to increase their skin temperature which facilitates hair growth.

Aialik Bay, located in Kenai Fjords National Park, has three tidewater glaciers, Aialik, Holgate and Pedersen Glaciers that produce ice used by harbor seals. Both Aialik and Holgate Glaciers are accessible to large motor vessels and are regularly visited by tour boats. In the past, harbor seals primarily hauled out on the ice in front of Aialik Glacier. Recently, Pedersen Lake's expanding ice habitat created by the recession of Pedersen glacier, has become the preferred haulout area for harbor seals during the molt. A small, shallow stream connects Pedersen Lake via Pedersen Lagoon to Aialik Bay. This stream is tidally influenced: at low tide, the water flows out of the lake, at high tide, marine water from Aialik Bay flows into the lake.

Ice calved from Pedersen glacier tends to be larger and persist longer than ice calved from Aialik Glacier. Due to the relatively shallow recessional moraines or gravel bars located throughout the lake, icebergs often are grounded for extended periods of time. In addition, the narrow outlet stream entraps ice within the lake. Because of its relative isolation and persistent glacial ice, Pedersen Lake has become a popular destination for seals and sea kayakers.

Between 1980 and 1989, the number of harbor seals in the Aialik Bay area declined by over eighty percent (Hoover-Miller 1994), paralleling trends were found throughout the Gulf of Alaska (Pitcher 1990; Small et al. 2003) and Prince William Sound, Alaska (Frost et al. 1999). Although the decline of the harbor seals was likely related to changes affecting marine mammals elsewhere in the Gulf of Alaska, there has

been concern about the added stress of human disturbance caused resulting from tourism. In 1979 and 1980, only one to three boats visited Aialik Bay daily and most did not venture into the glacial ice, a practice that resulted in few seals abandoning the ice (Murphy & Hoover 1981). In 1980, Kenai Fjords National Park was established and visitation increased. Visitation to the Park is either via road to the Exit Glacier area or via boat or aircraft into the fjords. Several tour operators offer day-trips into the Park onboard tour boats carrying 12 to more than 100 people. Another popular way to explore the fjords is by sea kayak. Water taxis shuttle sea kayakers, paddlers and guides from Seward into the fjords for one or multiple day adventures.

Goals of the study

The overall goal of the project was to reduce the impact of kayaking on harbor seals. Initially, we assessed interactions to determine the extent sea kayakers were disturbing seals and causing them to abandon ice haulouts. Next, we reviewed interactions in order to identify specific kayaker behaviors that caused seals enter the water. We then proposed paddling techniques to help reduce disturbance and provided them to sea kayakers through training workshops. Finally, we evaluated whether the paddling recommendations and mitigation trainings were effective at reducing disturbance to harbor seals.

Harbor seal behavior and sea kayaker activity were monitored from mid-July to mid-September, when harbor seals were molting. We collected data from 2004-2006 using a series of remotely operated cameras designed by SeeMore Wildlife Systems Inc.

(<http://www.seemorewildlife.com/index.php>) and operated out of the Alaska SeaLife Center in Seward, Alaska. Data were also collected while camped out along the shores of Pedersen Lake in 2005 and 2006.

Counts and Distribution of Seals

We counted seals daily from about 8AM to 5PM. This is when the greatest numbers of harbor seals haul out on glacial ice and the most popular time for kayakers to be in the lake. We divided the lake into six sections based on easily recognizable topographic features. The number of seals for each section of the lake was recorded. We made a total of 106 counts of seals while in the field during 2005 and 2006. We observed from zero to 340 seals hauled out on the ice. Eighty-five percent of the seals were counted in the upper portion of Pedersen Lake; fifteen percent were counted in the lower portion of the lake. This information was valuable for making recommendations to people visiting the area on how they could minimize their disturbance. If they only kayaked or walked along the shore in the lower portion of the lake, they would encounter a small portion of the seals. The majority of the seals in the upper lake could be viewed with binoculars from the lower portion of the lake and disturbance could be reduced.

Seal Behavior

In order to determine whether humans were altering the “normal” behavior of the seals, we observed seals when humans were not in the lake and when humans were sea kayaking and walking in the area of the lake. We used the seal behaviors collected when

humans were not in the lake as the “normal” behavior of the seals. To do this, we selected a group of seal(s) hauled out together on one iceberg and recorded their behaviors. When humans were present, in addition to observing seal behavior, the activity of the kayakers and walkers were monitored. Harbor seal behavior was categorized as resting, alert, or abandoning (Figure 2). A behavior was recorded every ten seconds for ten minutes.

Nearly 2,000 behavioral observations of seals were recorded and we found that when humans were present, harbor seals rested less and abandoned the ice more than they did when humans were absent. The ramification of increased amount of time spent alert and decreased time hauled out are unknown, but disturbing seals from their haulout may increase energy expenditure and potentially prolong the molt process. The extent to which these factors affect the health and survival of the seals are poorly understood.

Outreach and Education

Four companies in Seward, Alaska offered guided sea kayak tours in Kenai Fjords National Park during the years of the study. Every year the guides employed by these companies undergo a period of training. During May 2006, we presented a PowerPoint presentation with preliminary results from the 2005 season in which kayakers and walkers were identified as disturbing harbor seals. As a means to mitigate disturbance to harbor seals we provided paddling recommendations. We recommended: 1.) Choose the route with the least number of seals hauled out. 2.) Observe the seal behavior. Resting seals are usually lying flat on the ice. If they lift their heads and stare, they are alert. 3.)

Halt the approach or alter the route so the seals could return to the resting state. If the approach is continued, the seals will abandon the iceberg and enter the water. Seals swimming in a group have often times been recently disturbed. The seals, once they are in the water, will approach kayakers with apparent curiosity. They will also approach groups of seals still hauled out and flipper-slap an alarm. Often the seals hauled out will abandon the ice following this alarm. Once the seals have been disturbed from the ice by humans, they may not haul out again for several hours.

To test whether the recommendations were effective we observed differences in the responses of seals to kayakers receiving different levels of training. During the 2006 field season, when a group of sea kayakers entered the lake, they were classified as a guided or unguided group, a group receiving mitigation training or not receiving training, or a group of unknown/mixed training level. The difference in the behavior of the sea kayakers between guided and unguided groups was apparent. Guided groups stayed together better, minimizing their potential disturbance to one larger group instead of several smaller groups. In addition, the guided groups tended to be quieter and explore the lake with more caution. When a group with a guide who had received training was paddling in the lake, their concern for minimizing their disturbance of seals was apparent. They entered the lake slowly, seeking out the route through the ice with the fewest seals. They observed the behavior of the seals. If they observed seals becoming alert they would readjust their route. Often times, if they observed seals abandoning an iceberg, they would paddle to the shore and continue their exploration of the lake from the shore. For the time these groups spent in the lake, the number of seals disturbed was greatly

reduced from groups observed in previous years. The results of the educational training were evident. The guides were aware of their potential to disturb seals and actively modified their behaviors to minimize this disturbance.

Observing animals in the wild is exciting and should be considered a privilege. We are the visitors. By educating ourselves about the area we are visiting and the wildlife we may encounter, we can help minimize adverse impacts on the resident wildlife.

Acknowledgments

This project was made possible by support from the Exxon Valdez Oil Spill Trustee Council and the Ocean Alaska Science and Learning Center. We would like to thank our field volunteers Jacob Knight and Sarah Schoen and Alaska SeaLife Center camera assistants Suzanne Conlon, Kristi Heffron, Morgan Sternberg, and Rebecca Pearce. We would also like to thank the Resource Management Division of Kenai Fjords National Park Service for their guidance and the local sea kayak outfitters, especially Kayak Adventures Worldwide, for their support throughout the project.

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