Reactions of Steller Sea Lions *(Eumetopias jubatus)* to Vessels at a Haulout in Glacier Bay

by:

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ABSTRACT

Private and commercial vessels visiting Glacier Bay National Park commonly approach South Marble Island to observe Steller sea lions. To minimize disturbance of wildlife, National Park Service (NPS) regulations require that boaters remain more than 100 yds from haulouts. This study was designed to determine if the distance limit prevents disturbance and if visitors comply with the regulation. On 23 days we recorded resting and non-resting behavioral states and the number of animals in the water at 2 or 3 min intervals throughout the day and we measured vessel distances. Ninety cases involving paired control (before approach) and 'experimental' (during approach) observations were analyzed. Nineteen (21%) vessels approached closer than 100 yds; 2 of these were commercial tourboats, others were private motorized vessels or kayaks. Sixteen (18%) vessel operators caused disturbance of sea lions, defined as a >20% increase in activity or >10% increase in the number of sea lions in the water. Compared to tourboats and private boats, kayaks were significantly more likely to approach the haulout closer than 100 yds and more likely to cause disturbances. Disturbances occurred at distances of 42 – 345 yds (mean = 152 yds; SD = 84; n = 15). Disturbances of sea lions by vessels could be reduced by increasing the 100 yd distance and improving compliance with regulations through visitor education and increased enforcement, but it is likely that other factors in addition to distance affect sea lion behavior.

KEY WORDS: Steller sea lion, *Eumetopias jubatus,* Glacier Bay National Park, disturbance, vessel interactions, behavior

INTRODUCTION

Nonconsumptive recreational activities, including wildlife viewing and photography, are increasingly popular relative to traditional consumptive activities such as fishing and hunting (Duffus and Deardon 1990, Vickerman 1991). While such a shift in the public's focus reflects and potentially influences changes in attitudes that generally benefit conservation efforts, human proximity to wildlife can have negative consequences. In ungulates, these consequences include increased heart rates (MacArthur et al. 1982), elevated metabolism, reduced survival of fetuses or young, lowered birth weights, and changes in use of preferred habitat (Geist 1971). For pinnipeds at haulouts or rookeries (breeding haulouts), repeated human disturbance can reduce time spent resting, disrupt nursing or social interactions, or cause temporary separations of females and dependent young. Permanent separations between females and nursing young can result in the starvation and death of pups, or chronic disturbance can cause temporary or permanent abandonment of a haulout. While pinnipeds can habituate to human proximity, wildlife observations that occur during sensitive reproductive or vulnerable physiological stages are more likely to have negative energetic, social, or life history impacts than disturbances that occur outside of breeding periods. In Alaska, potential conflicts between humans and pinnipeds exist because breeding and early stages of rearing occur in late spring and summer when most pleasure boating and wildlife viewing in Alaska occur.

In Alaska, tourism is the fastest growing industry (Heacox 1994), and in southeastern Alaska, wildlife viewing of marine mammals from boats is a major attraction. In 1993, Glacier Bay National Park in southeastern Alaska was the sixth most popular area to be visited in Alaska (Alaska Division of Tourism, Juneau, AK 1998), and wildlife viewing is one of the primary recreational activities of visitors in Glacier Bay. Vessel entries into Glacier Bay are limited by the National Park Service (NPS) between 1 June and 31 August. The quotas for commercial tourboats, charter boats, and private boats were 3, 6, and 25 per day, respectively (Federal Register, May 30, 1996. Vol. 61(105): 27008). During this study there were no quotas for non-motorized vessels, primarily kayaks, in Glacier Bay.

A non-breeding Steller sea lion (*Eumetopias jubatus)* haulout at South Marble Island in Glacier Bay (Fig. 1) is the only reliable location for visitors to observe this high-profile species, and the majority of visitors, other than those on cruise ships, approach SMI to obsere nesting sea birds as well as Steller sea lions. To minimize disturbance and to promote visitor compliance with the Marine Mammal Protection Act, the NPS enacted regulations that require vessels to remain at least 100 yds[1] (91 m) from SMI or any sea lion on land (Federal Register, May 30, 1996. Vol. 61(105): 27018-27019). The National Marine Fisheries Service (NMFS) has also published marine mammal viewing guidelines (not regulations) with a 100 yd minimal approach distance recommended for all species of marine mammals (NMFS 1992).

In 1997, the Endangered Species Act listing for Steller sea lions in the western portion of their range (west of 144°W) in the North Pacific was changed from threatened to endangered status (U.S. Federal Register 62:24345-24355), due to continued declines that began in the eastern Aleutian Islands and spread to the Gulf of Alaska (Braham et al. 1980, Loughlin et al. 1992, Merrick et al. 1987, NMFS 1995). In the eastern portion of their range, from Cape Suckling (144°W) east to southern California and including Glacier Bay, Steller sea lions have been classified as threatened since 1990. In southeastern Alaska in recent years sea lion numbers appear to be stable or increasing (Calkins et al. 1999, Loughlin et al. 1992, NMFS 1995).

Several studies have examined the effects of human disturbance on harbor seals *(Phoca vitulina)* at haulouts [Johnson, 1977 #1962; Calambokidis, 1983 #185; Renouf, 1981 #2324; Johnson, 1989 #1964; Allen, 1984 #1459; Thiel, 1992 #4137; Brasseur, 1996 #4608; Suryan, 1998 #4991]. A few have addressed disturbance of sea lions [Lewis, 1987 #2047; Johnson, 1989 #1964; Riemer, 1995 #4984]. This study is the first to quantify sea lion behavior and vessel distance from a Steller sea lion haulout. The objectives of this study were to determine: 1) the range of vessel distances from the

[1] Because the minimal approach distance regulated by the NPS is provided in yards, these units will be used for all boat distances instead of meters.

haulout that cause changes in sea lion behavior, 2) if the 100 yd distance limit prevents sea lion disturbance, 3) the degree to which visitors comply with the NPS distance regulation, and 4) if disturbance was more likely in any of three vessel categories (tour/charter boat, private boats, and kayaks). Results from this study can be used to update regulations and guidelines to minimize the effects of vessel traffic on sea lions in Glacier Bay and elsewhere, and they could apply to other non-breeding haulouts. Reducing the effects of humans on the behavior of pinnipeds at haulouts would also preserve the quality of wildlife viewing opportunities for the public, an NPS mandate.

METHODS

Study Site

This study was done at South Marble Island (58° 38.5'N, 136° 02' W) in Glacier Bay National Park, Alaska (Fig. 1). There are two adjacent rock-ledge haulouts along the north end of the island; sea lions at the northeast ledge were the focus of this study. We observed sea lions and monitored vessels from an elevated site (ca 50 m above mean low tide) 150 m south of the haulout (Fig. 1). Our observation site was hidden from view as boaters approached from the south, but was visible if someone looked up and scanned the vegetated knoll where we were located. Because most boats approached the haulout from the south and visitors generally focused their attention on the sea lions after coming into our view, the majority (70%) of 73 operators and passengers did not appear to be aware of our presence.

Behavioral Sampling

Two observers monitored the haulout for a total of 23 days: 8 d in 1994 (1-7 Aug. and 8 Sept.), 5 d in 1995 (28 July – 1 Aug), and 10 d in 1997 (11-18 July; 27-28 Sept.). When a boat approached the haulout one person measured vessel distances while the other conducted systematic behavioral observations. On most days we began observations of the haulout between 07:00 and 07:30, before the first scheduled tourboat, and continued until 19:00-21:30. We monitored the haulout for a total of 233 h.

During periods when there was no boat traffic, one observer recorded sea lion behavior at regular intervals of 2 (1994 and 1995) or 3 (1997) min throughout the day and evening for approximately 1 h every 1.5 h, and whenever a boat was approaching or near the haulout. After a vessel departed, we continued behavioral scans for at least 20 min. The length of the behavioral scanning intervals was increased from 2 to 3 min in 1997 because the mean number of sea lions on the haulout increased from 82 and 61 (1994 and 1995) to 155 in 1997, and we could not complete behavioral scans of all animals within 2 min.

When boats approached within about 800 yds of the haulout the second observer began measuring vessel distances and bearings (see below). Our goal was to sample behaviors at least 20 min before and after a vessel approached the haulout, in addition to the entire time that a boat was within 800 yds of the haulout; in most cases our "before" and "after" observations lasted longer than 20 min. However, if we did not see or hear a boat coming or if we were not coincidentally conducting a behavioral scan, we were not always able to collect data immediately prior to a vessel approach; for most encounters we had recorded behaviors within 1 hour before each vessel arrival.

We recorded behaviors of all animals using instantaneous point scan sampling (Altmann 1973). We observed sea lions using Swarovski 7 X 42 or Zeiss 20 X 60 binoculars mounted on a tripod. A 3-digit tally counter was used to categorize the behavior of each sea lion into one of the following three behavioral categories:

> ***Resting:*** Sea lion with its head down or animal motionless with head held up and eyes closed (if visible); animal not interacting with other sea lions; periods of grooming included in this category, as long as animal was not simultaneously interacting or vocalizing.
>
> ***Active:*** Sea lion moving on the haulout, vocalizing, or interacting with another animal; includes all behaviors not considered resting, but not minor adjustments in position of a resting sea lion.

In the Water: After each behavioral observation scan, sea lions completely in the water were counted during ca 30 sec scans of the water surface near the haulout

Experimental and Control Periods

For each encounter, the period during which a vessel was visible and within about 800 yds of the haulout was considered to be the experimental, or 'during approach' period. The durations of vessel encounters varied from 3 min to 2 h (mean = 12 min, SD = 15 min, n = 98). As the control for each vessel encounter, I used an equivalent number of behavioral sampling intervals from a period immediately before the approach or within 2 h before an encounter, as long as no other boats had approached during that time.

I excluded behavioral intervals from control and experimental groups for 2 situations in which sea lions changed behavior during an observation due to a stimulus other than a vessel. On two of these occasions a humpback whale *(Megaptera novaeangliae)* surfaced within 40 yds of the haulout immediately before or during a vessel approach. In the first situation, the sea lions on the haulout became more active immediately after the whale surfaced and blew. In the other situation several sea lions entered the water and began to interact with the whale. In both cases, it appeared that the whale had elicited changes in sea lion behavior. In one unusually long encounter a motorized vessel remained at the haulout for 62 behavioral sampling sessions. In this one case I used a shorter control period with only 20 sampling cycles, because this was all that was available without another vessel nearby and within 2 h before the long encounter.

Using the differences in behavioral states between control and experimental sessions, rather than absolute behavioral states, presumably controlled for much of the natural variation in behavioral state of the sea lions. That is, if sea lions were already active before a vessel arrived, this was not then attributed to the presence of a vessel. A total of 92 matched control/experimental ('before approach'/'during approach') intervals were available for analysis of behavioral changes, and we measured vessel distances for 73 of these 92 encounters.

I defined disturbances as changes in behavior between control and experimental periods involving either a >= 20% increase in the activity level of the sea lions on the haulout or >= 10% increase in the maximum number of sea lions observed in the water.

Measuring Vessel Distance from the Haulout

In 1994, we measured angular bearings to vessels with *Fujinon* 7 X 50 binoculars with an internal compass and distances to vessels using a *Ranging, Range-Finder 1200*, an optical device that relies on parallax for distance measurements. The *Range-Finder 1200* measures distances up to 1000 m, but the accuracy of the device declines markedly with distance (+/- 1 m at 100 m, +/- 9 m at 300 m, +/- 100 m at 1000 m).

In 1995 and 1997, we used laser range-finding binoculars *(Leica Geovids,* 7 X 42; +/-1m accuracy at maximum range of 1000 m*)* for both the distance and bearing measurements. In the field we found that the maximum measurable distance to a target vessel was around 800 yds. In a test designed to compare the accuracy of the two distance-measuring devices, the optical (parallax) range finder underestimated distance and lacked precision compared to the laser range-finding *Geovids* (Fig. 2).

During vessel approaches, the observer took distance measurements about once every 30 seconds, providing 3-5 distances for every behavioral scan. The vessel observer also recorded information on vessel and passenger activities, including changes in vessel speed or direction, audible voices, or use of a public address system. This observer also drew a rough sketch of the boat's path, noting the approximate point and time of closest approach.

Prior to, or just after, each tracking session, the vessel observer recorded three measurements of their distance and bearing to a point on the seaward edge of the haulout. The repeated haulout measurements from 1994 were compared to more accurate measurements made with the laser range-finding binoculars in 1995. The differences in these measurements for each observer were used to develop conservative correction

factors for the less accurate optical range finder used in 1994. Distances between the haulout and the vessel were calculated using trigonometry from the measured distances and angles from the observer to the haulout and to the vessel (Fig. 3).

Vessel Categories

During our field observations, we classified vessels into one of 7 categories which were collapsed into 3 broader groups for analysis due to small sample sizes in the floatplane (n = 1) and charter boat (n = 2) categories (Table 1). The 3 categories were: 1) private vessels under power, 2) tour and charter boats, and 3) kayaks. In addition to considering motorized and non-motorized categories, the 3 broad categories were derived based on assumptions that: 1) tour and charter boat captains would be more likely to have prior experience approaching this or other sea lion haulouts, 2) private individuals operating power boats would be less likely to have experience near haulouts, and 3) kayakers were in a separate category because they were the only non-motorized craft we observed, and kayaker experience around pinniped haulouts varies widely. For example, commercial groups typically included an guide experienced in Glacier Bay. During the study we tracked 3 NPS vessels, however these boats were excluded from the analysis for two reasons: NPS staff were not involved in wildlife viewing activities and they were aware of the study. (All of the NPS vessels stayed well beyond 100 yds, and none caused disturbances.)

Sea Lion Behavior and Vessel Distance

To determine if a vessel's distance from the sea lions affected the percent of sea lions active or the percent in the water during an encounter, I tested for a correlation between the percent change in behaviors before and during each encounter and the distance at which disturbance occurred, or the minimal approach distance if a disturbance did not occur. Because vessel categories could also influence the response of sea lions during an encounter, I used multiple correlation analysis that included vessel length as a second independent variable. The dependent variable was the difference between the maximal percent of sea lions active (or in the water) during paired control and experimental

observation sessions. An arcsine root transformation was applied to the percent data before analyses.

In 8 cases (6 kayak groups and 2 private power vessel groups) two or more boats approached the haulout at the same time. The distance and characteristics of the closest boat was used in the analysis of these encounters.

Disturbance and Compliance with Distance Regulations by Different Vessel Types

I performed two Chi Square tests to determine whether vessels in one of the three broad categories (Table 1) were more or less likely to approach the haulout closer than 100 yds or to be involved in disturbances. To compare levels of compliance among the vessel types, I also compared the mean approach distance for each vessel category using a Kruskal-Wallis test.

RESULTS

Compliance with Distance Regulations

Nineteen of the 90 (21%) vessels did not comply with the NPS's 100 yd distance limit; 2 of these vessels were commercial tourboats; all others were private motorized vessels (n = 14) or kayaks (n = 3). Commercial vessel operators (tour and charter boats) were significantly more likely to comply with NPS distance regulations than private power boat operators or kayakers (Chi Square = 11.605, p = 0.0015) (Table 2a). In addition, the mean distance that kayakers approached the haulout was less than 100 yds and significantly closer than vessels in the tour/charter and private vessel categories (ANOVA; p = 0.0272, Sheffe's *F* multiple comparison test) (Fig. 5). The closest individual approach – to within at least 9 yds of the haulout – was by a private power boat (Fig. 5).

Sea Lion Disturbance by Vessel Categories

Sixteen of the 90 (18%) encounters (9 private boaters, 4 kayakers, and 3 tour/charter boat operators) caused disturbances (Table 2). Kayakers were significantly more likely to change the behavior of sea lions on the haulout than private operators of power vessels or experienced captains of commercial vessels (Chi Square = 10.604, p = 0.0098) (Table 2b). Only 1 of 41 tourboats was observed to increase sea lion activity by more than 20% or increase the percentage of sea lions in the water by more than 10%. The other 2 disturbances by vessels operated by commercial captains occurred during approaches to 176 and 345 yds by charter vessel operators (Table 2, Figs. 5).

Sea Lion Behavior and Vessel Distance

Disturbances occurred at distances of 42 – 345 yds (mean = 152 yds; SD = 84; n – 15). Six of the 15 (40%) encounters that resulted in disturbance occurred when boaters approached the haulout closer than 100 yds. The greatest distances at which disturbances occurred were during approaches by 2 charter vessels (345 and 202 yds), by a taxiing floatplane (265 yds), and a private power vessel (232 yds).

We observed increases in the percent of sea lions active up to 98% (Fig. 4a), and increases in the number of animals in the water up to 47% (Fig. 4b). The most extreme behavioral responses that we observed occurred during approaches by kayaks.

DISCUSSION

Compliance

Twenty-one percent of boat operators did not comply with the NPS 100 yd regulation, and private individuals in boats under power and kayakers were significantly less likely to comply with distance regulations compared to commercial operators (Table 2). Non-compliance may be due to: a) inaccurate distance estimation, b) lack of awareness of the distance regulation, c) intentional violation of the regulation, or d) situations in which sea

lions do not visibly change their behavior at <100 yds. I suspect that the first two factors were more often involved in the violations that we observed, although two cases of disturbance appeared to be intentional. All private power boaters in Glacier Bay are required to receive an orientation from NPS staff (covering regulations and wildlife closures in the Park) before entering the Bay; they receive written information on wildlife closures, so most visitors should be aware of NPS distance limits. Most private boaters do not have experience or training in estimating distances on the water, although many private vessels have radar that could be used. During our observations we did not observe any NPS ranger vessels near the haulout and no violators of the distance limit were stopped. In fact, NPS Rangers have no means of determining if a boat has approached the sea lion haulout closer than 100 yds. The lack of enforcement may be a factor in the observed non-compliance.

At least one situation involved intentional, rather than incidental, harassment of Steller sea lions. A private power vessel approached the haulout and a passenger threw a dead herring onto the haulout as the bow of the power boat came closer than 9 yds of sea lions. All of the sea lions became active (a 90% increase from the control period) and moved toward the edge of the haulout or dove into the water during the encounter. A few situations that resulted in disturbance of sea lions involved people trying to take photographs or videos of the animals.

Commercial operators were the least likely to violate the NPS's distance limit regulation, and there are several possible reasons for this. All of the tour and charter boat operators are presumably aware of the NPS distance regulations. Furthermore, these individuals, or their companies, operate under renewable concession permits issued by NPS, so there is incentive to comply with Park regulations. Moreover, captains of tourboats often used radar while approaching South Marble Island; their repeated experiences at the haulout allow them to improve their distance estimation, assessment of sea lion behavior, and vessel maneuvering tactics. One NPS Interpretive Ranger reported that disturbance at the haulout was much greater when a new captain was operating the daily tourboat early in the season (Personal Communication, R. Salazar, NPS Interpretive Division, Glacier Bay

NPS). In addition, many of the tourboat operators learned of our study during the three summers, so the results in this report may reflect biased behavior for tourboat captains.

Kayakers were most likely to come close to the haulout perhaps because: 1) kayakers may be more inclined to over-estimate their distance from sea lions due to their low aspect in the water, 2) kayakers may assume that a small, non-motorized vessel will be less likely to disturb wildlife, and 3) some kayakers and other wildlife observers were photographing sea lions, an activity that tends to entice individuals to get closer to wildlife than they might otherwise.

Differences in Disturbance by Vessel Category

Compared with tourboats, kayaks and private boats were significantly more likely to disturb sea lions at the haulout (Table 2). Operators of these latter vessels are more likely to be unfamiliar with the haulout, and less aware of NPS and MMPA regulations, or they may not believe that enforcement of the regulations will occur. In Oregon, a 500 ft closure to vessel traffic was implemented around Three Arch Rocks National Wildlife Refuge after researchers documented levels of disturbance to sea birds and pinnipeds (Riemer and Brown 1994). Signs about the refuge were placed at all nearby boat ramps and information on the refuge and closure area was distributed to the public. Numbers of people entering the 500 ft zone decreased, and the majority of violators were non-local, uninformed sport boaters (Riemer and Brown 1995). In Glacier Bay during summer months, private boaters and most kayakers received printed and verbal information about wildlife closures. Yet, the information provided did not prevent disturbances or distance violations in 18% and 21%, respectively, of the visitor groups, suggesting a need for improved public education and enforcement.

Only 3 charter boats were observed during the study, and this small sample size is why this group was not evaluated separately from tourboats. Two of the 3 charter boats elicited disturbances at greater than average distances (202 and 345 yds), although

neither boat came closer than 170 yds from the haulout. Possible explanations for the difference in sea lion responses to charter and tourboat operators include: 1) charter captains do not regularly approach the haulout as do tourboat operators, 2) charter vessels in Glacier Bay emphasize sport fishing rather than wildlife viewing, and 3) there is a higher turnover in charter compared to tourboat boat captains. In future studies charter operators should be considered separately from tourboat operators, if sample sizes allow.

In Washington state, rates of disturbance at a harbor seal haulout were significantly reduced after: 1) a local newspaper published an article on the problem, 2) signs and a float line were placed around the perimeter of the haulout, and 3) the Marine Mammal Protection Act was enforced (Calambokidis et al. 1991).

Possible Effects of Sound on Disturbance

Several observations from this study suggest that isolated noise, rather than steady or gradual changes in sound, is one factor that may affect sea lion responses to approaching vessels. In the first example the absence of any sudden noise may have prevented a response. A group of 10 people in five double kayaks approached the haulout, and rather than paddling past the sea lions in dispersed sub-groups, this large group rafted together north of the haulout and then used the tidal current to drift past the sea lions. The group approached no closer than 120 yds and did not paddle as they passed. We observed no disturbance during this encounter. In contrast, 2 other smaller groups that approached to 116 and 120 yds as dispersed groups, with individuals paddling slowly and cautiously, were involved in two of the more extreme cases of disturbance. These encounters both evoked 98% increases in sea lion activity levels (Fig. 4) and 15% and 47% increases in the number of animals in the water, respectively (Fig. 5).

The higher than expected tendency for kayakers to cause disturbance may be due to their "stealth-like" approaches, in contrast to approaches by powered vessels. When a kayaker approaches a haulout, the lack of a continuous acoustic signal may increase the potential for disturbing sea lions—as compared to a vessel under power—because the animals have not had any warning of the approach. Sudden isolated noise, such as a paddle

bumping the hull, appear more likely to change the behavior of sea lions than steady continuous noise, even if the steady noise is louder. In her behavioral studies in Yellowstone National Park, M. Altmann found that moose *(Alces alces)* fled from greater distances when she stalked them silently, whereas they let groups of noisy tourists approach much closer (Altmann 1958). The low silhouette of a kayaker may be more similar to that of a killer whale, one of the few predators of sea lions, and this may trigger a stronger response than a large boat that has approached slowly under power.

The vessel operator of the charter boat that caused disturbance from a distance of 345 yds turned the engine off for several min, and we heard a noise that sounded like something hard hitting the hull of the boat. The increases in sea lion activity (81% increase in activity and 19% increase in the number in the water) occurred immediately after this noise. Two other boaters turned off their engines while observing sea lions, and we observed a disturbance when they restarted their engines. These observations suggest that vessel noise should be kept low and constant, with engines left on, near haulouts.

Observations of the approach of a taxiing floatplane provide a final example that suggests that steady, even loud, sound may be less disruptive than a quiet approach in which sea lions are alerted to a vessel, either by a sudden change in sound or by visual or aural cues. On July 14, 1997 a private floatplane landed and was taxiing close to the southeast shore of the island when we first heard it. We began tracking it at 12:19 as it taxied up from the southeast shore and came within our view. It appeared that the passengers had been observing nesting shorebirds along the southeast shore. The airplane taxied toward the haulout, and at 12:24 the pilot cut the engine. At 12:30 the plane had drifted north to a point at which the passengers could no longer see the haulout with turning around in their seats. The pilot restarted the engine and revved it for take-off. Prior to this we had not detected a change in sea lion behavior on the haulout. After the take-off we counted 92 sea lions in the water, a 40% increase, and all but 5 of the 79 sea lions remaining on the haulout had turned toward the noise and were moving across the haulout toward the water; most of these animals had also begun vocalizing.

In a study using controlled disturbance trials, the distance between adult female mule deer *(Odocoileus hemioinus)* and people walking or operating motorized vehicles had a significant effect on the intensity of avoidance responses (Freddy et al. 1986). In addition, people walking had a greater effect on deer than did people operating motorized vehicles (Eckstein et al. 1979, MacArthur et al. 1982, Richens and Lavigne 1978, Schultz and Bailey 1978). In the controlled disturbance trials, deer began moving away from humans on foot at greater distances than they did from snowmobilers (190 m vs. 133 m), and they more frequently (80 vs. 24%) moved away from the disturbance when approached by hikers compared to smowmobilers (Freddy et al. 1986). These results are analogous to the responses of sea lions to kayaks compared to motorized vessels in this study. Deer showed a mild alert response (head raised or grazing stopped), however, at greater distances from snowmobilers than from pedestrians (Freddy et al. 1986).

Effects of Distance on Disturbance

Fourty three percent (7/16) of disturbances that we observed occurred during encounters involving boats that approached closer than 100 yds (1 of these disturbances was not measured, but the approach by kayakers was clearly less than 100 yds). The remaining 9 (57%) disturbances occurred when vessels approached between 101 and 345 yds. While an increase in the current distance regulation should reduce disturbance at South Marble Island, it is unlikely that a larger distance limit alone would prevent all disturbances, since 20% of boaters did not comply with NPS regulations. Additional enforcement or improved visitor education could improve compliance. In addition to distance regulations, minimization of vessel sound and changes in sound may decrease wildlife disturbances.

In addition to guidance on how close they can approach wildlife, viewers need to monitor the behavior of the animals that they are approaching for changes in activity that they are getting too close.

Some vessels approached the haulout closer than 100 yds and did not appear to alter the behavior of the sea lions. This indicates that factors besides distance influence the

potential for disturbance. These factors may include: operator experience, vessel size, changes in noise levels, human activity on deck, initial behavioral state of the animals, wind direction and smell, or the presence of a naturalist familiar with the haulout or sea lion behavior. Although this study was not designed to determine what aspects of a vessel's approach tend to disturb sea lions, we noted that motorized vessels that maintained a slow, steady speed and did not turn off their engines were less likely to elicit detectable changes in behavior compared to vessels whose engines were shut down and restarted. Movement of individuals visible on deck as well as sudden noises, may also increase the potential for altering behavior of pinnipeds at haulouts. A study involving controlled approaches could be used to determine which human behaviors are most likely to change the behavior of sea lions. Results from such a study could then be used to minimize disturbance through visitor education.

The occurrence of detectable changes in behavior of sea lions in response to vessel traffic near South Marble Island could be reduced by increasing the 100 yd distance to 200 yds, requiring that vessel noise levels remain constant, and by better enforcement and education.

While results of this study could be useful for minimizing disturbance at other sea lion haulouts, private and commercial boat operators in Glacier Bay may not be representative of those elsewhere in Alaska. From June 1 – August 30, private and commercial (except fishing) vessels must apply for a permit to enter Glacier Bay and the captain or a representative from each boat is required to go through an NPS orientation that includes information on wildlife viewing guidelines and regulations. These factors suggest that the average boater in Glacier Bay National Park may be more conservative in approaching wildlife compared to boaters in other areas where there are no restrictions on access to haulouts and where wildlife viewing regulations or guidelines are not widely publicized or enforced.

Commercial tours which feature wildlife viewing are experiencing unprecedented popularity (Duffus and Deardon 1990), as is marine wildlife viewing in southeastern

Alaska. While the number of vessel permits for Glacier Bay was increased by 8% for charter boats and private vessels per season in 1996, the daily caps of 6 and 25 boats, respectively, were not increased. Instead, increases in vessel numbers were implemented by extending the number of visitation days (Federal Register, May 30, 1996, Vol. 61, No. 105). Thus, if tourism increases in Glacier Bay sea lions may be exposed to higher levels of vessel traffic on more days during the spring and summer, but there is still an inherent limit on how many vessels approach the haulout on any given day. Visitation to haulouts outside of GB is not limited, so the potential for disturbance as the wildlife tourism industry grows may be greater at these sites.

Chronic disruption of resting and social interactions of sea lions ashore could have longterm effects on pup or juvenile survival and adult reproductive success. Pinnipeds require time ashore to rest and interact. Captive harbor seals that were deprived of opportunities to rest on platforms for a week showed significant increases in haulout duration after access to the haulout platform was restored (Brasseur et al. 1996). Repeated disturbances at haulouts could result in reduced reproductive success or survival through increased energetic demands or disruption of social interactions. At rookeries in Alaska, disturbance of sea lions by biologists on shore during counts of pups (during which adult sea lions were driven into the water by people on the beach) resulted in females engaging in more agonistic interactions and significantly less female-pup contact (Lewis 1987). Pup injuries from trampling may also occur during disturbances. Pinnipeds that have been chronically disturbed may stop using a haulout (Peterson and Bartholomew 1967). In addition, the quality of a wildlife viewing experience could be reduced if a boater causes sea lions to stampede into the water.

Additional Factors that May Influence Responses to Vessels

Factors in addition to distance that affect the response of ungulates to human activities include existing levels of sport hunting in the population (Geist 1971), potential for habituation (Richens and Lavigne 1978), reproductive and nutritional status, type of

habitat and season, and experience of individual animals (Altmann, 1958). These same factors are likely to influence whether sea lions respond to human activities.

Some hunting of Steller sea lions by Alaska Natives for subsistence use occurs in southeastern Alaska, although hunting levels are low compared to other parts of Alaska (Wolfe and Mishler 1993). Hunting within Glacier Bay is prohibited by NPS regulations, yet sea lions that use SMI clearly move beyond Park Service boundaries where they could be hunted. Even at low levels, we might expect individual animals that have been shot at to be more wary of boat approaches than animals that have not had such experiences.

Mammals can also become habituated to human proximity, and this is more likely to occur in populations that are not hunted (Geist 1971). If within-season habituation to vessels approaching for wildlife viewing does occur, we would expect sea lions at SMI to be more likely to react to vessels early in the summer, since most hunting occurs in fall and winter. We might also expect that vessel-specific habituation would be more likely for tourboats compared to other vessel categories, since they operate on a regular or daily schedule. Steller sea lions on haulouts may become familiar with a vessel's acoustic 'signature' or physical appearance. Habituation to specific vessels could explain some of the reduced reaction to tourboats compared to private and charter vessels, although alternative explanations exist.

The effects of vessel traffic on sea lions at rookeries is likely to be different from that at a non-breeding haulout like SMI. Differences in responses of harbor seals to human activities have been observed: haulouts used by females with pups tended to be more sensitive than those with fewer or no pups (Suryan and Harvey 1998). This study was conducted at a non-breeding haulout comprised almost exclusively of immature and mature males; thus, a comparable study at a rookery would be useful to determine if minimal approach distances for breeding animals are different (most likley greater) from those at a non-breeding haulout. The NMFS's current recommended minimal approach distance of 100 yds is likely to be inadequate for rookeries.

Studies on the effects of vessel traffic on harbor seals *(Phoca vitulina)* have demonstrated that human disturbance can alter seal behavior or distribution (Allen et al. 1984, Calambokidis et al. 1983, Thiel et al. 1992), or result in abandonment of traditionally-used haulouts (Peterson and Bartholomew 1967). Bowles and Stewart (Bowles and Stewart 1980) noted that California sea lions were most likely to react when vessels approach to within 200 m of a haulout, and Riemer and Brown (Riemer and Brown 1994) observed that proximity to vessels altered the behavior of several species of sea birds and pinnipeds, including sea lions. Human activities that cause pinnipeds to escape into the water can reduce mother-pup contact (Lewis 1987) as well as increase the energetic demands on both individuals.

Conclusion

Increasing the minimal approach distance to the SMI haulout could reduce disturbances at this haulout. Compliance could be improved through better visitor education – particularly of private boaters and kayakers – and better enforcement of regulations. Such measures should decrease the frequency and severity of disturbance of sea lions in Glacier Bay National Park, but factors such as vessel noise that also influence disturbance need to be evaluated. The longterm or population level effects of repeated disturbances of Steller sea lions also need to be examined, perhaps by developing a model that incorporates energetic and social costs of increased activities and of entering the water.

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Table 1. Specific vessel categories recorded in the field and broad categories used for analysis.

Broad Categories	Specific Categories
1 private boaters	1 private, power
	2 private, sailboat under power
	3 floatplane, on the water
2 commercial vessels	4 tourboat, regularly scheduled itinerary
	5 charter, no scheduled itinerary
	6 NPS, research or monitoring vessel
3 kayak(s)	7 non-motorized craft for one or two passengers; experience levels vary

Table 2. Chi Square contingency test results for vessel operators in three categories comparing (a) approaches to <=100 and > 100 yds and (b) approaches that caused disturbances at a sea lion haulout. Kayaks and private vessels were less likely to comply with NPS distance regulations, and also more likely to cause disturbances than were commercial tour and charter boats.

	a) Minimal Approach			**b) Disturbance**		
	<100 yds	>100 yds	Totals	Yes	No	Totals
Commercial Bts.	2	38	40	3	37	40
Kayak(s)	3	4	7	4	3	7
Private Boats	14	29	43	9	34	43
Totals =	19	71	90	16	74	90
	Chi Square = 11.6			Chi Square = 10.604		
	p = 0.0015			p = 0.0098		

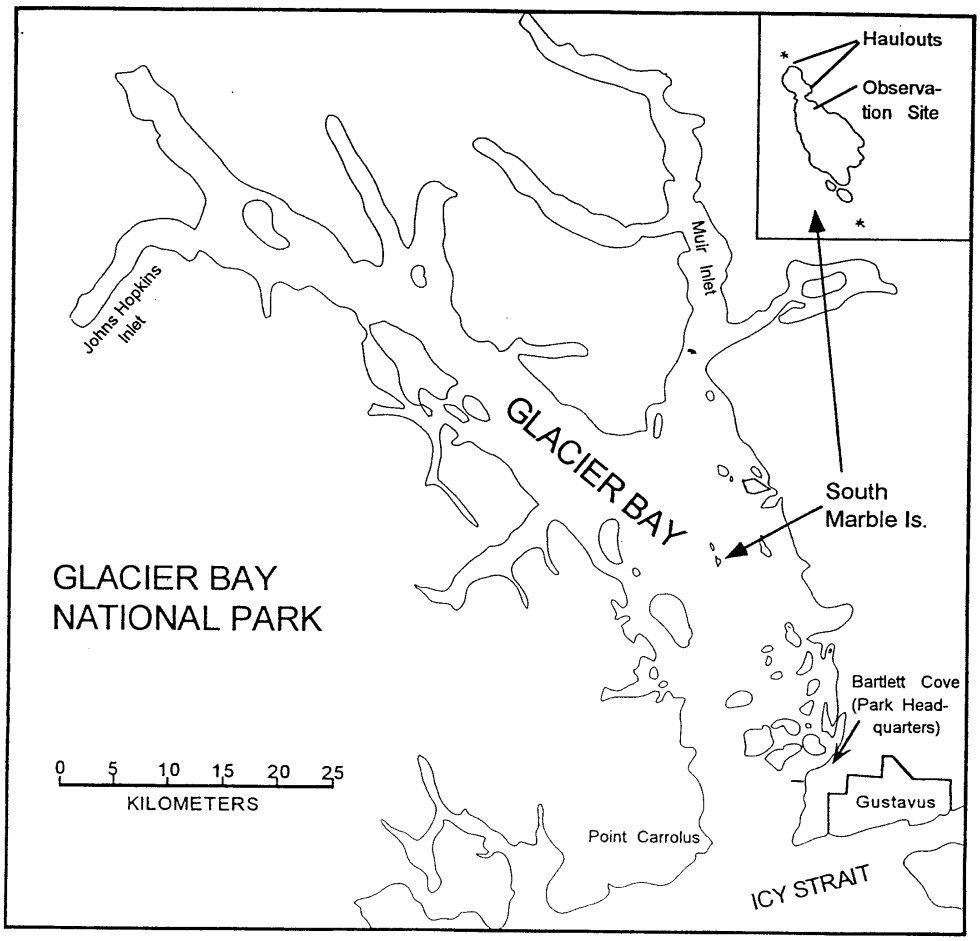

Figure 1. Map of Glacier Bay with the South Marble Island Steller sea lion haulout and observation site.

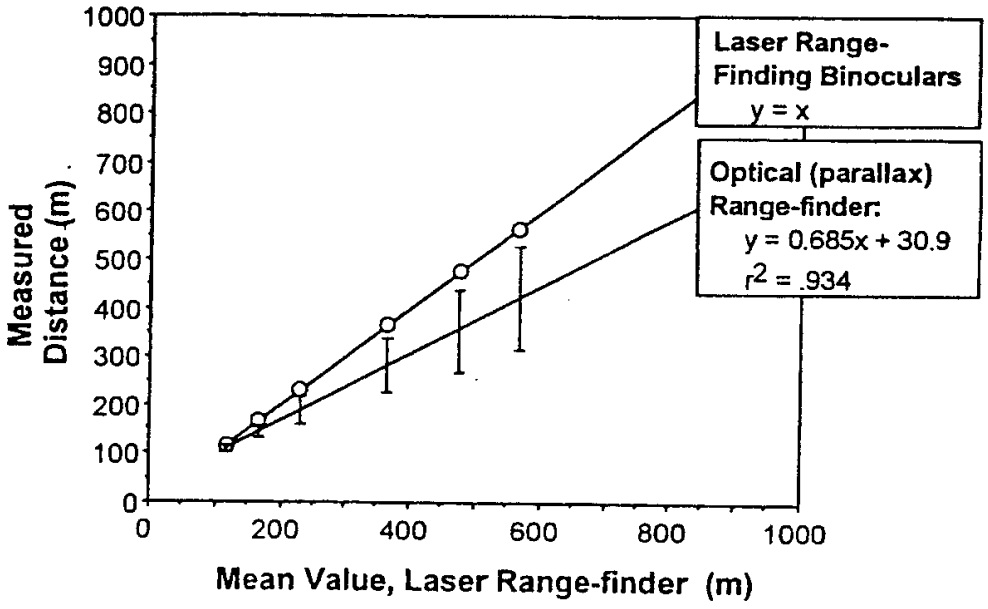

Figure 2. Comparison of distances measured using laser range-finding binoculars (*Leica,* Geovid BVD) and an optical range-finder (Ranging, Range-finder 1200). A regression line for the optical (parallax) range-finder was calculated from 20 repeated measures of each of six distances. Error bars are 95% confidence intervals; the 95% confidence intervals for the laser range-finding binoculars are too small to show on this scale.

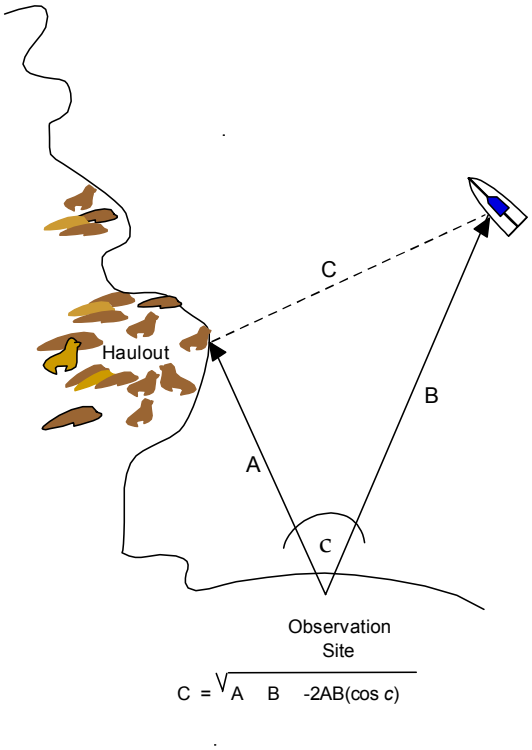

Figure 3. Method for calculating the distance between the sea lion haulout and boats as they approached. We measured sides A and B using an optical range-finder in 1994 and laser-equipped binoculars in 1995.

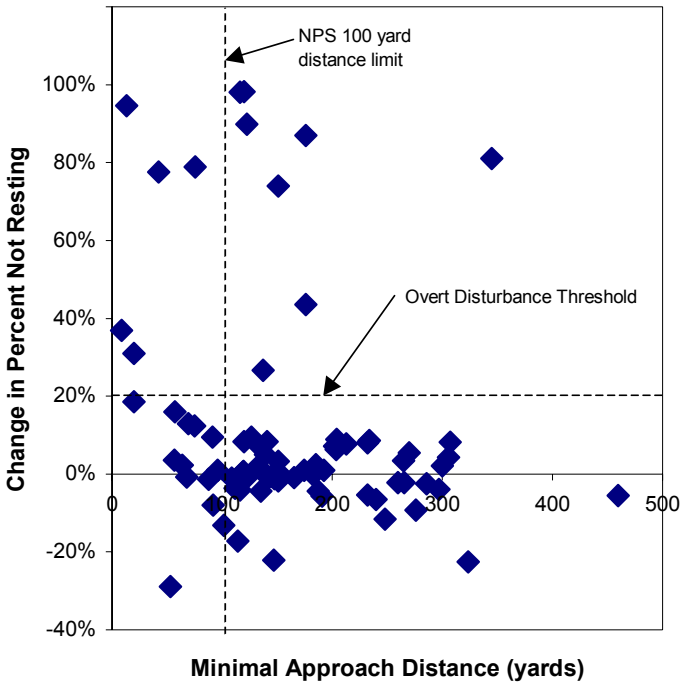

Figure 4a. Changes in the percent of sea lions not resting (active) between control periods before and "experimental" periods during the approach of 77 different vessels. Increases in activity greater than 20% occured in 13 of the 77 encounters.

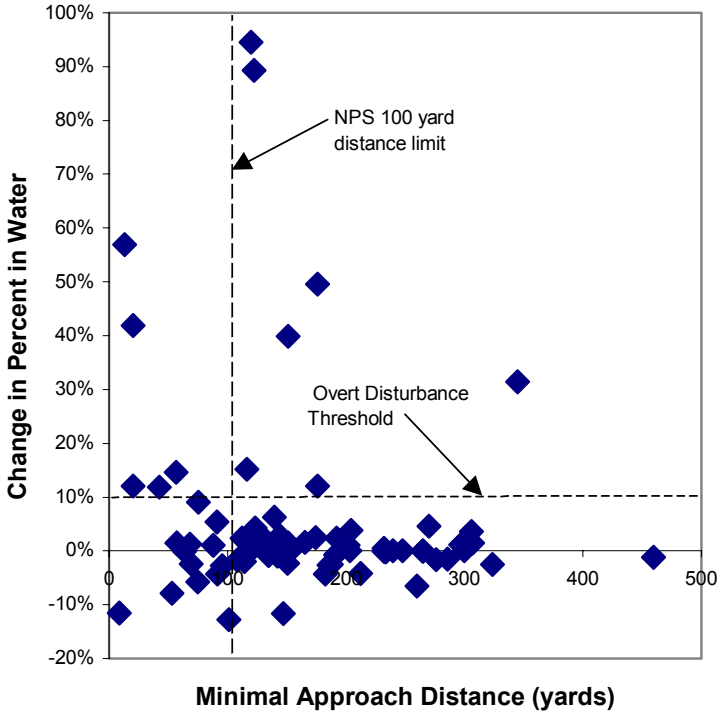

Figure 4b. Changes in the percent of sea lions in the water between 'control' periods before and 'experimental' periods during the approach of 77 vessels. Increases in activity greater than 10% occured in 13 of the encounters; two of these occurred during different encounters than the 13 which resulted in changes >20% in sea lions active. Data are from South Marble Island during summer months in 1994, 1995, and 1997.

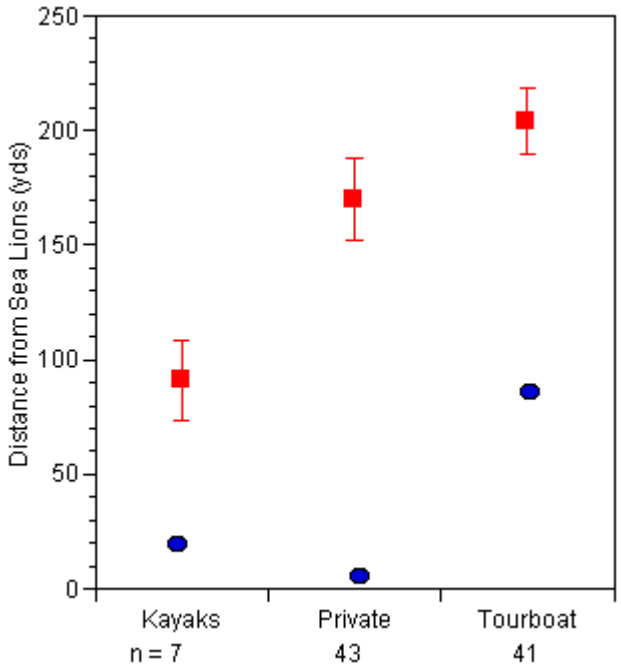

Figure 5. Mean (boxes) +/- 1 SE and minimal (closed circles) approach distances to a sea lion haulout by vessel category. Kayaks approached significantly more close than the other two types of vessels.