Disturbance of Harbor Seals *(Phoca vitulina)* and Potential Effects on Counts from Aerial Surveys, Glacier Bay National Park, 1991-1999

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ABSTRACT

Between 1992 and 1999, the number of harbor seals on terrestrial haulouts in Glacier Bay (GB) declined by 50%. To address a potential factor in this decline, we examined the effects of disturbance on seals at the Spider Island (SI) reefs, a primary terrestrial haulout in GB from which the National Park Service prohibits vessel approaches closer than ¼ nm. A disturbance was defined as any event that caused some seals to enter the water. We quantified the frequency of disturbances by cause (human, non-human, and unknown), determined the proportion of disturbances in which numbers of seals on the haulout reached the number observed immediately before the disturbance (= recovery), assessed the potential effects of disturbances on counts from aerial surveys, and compared the frequency of disturbances at SI from 1991 to 1997-1999. We observed seals on 27 days for a total of 229 hrs. Twenty (43%) of 46 disturbances were caused by human activities, 10 (22%) by non-human activities, and 16 (35%) by unknown sources. In 1998 and 1999, all vessels (n = 49) in the area were also monitored; 12 (24%) of these caused disturbances. No vessel disturbances occurred when boaters were farther than ¼ nm, and all vessels that approached within 100 yds (n = 7) elicited a disturbance. The disturbance rate (disturbances/6 hrs) did not change across the study years. However, seal counts as a percent of a day's high count were negatively correlated ($p < 0.0001$) with disturbances per day, although disturbance only explained 9% of the variance in counts. On average, 57% (SD = 36) of seals counted before a disturbance abandoned the haulout. Recovery occurred in 20 (43%) of 46 disturbances; the mean time from disturbance to recovery was 29 min (SD = 35 min). More recoveries occurred for human and unknown than for non-human causes. If compliance with the NPS's existing ¼ nm distance restriction for SI is improved, the number of disturbances should also decline. While disturbance of harbor seals on haulouts may be a factor in the population decline documented in Glacier Bay, it does not appear to be a primary factor.

KEY WORDS: harbor seal, *Phoca vitulina,* disturbance, ecotourism, aerial surveys, population monitoring

INTRODUCTION

Between 1992 and 1999, the number of harbor seals on terrestrial haulouts (resting sites) in Glacier Bay National Park declined by 48% (10.9%/yr; 95% CI = –16.4% to –5%) (Mathews and Pendleton 1999; Mathews and Pendleton 2000). Several factors are potentially involved in the decline, including increased mortality, emigration from the Park, and changes in seal behavior involving increases in the proportion of time spent in the water. To address one potential factor within the latter category, we examined data on the effects of disturbance (seals enter the water in response to some stimulus) on numbers of harbor seals at the Spider Island reefs, a primary terrestrial haulout for seals in Glacier Bay (GB). Specifically, we examined the potential effects of increases in disturbance from human or non-human (e.g., predators), and unknown sources on counts of seals on shore. While we consider disturbance of seals a factor in the observed declines in seals at terrestrial sites in Glacier Bay, it is unlikely that disturbance explains all of the 48% decline.

In Glacier Bay there are approximately 20-30 terrestrial haulouts (i.e., tidally influenced reefs and islets) that are commonly used by 1,200-2,500 harbor seals (Lentfer and Maier 1989, Mathews 1992, Mathews and Pendleton 1997). About 20 of these sites are typically occupied during August aerial surveys, with approximately 50% of the seals found on reefs near Spider Island, in the Beardslee Island Wilderness area (Figure 1). Spider Island is located in the central region of the Beardslee Islands, an area readily accessible to kayakers due to its proximity to National Park Service (NPS) headquarters in Bartlett Cove. Visitation of Glacier Bay by kayakers increased by 65% between 1991 and 1996 (Hennessy et al. 1996); trends in backcountry visitation have not been summarized since this date, although data collection has improved.

Aerial surveys of seals during the August molt have been conducted in Glacier Bay in all years from 1992-1999 except 1993. Seal numbers on the 3 reefs southwest of Spider Island plummeted from mean counts of 1,000 seals prior to 1997 down to 55 in 1997 and 230 seals in 1998 (Mathews and Pendleton 2000). During the aerial surveys in 1997, one of us (EAM) observed campers on Spider Island and on a small islet immediately west of Spider Island on two of the survey days. These islets are closured by NPS regulations to campers to reduce impacts on

breeding wildlife. On both survey days, depressions from seals' bodies were visible on the Spider Island reefs, but no seals were present. Given that the flights occurred within 30 minutes of very low morning tides (-2.9ft and –3.7ft, respectively), and that the reefs would have been mostly covered by the previous high tide, it appeared that seals had been flushed from the reefs within the immediate tide cycle. These and other observations of disturbances of seals (Mathews 1997) led us to wonder if the short-term effects of disturbances by vessels or non-human sources (e.g., predators) were key factors in the observed drop in numbers of seals using the reefs near Spider Island. Accordingly, we hypothesized that if disturbance was a factor, disturbance rates should have increased during the decline. From 1996 to 1999, motorized vessels, except those engaged in commercial fishing, have been prohibited from operating in the Beardslee Island Wilderness Waters from May through mid-September. Beginning in 1999, the NPS also prohibited commercial fishing vessels from these waters.

In Alaska, researchers and managers primarily rely on counts from aerial photographs to monitor the status and trends of harbor seals, and we assume that our counts of seals on haulouts provide a reliable index (vs. full count) of abundance. To distinguish between actual population declines and lower counts due to seals spending more time in the water, we need to know the degree to which disturbances may result in fewer seals counted simply because they have recently abandoned a haulout.

The primary objectives of this work were to quantify the frequency of disturbances by cause (human, non-human, and unknown), determine the proportion of disturbances in which counts of seals on the haulouts reached or exceeded the count immediately before the disturbance, assess the potential effects of increasing disturbances on counts from aerial surveys, and compare the frequency of disturbances at Spider Island from early years (1991 and 1992) to more recent years (1997-1999). In 1999, we specifically wanted to determine if the survey airplane caused disturbances not detected by the observers in the airplane; consequently, shore-based observations in this year occurred during the aerial survey period.

METHODS

Study Area

Spider Island is located in the central region of the Beardslee Islands, an area readily accessible to kayakers from Park headquarters in Bartlett Cove (Figure 1). Three tidally influenced reefs immediately west of Spider Island are typically occupied by resting harbor seals during low tide cycles, especially in spring and summer months. These 3 and up to 3 other reefs visible from a small island west of Spider Island were the focus of this study. We have observed seals at other sand bars, spits, and reefs nearby, but no other haulouts within 1 km of Spider Island have been used as predictably or extensively as these since at least 1991.

Aerial Surveys and Photographic Slide Analysis

We have flown aerial surveys for harbor seals in Glacier Bay every August since 1992, with the exception of 1993.Surveys are conducted during monthly low tides in August when seals molt (shed). We flew aerial surveys in single engine, fixed-wing aircraft (most often a Cesna 172 or 185). While looking for haulouts, we maintained a survey altitude of about 303 m (1000 ft). Our flight path is about ¼ mile (horizontally) from haulouts, both to allow the photographer to aim the camera out the open window and to avoid flushing seals from haulouts (Mathews and Dzinich 1997). Aerial surveys are conducted under a National Marine Fisheries Service (NMFS), Marine Mammal Protection Act (MMPA) Level B Research Permit (GA 527-1461).

Counts and Observations of Seals from Shore

In July or August 1991, 1992, 1997, 1998, and 1999, we observed seals near Spider Island from shore on 27 days for a total of 229 hours; most observations occurred in 1991, 1998, and 1999 (Table 1). Observations were made from an island about 2 km west of Spider Island (Figure 1). The 3 main reefs can be covered by higher tides, and seals typically begin to mingle near the haulout as the water drops until a portion of a reef becomes exposed. Occasionally, seals haul out on, or remain on, sandbars that are still awash. We began counts and behavioral observations of seals in the morning (6:10-11:15), usually starting before 8:00, and continuing throughout the day, until all seals had left the haulout, or until weather conditions (e.g., fog) obscured our view of seals.

Table 1. Summary of dates and total number of days and hours of harbor seal observations at the Spider Island Reefs.

	Days of Month		No. of	
Year	July	August	Days	Hours
1991		7-14	8	89
1992		26-28	3	9
1997	25-26		2	17
1998	19-26		8	74
1999		14-19	6	40
		Totals =	27	229

We observed seals using monocular spotting scopes (1991, 1992, and 1999), Zeiss 20 X 60 binoculars (1997), or a Swaroski 30 X 75 Twin Spotting Scope (1998) mounted on tripods. We counted seals approximately every 15-20 min (1991, 1992, 1997), 5 min (1998), or 10 min (1999), for the majority of every haulout cycle, usually until the last seal was forced off a reef by the rising tide or by a disturbance.

A disturbance was defined as any event that caused some or all of the seals on the haulout to enter the water within a short period of time. Disturbances involved seals moving rapidly in a group, or stampeding, toward and into the water. Individual seals quietly departing the haulout were not considered disturbances.

In 1991 and 1992, total counts of seals were made without categorizing behaviors. In other years, we used instantaneous scan sampling (Altmann 1973) to categorize and record behaviors (e.g., vigilant, non-vigilant/resting, and active) of seals on the reefs. We used 3 digit tally counters to assign a behavioral category to each seal. Total counts of seals were obtained by summing behavioral categories. For this report, only total counts of seals on shore were used.

We scored the behaviors of seals beginning on the far left (north) of our field of view and moved systematically to the right (south). At the end of each scan session, the observer searched the nearby water for seals and recorded the total in the water. Seals that entered the water typically

dove or dispersed quickly from the haulout. Consequently, the numbers of seals counted in the water often dropped steeply between scanning intervals.

Disturbance Categories

When a disturbance occurred, we recorded the type of disturbance or if it was not known. The following disturbance categories were recorded during field observations: kayak(s), power boat, commercial crab boat, eagle(s), killer whales, sea lion(s), and airplane (survey or non-survey). On one occasion in 1991, seals abandoned the haulout in response to a mild earthquake. For analysis, field categories were grouped into one of the following broader categories: human, non-human, or unknown.

Vessel Monitoring and Distance Estimation

When a disturbance was caused by a vessel, we recorded the type of vessel (kayak, commercial fishing, or power boat) and its activity. In 1998 and 1999, in addition to recording vessel information when a disturbance occurred, we also monitored vessel activities throughout the day and estimated distances of vessels from seals on haulouts. When there were 2 observers, one person counted seals and the other systematically scanned for vessels and other potential sources of disturbance, such as Bald Eagles *(Haliaeetus leucocephalus)*, which commonly feed on harbor seal placentas (Calambokidis and Steiger 1985). When there was 1 observer, she scanned for vessels before and after each count of seals. All disturbances were recorded, regardless of whether they occurred during the scheduled vessel scan. When the seals became notably more vigilant or active, we also scanned to try to determine the potential stimulus. If a disturbance occurred between scheduled counts and 2 observers were present, 1 observer started a count and the other monitored vessels if they were present. Higher counts occasionally occurred just before a disturbance due to the increased visibility of seals when they raised their heads.

The approximate route of each monitored power boat, kayak or kayak group was drawn on a datasheet with a map of the area (Appendix A) that included estimates of ¼ nm distances from the haulouts at high and low tides. The map and distances were developed using geo-referenced aerial photographs and National Oceanic and Atmospheric Administration (NOAA) coastline of the reefs that were part of an existing GIS database.. In the field, distance categories of kayakers

from the haulout were estimated using land marks and the map datasheet. Distance categories were: >1.5 nm, 1-1.5 nm, 0.5-1 nm, 0.25-.5 nm, and <=100 yds. (Non-metric measurements were used due to standards provided in the NMFS guidelines for viewing marine mammals and those on marine charts.) The extreme tidal range in the area meant that the edge of the haulout could be substantially closer to a vessel at a low, compared to a higher, tide. Observers tried to correct for the dynamic nature of the actual location of seals relative to vessels.

Due to the low aspect of our observation site, the entire water surrounding the haulout area was not visible from the observation sight, so there were times when it was not possible to monitor a vessel's entire route. At times because of blind spots, we could not see a kayak until after the seals had been disturbed. In other cases, we were not able to determine accurately the closest approach of a kayaker to the seals if the kayaks were hidden from our view.

Disturbance Rates by Study Year

To standardize time intervals for comparing mean disturbance rates across years, disturbance rates were calculated by dividing each year's observations into 6 hour "bins" and tallying the number of disturbances that occurred in each bin. In 1992, there were only 9 hrs of observations, so this year was not used in this analysis. The mean number of disturbances/6 hrs was then compared for the 4 different study years (1991, 1997-1999). Disturbance rate data for 1997-1999 were also pooled and compared to that for 1991 using a Mann-Whitney U test to determine if rates had increased in recent years.

Potential Effects of Disturbance on Counts from Aerial Surveys

Most aerial surveys of harbor seals are conducted near monthly low tides, and researchers try to fly surveys with 2 hours of low tide, since this is when a higher proportion of seals are likely to be found resting on haulouts. To test for possible effects of disturbances on the likelihood that a "snapshot" view of the haulout would record a number of seals close to the maximal count of seals, we converted each shore-based count into a percent of the maximal count for that day. Only counts within 2 hours of low tide were used in this analysis. We used a simple linear regression to determine if the number of disturbances per day was negatively correlated with the

probability that counts would be close to the maximal count. Disturbances per day were the independent variable and proportion of high count was the dependent variable.

In 1999, observers monitored seals from shore during 6 of the 8 aerial survey days; in all other years we did not have observers watching from shore during aerial surveys. One objective of this work was to determine if the approach of the survey airplane caused disturbances not detected by observers in the airplane. During aerial surveys, the photographer and observer (if present) look ahead to try to locate seals and to detect disturbances, should they occur.

Responses to Disturbance: Percent of Seals Departing and Recovery

For each disturbance, the number of seals counted on the haulout immediately before (B) the disturbance was compared to the number of seals remaining immediately after (A) the disturbance. The percent change in seals ([A-B]/B) was calculated, and situations in which this percent was greater than –5% were categorized as "fully recovered." This approach is similar to that of Suryan and Harvey (Suryan and Harvey 1998), although we allowed for a 5% counting error in categorizing recoveries. Also following Suryan and Harvey's (1998) work, we further categorized the remaining situations as: 1) partial recovery (counts of seals ashore increased after a disturbance but did not reach original numbers), 2) no recovery (counts did not increase following a disturbance), and 3) no chance for recovery due to a rising tide or additional disturbances. For those situations in which full recovery occurred, we calculated the amount of time between the disturbance and when seal numbers on the haulout reached or first exceeded the count immediately before the disturbance.

For each disturbance event, we also used the lowest number of seals remaining on the haulout during (D) a disturbance to calculate the percent of seals that departed ([B-D]/B). The means of these values were then tested for differences between the 3 disturbance categories (human, non-human, and unknown) (Kruskal-Wallis analysis).

RESULTS

Disturbances Observed

Forty-six disturbances were observed during 229 hours of observation (Table 2). Most observations were made in 1991, 1998, and 1999. Twenty (43%) of the 46 disturbances were caused by human activities; 10 (22%) were attributed to non-human activities including eagles (n = 4), killer whales (n = 3), Steller sea lions (n = 2), and a small earthquake (n = 1). For 16 disturbances (35%) there was no known cause.

Table 2. Summary of disturbances observed and hours of observation by year and categories of disturbance used for analysis. Forty-six disturbances were observed.

Year	# Events	Cause	Disturbance Category
1991	3	kayak(s)	human
(84 hrs)	1	person on shore	human
	2	power	human
	2	eagle	non-human
	1	earthquake	non-human
	6	unknown	unknown
1992 (9 hrs)	1	unknown	unknown
1997	1	crab boat	human
(17 hrs)	1	person on shore	human
	1	eagle	non-human
	1	killer whales	non-human
	1	sea lion	non-human
	2	unknown	unknown
1998	2	crab boat	human
(74 hrs)	4	kayak(s)	human
	1	kayaks & crab bt	human
	1	eagle	non-human
	2	killer whales	non-human
	1	sea lion	non-human
	1	unknown	unknown
1999	3	kayak(s)	human
(40 hrs)	1	plane, non-survey	human
	1	plane, survey	human
	6	unknown	unknown

Vessel Distances and Disturbances

The majority of vessels (37 of 49 = 76%) monitored in the Spider Island area in 1998 and 1999 did not cause disturbances of seals. All vessel disturbances of harbor seals occurred when boaters approached the Spider Island reef complex closer than ¼ nautical mile, and all vessels that approached within 100 yds (n = 7) elicited a disturbance response from seals (Figure 2). In general, vessels that approached the haulout closer were more likely to disturb seals than vessels that stayed farther away.

Eighteen powerboats, including 15 commercial crabbing vessels, were monitored, and 17 of these were observed in 1998 (due to the closure to motorized vessels in 1999). Two (11%) of the motorized vessels disturbed seals on the reefs and both were commercial fishing boats. Thirteen percent (2 of 15) of commercial crab boats that we monitored disturbed seals.

Of the 28 kayakers or kayak groups monitored in 1998 and 1999, 7 (25%) caused a disturbance of seals and all of these groups approached seals closer than approximately ¼ nm. Eight kayakers approached seals on the haulout within ¼ nm, and 7 of them caused a disturbance.

Disturbance Rates by Study Year

The mean disturbance rate ranged from 0.92 (SD = 0.95, n = 13) disturbances/6 hrs in 1998 to 2.3 (SD = 0.58, n = 3) in 1997 (Fig. 3). There was no trend in disturbance rates during the study years (Linear Regression, $r^2 = 0.009$, $p = 0.56$) (Fig. 3). In addition, the mean disturbance rate for the 1997-1999 pooled data (1.3 disturbances/6 hrs, SD = 1.02, n = 23) was not significantly higher than that for 1991 (1.4 disturbances/6 hrs, SD = 1.38, n = 14) (Mann-Whitney U test, $p = 0.30$).

Potential Effects of Disturbance on Counts from Aerial Surveys

The percent of the daily high count from the beginning of surveys to low tide plus 2 hrs declined as the number of disturbances increased from none to 4 (Fig. 4). While counts of seals as a percent of the high count were negatively correlated ($p < 0.0001$) with the number of disturbances per day, disturbance only explained 9% ($r^2 = 0.089$) of the variance in counts. On days when there were no disturbances, counts of seals from aerial surveys would have a mean value of 76% (SD = 22%) of the day's high count (Fig. 4). In contrast, on days with 3 disturbances before the

low tide + 2 hrs, counts from the air would tend to be 55% (SD = 33%) of the day's high count. Surveys flown when 4 disturbances occurred would tend to record 58% (SD = 27%) of the day's high count.

On 1 of the 6 days during aerial surveys in 1999, shore observers noted a disturbance of seals apparently caused by the survey airplane. The observer/photographer conducting the survey independently recorded the disturbance, which occurred as the plane passed over the haulout.

Responses to Disturbance: Percent of Seals Departing and Recovery

On average, 57% (SD = 36%, n = 46) of seals counted before a disturbance abandoned the haulout. For disturbances by humans, non-humans, and unknown causes, the mean percent of seals departing was 63% (SD=34%, n = 20), 60% (SD=36%, n = 10) and 47% (SD=38%, n = 16), respectively, and there was no difference between cause categories in the percent of seals that left the haulout ($p = 0.583$).

Full recovery occurred in 20 (43%) of the 46 disturbances. More full recoveries occurred for human and unknown cause categories than for non-human events. In 50% of the human and unknown disturbances the number of seals on the haulout returned to or exceeded the number on the haulout prior to the disturbance (Fig. 5). In contrast, full recovery occurred in only 20% of the non-human disturbances, while partial recovery occurred in 60% (Fig. 5). Among kayakers who caused a disturbance, the proportion that recovered (n = 4), partially recovered (n = 3), or had no chance to recover (n = 4) was more evenly distributed among the full recovery categories than for all human causes combined (Fig. 5).

The mean time from a disturbance to full recovery for all cause categories combined was 30 min (SD = 36 min, n = 19). Mean recovery duration for human, non-human, and unknown disturbances was 44 min (SD = 51, n = 8), 15 min (n = 3), and 21 min (SD = 14, n = 8), respectively. There was no difference in the time to full recovery between the three disturbance categories (Kruskall Wallis test, $p = 0.16$).

DISCUSSION

In 1999, the NPS began implementing regulations to prohibit motorized traffic from entering the Beardslee Island Wilderness area. In addition, the NPS prohibits boaters from approaching the Spider Island complex closer than ¼ nm and foot traffic is been prohibited on Spider Island and adjacent reefs from May through August. Yet, our observations indicate that 25% of kayakers and -- before closures to all motorized vessels -- 13% of commercial crab vessel operators, approached the haulout closer than ¼ nm and caused seals to abandon the haulout. All of the disturbances that we observed during 1998 and 1999 occurred within approximately 1/4 nm of the haulout (Fig. 2). Thus, if compliance with the NPS's existing distance restriction is improved, there should be a corresponding reduction in the number of disturbances of harbor seals at the Spider Island reefs. Compliance could be improved through more specific education of kayakers (see Recommendations below) and through enforcement of existing regulations. Currently there is virtually no enforcement of wildlife regulations within the Beardslee Island Wilderness area; NPS rangers must obtain special permission to enter Wilderness Waters in the motorized vessels they use to patrol.

We found a negative correlation between the number of disturbances on a given day and the deviation of a count from the maximal shore-based count for that day (Fig. 4). Thus, if disturbances of harbor seals, by either humans or predators, increases in an area, we should expect counts from aerial surveys to be lower. In light of this, it may be valuable to incorporate disturbance of seals as a potential covariate in trend analysis of harbor seals. The limitation to this usage is that in most cases we do not know how much disturbance is occurring. The continuous scan methods described in this paper are labor intensive, and we have relied heavily on students and volunteers to accomplish this work. Another approach for assessing disturbance rates at key haulout sites that could be employed is the use of either fixed or remotely operated video cameras, such as the *Seemore Wildlife* camera system developed by Daniel Zatz (7915 Silverton Ave., Suite 317, San Diego, CA 92126; http://www.seemorewildlife.com/) and currently in place at several Steller sea lion haulouts in Alaska.

We found no increasing trend in disturbance rates over the 9 year span of the study (Fig. 3), and the disturbance rates for the pooled observations for 1997-1999 were not higher than those in August, 1991. While this suggests that disturbances in the Spider Island area have not increased notably between 1991 and 1997-1999, there are some problems comparing these results to the declining trend in seal numbers on haulouts. Disturbance may still have had an effect on the numbers of seals observed during surveys, but because we do not have disturbance data during the aerial surveys, except in 1999, we cannot rigorously test for the effects of disturbance on our aerial survey counts. It is apparent and logical, however, that increases in disturbances could lower the number of seals ashore during an aerial survey (Fig. 4).

No disturbances of seals by the survey airplane occurred during the 6 survey days in 1999, and we rarely observe disturbances from aircraft during surveys. While additional years of data are needed to confirmif most disturbances by the survey airplane are detected by observers, this is consistent with our impression from 9 years of observations during aerial surveys. We avoid flyng directly over haulouts and we instruct our pilots to not make tight turns when near a haulout. These measures seem to greatly reduce the likelihood of disturbing seals from the air. However, even with these instructions certain pilots are less likely than others to cause disturbances. We have also observed that a change in aircraft, from a smaller Piper Supercub to a Cessna 172, may have resulted in more disturbances from the aircraft, although disturbances do not occur very often, with none in most years and up to 2 per survey year.

In this report we have mainly addressed the potential short-term implications of disturbances of seals at haulouts, but there is also the potential for repeated disturbances to have an effect on a population through increased mortality or emigration. Some mechanisms by which repeated disruption of resting seals at haulouts could affect population dynamics are summarized below.

1) Disturbance that causes groups of seals to stampede into the water may result in permanent separation of females and their dependent pups; harbor seal pups separated prematurely from their mothers will starve and die if not reunited (Allen et al. 1984, Bishop 1967, Johnson 1976, Streveler 1979), or they may be easy targets for predators during periods of separation.

2) Repeated disturbance of females with dependent offspring can result in short-term separations and reduce opportunities for resting and nursing; this may result in reduced likelihood of survival or lower overall fitness of individuals through increased energetic demands.
3) Chronic disturbance can cause harbor seals to alter their haulout patterns (Allen et al. 1984) or stop using a traditional or favored haulout (Mathews and Pendleton 2000, Newby 1971).
4) Disruption of haulouts may interfere with social interactions of seals.

The declines in the number of seals on haulouts in Glacier Bay during August surveys range from 35%-50% for 1992-1999 (Mathews and Pendleton 1999). These declines are on the same order of magnitude as those noted in the Gulf of Alaska, where large scale changes in the marine ecosystem are suspected as causative factors in declines of harbor seals and Steller sea lions (Calkins et al. 1998, Merrick 1995, Merrick et al. 1997, Merrick and Loughlin 1997, Merrick et al. 1987, Pitcher 1990). While disturbance of harbor seals on haulouts may be a factor in the declines in Glacier Bay, it does not appear to be a primary factor in the declines. In our analysis, the number of disturbances per day explained only 9% of the variance in counts as a percent of daily high counts. Furthermore, we did not detect increases in levels of disturbance over the study period (1991-1999), although the power of this analysis is low due to the lack of concurrent shore-based observations and aerial surveys. Where disturbance of harbor seals is suspected to be high or changing, efforts to include it as a potential covariate in trend analyses (Frost et al. 1999, Link 1994, Link and Sauer 1997, Mathews and Pendleton 1997) should be made, and we recommend that additional observations be made of the Spider Island reefs during aerial surveys to specifically test this hypothesis.

RECOMMENDATIONS

All vessel disturbances of harbor seals occurred when boaters approached the Spider Island reef complex closer than ¼ nautical mile. Given that motorized vessels are no longer allowed in the Beardslee Island area, focusing on changing the behavior of kayakers – through education and

enforcement of existing regulations -- should reduce disturbances of seals. This problem has been addressed in the past (Appendix B), and some recommendations made in 1998 may have been implemented. We recommend that the way kayakers are educated be carefully evaluated and that efforts be made to improve compliance with the ¼ nm distance regulation for the Spider Island complex, as well as other seal haulouts.

In 1999, the NPS rangers at the Visitor Information Station (VIS) began revising the information and maps given to campers and kayakers during the orientation process (Tulup Morrow, NPS VIS ranger, personal communication), but to our knowledge this project was not completed. Information about how to avoid disturbing seals should be an integral part of the orientation and written materials, and we strongly recommend that personal contact be made with kayakers during the orientation, rather than relying solely on written or video-taped information.
Our general sense is that kayakers that disturbed harbor seals near Spider Island did so because they were unaware that they were in a restricted area or near resting seals until it was too late. All kayakers, except those who have rented a kayak for a day trip or a local person who owns a kayak, are required to have a permit to camp overnight during the summer and part of the permitting process includes an NPS backcountry orientation. Even so, 25% of kayakers observed in 1998 and 1999 approached the haulouts closer than 1/4 nm. This may be because they did not understand the distance regulation or were unable to judge how far they were from the haulout,or they were disoriented and did not realize where they were in relation to the Spider Island complex. Estimating 1/4 nm from a kayak is difficult for even experienced mariners. Many of the islands and islets in the area are unnamed and translating the planar view presented on a marine chart into what you see from your kayak can be difficult for novices, and even experienced kayakers.

The general public is often not aware of the reasons for not disturbing seals that are hauled out of the water. They may not realize that disturbing seals can potentially have negative impacts on the animals, and they are most likely not familiar with the Marine Mammal Protection act which prohibits “harassing” marine mammals. In addition, people may have other priorities as they kayak through the Beardslee Islands. They may be focused on navigating from one place to another, viewing wildlife, or finding a campsite rather than avoiding seals. In addition, the

weather may play a role in the route they take through the Beardslee Islands. On days when the visibility was limited, kayakers were more likely to hug the shorelines to aid in navigation and were less likely to disturb the seals as a result. On sunny days kayakers seemed more likely to cut across the bay, going close to the reefs rather than hugging the shores of the larger islands. More disturbances occurred in these situations.

Neither the camper orientation video shown during kayaker orientations, nor the maps and charts on the wall at the VIS center give a strong message or visual information about avoiding the Spider Island reefs. The video says not to camp on the treeless islands in the Beardslee islands, but does not give specific information on how to avoid the seals. Furthermore, some of the closed islands do have trees on them: Spider Island and the reef northwest of it have trees on them. Information presented by VIS staff to kayakers about the seal closures is not always accurate. One of us was told that as long as you didn't walk on the Spider Islands you were in compliance with the rules. On a separate occasion, we learned that VIS staff were advising kayakers that they could camp on islands as long as they had trees on them.

The current "Camper Orientation Guide" given to kayakers does not specifically discuss seals or the restrictions that apply to remaining ¼ nm from the Spider Island complex. In 1999, kayakers were given a hand drawn map that highlighted closures near Spider Island and some islands closed to foot traffic due to nesting birds. While it was a distinct improvement, the map did not accurately represent the ¼ nm restricted area and it did not differentiate between bird and seal closures.

People who do day trips are not required to go through an orientation with NPS staff. Day trips are done by a variety of park visitors including local residents, NPS employees, employees of the lodge near NPS headquarters, and people who have rented kayaks from Glacier Bay Sea Kayaks and Sea Otter Kayaks. These kayaks can be used for day trips in the Beardslee Islands. It is possible to be dropped off north of the Beardslee Islands by the Park's concession drop-off boat and then paddle back to Bartlett Cove in one day. The Spider Island reefs are in direct line with the quickest route back to Bartlett Cove. Kayakers who bypass the NPS orientation may not be

aware of the closures to foot traffic and distance restrictions, and they may not appreciate the rationale behind wildlife closures.

Our specific recommendations to address some of the issues described above follow:

1. Provide a more detailed orientation to kayakers. The orientation should include information about the potential consequences of repeated disturbances to wildlife in general and the importance of the large breeding aggregations of harbor seals near Spider Island and in Johns Hopkins Inlet. NPS staff could discuss the kayakers objectives and then suggest a route of travel that would reduce the likelihood of disturbing seals, or several specific transit routes could be recommended or required. For example, kayakers could be advised to follow the shorelines rather than cutting across more open water on a trajectory that would take them closer than ¼ nm from the Spider Island reefs. 2. Information about wildlife closures and recommended travel routes should be included graphically on the informational map provided by the VIS staff.

3. NPS personnel who work in the VIS would likely benefit from first hand experiences kayaking in the Beardslee Islands. Perhaps part of the job orientation for new employees or any VIS staff unfamiliar with the Beardslee Island Wilderness Area could include paddling into the area via the most common route used by visitors.

4. Create a display for the Visitor Information Station that specifically addresses harbor seal (or pinniped) disturbance. This could include educational information and maps. All types of maps used by kayakers should be included in the display, including the inch-to-the-mile quad sheets often carried by backcountry visitors, a marine chart, and the map that VIS is preparing/has recently prepared [???].

5. Distribute a photograph (or sketch) of the Spider Island complex from the view that a kayaker would have as they came through the "cut" along the north shore of the small island just north of the northeast end of Lester Island (58 30'N, 136 53.5'W). It is very easy to become confused about your exact location when you enter an area as complex as the Beardslee Islands. (For an example of the type of view we are recommending, see an issue of *Charlie's Charts*.)

6. Offer a workshop or seminar on the values of wilderness, sensitive areas within the bay, and minimizing camper impacts on wildlife and the environment for people who are frequent users of the Bay, such as Lodge and NPS employees, staff of the kayak rental businesses, and Gustavus residents.

7. Evaluate the effectiveness of improved educational efforts on reducing disturbance (see recommendation in (Mathews 1997); if these are not as effective at reducing disturbance as desired, consider testing other approaches such as using buoys or other discrete markers to ensure that kayakers know where they are.

8. Require orientations for day users and other groups who are currently not receiving information about wildlife closures and NPS regulations.

Spider Island is not the only area within Glacier Bay National Park with sensitive wildlife habitat, but because it is a key breeding site for harbor seals and the Beardslee Island Wilderness Area is also a primary destination for kayakers in Glacier Bay, it may warrant special attention. If changes are implemented in how kayakers are oriented or if enforcement of regulations is implemented, we also strongly recommend that the results of such changes be monitored to determine if they are indeed having the desired effect.

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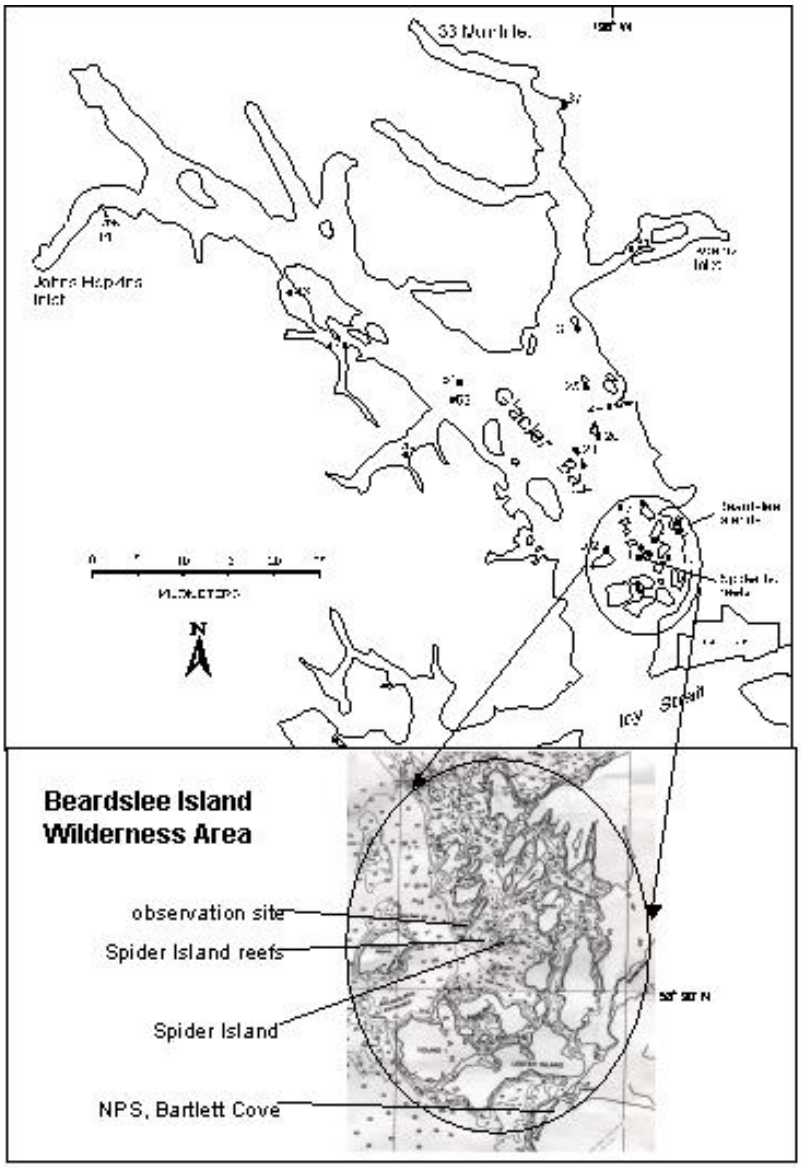

Figure 1. Spider Island and nearby reefs in the Beardslee Island Wilderness area of Glacier Bay National Park, Alaska.

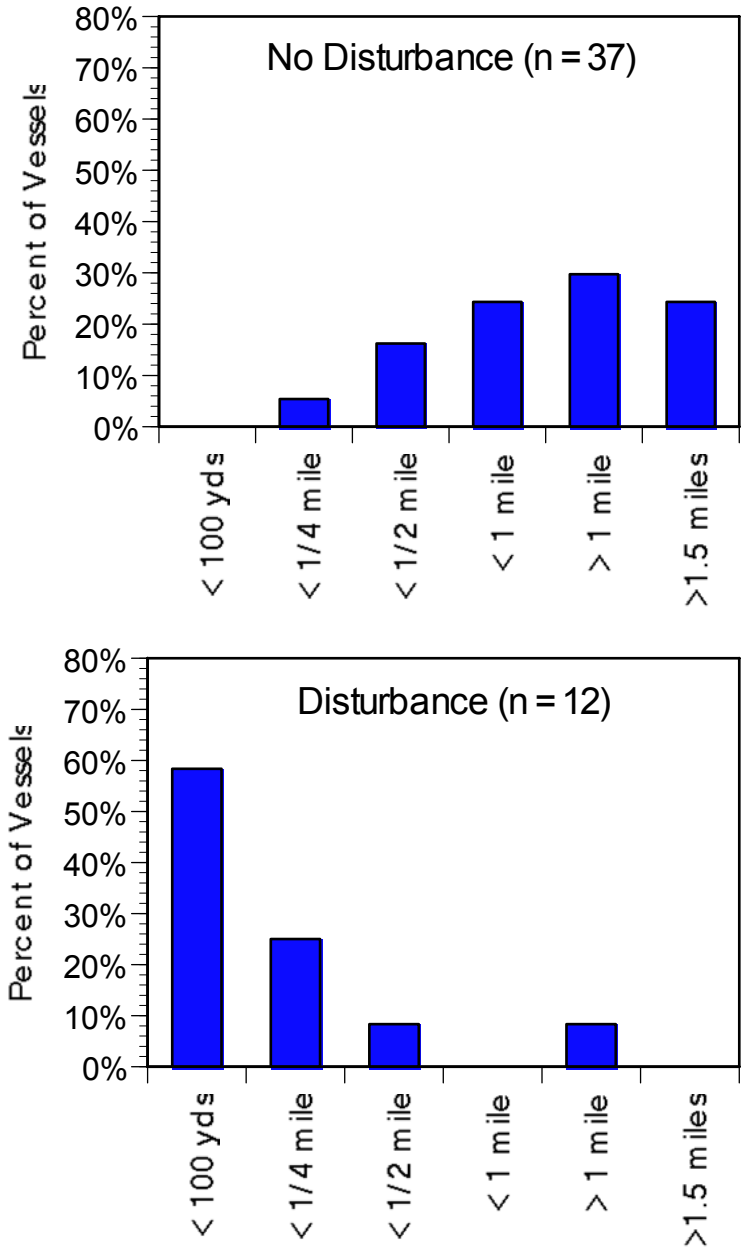

Figure 2. Closest approach distance categories of vessels near a harbor seal haulout. a) Vessels that did not cause seals to leave the haulout (No Disturbance) tended to stay farther away, compared to b) vessels that caused seals to abandon the haulout. Data are from 1998 and 1999.

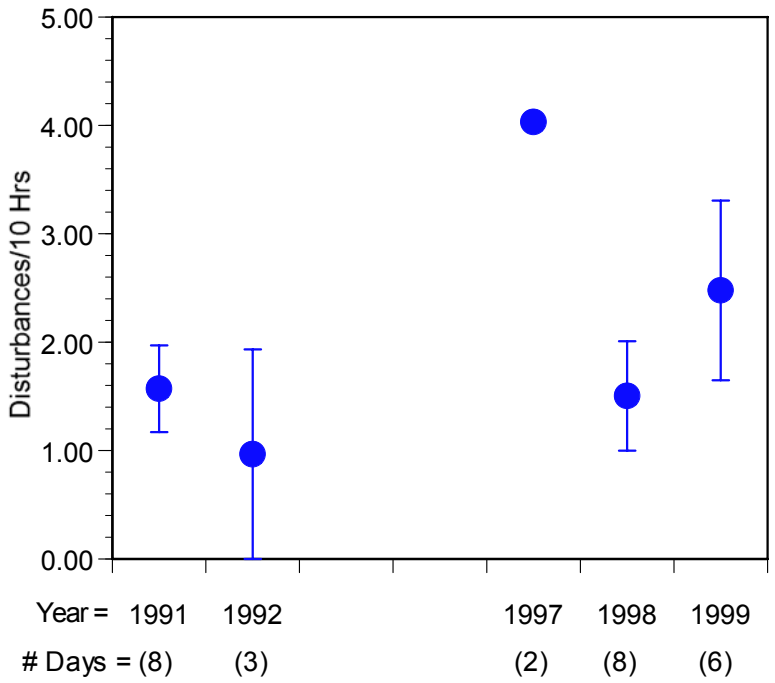

Figure 3. Mean rates of disturbance (number of events/10 hrs) of harbor seals near Spider Island during continuous shore-based observations in 5 different years. All observations were in July or August. Error bars are one standard error around the mean.

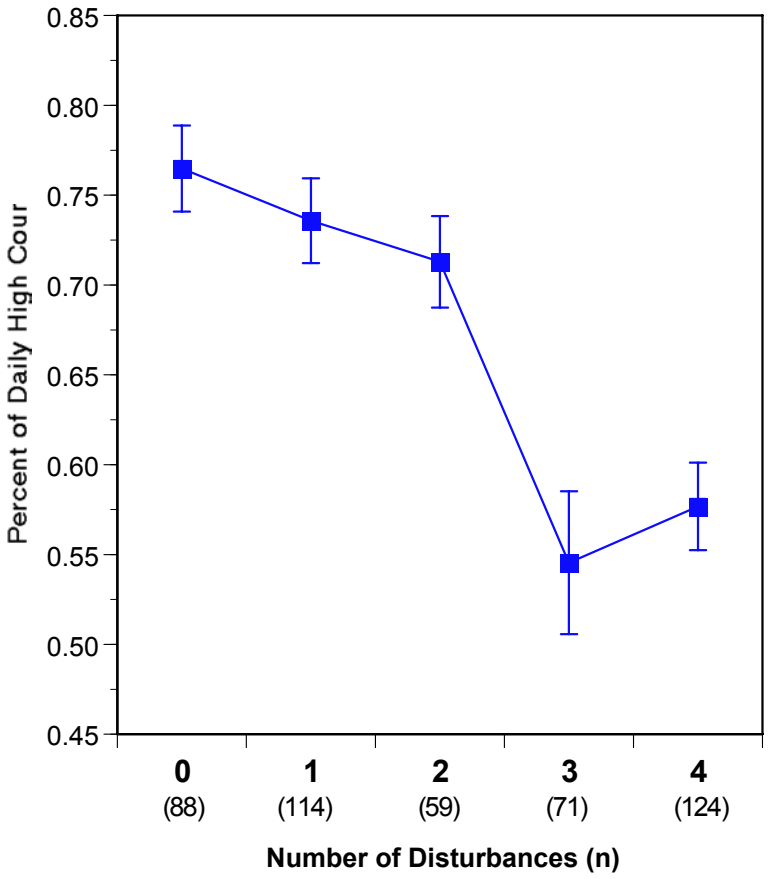

Figure 4. Number of disturbances of harbor seals from the beginning of surveys to low tide + 2 hrs compared to counts of seals as a percent of the high count for the day. Counts as a percent of the day's high count were negatively correlated with the number of disturbances per day (simple linear regression, $p < 0.0001$, $r^2 = 0.089$).

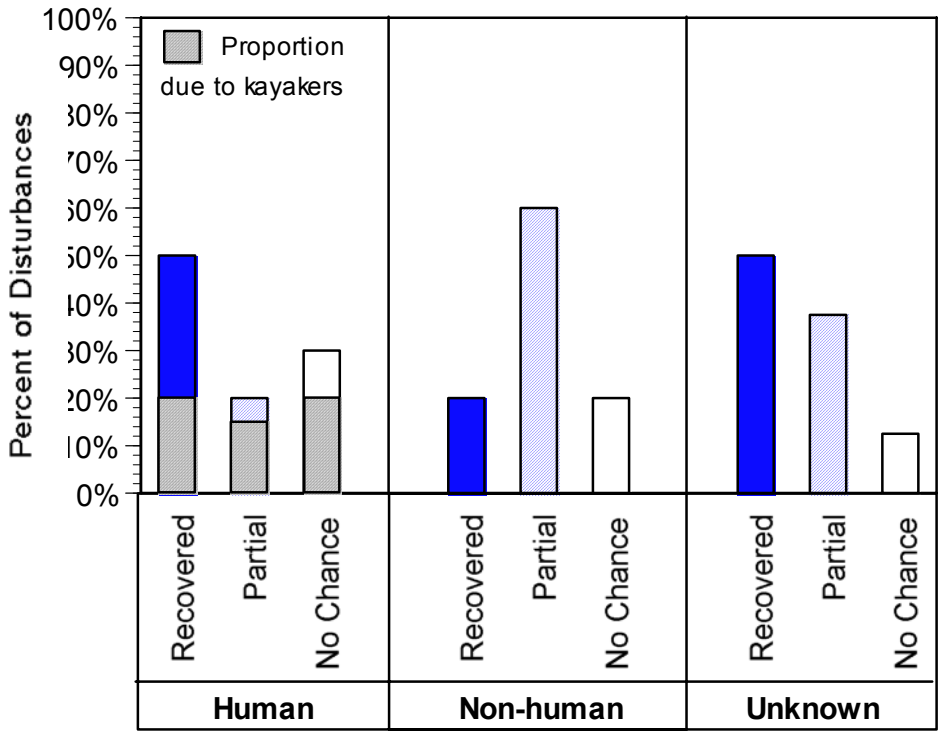

Figure 5. Percent of disturbances in which seal numbers: 1) reached or exceeded pre-disturbance levels (Recovered), 2) increased after the disturbance, but did not reach pre-disturbance levels (Partial), and 3) had no chance to increase due to a falling tide (No Chance).