PROGRESS REPORT:

Measuring the Effects of Vessels on Harbor Seals *(Phoca vitulina richardsi)* at North Marble Island, a Terrestrial Haulout in Glacier Bay National Park

By:

Elizabeth A. Mathews
University of Alaska Southeast
Biology Department
11120 Glacier Highway
Juneau, Alaska 99801
Beth.Mathews@uas.alaska.edu

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Glacier Bay National Park and Preserve
Resource Management Division
P.O. Box 140
Gustavus, Alaska 99826

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INTRODUCTION

Between 1992 and 1998, the number of harbor seals observed on terrestrial and glacial ice haulouts (resting areas) in Glacier Bay National Park declined by 25-48%, and the minimal population estimates for seals on haulouts declined from 7000 to 4800 seals (Mathews and Pendleton 1999). The mean number of seals observed at the Spider Island reefs, previously the largest terrestrial haulout in the Park, dropped to 17 (SD = 40, n = 6) in 1997 and 683 (SD = 329, n = 6) in 1996 compared to 1,056 – 1,384 (SD = 54 and 142, respectively) for August molt surveys between 1992 and 1995 (Mathews 1997). During surveys in August 1997, there was evidence (depressions in the sand on the reefs) that seals had abandoned these reefs due to campers on adjacent islands or due to other sources of disturbance on at least 3 of the 6 survey days. The observed decline in seals on haulouts may be due to both human-induced changes in seal behavior (e.g., vessel disturbances) that have reduced the proportion of time spent on haulouts, as well as changes in population dynamics (e.g., increased mortality, reduce birth rates, or emigration). Quantifying the effects of human disturbance on counts of seals during surveys is one step necessary for understanding the declines in harbor seal numbers in Glacier Bay.

Studies on the effects of vessel traffic on harbor seals in glacial fjords in Glacier Bay, where seals rest on drifting ice bergs rather than reefs or beaches, have shown that commercial and private vessels frequently cause seals to abandon their haulouts (Calambokidis et al. 1985 , Mathews 1996a). The average distance at which disturbance occurred for 50% of seals monitored in a glacial fjord where seals rest on icebergs was 167 m (Calambokidis et al. 1985). Human activities that cause marine mammals to change their behavior are classified as “harassment” under the Marine Mammal Protection Act (MMPA, 1972), and they are considered violations of this Act. Since 1988, Johns Hopkins Inlet (a glacial fjord and1of the largest breeding areas for harbor seals in Alaska) has been closed to all vessel traffic from May 1-June 30 to protect seals during pupping and nursing periods. This closure was initiated as a result of earlier research (Calambokidis et al. 1985) on the effects of vessel traffic on seals. In addition, the NPS has instituted wildlife closures around some islands that serve as harbor seal haulouts. For example, Spider Island reefs, in the Beardslee Island Wilderness area, have a ¼ mile closure around them as well as a foot traffic closure. Despite such protective measures, disturbances of pinnipeds by visitors to the Park is known to occur and may be increasing (Mathews 1996a, 1996b, 1997).

Increasing numbers of kayakers in Glacier Bay and the lack of data on the effects of vessels on seals at terrestrial haulouts (other than Spider Island), coupled with the NPS's mandate to minimize human disturbances of wildlife, were factors in the initiation of this pilot study. The work in 1998 was designed to develop methods for monitoring vessel effects on harbor seals at North Marble Island; if this terrestrial haulout were determined to be an appropriate study site, we would conduct a more extensive study in 1999. A method to measure vessel distance from a Steller sea lion haulout using laser range-finding binoculars (Mathews 1996b) could not be applied, because harbor seals in Glacier Bay have a much greater flight distance than Steller sea lions (personal observation), and most disturbances would likely occur beyond the usable range (~800 m) of the laser range finding binoculars.

The specific objectives of the pilot study were to: 1) locate a terrestrial haulout in Glacier Bay that would be suitable for conducting opportunistic and controlled studies on interactions between vessels and campers and harbor seals, 2) determine the feasibility of using a surveyor's theodolite for tracking boat speed and distance as boaters approached or passed a haulout, and 3) determine if a computer program ("Aardvark") written by Harold Mills (Cornell University) to track vessels and whales could be adapted for use in this study. The broader objectives of the study were to determine: 1) vessel distances and speeds at which disturbances of seals occurred, 2) the duration of abandonment of resting areas following disturbances, and 3) the levels of compliance with NPS and MMPA regulations that prohibit disturbance of harbor seals.

METHODS

Study Site and Dates of Observations

This work was conducted from the north end of North Marble Island (58º 40' 03"N; 136º 03' 09" w) in Glacier Bay National Park, Alaska. A harbor seal haulout that has been used at least since 1992 (and most likely longer) is located at the northern end of the island. This site was selected for the study because steep terrain above the northern rocky extension of the island provides an excellent view of the haulout and an unobstructed view of the surrounding waters for tracking vessels from a long distance. The observation site is also high enough to accurately track vessels using a surveyor's theodolite, a widely used method to study whale and dolphin movements, as well as to track vessels (Wursig et al. 1991).

The seal haulout on North Marble Island is a low, rock extension of the island connected to the island by a short stretch of cobble beach. The haulout remains partially exposed throughout the tide cycle. When undisturbed, harbor seals may rest on the haulout throughout the tide cycle.

From July 25 to 30, 1998 we tracked vessels and systematically recorded the behavior of harbor seals at the north end of North Marble Island. Each day, we observed seals and tracked vessels from approximately 07:30 to 20:30.

Behavioral Observations

One person conducted behavioral observations and recorded and/or entered data into a computer or onto datasheets (Appendix I), while the second person operated the theodolite to track vessels and measure tide heights. Both observers scanned for approaching vessels.

We recorded harbor seal behavioral states using instantaneous scan sampling (Altmann 1973) every 3 minutes for 10 cycles (30 minutes) approximately once every hour throughout the day. Behavioral sampling methods similar to those used in an earlier study on the effects of vessel approaches on Steller sea lions (Mathews 1996b) were followed. We categorized all seals on the haulout into 1 of following 3 behavior categories:

Resting/Not Active:	seal is lying motionless with head either down or held steadily in 1 position and not looking outward; animal appears to be resting; this category includes grooming and scratching while resting and not looking around, as well as minor adjustments in position with eyes closed or head down
Vigilant:	head is up and seal is looking around or out to sea
Active:	seal is moving across the haulout or interacting with another seal or vocalizing; does not include vigilant behavior (see above) or wriggling in place or grooming while resting

In this study I defined disturbance as seals entering the water in apparent response to some external stimulus. Some level of disturbance (change in behavior), such as increased vigilance or movement toward the water, invariably precedes departures from a haulout; however, we used entry into the water because it is an unambiguous, easy to measure behavior that is a maximal behavioral response available to a seal resting on shore.

Vessel Tracking Procedures

At the beginning of each day we set up and leveled the *DK5 Sokkia* theodolite according to the instructions in the user's manual. Prior to the study I set the theodolite so that the zenith was at 0 degrees and the horizontal setting was at 90 degrees. After turning the theodolite on, we checked to ensure that the battery level was high enough to track vessels without losing power in the middle of a tracking session.

We zeroed the theodolite's horizontal reading on a small distinctly white rock at the northern (left from our perspective) end of Sturgess Island (Fig. 1). There is a larger white rock to the right of this 'centering' rock that lies directly below the beginning of the treed section of the island. After turning on the computer, we measured the tide height using the theodolite. At least 1 tide height was recorded at the beginning of each day (or tracking file), prior to any vessel fixes, and a tide height was also measured at the end of each day, after all theodolite fixes had been taken. The tracking program uses a function to linearly interpolate tide height between actual measurements (H. Mills, personal communication). We also took tide height readings approximately every hour.

Measuring the Height of the Observation Station above Water

At 09:38 on 25 July 1998, we used the theodolite to measure the vertical angle (=α) to the water line on a selected rock near the haulout. We then measured the distance to the waterline on this rock (3 times) from the center of the theodolite's spotting scope using a pair of laser range-finding binoculars *(Leica, Geovids).* The accuracy of distance measurements with these binoculars is +/-1 m at 1000 m and our 3 measurements never differed by more than 1 meter from 1 another. Using this distance (=176 m) as the hypotenuse (= C) of a right triangle, I calculated our height above the current tide as follows:

Height = C (cosine α)
= 176 m (cosine 69.9°)
= 60.6 m

Height Corrected to Zero Tide
= 60.6 m – 0.97 m (negative tide height at time of measurement)
= 59.6 m

Use of the Vessel Tracking Computer Program ("Aardvark")

We used a program (Aardvark version 1.22) developed for tracking vessels and whales written by Harold Mills (Cornell University). The program is designed to run on a

PowerBook (Macintosh) computer connected directly to a theodolite by a cable so that horizontal and vertical angle measurements are downloaded electronically to the computer file with the date and time. However, the cable that was built for our project did not work, so we had to manually enter the horizontal and vertical readings. We did this in 1 of 2 ways. If we were only tracking 1 or a few distant boats and the theodolite readings were more than about 30 seconds apart, the data entry person could capture the exact time of each reading by hitting the appropriate key (= 'v') on the computer. This was when the vessel observer called "mark" which they did when the boat's water line was centered on the cross hairs in the theodolite telescope. The data recorder then manually entered the horizontal and vertical readings into the computer as they were called out by the vessel observer. If there were too many theodolite readings to enter using this method, or if we ran out of battery power for the computer, we used data sheets (Appendix I) to record behaviors and angles; these were then entered into the computer at a later time.

Proposed Method for Controlled Approaches

The protocol we established for using controlled approaches during this study was that such approaches would only be initiated if there were at least 2 days without any disturbances of seals. This was to allow time for the seals to recover from disturbance before conducting controlled approaches. We had scheduled the first controlled approach for 28 July, but because a vessel disturbance occurred on this day and the pilot study ended on 30 July, we did not conduct any controlled approaches.

File Management and Data Storage

Each day we opened an "Aardvark" file named "Template" and renamed this file with the day's date. After opening the day's file, the data recorder activated the program for recording data (using the "make live" setting). The raw and edited data files from this project are currently stored on a Macintosh Powerbook (1400c/166; NP9700027512) and on backup floppy disks stored in the project data notebook. Vessel tracks have not been plotted.

RESULTS

Disturbances of Harbor Seals

We tracked 41 vessels from distances up to 10 nm away, including cruise ships (Table 1) travelling up or down the bay. The majority of these vessels did not approach the haulout to view harbor seals. Five disturbances were observed; 3 of these were attributed to vessel wakes; 2 were in response to nearby vessels (a powerboat and kayaks). These latter disturbances caused all seals present at the time to leave the haulout (34 and 2 seals, respectively).

At the beginning of the study we typically observed from 15 to 55 (max) seals on the haulout throughout the day. However, no seals were observed on the haulout during the last 2 days (52 hours) of our observations, following a direct disturbance by a power vessel and use of the haulout by two groups of kayaking campers. On 28 July at 10:20 a power vessel passed close to the haulout and caused all (34) of the seals to enter the water. A few minutes later, at 10:45, a second powerboat passed very close (<100 m) to the haulout from the southeast side of the island. We saw no seals on the main haulout after the initial disturbance at 10:20, and by 11:30 there was only 1 seal visible in the water. At 12:42 1 seal hauled out on a small rock north of the main haulout, and by 12:54 there were 6 seals crowded on this rock. Low tide (2.8 ft) was at approximately 11:55. As the tide came up, the rock became awash and by 13:48 all 6 of the seals had left the rock. We remained at our overlook, but only observed 2 to 5 seals in the water and 1 seal that was partially submerged on the edge of the main haulout during our 30-minute and other scans. At 17:45 that same day (28 July), 4 people in 2 double kayaks came ashore to camp; they left the next morning (29 July) at 10:25. At 8:55 on 29 July we observed 1 seal on the rock north of the main haulout, but it had left by 9:20, and no seals were observed on the main haulout at all on the 29th. At mid afternoon on 29 July, 2 people in single kayaks came ashore to camp on the evacuated haulout, and as they approached they passed within 100 m of a small offshore rock where 2 seals were resting. Both seals left that haulout.

On 30 July, no harbor seals had re-hauled before we left the island at 14:15, 52 hrs after the first disturbance. In contrast, most seals re-hauled within minutes or a few hours following the 3 earlier disturbances resulting from vessel wakes (Table 1).

DISCUSSION

Disturbances of Harbor Seals

Although vessel wakes were responsible for 3 of the 5 disturbances observed on North Marble Island, the short recovery time from these events compared to greater than 52 hours for recovery from a power boat disturbance followed by camping on the haulout, suggests that human proximity to seal haulouts has a much greater effect on seal behavior than waves from vessel wakes. We have also observed seals disturbed by kayakers or by power boats at the Spider Island reef haulouts (Mathews 1997); however, in these situations, seals returned to the reefs at low tide on the following day. While additional data are needed to compare the effects of vessel disturbances to the effects of people ashore on or near a haulout, it is not surprising that people on a haulout significantly alter seal use of that haulout. It would be valuable to determine which seal haulouts in Glacier Bay are used by kayakers for camping or rest stops. Measuring the compliance with NPS wildlife closures at seal haulouts is needed to evaluate the effectiveness of such regulations.

Harbor seals haul out to rest, give birth, suckle, (Ronald and Thomson 1981) and to molt (shed) (Feltz and Fay 1966, Thompson and Rothery 1987). Harbor seals deprived of access to haulouts will increase the time that they subsequently spend ashore, indicating that time out of the water is needed for normal maintenance (Brasseur et al. 1996). Repeated disturbance at seal haulouts could result in reduced survival of pups, disruption of social interactions, increased energy expenditures, protraction of the molt process, increased susceptibility to predation, and/or abandonment of a haulout. We observed multiple day abandonment of the haulout at North Marble Island, and chronic disturbances could result in longer term abandonment of this haulout.

A recent study indicates that the age/sex composition of harbor seals on haulouts may affect how animals respond to disturbances, and that groups comprised of higher proportions of pups tend to be more sensitive (Suryan and Harvey 1998). In a study of breeding Magellenic penguins *(Spheniscus magellanicus)*, researchers found that when colonies of breeding penguins with a history of either no or low levels of human proximity were exposed to human presence, they exhibited a strong physiological stress response, as indicated by significant increases in circulating corticosteroids (Fowler 1999). In contrast, penguins from a colony of birds surrounded by a fence and visited regularly by tourists accompanied by a park ranger, showed no such response to humans. Fowler and co-authors (1999) note that this result could be due to selection for birds with a higher tolerance for humans, since the penguins can select nest sites or relocate, or that it might be due to habituation.

In Glacier Bay some islands or sections of an island are closed to foot traffic or camping to protect wildlife, including harbor seals, from disturbance. North Marble Island is currently open to foot traffic and camping. It is less than 2 km from South Marble Island, a well known site for wildlife viewing of sea birds and Steller sea lions. South Marble Island is closed to all foot traffic, so kayakers viewing wildlife at South Marble Island may come ashore on North Marble Island to rest or camp, since it is so close to South Marble Island (Figure 1). Except for the north point, North Marble Island's perimeter is characterized by blunt rocky shores. Thus, the only shoreline on North Marble Island that is suitable for beaching a kayak is the north shore, where the seal haulout is located. As such, visitors who camp or stop on North Marble Island have an extremely high likelihood of disturbing seals or preventing seals from hauling out on the island, activities that violate both the Marine Mammal Protection Act and NPS regulations.

The apparent extreme reaction of harbor seals to the primary disturbance by a power boat followed by campers on the haulout the following 2 evenings suggests that either vessel disturbance or people on shore, or some combination of the 2 events, can result in seals not using this haulout for multiple days (>52 hours). This is the longest response to human disturbance that I have observed, and it may reflect a more severe response to human presence on a haulout, compared to disturbance by vessels at sea. Because our study was only 5 days long, it is also possible that seals use of the North Marble Island haulout is sporadic independent of human disturbance. In future studies on disturbance and seals, the time between evacuation of a haulout and re-occupation of the haulout should be compared between disturbance events (by categories of vessel type, speed, or distance, and no known disturbance, for example), as the duration for rehauling is an important indicator of the severity of a disturbance. More information on the frequency of occurrence and effects of human disturbance at haulouts in Glacier Bay is needed. This could be potentially accomplished by monitoring several haulouts using remote time-lapse video cameras (Allen et al. 1980).

Suitability of North Marble Island for Seal/Vessel Interaction Research

North Marble Island is one of a very few terrestrial haulouts in Glacier Bay proper for which there is an elevated observation site close enough to the haulout to use a theodolite to accurately measure vessel distance and speed while monitoring the behavior of individual seals. The observation site also offers an excellent long-range (>15 nm) view of vessels as they move toward the haulout or toward either the west or east arms of the bay, with only a small obstructed area to the south (Fig.1). Thus, North Marble Island is topographically and geographically well-suited for a study on the effects of vessel traffic on harbor seal behavior. However, because of the limited opportunities to conduct controlled approaches and the protracted abandonment of the haulout following a disturbance, several terrestrial haulouts may need to be monitored to collect sufficient data to assess the effects of vessel distance and speed on harbor seals at terrestrial sites.

Feasibility of Using a Theodolite and the "Aardvark" Computer Program to Track Vessels and Monitor Seal Behavior

The computer program ("Aardvark") and linked theodolite system developed for tracking vessels and whales worked very well for recording angles to vessels, obtaining fixes on the haulout, and measuring tide height. In contrast, the program did not lend itself well to recording seal behavior on the haulout (and it was not designed with this in mind). I recommend that if this program is used for future seal/vessel interaction studies that we work with the program's developer (H. Mills, Cornell University) to modify it to record harbor seal behavioral data to facilitate analysis of the effects of distance and speed on seal behavior and to reduce data entry time. In addition, more time needs to be allowed for training staff in the use of this program both for data collection and analysis.

In conclusion, North Marble Island is a site that is physically well-suited for studying harbor seal disturbance, and this short study suggests that disturbance may have long-term effects on seal haulout patterns at this site. While further research on the effects of vessels on harbor seals at North Marble Island would be valuable for verification of the results of this pilot study, determining the frequency of occurrence and effects of human activities on harbor seals at haulouts throughout Glacier Bay may be a more informative, cost-effective step in developing a comprehensive plan to minimize human disturbance of harbor seals. Broadening the scope of the study to include several terrestrial haulouts would also help to account for potential variation in how seals at different sites respond to vessels and to people on shore nearby.

RECOMMENDATIONS

1. Because of the lack of sites for kayakers to safely beach their boats on North Marble Island other than the harbor seal haulout at the north end of the island, North Marble Island should be closed to campers and foot traffic, due to the high likelihood of disturbance of seals and the potential for multiple day abandonment of the haulout following such disturbance.

2. Several terrestrial haulouts should be monitored to collect sufficient data to assess the frequency of occurrence and range of effects of camping and other human disturbances of seals at terrestrial sites in Glacier Bay. Such a study could determine which seal haulouts in Glacier Bay are used by kayakers to come ashore or for camping and whether or not islands closures to foot traffic are effective at preventing such use.

3. A study to determine the effects of management actions on the frequency and severity of disturbances of harbor seals at terrestrial haulouts is recommended, particularly at the Spider Island reefs. Such a study could be used to determine the effects visitor education during NPS orientations provided for kayakers. This could be accomplished through the use of "control" and "experimental" periods, perhaps in 1 or 2 week blocks. During the study, NPS employees in the backcountry office as well as private companies that rent kayaks, would either provide verbal and written information to kayakers (= "experimental") or not provide cautionary information (= "control") about avoiding particular seal haulouts. Such an approach could also be used to test the effectiveness of different methods for providing information to visitors (e.g., personal interactions vs. videos vs. written materials). Remote, time-lapse video cameras could be used quite effectively to monitor several sites for disturbance during "experimental" and "control" periods throughout the tourist season (May-August), either in addition to or in place of having people in field camps to monitor haulouts.

4. If the computer program "Aardvark" is used for future seal/vessel interaction studies, the program's developer (H. Mills, Cornell University) should be consulted to modify it to record harbor seal behavioral data in a way that would facilitate analysis.

5. If measuring the distance and speed of vessels is desirable during seal/vessel interaction studies in Glacier Bay, then efforts to develop methods in addition to using a single theodolite should be examined or developed for sites that do not have an elevated vantage point nearby. In addition, controlled approaches in which vessels

are equipped with either radar or (differential) GPS systems could be included in the studies, since most seal haulouts in Glacier Bay are not close to areas with adequate elevation to track vessels with a single theodolite. If laser range-finding binoculars with a range of 2 km or more become available, using them to measure vessel distance from haulouts would become an appropriate, cost-effective method that could be applied at most harbor seal haulouts.

Table 1. Summary of vessels (and whales) observed or tracked near North Marble Island, July 25-30, 1998. (* = no seals on the main haulout)

				Disturbance		Vessel Information				
Date	#	Start	End	yes/ no	Distrb Type	Vessel Type	~Length (ft)	Aware of Obsrvrs?	Track-ed?	Comments
7/25/98	1			yes	wake			no	no	vessel not observed; wake from west hit haulout; seals left, but rehauled in a few minutes
7/25/98	2	16:01	16:18	no		power boat	32	no	yes	steady travel, stayed > ~1 nm
7/25/98	WL1	16:44	16:49			humpback			yes	whale surfaced close to haulout; a few seals looked in direction of whale
7/26/98	1	8:56	9:10	no		tourboat		possibly	no	Heard naturalist mention harbor seals on PA; didn't come close to haulout
7/26/98	2	9:45	9:48	no		tourboat	85	no	no	came along W shore and passed well to N
7/26/98	WL2	12:55	12:52			humpback			yes	close to rock north of haulout, then toward Sturgess
7/26/98	3	13:11	13:37	no		power boat	35	no	yes	steady travel frome E. Arm - Seebree thend to W of haulout and island
7/26/98	4	13:48	14:02	no		cruise ship	600+	no	yes	
7/26/98	5	14:15	14:36	no		power boat	26	no	yes	
7/26/98	6	15:26	16:25	no		tourboat	100	possibly	yes	
7/26/98	WL3	15:47	15:51			humpback			yes	whale west of rock north of haulout again
7/26/98	7	17:24	17:31	no		power boat	25	possibly	yes	tracked 2 times
7/27/98	1	8:50	9:07	no		tourboat	157	no	yes	steady travel 2-3 nm north and west of NMI
7/27/98	2	9:14	9:23	no		power boat	38	no	yes	steady travel to south; did not approach haulout
7/27/98	3	9:36	9:47	yes	wake	tourboat	85	yes	yes	fast travel to west, heading N; waves hit haulout
7/27/98	4	10:14	10:23	no		power boat	25	yes	yes	steady, fast, distant
7/27/98	5	10:10	10:11	no		power boat	35	no	yes	to east, distant
7/27/98	6	13:39	13:48	yes	wake	cruise ship	600+	no	yes	tracked for only 3 fixes but speed steady
7/27/98	7	15:53	16:06	no		power boat	36	no	yes	steady travel toward Sturgess Is
7/27/98	8	16:15	16:32	no		power boat	38	no	yes	traveling toward Sandy Cove
7/27/98	9	16:19	16:24	no		power boat	42	no	yes	steady, moderate travel to S along E
7/27/98	10			no		power boat	18	no	yes	
7/27/98	11	17:22	17:26	no		power boat	18	no	yes	steady, fast, travel to S along east side, distant
7/27/98	12	18:04	18:07	no		tour boat	110	no	yes	
7/28/98	1	8:39	8:43	no		tour boat	100	no	yes	moderate, steady travel
7/28/98	WL4	8:47	9:59			humpback			yes	whale west of rock north of haulout again
7/28/98	2	9:28	9:31	no		tourboat	85	yes?	yes	
7/28/98	3	10:19	10:27	yes	direct	power boat	24	yes	yes	traveled from north to northeast shore
7/28/98	4	10:44	10:53	*		power boat	30	yes	yes	came in very close to shore
7/28/98	WL5	16:29	16:36	*		Minke whale		no	yes	Minke whale: species ID not confirmed
7/28/98	5	17:07	17:11	*		power boat	55	no	yes	
7/29/98	1	8:08	8:11	*		tour boat	104	no?	no	fast, steady travel
7/29/98	2	8:37	8:44	*		tour boat	150	no?	yes	moderate, steady travel
7/29/98	3	9:29	9:36	*		power boat	50	no	yes	slow, steady, dark hull
7/29/98	4	9:39	9:44	*		tour boat	85	no?	yes	fast, steady travel
7/29/98	5	10:24	10:33	*		kayaker(s)	18	yes	yes	4 people camped overnight on haulout
7/29/98	WL6	10:33	10:42	*		Minke whale			yes	may be feeding?
7/29/98	6	10:51	10:54	*		power boat	40	no?	yes	
7/29/98	WL7	12:11	12:13	*		humpback			yes	tail lobbing by Sturgess Is
7/29/98	7	12:09	12:13	*		power boat	30	no	yes	steady, moderate travel
7/29/98	8	12:15	12:19	*		cruise ship	600+	no	yes	
7/29/98	9	12:39	12:47	*		power boat	40	no	yes	steady, moderate travel
7/29/98	10	13:52	13:55	*		power boat	40	no	yes	passed close to haulout
7/29/98	11	15:33	15:40	*		kayaker(s)	16	no	yes	came to haulout to camp
7/30/99	1	9:08	9:19	*		power boat	50	no	yes	Demijohn (also tracked from 10:14-11:54)
7/30/99	2	9:20	9:23	*				no	yes	
7/30/99	3	9:38	9:39	*		tour boat	85	no	yes	
7/30/99	4	9:36	9:56	yes	direct	kayaker(s)	16	no	yes	2 people camped on haulout leave; 2 seals on N. Rk left haulout as kayakers passed within 100m
7/30/99	5	11:56	12:04	*		power boat	40	no	yes	slow, steady travel
7/30/99	6	13:34	13:50	*		cruise ship	600+	no	yes	heading south
7/30/99	7	13:46	14:04	*		cruise ship	600+	no	yes	also heading south, behind vessel 6

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PERSONAL COMMUNICATIONS

Mills, Harold. Cornell University, Bioacoustics Lab, Ithaca, New York.

LITERATURE CITED

Allen, S. G., D. G. Ainley, and G. W. Page. 1980. Haul out patterns of harbor seals in Bolinas Lagoon, California. U.S. Marine Mammal Commission.

Altmann, J. 1973. Observational study of behavior: sampling methods. *Behaviour* 49: 227-265.

Brasseur, S., J. Creuwels, B. v/d Werf, and P. Reijnders. 1996. Deprivation indicates necessity for haul-out in harbor seals. *Marine Mammal Science* 12: 619-624.

Calambokidis, J., L. E. Healey, and G. H. Steiger. 1985. Reaction of Harbor Seals (*Phoca vitulina*) to boats in Glacier Bay, Alaska. Cascadia Research Collective.

Feltz, E. T., and F. H. Fay. 1966. Thermal requirements *in vitro* of epidermal cells from seals. *Cryobiology* 3: 261-264.

Fowler, G. S. 1999. Behavioral and hormonal responses of Megellanic penguins *(Spheniscus magellanicus)* to tourism and nest visitation. *Biological Conservation* 90: 143-149.

Mathews, E. A. 1996a. The effects of seismic reflection surveys and vessel traffic on harbor seals in Johns Hopkins Inlet, Glacier Bay National Park: A Preliminary Assessment. Glacier Bay National Park, Gustavus, AK.

Mathews, E. A. 1996b. Effects of vessel traffic on Steller sea lions *(Eumetopias jubatus)* in Glacier Bay National Park. Glacier Bay National Park, Gustavus.

Mathews, E. A. 1997. Preliminary assessment of haulout behavior of harbor seals *(Phoca vitulina)* and sources of disturbance at the Spider Island reefs, Glacier Bay National Park. Glacier Bay National Park, Gustavus, AK.

Mathews, E. A., and G. W. Pendleton. 1999. Declining trends in harbor seals *(Phoca vitulina richardsi)* at glacial ice and terrestrial haulouts in Glacier Bay National Park, 1992-1998. Pages 25. Glacier Bay National Park, Gustavus, AK.

Ronald, K., and C. A. Thomson. 1981. Parturition and post partum behavior of a captive harbour seal, *(Phoca vitulina)*. *Aquatic mammals* 8: 79-90.

Suryan, R. M., and J. T. Harvey. 1998. Variability in reactions of Pacific harbor seals, *Phoca vitulina richardsi,* to disturbance. *Fisheries Bulletin* 97: 332-339.

Thompson, P., and P. Rothery. 1987. Age and sex differences in the timing of moult in the common seal *(Phoca vitulina)*. *Journal of the Zoological Society of London* 212: 597-603.

Wursig, B., F. Cipriano, and M. Wursig. 1991. Dolphin movement patterns. Information from radio and theodolite tracking studies. Pages 79-111 in K. Pryor and K. S. Norris, eds. *Dolphin Societies*.