The Effects of

Seismic Reflection Surveys and Vessel Traffic on

Harbor Seals in Johns Hopkins Inlet,

Glacier Bay National Park:

A Preliminary Assessment

by

Elizabeth A. Mathews[*]

Wildlife Biologist
Glacier Bay National Park and Preserve
P.O. Box 140
Gustavus, AK 99826

September 1994

Revised November 1996

---

[*] Current Address: University of Alaska Southeast, Education, Liberal Arts and Science, 11120 Glacier Hwy, Juneau, Alaska 99801

TABLE OF CONTENTS

The Effects of Seismic Reflection Surveys and Vessel Traffic on Harbor Seals in Johns Hopkins Inlet, Glacier Bay National Park: A Preliminary Assessment

Elizabeth A. Mathews[1]
Wildlife Biologist
Glacier Bay National Park and Preserve
P.O. Box 140
Gustavus, AK 99826

September 1994
Revised November 1996

ABSTRACT

In August 1994, seismic surveys and piston-core sampling were scheduled to occur in Johns Hopkins Inlet, a glacial fjord in Glacier Bay National Park that is used by 3000-5000 harbor seals as a pupping, rearing, and resting area from May to September. Because of concerns about the potential for disturbance of recently weaned and molting (shedding) seals, a preliminary study was initiated to monitor the effects of seismic sampling on harbor seals, and to compare the effects of the research vessel's activities to those of private and commercial vessels. Seals that left an iceberg as a vessel approached were considered to have been "disturbed." Four variables were measured: 1) total number of seals disturbed, 2) disturbance rate, 3) percent of seals disturbed, and 4) distance from seals when they entered the water. The seismic survey vessel disturbed the second highest number of seals, although it was also in the inlet more than twice as long as the other vessels. The disturbance rate and percent of seals disturbed by the seismic survey vessel did not differ significantly from mean values for the seven other vessels. All but one of the eight vessels violated the Marine Mammal Protection Act by causing seals to enter the water, and all vessels appeared to have violated NPS regulations for remaining more than 1/4 nm from seals. These results suggest that vessel operator compliance

---

[1] Current Address: University of Alaska Southeast, Education, Liberal Arts and Science, 11120 Glacier Hwy, Juneau, Alaska 99801

with Federal (NPS and MMPA) regulations for minimizing wildlife disturbance is lower than previously assumed, and that harbor seals may experience additional energetic costs from disturbances during crucial phases (pupping and molting).

INTRODUCTION

Between May and September, 3,000 to 5,000 harbor seals *(Phoca vitulina richardsi)* rest, give birth, nurse, and molt on ice bergs in Johns Hopkins Inlet in Glacier Bay National Park (Calambokidis et al. 1987, Mathews 1992, Streveler 1974). This active tidewater glacial fjord is used by the largest known breeding aggregation of seals remaining in Alaska (Calambokidis et al. 1987, Mathews 1992). Harbor seal numbers in other parts of Alaska (i.e., Gulf of Alaska) have declined by up to 80%, and listing seals in Alaska as threatened under the Endangered Species Act has been proposed.

During the pupping season in May and June, since 1988, Johns Hopkins Inlet is closed to all vessel traffic by the National Park Service (NPS) to minimize disturbance of females with pups, and during the remainder of the summer all vessels are required to remain more than 1/4 mile from seals on ice bergs (Glacier Bay National Park and Preserve Compendia, 1988-1992). The Inlet is opened to the public during the rest of the year. Vessel traffic is known to potentially cause seals at haulouts to enter the water (Allen et al. 1984, Calambokidis et al. 1985, Johnson et al. 1989), resulting in an unknown, but increased, energetic cost to the animals.

The main objective of the project was to assess whether the survey vessel's operations were more likely to disturb harbor seals than other vessels in Johns Hopkins Inlet. A second objective was to begin to assess the degree of compliance by vessel operators with: 1) NPS regulations which require that vessels remain 1/4 mile from seals (Glacier Bay NPS Compendium, 1994), and 2) the Marine Mammal Protection Act (MMPA) which prohibits "the negligent or intentional operation of *(a)... vessel, or the doing of any other negligent or intentional acts which result in disturbing or molesting a marine mammal" (50 CFR 216.3). (For a summary of the MMPA regulations, see Appendix I)

Glacier Bay has experienced one of the most dramatic marine deglaciations, and it is one of the best-studied glacial systems in the world (Cowan 1990, Field 1947, Powell 1984, Powell 1990, Powell and Cowan 1987, Wright 1887). In 1993 and 1994 Drs. Ellen Cowan and Ross Powell were funded by the National Science Foundation (NSF) to characterize the changing marine sediments associated with glacial activity in southcentral and southeast Alaska, including Glacier Bay. The seismic reflection profiling and sediment coring work is part of a long term study to monitor the dynamics of glacial sedimentation in Alaska and to interpret historic activity of glaciers (Cowan and Powell 1991, Cowan et al. 1988). During the 1993 survey in Glacier Bay, the Park did not issue a research permit for sampling in Johns Hopkins Inlet because of concerns and uncertainty about the potential effects of seismic profiling and related vessel operations on harbor seals. In 1994 the Park granted the research team permission to sample in Johns Hopkins Inlet, provided that the work was conducted at a time when Park biologists could monitor the research activities. The decision to allow the seismic sampling to proceed in Johns Hopkins Inlet was made because:

1) the potential effects of the proposed hydroacoustic sampling on harbor seals were not known to be different from those of private and commercial vessels, limiting justification for denying the *R/V Alpha Helix* access to the Inlet;

2) the Park recognizes the value of monitoring changes in glacial sediments as fundamental to our understanding of the marine dynamics of Glacier Bay; and

3) similar hydroacoustic profiling is proposed to continue for many years, and the face of Johns Hopkins glacier, one of a few advancing glaciers in the Park, will provide valuable comparative information on marine sediments.

In this report I describe the protocol used to monitor vessels and seals in 1994, and I compare three variables (total number of seals disturbed, seals disturbed per hour, and percent of seals disturbed) from the *R/V Alpha Helix* to the same variables from seven other vessels which were monitored. I also present a brief review of other harbor seal and vessel disturbance studies and make recommendations for minimizing wildlife disturbance.

Because this was a pilot study and the number of vessels sampled is small, a more thorough study of vessel activity and seal behavior is recommended to document potential effects of vessel traffic in general and seismic surveys in particular. Assessment of compliance with the MMPA and NPS regulations may need to be repeated on a regular basis, particularly if vessel traffic in Glacier Bay increases as anticipated.

METHODS

Seismic Surveys

The *R/V Alpha Helix*, a 130 foot vessel operated by the National Science Foundation (NSF), was used for the seismic reflection profiling and sediment coring work. Side scan sonar and a Huntec transducer were towed at a depth of ___m behind the vessel, and it emitted pulsed sounds between 500 Hz and 8 kHz; (maximum 217 dB[1] re 1 µPascal). Echoes from the transducer produce high resolution seismic profiles of benthic sediments. To ground truth the seismic information and to interpret sediment composition and depth, sediment samples were also collected using a gravity and piston coring device (Cowan, Oct. 6, 1993, NSF Proposal, personal communication with NPS) (Cowan and Powell 1994).

During profiling, the R/V Alpha Helix followed pre-determined transects back and forth across the Inlet. The vessel operated in the Inlet from about 9:30-12:00 on the 12th. The survey vessel returned for core sampling at about 17:30 and remained until about 02:00 (8/13). Overall, they were in the Inlet approximately 11 hours. My field assistants and I monitored vessel and seal behavior for six hours during two sessions which included both seismic profiling

[1] During a review of this work, the reported decibel levels of the Huntec came into question. The actual sound source level may be lower than 217 dB (K. Englund, NPS Report August 1994).

(9:36 to 11:16) and piston coring (17:44 to 21:05). Because the piston coring work continued into the night, we were not able to monitor seal behavior during all of these activities.

Observations of Vessels and Harbor Seals

Our field camp and observation site was located at the point below Tyeen Glacier along the north shore of Johns Hopkins Inlet in Glacier Bay National Park (Figure 1). A line between Kashoto Glacier and the point below Toyotte Glacier was used to define when vessels 'entered' Johns Hopkins Inlet (Figure 1b). (Seals were rarely observed on icebergs north of this line.) My three field assistants and I were in the Inlet to census harbor seals and conduct behavioral observations from August 10-16, and I returned to the Inlet from August 28-30.

Although we only conducted focal observations of eight vessels for this study, we recorded when any vessel entered or left the inlet. The seismic work in the Inlet occurred on August 12; the other vessels were monitored on August 14 (N=1), 15 (N=4), and 28 (N=2). On August 12, monitoring *the Alpha Helix* was our priority, whereas obtaining two to three paired counts was the priority during the remainder of the study. Consequently, the selection of vessels (other than the *Alpha Helix)* for focal observations was primarily based upon whether or not two of us were available to observe and record vessel actions and seal behavior.

Once a decision was made to begin a continuous, focal observation of a vessel during the time that it was in the inlet, we used the following procedure to monitor seal response. As a boat approached seals on an ice berg we began recording the number of seals per iceberg for groups within, but ahead of, the anticipated path of the vessel. One observer used binoculars to monitor seals and to scan the area ahead of and behind the boat. A second person recorded observations called out by the first observer. These included: a) the number of seals per ice berg before a vessel passed, b) an estimate of the minimum approach distance or the distance between the boat and an iceberg when a seal abandoned it, and c) the number of seals entering the water per iceberg as the boat passed or whether no seals entered the water. Seals which left an iceberg as a vessel approached or passed were considered to have been disturbed. We also estimated the distance between seals and a passing vessel by using boat lengths. (Later, the exact measurements of cruise ships and commercial vessels were obtained from NPS files and used to estimate total distance.)

The recorder noted the times of events and observations and other comments regarding the behavior of the boat or seals. In addition, we typically noted if a vessel changed direction or speed in a noticeable way or whether or not a group of seals became vigilant (head up and actively looking around) or remained resting during an approach. Our methods were a simplified version of those used by Calambokidis *et al.* (1983, 1985). Calambokidis's team used a surveyor's theodolite to accurately measure distances and to calculate boat speed and direction of travel; distances in this study were visually estimated using boat lengths.

Total Number of Seals Disturbed

The number of seals we observed entering the water in the path of a vessel was summed over the entire time for each observation. The value of this variable from the *Alpha Helix* was then compared using a Mann Whitney-U test to that of the mean value for the other seven boats.

Disturbance Rate and Percent of Seals Disturbed

Boats were monitored for different lengths of time varying from 10 minutes for one of the cruise ships to six hours for the research vessel (Table 1). To partially control for the differences in monitoring time, I also calculated and statistically compared (Mann Whitney-U test) the disturbance rate (number of seals which entered the water per hour) of the *Alpha Helix* to that of the seven other vessels.

The number of seals which were observed entering the water divided by the total number of seals monitored during each vessel tracking session was used to calculate the percentage of observed seals which were disturbed for each focal vessel observation . The value for this variable was then also compared to that of the mean value for the seven other vessels (Mann Whitney-U test).

Distance from Seals during Disturbance

To examine the distances at which seals were disturbed, I graphed the average distance between a vessel and seals on an iceberg when disturbances occurred for each vessel. These values were also compared to the NPS's ¼ nm distance limit for vessels in Johns Hopkins Inlet.

RESULTS

Total Number of Seals Disturbed

The total number of seals disturbed by a vessel's path through the Inlet ranged from a maximum of 124 seals, which were disturbed by a 40 ft private sailboat under power, to none during the passage of a 105 ft tour boat (Table 1; Figures 2a and 3a). On another day the same tourboat did not disturb any seals, although more than 15 times as many seals were monitored during this second observation. Sixty-eight seals entered the water near the *R.V. Alpha Helix* (Figure 3a) during the six hour monitoring period. Although this was the second highest number of seals disturbed by a vessel (Figure 2a), it was not significantly different from that of the mean value of the other seven vessels (Figure 3a).

Table 1. Summary of monitoring duration, numbers of seals monitored and disturbed for eight vessels, including the *R/V Alpha Helix (R/V AH)* in Johns Hopkins Inlet, August 1994. Vessels are organized by size, from the largest to the smallest.

	1	2	3	4	5	6	7	8
Type:	Cruise	Cruise	***R/V AH***	Tour Bt	Tour Bt	Sailbt*	Power	Kayak
Size:	800ft	750ft	130 ft	105ft	105ft	40 ft	40 ft	18 ft
VESSELS:								
Monitoring Duration	0:33	0:10	6:01 (2 ses-sions)	0:35	1:14	1:40	1:01	0:28
Min. Distance (ft)	133	94	65	210	105	120	80	300
Mean Distance (ft)	322	402	339	245	428	301	263	414
SEALS:								
Seals Monitored	56	31	236	11	174	243	27	85
Icebergs Monitored	17	7	66	6	52	53	7	35
Seals Disturbed	48	27	68	7	0	124	10	42
No. Disturbed/Hr	87	162	11	12	0	74	10	90
% Disturbed	86%	87%	29%	64%	0%	51%	37%	49%
				4 & 5 = same bt		*6: under power*		

Disturbance Rate

One of the two cruise ships had the highest rate of disturbance (162/hr; duration of observation = 10 min), while the double kayak had the second highest rate of disturbance (90/hr; duration of observation = 28 min) (Table 1, Figure 3b). The disturbance rate of the *R/V Alpha Helix* was 11/hr (duration of observation = 361 min), the fifth highest of the 8 vessels (Figure 2b). This value was lower than, and not significantly different from the mean value of the seven other vessels that we monitored (Figure 3b).

Percent of Seals Disturbed

The *R.V. Alpha Helix* disturbed 29% of the 436 seals we observed in or near its path. The two cruise ships disturbed proportionately more seals (86% of 56 seals and 87% of 31 seals) than other vessels (Figure 2c). Among the eight vessels we monitored, the seismic survey vessel ranked seventh for this factor (Figure 2c), and it was not significantly different from the mean percent of seals disturbed by the other vessels (Mann Whitney-U test) (Figure 3c).

The same tourboat entered the inlet and was monitored on two different days. On one day it disturbed 64% of the 11 seals it passed, whereas none of 174 seals near its path were observed entering the water on the second day.

Average Distance from Seals during Disturbance

Seven of the eight vessels monitored caused seals to enter the water during our observations. Figure 4 summarizes the average and maximum distance between a vessel and seals on an iceberg for each occurrence of disturbance. The sample size (n) for each vessel is the number of ice bergs for which at least one seal entered the water as the vessel passed. All eight of the vessels approached seals to within a 1/4 mile, despite NPS regulations requiring that greater distances be maintained.

Potential Effects of Disturbance on Number of Seals Hauled Out

On August 13 -- the day after the seismic survey transects and piston coring -- we observed the lowest number of seals hauled out on ice bergs (2,035 and 2,101). The third lowest count occurred on August 15 (2,181 seals), shortly after a private vessel motored through a dense aggregation of seals (Figure 5). The three highest of the 20 counts made during August were 3,631, 3,928, and 4,354 seals.

DISCUSSION

The results from this preliminary study indicate that:

1) the research operations of the *R/V Alpha Helix* did cause at least 68 seals to enter the water, but their disturbance rate and proportion of seals entering the water were not significantly higher than those of private and commercial vessels, and

2) compliance with NPS regulations and the MMPA by private, commercial, and research vessel operators in Johns Hopkins Inlet may be much lower than previously believed.

In the sections which follow, I first discuss aspects of the results of the comparison of the *R/V Alpha Helix* to that of the seven other vessels. In the second section, I discuss the observed lack of compliance with MMPA and NPS regulations for minimizing disturbance. The third section provides information on two other studies of harbor seals and vessels, and the final section includes some recommendations for future studies and for reducing disturbance.

Comparison of the R/V Alpha Helix's Effects on Seals to Other Vessels

The total number of seals disturbed by the *R.V. Alpha Helix* (68), its disturbance rate (11/hr), and the proportion of monitored seals which entered the water in or near its path (29%) were not significantly different from the average values of these variables for the other seven vessels. The research vessel's disturbance rate and the percent of monitored seals that were disturbed ranked sixth and seventh among the eight vessels (Figure 2), suggesting that *Alpha Helix* disturbed relatively fewer seals than most of the other vessels, considering the longer duration of its operations near seals. The survey vessel also followed predetermined transect lines during much of the time it was in the Inlet. These two factors would presumably increase the potential for disturbing seals, compared to vessels which were in the Inlet for a much shorter period and which usually had options to traverse areas of lower seal or ice density. One factor which may have contributed to the relatively low impact of the research team's operations -- despite its longer duration of activity -- is that they were aware of our monitoring efforts, and they had an NPS observer on board. When possible, the Captain of the *Alpha Helix* maneuvered the vessel to avoid or minimize seal disturbance.

Monitored vessels exhibited a high degree of variation in all three variables of seal disturbance (Figure 2). Whether or not harbor seals respond to a vessel may be influenced by several factors including: 1) the distance between the seal and the boat, 2) vessel operation (i.e., speed, erratic vs. steady maneuvering, etc.), 3) size and type of the vessel (Calambokidis et al. 1983) and 4) the behavioral state of seals at the time of an approach (Kovacs and Innes 1990), and 5) possibly prior experience of the animals to vessel traffic. Although all of these factors potentially influence seal response to boats, the wide range of disturbance (Figure 2) and the low relative level of impact observed from the *R/V Alpha Helix,* despite its longer duration in the Inlet, suggest that a key factor influencing disturbance is the vessel operator. The captain of the *Alpha Helix* was aware of our monitoring work, and he attempted to avoid areas with concentrations of seals. A vessel's behavior and the duration of each visit need to be considered together for full assessment of potential effects on seals.

Compared to commercial vessels (i.e., cruise ships, charter vessels, and tour boats) with operators who enter the Park several times a summer, one-time or infrequent visitors may be more likely to disturb animals due to a lack of experience around harbor seals, a lack of awareness of regulations, or a lack of concern for disturbing wildlife. The operator of the 40 foot sailboat, which disturbed the largest number of seals (124), knew that we were studying harbor seals at the time that he entered in the Inlet -- he spoke with one of my field assistants as he passed by our field camp. At one point, we counted 138 seals in the water within several hundred feet of his boat. This was the highest number of seals that we observed in the water during any of the 20 counts we made on nine days. I surmise that the captain of this boat was unaware of regulations against disturbing harbor seals, since he did not appear to avoid areas of high seal concentration. This suggests that improved visitor education could reduce wildlife disturbance (Fagen and Fagen 1990).

To resolve the question of whether or not a public education program might be an effective means of minimizing disturbance of harbor seals (and other wildlife) in the Park, an adaptive management regime might be implemented for one summer. One possible approach would be to have Johns Hopkins Inlet alternately open for three or four days and then closed for an equivalent period of time. Park visitors in private vessels could be divided in to two groups: one group would receive information on the vessel interaction study and the reasons for the work, the other group would not receive any information on the project. Visitors could be informed in one of two ways. Before their visit to the park, perhaps during an orientation at the Back Country office, visitors could be given an informative brochure describing the project and with background information on the status of harbor seals in Alaska; the second group would not be given any information on the subject. If such a program is not effective in significantly reducing the level of disturbance in Johns Hopkins Inlet during breeding and molting (July and August), then enforcement of the MMPA to eliminate 'takes' of seals may be required.

Because our protocol did not include systematic monitoring of seals in the water, we cannot conclude that the operation of the transducer itself did or did not affect the behavior of seals. There was suggestive evidence that seals in the water may be attracted to underwater sounds produced by the towed Huntec. On August, 12 we observed eight seals which swam toward and then followed the research vessel for a few minutes during active seismic operation. Harbor seals are curious and will follow other boats *(personal observation)*, so it is not clear if they were simply attracted to the vessel or by the novel underwater sounds. An experiment could be designed to test whether seals change behavior in response to underwater sounds during seismic operations. One possibility would be for the survey vessel follow a transect with its transducer turned off and then repeat the procedure with the transducer in operation. The behavior of seals could then be monitored to assess for potential effects. Ideally, behavioral observations would be made without knowing when the transducer was on or off.

Compliance with MMPA and NPS Regulations

A larger point which needs to be addressed is that all but one of the eight vessels violated the MMPA by causing seals to enter the water, and all of them appeared to have violated the NPS regulation for remaining more than 1/4 mile from seals on ice bergs (Figure 4). While these results are preliminary, they suggest that a majority of vessel operators are not maneuvering adequately around harbor seals. Explanations for why MMPA and NPS regulations are not being observed include: 1) a lack of awareness or a misunderstanding of the regulations, 2) an inability to accurately estimate distances to seals, 3) an inability to see seals until they are already reacting to the vessel, 4) an active disregard for the regulations, and 4) possibly distractions caused by a primary interest in the active glacier.

This work was conducted on only nine days of the two month season (July-August) when vessels are permitted to enter Johns Hopkins Inlet, and the study occurred after the peak in the tourist season. Consequently, it is likely that the magnitude and frequency of seal disturbance may be even higher than that reported here.

Other Studies on Vessel Traffic and Harbor Seal Behavior

Calambokidis and co-workers (1987) studied the effects of vessel traffic on harbor seals in Muir Inlet, a glacial fjord in the east arm of Glacier Bay (Figure 1). Calambokidis's team used a more accurate method to measure distances between vessels and seals, and they divided vessels into four categories: 1) ocean-going cruise ships (approximately 135 m long), 2) tour boats (15 - 30 m), 3) pleasure boats (5 - 15 m), and 4) kayaks. They found that the mean distance at which 50% of monitored seals were disturbed was greatest for cruise ships (Table 2). These researchers also noted that the maximum daily count of all seals in Muir Inlet tended to be lower on days when larger vessels entered the inlet around midday.

Table 2. Mean distances at which 50% or more of the harbor seals on a monitored ice berg first entered the water in reaction to different vessel types in a study conducted by Calambokidis *et al.* (1985, *from:* Table 1, p.14). This work was conducted in Muir Inlet, Glacier Bay, Alaska.

Vessel Type	Mean (ft)	Mean(m)	SD(m)	N-Approaches	N-Vessels
Cruise Ships	914	277	148	17	4
Pleasure Boats	558	169	75	17	7
Tour Boats	442	134	88	47	25
Kayaks	429	130	87	9	5
All Vessels	551	167	112	90	41

We observed the lowest number of seals hauled out on August 13 (2035 and 2101), the day after the seismic survey transects, and on August 15 (2181 seals), shortly after the private vessel motored through a dense aggregation of seals (Figure 5). The three highest of the 20 counts made during this field session were 3631, 3928, and 4354 seals. During the August, 1994 census we did not have any 'non-disturbance' days (i.e., no vessels in the inlet) to test whether levels of vessel traffic or identified disturbance statistically influenced the number of seals hauled out.

In a study of harbor seals at a land haulout, Allen *et al.* (1984) used time-lapse photography to monitor human disturbance in Bolinas Lagoon, California. They recorded disturbances by humans and dogs on land, as well as disturbance from the water by power and non-power boats. Allen and her colleagues found that seals were disturbed on 71% of the days. Distance was the most important factor in determining whether or not seals would abandon the haulout. Most disturbances occurred within 100 m. Of the vessel (i.e., non foot traffic) disturbances 80% occurred within 100m, 16% were between 101 and 200 m, and 4% were recorded beyond 200m. Allen reported that the majority of disturbances were caused by non-motorized boats, predominately canoes. However, the proportion of non-power and power boats which caused a disturbance were nearly identical: 82 of 104 (79%) non-powered and 20 of 25 (80%) powered vessels resulted in disturbances of seals.

While the results of Allen's study are quite valuable, two cautions need to be made: 1) this work was on harbor seals at a land haulout and the results may not directly apply to seals resting on ice bergs, and 2) seals at land haulouts in Glacier Bay may have different flight distances than seals in other parts of their range. A researcher who had worked for several years on harbor seals off Vancouver Island noted that the seals in Glacier Bay were much more skittish and tended to abandon haulouts at much greater distances than in his study area in British Columbia (Paul Cottrell, UBC, personal communication 1991). Although this observation was not quantified, seals are still hunted in Alaska, and they may be more alert to vessel approaches as a result. Pitcher and Calkins (1979) noted that the disturbance threshold for aircraft was above

2000 feet for harbor seals at Tugidak Island (off Kodiak) compared to 1000 feet at other haulouts.

Conclusions and Recommendations

The seismic surveys and piston coring work conducted by the *R/V Alpha Helix* in Johns Hopkins Inlet did not result in disturbance levels significantly different from those of seven other vessels which operated in the Inlet. However, because seal behavior was altered and this is in violation of the MMPA, I recommend that researchers who wish to conduct geophysical or other surveys in Johns Hopkins Inlet apply to the National Marine Fisheries Service for a permit allowing for this type of "take". This would prevent violoations of the MMPA and provide a mechanism for monitoring the level of harbor seal disturbance during research activities. Although the results presented in this report are preliminary, they provide a framework for recommendations to reduce disturbance of harbor seals and for designing a more rigorous study to evaluate the potential effects of seismic explorations and other vessel activities near seals resting on icebergs.

The results also indicate that harbor seals may be disturbed, or "taken", in the Park more often than previously recognized. Wildlife tourism has increased steeply in the last decade, and non-consumptive uses of wildlife are expected to exceed consumptive uses (i.e., hunting and fishing) (Flather and Cordell 1995). The combined attraction of Johns Hopkins Inlet -- visitors come to the fjord both to observe harbor seals and the active tidewater glacier -- makes this area of particular interest and concern. Conflicts will increase as the demands of a growing tourist industry confront the needs of harbor seals for undisturbed habitat for parturition, nursing, breeding and molting.

ACKNOWLEDGEMENTS

This work was supported by funds from an NPS Challenge Cost Share Grant, a University of Alaska Natural Resources Fund, and participation of three biology students from the University of Alaska Southeast. I am very grateful to Lara Dzinich, Chris Knight, and Ami Knuth for their essential assistance and good nature during the field work for this project. National Park Service rangers provided logistic support. A draft of the report was improved by comments from Kathy Cushman (NPS).

LITERATURE CITED

Allen, S. G., D. G. Ainley, et al. (1984). "The effect of disturbance on harbor seal haul out patterns at Bolinas Lagoon, California." Fishery Bulletin **82**(3): 493-499.

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

Calambokidis, J., G. T. Steiger, et al. (1983). Behavior of harbor seals and their reaction to vessels in Muir Inlet, Glacier Bay, Alaska. 5th Biennial Conference on the Biology of Marine Mammals, Boston, MA.

Calambokidis, J., B. L. Taylor, et al. (1987). "Distribution and haul-out behavior of harbor seals in Glacier Bay, Alaska." Canadian Journal of Zoology **65**: 1391-1396.

Cowan, E. (1990). "Geologic processes in glacial fjords of Alaska." Appalachian State University Research News: 3.

Cowan, E. A. and R. D. Powell (1991). Ice-proximal sediment accumulation rates in a temperate glacial fjord, southeastern Alaska, Geological Society of America**:** 61-73.

Cowan, E. A. and R. D. Powell (1994). Cruise report R/V Alpha Helix Cruise 173, August 17-September 3, 1993, National Science Foundation.

Cowan, E. A., R. D. Powell, et al. (1988). Sediment accumulation rates in a temperate glacial fjord, McBride Inlet, Glacier Bay National Park, Alaska. Annual G.S.A.

Fagen, J. M. and R. Fagen (1990). "Interactions between wildlife viewers and habituated brown bears, 1987-1992." Natural Areas Journal **14**: 159-164.

Field, W. O. (1947). "Glacier recession in Muir Inlet, Glacier Bay, Alaska." Geographical Review **37(3)**: 369-399.

Flather, C. H. and H. K. Cordell (1995). Outdoor recreation: historical and anticipated trends. Wildlife and Recreationists: Coexistence through Management and Research. R. L. Knight and K. J. Gutzwiller. Washington, D.C., Island Press**:** 3-16.

Johnson, S. R., J. J. Burns, et al. (1989). Synthesis of information on the effects of noise and disturbance on major haulout concentrations of Bering Sea pinnipeds, U.S. Minerals Management Service.

Kovacs, K. M. and S. Innes (1990). "The impact of tourism on harp seals *(Phoca groenlandica)* in the gulf of St. Lawrence, Canada." Appl. Anim. Behav. Sci. **26**: 15-26.

Mathews, E. A. (1992). Harbor seal *(Phoca vitulina)* censuses in Glacier Bay National Park and Preserve: a comparison of land-based and aerial censusing, U.S. National Park Service, Glacier Bay National Park and Preserve.

Pitcher, K. W. and D. G. Calkins (1979). Biology of the harbor seal *(Phoca vitulina richardsii)* in the Gulf of Alaska, Outer Continental Shelf Environmental Assessment Program.

Powell, R. D. (1984). Guide to the glacial geology of Glacier Bay, southeast Alaska: glacial history, glacial sedimentology, glacial geomorphology and glaciomarine sedimentation, Geological Society America, Cordilleran Section, Alaskan Geological Society.

Powell, R. D. (1990). Advance of glacial tidewater fronts in Glacier Bay Alaska. Proceedings of 2nd Glacier Bay Science Symposium, Glacier Bay National Park, Gustavus, AK., U.S. National Park Service, Alaska Regional Office, Anchorage, AK.

Powell, R. D. and E. A. Cowan (1987). Depositional processes at McBride Inlet and Riggs Glacier. Observed processes of glacial deposition in Glacier Bay, Alaska. P. J. Anderson, R. P. Goldthwait and G. D. McKenzie. Columbus, Ohio State University. **236:** 140-156.

Streveler, G. P. (1974). Harbor seal studies in Glacier Bay, Alaska, U.S. National Park Service, Glacier Bay National Park and Preserve**:** 1-14.

Streveler, G. P. (1979). Distribution, population ecology, and impact susceptibility of the harbor seal in Glacier Bay, Alaska, U.S. National Park Service, Glacier Bay National Park and Preserve**:** 49.

Wright, G. F. (1887). "The Muir Glacier." American Journal of Science **3**: 1-18.

APPENDIX I: Wildlife Protections Regulations

NPS Regulations

Glacier Bay National Park has an admirable record of minimizing vessel traffic to protect wildlife. Because seals are more vulnerable to disturbance during pupping and nursing (Kovacs and Innes 1990), and vessel disturbance may contribute to increased neonatal mortality through separations between the mother and pup (Pitcher and Calkins 1979, Streveler 1979) the NPS has closed Johns Hopkins Inlet to all vessel traffic during a portion of spring and summer since 19__. In 1994, commercial and private vessels were not allowed to enter Johns Hopkins Inlet from May 1 to June 30 (GBNPP Compendium, May 31, 1994, p. 9). Beginning in 1994, the closure was extended to June 30th from the 15th to more fully cover parturition, nursing, and breeding activities. In July and August vessels are permitted in the Inlet, but the 1994 Compendium for Glacier Bay states that vessels must remain at least 1/4 nautical mile from harbor seals on ice bergs, unless safe navigation is compromised.

Marine Mammal Protection Act

MMPA prohibits the taking of a marine mammal unless a permit has been issued to allow the take. The definition of "take" is to "harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal. This includes, without limitation, any of the following: ...the negligent or intentional operation of an aircraft or vessel, or the doing of any other negligent or intentional acts which result in disturbing or molesting a marine mammal..." (50 CFR 216.3).

Because of confusion about the interpretation of the MMPA with regard to disturbance and conflicts with commercial fisheries, in 1992 the National Marine Fisheries Service proposed guidelines for approaching seals and sea lions. In 1992 the draft guidelines for approaching seals and sea lions were published in the Federal Register[2], however the guidelines have not been finalized at this time. The guidelines state that "*(a)lthough harassment of a marine mammal from any distance is defined as a *take*, and, therefore, prohibited, these guidelines reduce the opportunity and likelihood that seals and sea lions will be harassed." The guidelines recommend that approaches to seals and sea lions be no closer than: a) 50 yards for seals or sea lions in the water, and b) 100 yards for seals or sea lions on land. They also recommend that individuals should "not operate a vessel or aircraft or carry out an activity in a manner that disrupts the normal movement of a seal or sea lion. A disruption of behavior may be manifested by, but is not restricted to, the following: a rapid change in direction or speed; escape tactics such as prolonged diving or fleeing into the water from a haulout or rookery, evasive swimming patterns; interruptions of feeding or migratory activities; aggressive postures or changes directed at intruders; attempts by a seal or sea lion to shield a pup from a vessel or human observer; the abandonment of a previously frequented area; or other stress-related behavior."

[2] Federal Register, 57 (149): 34121-2, August 2, 1992.

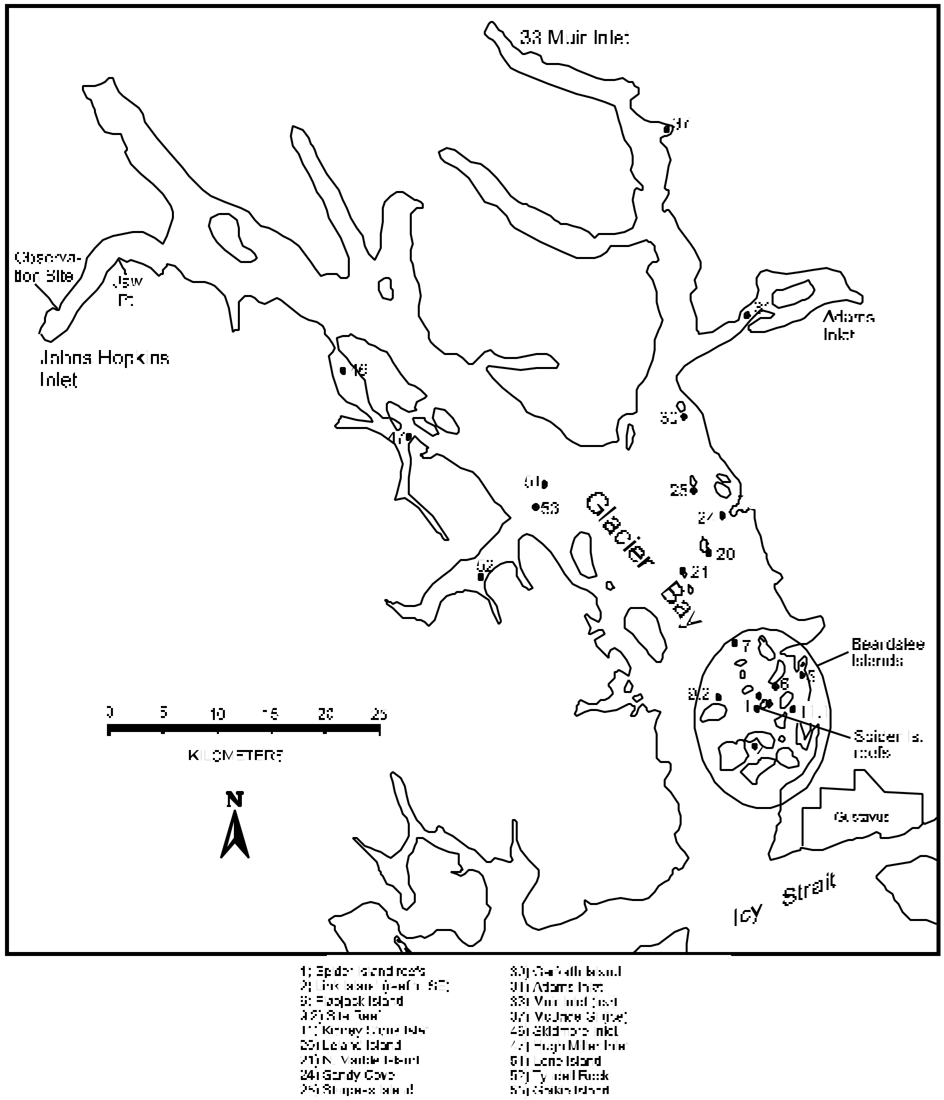

Figure 1. Map of Glacier Bay showing Johns Hopkins Inlet, the study site in 1994, and Muir Inlet, where John Calambokidis et al. monitored seals and vessel traffic in the summer of 1983.

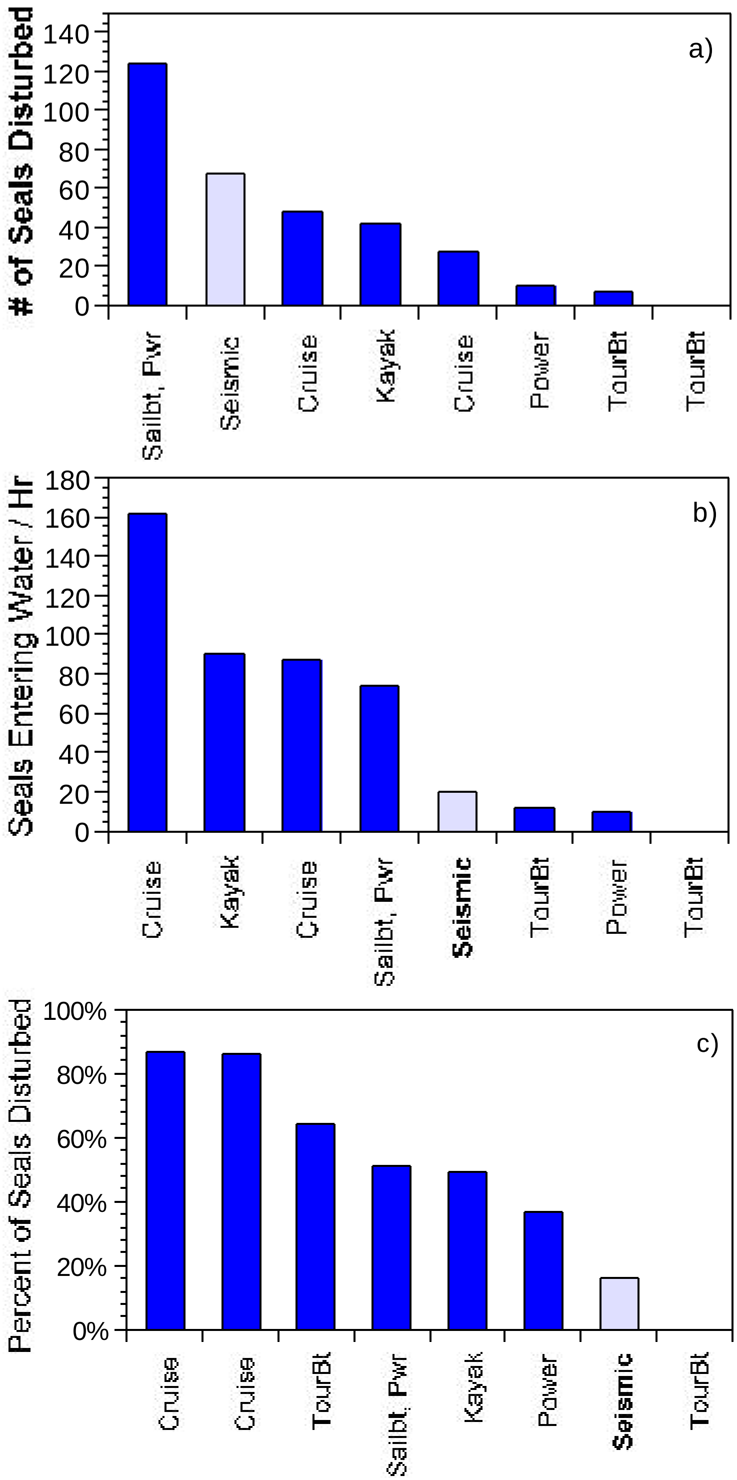

Figure 2. Effects of the seismic research vessel (dashed bars) and 7 other vessels on harbor seals in Johns Hopkins Inlet: **a)** total number of seals disturbed (entering water) during observations; **b)** number of seals that entered the water per hour; **c)** percent of monitored seals that entered the water.

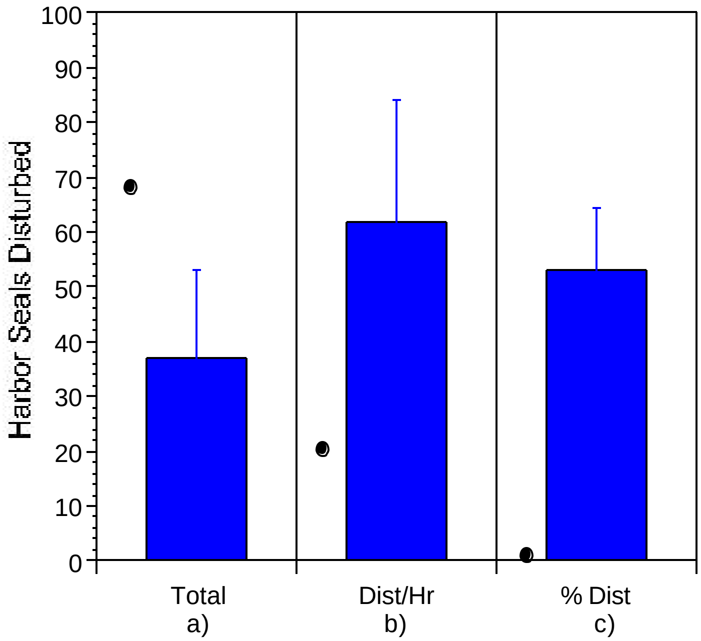

Figure 3. Comparison of the *R/V Alpha Helix* (dots) to the mean values for 7 other vessels for three seal disturbance variables: a) total numbers of seals that entered the water during observations, b) number of seals entering the water per hour, and c) the percent of seals monitored that entered the water. Error bars are one standard error.

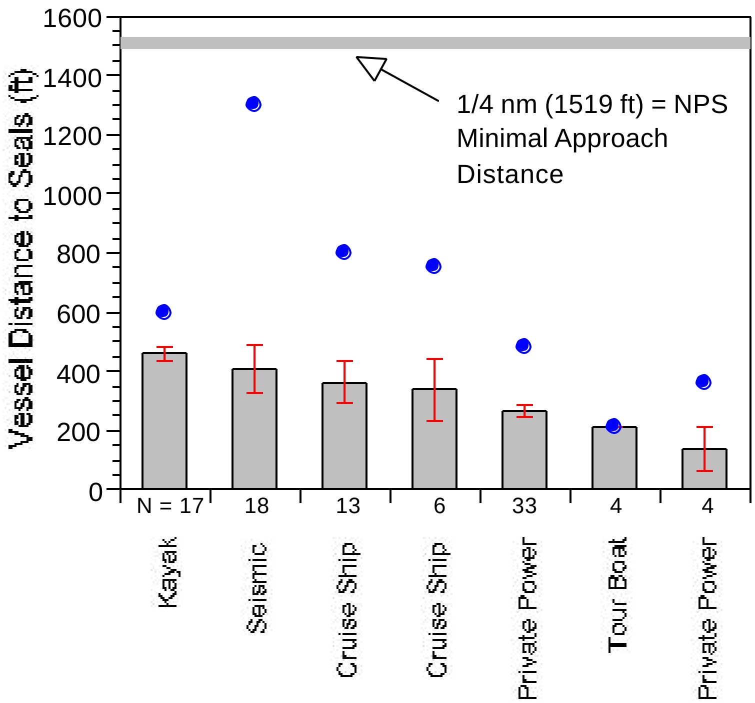

Figure 4. Mean (bars) and maximal (dots) distance (ft) when harbor seals were disturbed (entered the water) by seven of the eight vessels monitored in Johns Hopkins Inlet, Glacier Bay during August, 1994. NPS regulations require that vessels remain farther than 1/4 nautical mile from seals on icebergs. All of the eight vessels monitored appeared to approach closer than this limit; however distances were estimated, not measured. (Bars are one standard error around the mean.)

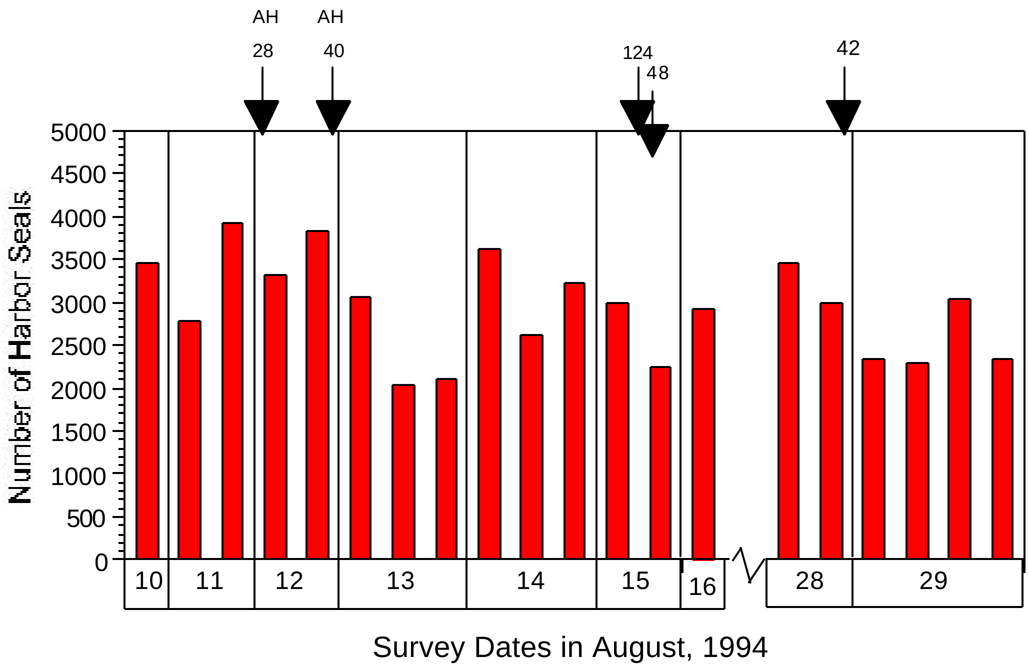

Figure 5. Mean values of paired counts during the August, 1994 surveys of harbor seals in Johns Hopkins Inlet (Counts on August 29 are values of four single counts.). Arrows denote relative timing of the *Alpha Helix (AH)* seismic surveys and the timing of the three vessels that were observed to disturb the highest number of seals. Numbers next to arrows denote the number of seals we observed entering the water near a vessel.