

Disturbance and Displacement of Brown Bears by Vessels in Glacier Bay

Preliminary Analysis

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March 2010

Introduction

Wildlife viewing is a popular recreational activity in Glacier Bay where the vast majority of visitors travel and view wildlife in motorized vessels. In the recently de-glaciated fjords of Glacier Bay where glaciers and steep rock walls predominate, brown bears are particularly dependent on the marine intertidal zone and adjacent strips of beach meadow. Brown bears are of particular management concern because of their reliance on coastal habitats as well as the potential threat they pose to human visitors.



Figure 1. Study area is Glacier Bay proper in Glacier Bay National Park and Preserve, northern Southeast Alaska. The green line represents the boundary of Glacier Bay National Park and Preserve and dark green represents the border of Alaska and British Columbia.

Recent studies of bear habitat and activity along the coastline of Glacier Bay (Smith et al. 2007, Partridge et al. 2009) show the importance of the marine intertidal zone and adjacent narrow strips of beach meadow particularly to brown bears in the upper reaches of the bay where glaciers and steep rock walls predominate. One study examined the bear displacement potential at popular camping locations (Smith et al. 2007), but there has been no research in Glacier Bay on bear disturbance and displacement by vessels. Bears are potentially vulnerable to disturbance from boats in the upper bay because the beaches contain the earliest plant growth, access to intertidal resources, and unrestricted movement corridors, yet there are limited trees to provide cover. Repeated disturbance and displacement from key shoreline feeding areas may cause reduced survivorship and reproductive success of individuals, which could affect the health of the population. Researchers in southwestern Alaska found that human-bear interactions along a salmon stream temporarily displaced bears up to 64% of the time, while almost 25% of the encounters resulted in bears immediately ceasing their foraging and leaving the river for several hours (Smith 2002). A more recent study in south-central Alaska revealed that time spent foraging decreased and vigilance increased for brown bears when people were present and some GPS-collared bears vacated productive sections of salmon streams (Rode 2006). Very little data have been collected on bear disturbance and displacement caused by vessels in Alaska, or on potential effects of repeated disturbance on the reproductive fitness of brown bears.

A two year study beginning in 2009 examines the effects of vessel based bear-viewing on the behavior of brown bears on the shoreline using controlled experimental vessel approaches. The results of this study will be used to establish bear viewing minimum distance recommendations and/or regulations for vessels to minimize bear disturbance and displacement.

Methods

Protocols consist of experimental approaches of brown bears on the beach as follows:

- Locate brown bears from a mid-size (20-50 feet) motor vessel.
- Observe the bear at 400-500 meters and document the bear's initial behavior.
- Approach the bear at a direct bearing and slow (1-3 knots) speed.
- Record instantaneous behavioral observations and associated covariates approximately every 3 seconds.

- Determine distance from vessel to bear at every behavioral obs. with Leica Geovid laser range finders.
- Attempt to take photos of all bears for photo ID to prevent approaching the same bear more than once per sampling period.
- If the bear is disturbed, the boat retreats.
- If the bear is not disturbed, the boat retreats after reaching its closest point of contact.

A disturbance threshold is reached if either the bear runs away from the boat, or the bear increases distance from the boat in association with one or more stress behaviors. Stress behaviors are defined in the bear activity categories below:

- Energetic Gain: foraging (actively feeding and/or visually searching for food), and resting (standing, sitting, or lying down).
- Movement: walking, running (record direction), swimming, and departing into cover.
- Stress: vigilant towards vessel, posturing, and mouthing (jawing, yawning, or frothing).
- Unknown: vigilant towards other, urinating, defecating, sniffing, playing, and interacting with another bear.

Data analysis

For each trial, if the disturbance threshold was reached, the distance of disturbance is the value of the predictor variable and the response is positive, or 1. If the disturbance threshold was not reached, the closest distance of the approach is the value of the predictor variable and the response is negative, or 0. A logistic regression model was generated with distance and wind direction as covariates.

To detect changes in bear behavior across distance, I calculated the frequency of various behaviors exhibited at given distance categories for each trial and then calculated the mean of these frequencies across all trials with associated 95% confidence intervals. Because the means are proportions, an arcsin square root transformation is suggested. For this analysis I focused on behavior categories “stress” and “energetic gain” as indicators of negative vs. positive effects of vessel approaches.

Results

Disturbance

In 2009 we conducted thirteen experimental vessel approaches of brown bears. Bears were disturbed in 8 out of 13 approaches at distances ranging from <20m to 421m. Seven out of 9 bears (78%) approached within 100m were disturbed (Figure 2). Bear #9 was disturbed at 431 meters, four times the distance of any other disturbance. By contrast, bear #8 was not disturbed at a distance less than 20m, by far the lowest distance of non-disturbance recorded. These two observations represent possible outliers in the small data set.

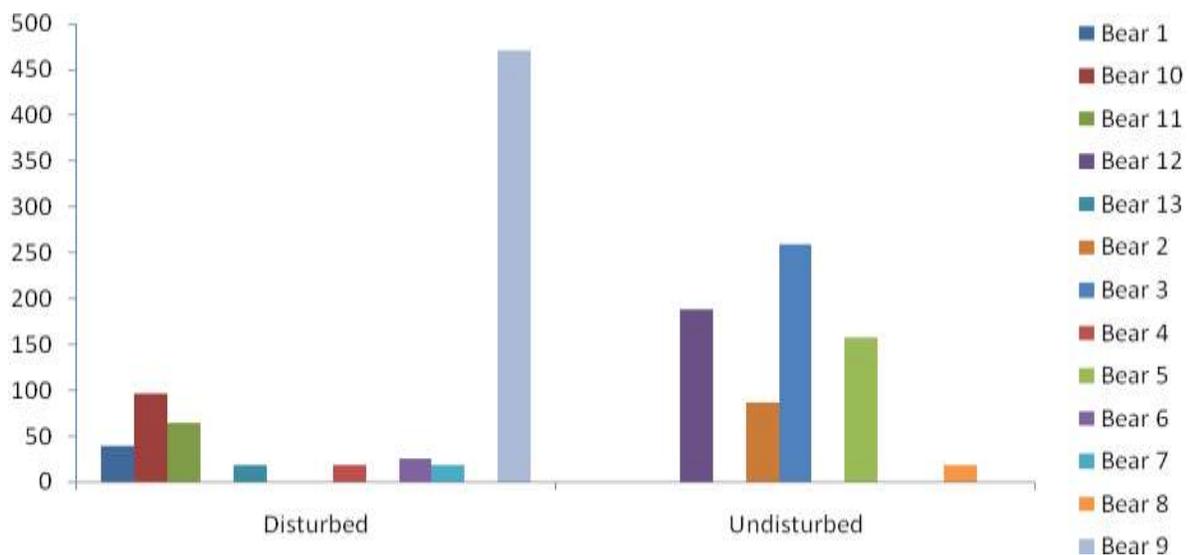


Figure 2: Closest approach distances of each bear and consequent disturbance or non-disturbance. Bear #9 is on the right side of the disturbed category and #8 is on the right side of the undisturbed category.

A logistic regression model of the 13 bear approaches with distance as the predictor variable and disturbance as the response did not produce significant results ($p=0.514$ with odds ratio of 2.25 and confidence intervals of 0.98 to 1.00). Diagnostic plots indicate that bear #9 was an extreme outlier that may strongly affect model results (Figure 3). Removing bear #9 produced a better chi-squared plot (Figure 4) and a lower p -value (0.08 with odds ratio of 12.78 and confidence intervals of 0.93 to 0.99) indicating that the distance parameter estimate is marginally significant in this model.

When wind direction was added to the model as a covariate the Chi squared goodness of fit test indicated that the reduced model, Disturbance \sim Distance, is preferred ($p=0.65$).

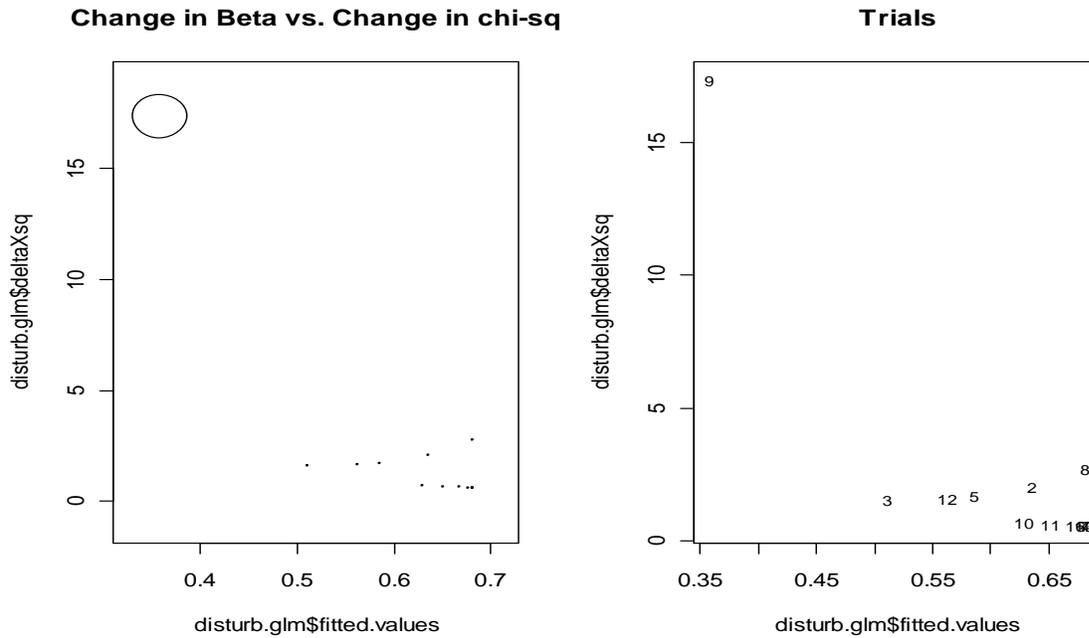


Figure 3: Diagnostic chi-squared plot shows bear #9 is an extreme outlier (upper left corner).

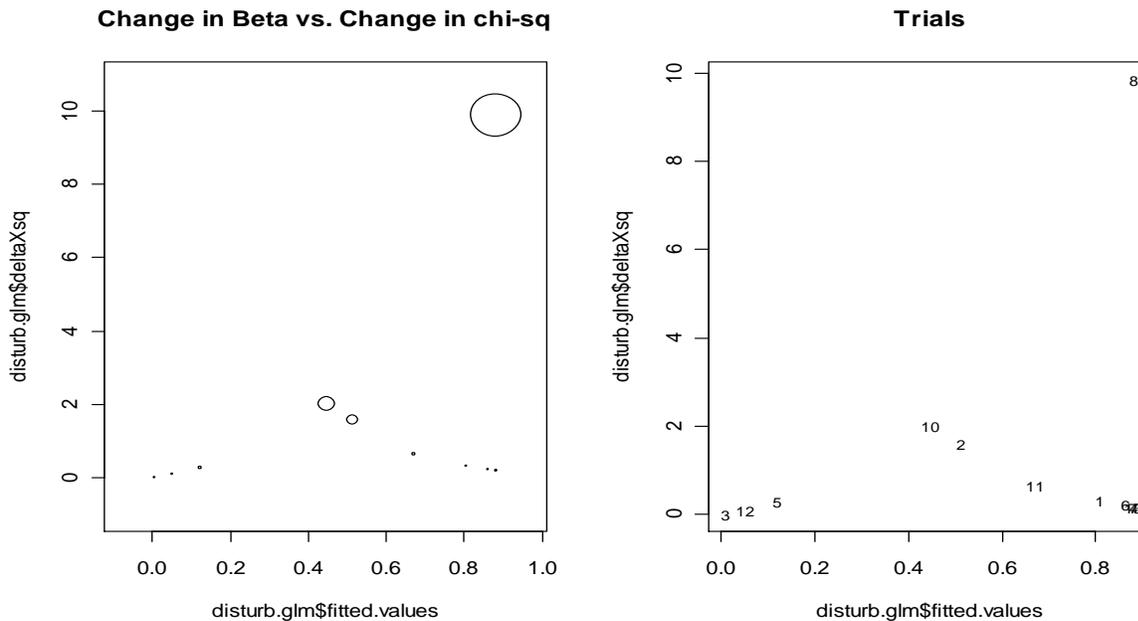


Figure 4: Diagnostic chi-squared plot with bear #9 excluded shows more clustered data points. Bear #8 (upper right) is now the greatest outlier.

Behavioral Changes

The untransformed mean frequency that bears spent exhibiting energetic gain behaviors decreased from a high of 0.66 ± 0.15 at 401-500 meters to 0.40 ± 0.23 at 1-100 meters. Mean frequency bears spent exhibiting stress behaviors increased from a low of 0.02 ± 0.07 at 301-400 meters to 0.27 ± 0.11 at 1-100 meters. Results after the arcsin square root transformation indicate that distance categories 1-100m is significantly different at a 95% confidence interval from 101-200m, 201-300m, 301-400m, and >501 (Figure 5).

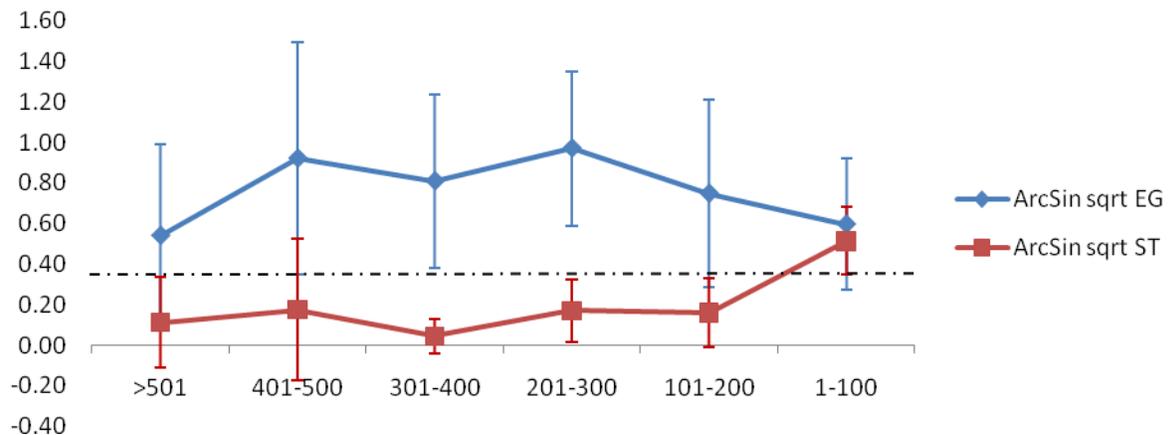


Figure 5: Mean frequency (with arcsin square root transformation) that bears exhibited energetic gain (EG - blue) and stress behaviors (ST - red) across distance classes (in meters) with 95% confidence intervals. A dashed axis line drawn at the lower 95% confidence range of distance category 1-100 shows there is a significant difference in stress behavior between the 1-100m and 101-200m, 201-300m, 301-400m, and >501 distance categories.

Discussion

Disturbance

Bears exhibited disturbance behavior more frequently as the vessel approached within 100 meters. Logistic regression models shows that distance is not a significant predictor of disturbance across all 13 trials but is significant if bear #9, an extreme outlier, is excluded. Excluding bear #9 may be necessary to fit this model with such a small sample size, but ideally an increased sample size will allow for variation such as this. Bear #9 is an important data point because while most bears were quite tolerant of the experimental vessel up to 100m, the reaction of bear #9 illustrates that some bears may be intolerant at vessels approaching at any distance.

So while it is important to keep such reactions in the data set, with such a small sample size, observations such as these can be very problematic.

Behavioral Changes

There appears to be a positive correlation between vessel distance and proportion of time that bears spend exhibiting energetic gain behaviors and an inverse correlation between vessel distance and time exhibiting stress behaviors. Stress behavior mean frequency in distance category 1-101m was significantly different than the rest of the categories with the exception of 401-500m, which is probably due to the extreme outlier (bear #9) in this distance class.

Energetic gain mean frequencies did not vary significantly across distance. These results indicate that although bears exhibit more stress when a vessel is approaching within 100m, they continue to forage at approximately the same frequency. So while close vessel approaches may increase stress behaviors in bears, they may not have an effect on bears' acquisition of calories.

One potential effect on a bear's ability to acquire calories is displacement from the beach by vessels. In these experiments, five out of the 8 disturbed bears were displaced a small distance (10-20m) but remained on the beach foraging while three bears were overtly displaced from the beach completely. Two instances were single bears who each ran into cover when the boat was 471m and 64m respectively. In both instances there was an onshore breeze in which the bears may have captured our scent. The third bear displaced from the beach was a mom with two dependant young. These bears ran into cover at 96m but interestingly it was not the mother who instigated the displacement, but one of the cubs. As we approached in the vessel the mom and one of the cubs foraged in the intertidal zone while the other cub displayed increasing vigilance the closer we came. Finally this cub ran for cover and the other cub and mother followed without ever looking at our vessel. We had the opportunity to watch this family group emerge from cover down the beach approximately 5 minutes later and return to the intertidal zone to resume foraging at which time a tour boat saw them and stopped. The wary cub again fled to cover and the other cub and mom followed. This example illustrates the potential negative repercussions of repeat vessel disturbance on wary bears, particularly family groups.

An onshore wind was present in three approaches, two of which were described above. During the third approach the boat was only able to get within 158m of the single bear. This bear

walked along the brush line foraging the entire time of observation and never acknowledged the vessel. The bear did, however, disappear into cover and we cannot be sure if the vessel displaced the bear or not. This example illustrates the difficulty in assessing disturbance from vessels if the bear does not overtly change its behavior. This bear was considered “undisturbed” because it did not reach the defined disturbance threshold. It should be noted that this disturbance threshold is a conservative estimate of disturbance, and may not detect subtle displacement and behavioral changes that may be caused by the vessel (Figure 6).

Conclusions

Seven out of eight disturbances occurred within 100m indicating that 100 meters appears to be a distance threshold within which bears are disturbed by vessels. In addition, frequency of stress behaviors increases significantly within 100 meters. If these trends are substantiated with a larger sample size, a 100 meter required or recommended minimum approach distance may prove to be a sound management action to reduce disturbance of bears on the beach of Glacier Bay. More trials will be necessary to balance the data and decrease the variance, particularly with inclusion of extreme outliers. Preliminary power analysis of this data set indicates that 190 trials would be necessary with bear #9 (outlier) included but only 20 trials with bear #9 excluded. Non-parametric analysis of the data set may be appropriate if extreme outliers are a continued issue with increased sample size.

With increased sample size, further analysis may include:

- The effects of wind direction and boat behavior on bear disturbance,
- The relationship between direction of bears’ movement and boat distance,
- Seasonal changes in bears’ response to vessel approach.
- Effects of vessel approaches on single bears verses family groups.
- Opportunistic observations of bears’ reactions to tour vessels.



Figure 6. A brown bear (bear #8) <20m from the vessel. This bear increased its vigilance as the vessel approached but continued foraging and did not reach the disturbance threshold.

ACKNOWLEDGEMENTS

Thank you to my graduate committee advisors: Sanjay Pyare, Kris Hundertmark, and Terry Chapin. Thanks also to past and present Glacier Bay staff members who have helped with this project: Craig Smith, Susan Boudreau, Justin Smith, Randy Larsen, Gus Martinez, Margaret Hazen, Rusty Yerxa, Jesse Soder, Janet Neilson, Whitney Rapp, Bill Eichenlaub, Lewis Sharman, Todd Bruno, Wendy Bredow, Max Girth, Pat Reinman, Marylou Blakeslee, and Mary Sullivan. Many thanks to my volunteers extraordinaire including Barb Bruno, Loren Lewis, Sylvia Muths, Eric Syrene, Ursula Syrene, Greg Streveler, and Sean Neilson. Thank you to Army Blanchard, John Caouette, Terry Bowyer, and Chris Hay-Johans for outstanding statistical advice. And thank you to the bears of Glacier Bay and beyond, who give me hours of amazing observations and ecological ponderings.

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