BEHAVIORAL CHANGES OF PACIFIC WALRUS (*Odobenus rosmarus divergens*) IN RESPONSE TO HUMAN ACTIVITIES

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ABSTRACT

In 1993, the Fish and Wildlife Service (USFWS) and the Alaska Department of Fish and Game (ADFG) initiated a cooperative program to conduct walrus counts on Round Island, Bristol Bay, Alaska, and to test a study design for monitoring walrus' reactions to localized human activities. Between May 19 and August 7, we conducted 79 hours of complete record sampling observations to quantify and compare rates of 3 target behaviors: head raises, orientations, and displacements. Two-minute behavior samples (n = 1,370) were analyzed to determine if hauled out walrus reacted to terrestrial, aerial, and vessel-based human activities on and in the near shore waters within 1km of Round Island. Walrus reacted to the presence of boats by increasing rates of head raises and orientations. In particular, reactions were most pronounced when small boats approached within at least 400 m. Terrestrial human activities did not have an appreciable effect on the rates of target behaviors. The limited number of observations of aerial stimuli precluded statistical analyses of this potential disturbance category. Comparisons of flight distances, the closest approach by a vessel before all walrus left a haulout, made between approaches of large (>11 m) and small (≤11 m) boats indicated that flight distances were greater and tolerance periods, the time between the onset of the stimulus and the flight of walrus from a haulout, shorter for large boats approaching with the wind than for small boats in similar conditions. In order to provide a more comprehensive assessment of walrus responses to different levels of human activities in the Bristol Bay area, we suggest expanding the study effort to include other terrestrial walrus haulout sites.

Key words: *Odobenus rosmarus divergens*, Pacific walrus, eastern Bering Sea, behavior, disturbance, marine mammals, pinnipeds, Round Island, Alaska.

INTRODUCTION

Following their winter cycle of birthing and breeding on pack ice in the Bering Sea, Pacific walrus (*Odobenus rosmarus divergens*) females, young, and some males follow the receding ice northward. Most males, however, move south to form herds on traditional terrestrial hauling grounds on the eastern Russian coast and sites in southwestern Alaska (Fay 1982). Many male walrus concentrate in northern Bristol Bay at Round Island (58° 36' N, 159° 58' W), one of North America's largest terrestrial walrus haulout areas. The Walrus Islands State Game Sanctuary was established in 1960 (AS 16.20090-140) to protect important walrus haulouts in northern Bristol Bay. It encompasses Round, Crooked, High, and Summit Islands, Black Rock, and the Twins (Figure 1). A moratorium on access (restrictions on aircraft, vessels, and public entry) was established to minimize human impact on walrus utilizing Round Island's rocky beaches (5 AAC 92:066, ADFG 1991). Since 1977, the Alaska Department of Fish and Game (ADFG) has supported personnel to monitor walrus numbers and human use of the island and its immediate surrounding waters (e.g. Taggart and Zabel 1985, Sherburne 1985, 1986, Sherburne and Lipchak 1987, Hessing and Brandt 1988, Hessing and Sheffield 1989, 1990, Hessing and Van Daele 1991, 1992, Koenen and Kruse 1993).

In 1993 the ADFG and the Fish and Wildlife Service (USFWS) initiated a cooperative program to continue walrus counts on Round Island and to test a study design for monitoring walrus' reactions to human activities. Both organizations agreed it was important to identify and eventually mitigate potential negative effects of human disturbance. In the summer of 1993, we conducted a field study to test the hypothesis that rates of 3 walrus behaviors would not change in response to various types of anthropogenic stimuli. The purpose of this report is to: (1) evaluate the procedures tested for monitoring disturbance of walrus; and (2) present data collected on sources of disturbance and any subsequent responses of walrus. Data summarizing daily walrus counts are presented elsewhere (Koenen and Kruse, 1993).

METHODS

From May 4 to August 14, 1993, we conducted daily counts and collected behavioral data on walrus hauled out on Round Island. Following an established sampling protocol (Hessing and VanDaele 1991) we counted walrus within 2 hours of low tide each day. Counts were limited to the beaches on the island's northeastern shore which were accessible by foot (Figure 2). When walrus herds comprised approximately 200 or fewer animals, we counted individuals. Larger herds were estimated by counting walrus within a small, representative subsection of the herd, and extrapolating that number over the remaining herd area. Counts were considered final if 2 consecutive counts varied less than 10%. If more than 3 counts were made, the average was taken and recorded as the final count.

We used a 5 m inflatable skiff with a 15 hp outboard motor to complete whole-island surveys when feasible (periods of calm weather on a rising or high tide).

Detailed observations of walrus haulout behavior and anecdotal information on disturbance responses of walrus were collected opportunistically throughout the summer.

Behavioral Monitoring

Site selection: Basing our selection on the following criteria, we limited behavioral observations to the following 3 haulout areas: Boat Cove (BC), Campground (CG), and First Beach (FB) (Figure 2). The site selection criteria included:

1. Safe, well-placed overlooks where observers could approach animals closely (to within 20 m) without detection, yet allowing unobstructed views of walrus without the need for binoculars or spotting scopes. Proximity to the animals was desirable to ensure we had a broad, immediate view of haulout conditions and factors which might have affected walrus behavior.
2. Sites known by previous observers to be subject to human impact throughout the season. Proximity to heavily used trails, the vessel entrance corridor, and the visitor staging area enabled us to maximize our observations on the potential effects of human activities on animal behavior.
3. Sites previously known to be used by animals throughout the season.
4. Beach areas with numerous distinctive landmarks to facilitate accurate re identification of walrus focal groups.
5. Ready access by observers, regardless of weather and trail conditions.

We divided beaches at Boat Cove and First Beach to help identify observation areas. BC was comprised of Flat Rock (FR), Boat Cove North (BCN), and the visitor staging area, or Boat Cove Beach (BCB). We split FB into 4 main beach areas (I, II, III, IV) (Figure 2). Because of distinctive physical features, areas II and III were broken down into tidal zones A (comprised of small, rounded cobbles and exposed during low and moderate tides only) and B (large, rough boulders and platforms: the beach area above high tide).

Behavioral observations: We implemented complete record sampling (event sampling) techniques to record all occurrences of 3 target behaviors (Hutt and Hutt 1974, Altmann 1974). Between May 19 and June 28, small groups of walrus were observed for 10 minute intervals (sample). Following the end of each sample the observer selected another group from the herd, or walked to another beach to resume observations. Each 10 minute sample was treated independently in subsequent analyses.

On June 29 we reduced 10 minute complete record sampling periods to 2 minute samples. Each 2 minute observation was conducted on a different focal group within a herd. Sample collection was separated by periods of at least 1 minute. Each sample was treated as an independent point in subsequent analyses.

Following convention set by Salter (1979) we used 3 easily recognizable behaviors as indices of walrus' arousal levels during the behavioral watches:

1. Head Raise (HR)- animal raises its head and neck to the extent that its shoulders flex (shoulder shifting was our primary cue for this behavior).
2. Orientation (OR)- animal shifts the axis of its body (at least 45°).
3. Displacement (DS- revised from Salter's "dispersal")- animal moves its tusks beyond the established perimeter of the focal group (Taggart 1987).

After each 10 or 2 minute sampling period, we summed occurrences of these 3 behaviors. Total occurrences of target behaviors and the number of animals remaining in the focal group were recorded at the end of each period and used to calculate the number of behaviors performed per animal per minute of observation.

Focal group selection: Small, easily discernable focal groups (mean= 10, range = 2-52 individuals) were selected within larger aggregations to ensure that all occurrences of the target behaviors could be recorded (Altmann 1974, Lehner 1979). We determined a focal group's physical perimeter by using distinctive beach features as landmarks. A walrus was considered part of the focal group if its tusks fell within the group's perimeter (Taggart 1987).

Sampling scheme: Between May 19 and June 28 behavioral observations were made during 10 minute sampling periods which were collected opportunistically. On June 29 we began using 2 minute sampling periods and attempted to use an observation schedule. The sample duration was changed to 2 minutes because the 10 minute samples were too long for observers to reliably record all occurrences of target behaviors during event sampling sessions. Additionally, we subjectively felt that the 2 minute samples ensured that stimuli and subsequent behavioral changes were linked closely over time, and found that changes in behavioral rates were more clearly observed. The shorter sampling periods made it easier for observers to focus on target behaviors and ensured that all behaviors were recorded, especially during times of high walrus activity.

We attempted to randomize the times and locations of behavioral observations by drawing locations and times (with replacement) from cards placed in a hat. However, we were unable to follow a randomized observation schedule because the presence of animals on particular beaches was not random. Some beaches were reliably used while others were infrequently occupied. Subsequently, we resorted to an opportunistic schedule and tried to equalize effort to time of day. Observation sessions ranged from 10 to 180 minutes, depending on availability of animals, weather conditions, and availability of dedicated observer time.

We began behavioral observations by recording:

1. Beach and focal group location.
2. Estimated closest distance from the focal group perimeter to the waterline.
3. Number of animals hauled out on the entire beach.
4. Number of animals in the focal group.
5. A classification of focal group density:
   1 =low- the majority of animals in the group are > 1 body length apart
   2 =moderate- the majority are separated by < 1 body length
   3 =high- the majority are in physical contact
6. The begin and end times of the watch.
7. Wind speed (estimated km/hr).
8. Wind direction (estimated).
9. Tide stage (rising, high, falling, low).
10. Beaufort sea state (outside the influence of land, at least 300 m offshore).
11. Beach condition:
    0 =calm- shoreline is calm, no wave splash
    1 =moderate- wavelets to 0.3 m breaking onshore
    2 =rough- breaking waves from 0.3 - 0.9 m
    3 =very rough- surf > 0.9 m
12. Percent overcast.
13. Precipitation
    0 = none
    1 = fog or rain

Stimulus observations: All disturbance events were opportunistic; no experimental disturbances were made. We defined test stimuli as any anthropogenic sound or sight perceived by the observers during behavioral observations. Because this study was intended to identify walrus' reactions to human activities, we did not consider effects of intraspecific or other natural disturbances. Although we did not identify the sensory modality by which an animal perceived a particular stimulus, we assumed that if an observer could sense a particular stimulus, the walrus probably could as well (Loughrey 1959, Salter 1979, Kastelein *et al.* 1993a).

Although olfactory cues have been linked to disturbances of walrus (Loughrey 1959, Fay *et al.* 1986, Fay and Kelly 1982), we did not attempt to assess the significance of these cues. Wind patterns are extremely complex around the steep cliffs and small embayments of Round Island and it was not possible to assess the effects of scents.

We recorded 4 types of stimuli during this study:

1. Terrestrial (TER) - a human walking, standing, or sitting near the haulout and within view of the observer (and presumably, the walrus).
2. Aerial (AER) - any type of aircraft seen or heard during behavioral observations.
3. Large Boat (LGB) - any craft with a hull at least 11 m (36 ft) long seen or heard during sampling periods. Length categorization was based on the hull length limitation of Bristol Bay gillnet fishing vessels, the typical vessel visiting the island. Usually, LGB's were powered by large, inboard engines (presumably diesel).
4. Small Boat (SMB) - any vessel less than 11 m long seen or heard during sampling periods. SMB's typically were limited to fishing vessels' skiffs, our 5 m inflatable, and a 10 m aluminum passenger skiff which made weekly trips between the mainland and the island. These vessels invariably were powered by outboards of various sizes.

Stimuli identified during behavioral observations were recorded at the time they were first noticed by the observer. Additionally, observers collected information on stimulus type, estimated closest approach, and the stimulus duration. We classified samples as test if an anthropogenic stimulus was recorded at any time during a 2 or 10 minute behavioral sample, and control if no stimuli were recorded.

Data Analyses

After creating 2 data sets (one each for 2 and 10 minute samples), we used PCSAS software to calculate descriptive statistics and conduct preliminary analyses. Rates of the 3 focal behaviors (# of behaviors/walrus/minute) were calculated.

A Kruskal-Wallis test was used to test if rates of target behaviors varied in response to anthropogenic stimuli (Sokal and Rohlf 1981). Tests were run using an alpha of 0.05. We analyzed the 10 and 2 minute data sets separately. Because the 2 minute set was much larger, we concentrated subsequent analytical efforts on it. Test data were categorized by stimulus type. Although we did not reorder non-vessel stimuli by ancillary factors collected, boat stimuli were broken down by hull size (greater or less than 11 m long) and estimated closest approach (greater or less than 400 m away). We visually estimated vessel sizes and distances. On several occasions our estimates were calibrated by vessels equipped with GPS or RADAR navigation systems.

Anecdotal observations

We recorded anecdotal observations of walrus' responses to anthropogenic stimuli in our daily log. Visitors also were encouraged to report disturbances to the island staff.

RESULTS

Effort

Between May 19 and August 7, we conducted 79 hours of behavioral observations. Ten minute samples collected between May 19 and June 28 comprised 33 hours of the total effort. Two minute samples collected between June 29 and August 8 comprised 46 hours of the total effort. For both sampling periods, oservations were nearly equally distributed between morning and afternoon hours (44 and 56% respectively).

Behavior-complete record sampling

The 2 minute samples were reduced to 830 control (no human activities present) and 540 test (human activites recorded during observation period) observations (Figure 3). When comparing all control and test observations, we detected significant changes in head raise (HR), ($\chi^2 = 55.8$, $p < 0.0001$) and orientation (OR), ($\chi^2 = 27.8$, $p < 0.001$), but not displacement (DS) rates, ($\chi^2 = 4.1$, $p < 0.392$).

While the intensity of their responses was quite variable, walrus displayed a stereotypic graded series of behaviors in response to all disturbance types, similar to those previously reported elsewhere (Fay et al. 1986, Salter 1979, Brueggeman 1993). An increase in HR rate was categorically the most common response to anthropogenic stimuli. As the intensity of the walrus responses increased, OR rates increased. Displacement from the focal group was the most severe, and least common, response to all forms of stimuli. Walrus behavior was highly synchronous and reactions to various situations appeared to be contagious through focal groups. In some cases, it appeared that the intensity of a group's response to a stimulus was affected more by activities within the herd than the intensity of the anthropogenic stimulus.

Qualitatively, walrus on Round Island appeared to respond more dramatically to human activities after they had been repeatedly exposed to particular stimuli over short periods of time (less than several hours). Reactions to individual disturbance events appeared to be graded: repeated or synergistic (more than 1 stimulus present at the same time) stimuli tended to elicit more drastic responses than a single stimulus event. For example, although walrus appeared to tolerate a prolonged period of human activity during a visitor transfer in Boat Cove, the animals finally deserted their haulout together after displaying a gradual increase in vigilance after enduring the constant human presence for a period of 115 minutes.

After identifying detectable changes in rates of target behaviors, we categorized the data by stimulus type and tested for significant factors affecting walrus disturbance responses (Figure 4, Table 1).

Aerial vs. Control: We logged only 5 samples in which aerial stimuli were present. Because of the small and unequal sample (5 test and 819 control samples) we did not examine this category statistically. However, several severe responses to aircraft overflights were observed opportunistically (Appendix 1). The most striking occurred on July 30 when a Cessna 185 cleared a beach of about 450 animals after making 4-5 low passes (altitude < 300 m) over a densely packed haulout. The first and second passes elicited a wave of head raises followed by an increase in orientation behaviors. The third pass caused the majority of animals to orient towards the water. This general movement was enough to cause approximately 450 walrus to rush into the water as the plane circled again. Once in the water, animals gathered into small, closely packed subgroups of 6-12 animals which moved eastward along shore towards other haulout areas. Intraspecific disturbances at other haulouts increased when these displaced animals attempted to gain access to already crowded beaches.

Terrestrial vs. Control: Although we found no distinguishable changes in the rates of target behaviors as a result of TER events (287 test and 819 control watch periods; Table 1), extreme reactions to people were reported on 6 occasions (Appendix 1). There were no obvious clues to what might elicit a response to TER stimuli. However, responses seemed to occur after people made overt visual displays of their presence (moving after having stood quietly for protracted periods along a cliff edge near the haulout and/or making abrupt movements within sight of the animals).

Vessels vs. Control: In order to test if response levels were related to the distance between walrus and vessels, we pooled vessel type data and categorized by estimated closest approach. Brueggeman (1993) reported the highest proportion of walrus reacted to icebreaker activities when they were within 0.46 km of the stimulus. In addition, Brooks (1954) claimed that walrus hauled out on ice did not react to the sounds of outboard engines on small boats at distances of 400 m. In light of these observations, we selected 400 m as our cut-off criterion for a close vessel approach.

All boats > 400 m away vs. Control: We compared test data where vessels were observed, but had kept at least 400 m from focal groups with control data. We did not detect significant changes in any walrus activity between control and test conditions (n = 67 samples, Table 1).

All boats < 400 m vs. Control: We logged 181 behavioral samples during which vessels approached within 400 m of groups. All 3 behavior categories reflected significant changes in response to close vessel approach when compared to control rates (Table 1).

In order to determine if walrus responded differently to close approaches by large or small boats, we reordered samples by hull size.

Large Boats < 400 m away vs. Control: We collected 53 samples during which large boats approached within 400 m of walrus. Significant results were obtained for head raise and orientation rates, but not displacements (Table 1).

Small Boats < 400 m away vs. Control: We collected 128 samples during which small boats approached within 400 m of resting walrus. Significant changes were detected for rates of all 3 target behaviors (Table 1).

All walrus in the subject focal group abandoned the haulout on 6 occasions (1.1% of test observations, Table 2). Two abandonments occurred in the presence of large boats; 4 abandonments coincided with the presence of small boats. All occurred in light wind conditions (< 18 km/hr). Wind directions were variable. Flight distance, the estimated distance between a stimulus and walrus at the moment of site departure (Fay *et al.* 1986), ranged from 30 to 400 m (mean = 118 m, sd = 141 m). The tolerance period, or the continuous time between the onset of the stimulus and the dispersal of walrus (Fay *et al.* 1986), ranged from 16 to 115 minutes (mean = 47 minutes, sd = 38 minutes).

Flight distances were greater and tolerance periods shorter for large boats approaching walrus with the wind (100 and 400 m, 28 and 43 minutes, respectively) than for small boats in similar wind conditions (60 and 30 m, 115 and 65 minutes) (Table 2). On 2 occasions, small boats approached in a cross wind (traveling on a course in line with the walrus haulout and perpendicular to the wind direction). While flight distances were comparable to those observed for small boats approaching with the wind (40 and 75 m), the tolerance periods were markedly shorter (16 minutes in both cases).

Anecdotal observations

Twenty-eight anecdotal accounts of walrus responses to disturbing stimuli were logged: 15 involved aircraft, 6 involved humans, 5 involved unknown stimuli, and 2 involved vessels (Appendix 1).

DISCUSSION

Study design and sampling protocols

Smaller haulouts on the northeastern side of the island were selected for this study because they were more readily accessible by observers and animals could be approached more closely than those hauled out on Main Beach or the Spit. During the 1993 season, Flat Rock and First Beach were the most reliable sites for finding walrus. At any one time, a maximum of 25 individuals hauled out on Flat Rock. As many as 300 individuals hauled out on First Beach. Although effects of factors such as group size were not analysed, we caution that animals in varied group sizes may react differently to anthropogenic stimuli (Terhune 1985).

The complete record sampling technique used in this study was an adequate approach for quantifying changes in rates of 3 specific walrus behaviors in response to human activities. We found that the 2 minute samples were preferable over the 10 minute samples because the observers could more reliably count all of the target behaviors occurring during the shorter period and stimulus-response events were tied closely temporally. However, in order to eliminate potential complications of covariance in behaviors within focal groups, subsequent studies should use focal animal observations.

The target behaviors, HR, OR, and DS appeared to be good indicators of walrus' arousal levels. These behaviors were easily distinguishable in the field and permitted both observers to consistently categorize behaviors throughout the study. While HR rate could be affected by social interactions between animals and was not always specifically linked to human activities, it reflected an overall level of walrus arousal. OR and DS behaviors were nearly always characterized by extreme reactions to anthropogenic stimuli and were infrequent during social interactions between animals.

The field protocols we established on Round Island may be applicable to subsequent studies at other terrestrial walrus haulouts. However, minor modifications in the field methodology may be required to accommodate differences in walrus haulout patterns and beach topography at each location.

Walrus' responses to human activities

Published reports of walrus response to human disturbances are anecdotal and few quantifiable assessments of the nature or level of behavioral responses are available (see Johnson *et al.* 1989 and Richardson *et al.* 1989 for reviews). It is difficult to compare the significance of the Round Island data to other observations or put them into a meaningful biological perspective.

Walrus reacted to aircraft by becoming alert, and in some cases by rushing into the water. Anecdotal observations indicated that aircraft occasionally caused extreme reactions. However, the variability of walrus responses was large and unpredictable; such responses occurred infrequently in 1993. Other investigators have implicated factors including aircraft type, altitude, flight pattern and range, the age and sex classes of animals involved, and group size in contributing to the variability of walrus responses to aerial disturbances (Banfield *et al.* 1955, Salter 1979, Fay 1981). Additionally, correlations have been drawn between temperature, wind conditions, cloud cover and walrus sensitivity to aircraft disturbances (Burns and Harbo 1977, Fay *et al.* 1986).

On Round Island, walrus reactions to aircraft were variable and largely unpredictable. Occasionally, intense reactions (displacements) were caused by commercial jets flying well above 4000 m. Single engine planes making repeated low passes over resting walrus caused large reactions on several occasions. However, at other times, low altitude (< 300 m) overflights which were disruptive to nesting seabirds did not elicit notable responses from walrus hauled out nearby. To generalize, we found that walrus reacted to aircraft in a manner consistent with that reported by Davis *et al.* (1991). Walrus tended to be more sensitive to low-flying than high-flying aircraft, to aircraft that were overhead as opposed to those closer to the horizon, and to abruptly changing sounds than to steady sounds.

Although people occasionally approached to within 10 m of resting walrus, these encounters were not observed to have a significant effect on walrus behaviors at Round Island. However, we speculate that visitors may have altered their activities around haulout areas when we were making observations; thus minimizing disturbance to walrus. We logged 6 anecdotal accounts when terrestrial activities caused noticeable disturbances on haulouts. Each of these was characterized by the dispersal of at least some of the walrus from the beach. The most significant response was the total abandonment of a haulout (300+ animals) caused when 2 hunters closely approached a resting group and shot at several individuals (L. Van Daele, pers. comm., 1993). Van Daele observed that the animals appeared to watch and slowly move towards the water as the hunters approached to within 20 m. A panic response and subsequent desertion of the beach occurred only after shots were fired.

Frost *et al.* (1983) stated that walrus commonly fled into the water when approached by humans, but did not provide details of distance or activities. Unlike mainland haulout sites, the limited access to beaches and observation areas on Round Island restricts close contact between humans and walrus. Beach access at Round Island is limited by extreme terrain; planes cannot land on the island, and the use of all-terrain vehicles or other motorized vehicles is not permitted. Island staff encourages the limited numbers of permitted visitors to minimize their impacts on animals by being quiet and unobtrusive while using the trails and overlooks around haulout areas; visitor access to beaches is forbidden. In 1993, fishermen and hunters generally cooperated with the legislated 5 km access prohibition around the island. The combination of the ban on motorized vehicle use, limited island access, and public awareness of disturbance issues may minimize the number of terrestrial human-related disturbances experienced by walrus relative to levels at other locations. Comparative quantitative data from such sites would be useful in identifying changes in levels of human activities and subsequent changes in walrus behavior patterns throughout Bristol Bay.

This study focused on human activities occurring within 1 km of walrus haulouts. For these activities, walrus displayed the most severe behavioral reactions to the close approach (< 400 m) of small boats (< 11 m long). In particular, rates of all behaviors increased significantly when boats approached animals to within 400 m. Fay *et al.* (1986) reported that in the winter, male walrus reacted to an icebreaker when the vessel was within 100-300 m. Vessel speed affected walrus sensitivity to vessel approach, and slow moving ships (traveling less than 7.4 km/hr) could approach animals within 200 m while faster ships (11-22 km/hr) caused reactions at distances of 500-600 m (Fay *et al.* 1986). Although our analyses did not distinguish disturbances by speed of approach or other qualitative categories, our subjective impression was that repeated passes, high levels of activity on the boats (e.g. loud crew and vessel noises), and erratic changes in engine speed seemed to increase the reactions of walrus to these types of vessels. Similar relationships between response levels and vessel activities were observed by Salter (1979) and Brueggeman (1993).

Close approach by small boats appeared to have a more marked effect than large boats. These results may be biased by small sample size and because small boats frequently approached walrus more closely (occasionally within 30 m of focal groups) than large ones. However, similar responses to small vessels have been reported elsewhere (Fay *et al.*1986, Richardson *et al.* 1989). In-air sounds of boats may be a factor in the behavioral response of walrus hauled out on the beach. During this study, low frequency diesel engines (characteristic of vessels in the large category) appeared to elicit milder reactions than high frequency outboard engines (Fay *et al.* 1986). Previous experience also may affect walrus responses: changes in approachability were noticed when walrus had been hunted and corresponded with the types of engines used in the pursuit of the animals (Richardson *et al.* 1989).

Flight distances in response to boats were observed on 6 occasions. Comparisons between approaches by small and large boats indicated that flight distances of walrus were greater and tolerance periods were shorter when large boats approached with the wind than when small boats approached in similar wind conditions. Fay *et al.* (1986) reported a 10-fold increase in flight distances when boats approached walrus with the wind, and attributed the increase to the animals' sense of smell, which was considered keenest when compared to hearing and sight. Our small sample does not indicate a clear trend with regard to wind direction and we did not attempt to address the issue of walrus sensitivity to odors over other stimuli. However, the shortest tolerance periods (a possible indicator of disturbance intensity) were recorded when small boats approached in a cross wind, and presumably were not detected by smell. We speculate that the animals were especially sensitive to approach because they were hauled out in the end of a shallow, narrow bay with severely restricted access to open water.

Although our data clearly indicate changes in walrus behavior in response to close approaches by small boats, we caution against a simplistic interpretation of walrus responses to all vessel categories. The apparent disparity between observations of flight distances associated with the approach of large boats (indicating a high level of disturbance) and significant increases in walrus activity associated with the close approach of small boats (another sign of disturbance) exemplify the complicated nature of walrus disturbance responses. More data are needed to clarify significant attributes of disturbing stimuli. During this short study, we were unable to assess the entire spectrum of vessel effects on walrus behavior. For instance, we did not have the opportunity to observe reactions of walrus to very large boats (>20 m) or to seasonal increases in vessel traffic more than 1 km offshore. All observations were made of walrus on terrestrial haulouts where vessel engine noises were probably obscured by the dampening characteristics of the air-water interface and environmental masking (Kastelein *et al.* 1993b). The underwater sound environment was not assessed in any way and the potential effects of human activities on free-swimming walrus were not studied.

Habituation, or the decrease in response over prolonged exposure to disturbance, may be responsible for variability in walrus' responses to similar or repeated exposures to stimuli (Richardson *et al.* 1989). Habituation of walrus to anthropogenic stimuli over the course of this study was not addressed quantitatively. However, anecdotal observations of extreme disturbance responses throughout the summer may indicate that animals did not habituate to sporadic airborne, terrestrial, or seagoing human disturbances.

Continued sensitivity to human disturbance has been linked to both short and long-term haulout abandonments and shifts in walrus use of particular areas (Frost *et al.* 1983, Irons 1983, Fay *et al.* 1986, Johnson *et al.* 1989, Jemison 1992). Walrus frightened from haulout beaches at Cape Seniavin, Bristol Bay, returned to this same location but were more likely to temporarily leave beaches in response to subsequent human disturbances (Fay *et al.* 1986). Repeated vessel, aircraft, and terrestrial disturbances were linked to permanent abandonment of several former haulouts in Chukotka, Russia (Fay *et al.* 1986) and shifts in haulout use at Cape Seniavin (Richardson *et al.* 1989). Frost *et al.* (1986) citing Fay (ADFG, unpub. data), claimed that regular vessel and aircraft disturbances prevented long-term use of haulouts at Cape Newenham, Sledge Island, and King Island. Shootings and other anthropogenic disturbances affected reoccupancy of Cape Peirce in the early 1980's (Richardson *et al.* 1989, citing Brueggeman, pers. comm). Airborne and underwater noise and vessel activities near haulout areas associated with the yellowfin sole fishery presumably resulted in large declines in peak numbers of walrus at Round Island in 1987 and 1991, and led to a permanent seasonal closure within 22.2 km (12 nautical miles) of the island and Cape Peirce (Jemison 1992, 59 Federal Register 10432, March 26, 1992). The link between human disturbance and changes in walrus behavior and haulout patterns has been clearly established at some terrestrial haulout areas. However, the biological significance of these affects has not been adequately addressed.

On Round Island, walrus' reactions to human activities ranged from no observable effect to temporary haulout abandonment. At this time we do not have adequate information to identify or assess either large-scale or long-term effects of human activities on walrus hauling out on Round Island.

CONCLUSIONS

In summary, we established and tested a study protocol using complete record sampling techniques that was useful in assessing changes in walrus behavior due to human activities. We preferred 2 minute samples over 10 minute samples because observers could more easily record all occurrences of the target behaviors during the shorter observation periods and stimulus-response events were tied closely temporally.

Although the intensity of their responses was variable, walrus displayed a stereotypic series of behaviors in response to all of the disturbance categories. In general, walrus responded to specific human activities by increasing rates of head raises and orientation behaviors. Displacement from the focal group was the most extreme and least common behavioral response. Reactions were most pronounced when small boats approached within at least 400 m. Terrestrial human activities were not observed to have an appreciable effect on the rates of target behaviors. However, observations of human activities on the island trails may have been biased by visitors' awareness of our study. The few observations of aerial disturbances precluded statistical analysis.

We observed several instances where walrus abandoned the haulout in response to approaches by boats and determined that flight distances were greater and tolerance periods shorter for large boats approaching with the wind than for small boats in similar environmental conditions.

Although the data clearly showed instances when walrus behavior changed in response to near shore human activities, additional observations are needed to more clearly describe walrus responses to varied levels and types of human activities. We were able to observe only a small portion of possible disturbance events. For instance, we did not have the opportunity to assess the effects of very large boats (>20 m long), boats operating more than 1 km offshore, or other relevant situations.

Monitoring changes in the level and focus of human activities and their potential for disturbing walrus are important components of a comprehensive walrus management program. Increased sample sizes and a closer examination of environmental factors which might increase animals' susceptibility to human disturbance would improve our ability to evaluate effects of human activities. A carefully designed monitoring program including concurrent, comparative studies at other haulout locations would facilitate assessment of immediate and long-term effects of human activities on walrus in Bristol Bay.

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Table 1. Summary of Wilcoxon tests on 2 minute behavioral samples from walrus at Round Island, Bristol Bay, Alaska, summer 1993. Test categories represent human activities observed during behavioral observations which were compared to control samples during which no human activities were observed (n = 830).

Test Categories	Sample Size	Behavior	Z	Probability
All Categories	540	HR	3.61486	0.0003**
		OR	2.88613	0.0039*
		DS	1.30342	0.1924
		HR	-0.850166	0.3952
Terrestrial	287	OR	0.065689	0.9476
		DS	O.328021	0.7429
		HR	-0.798542	0.4246
All boats > 400m	67	OR	0.357169	0.7210
		DS	0.531041	0.5954
		HR	8.66104	0.0001**
All boats < 400 m	181	OR	5.48689	0.0001**
		DS	1.98843	0.0468*
		HR	5.26577	0.0001**
Large boats < 400 m	53	OR	2.56597	0.0103*
		DS	0.513351	0.6077
		HR	7.33604	0.0001**
Small boats < 400 m	128	OR	5.35173	0.0001**
		DS	2.13618	0.0327*

Large boats > 11 meters long
Small boats < 11 m long
HR = Head raise
OR = Orientation
DS = Displacement
* Denotes significance at 0.05 level
** Denotes significance at 0.001 level

Table 2. Summary of conditions leading to haulout abandonment by groups of walrus observed on Round Island, Bristol Bay, Alaska, summer 1993.

Stimulus Type	Duration of disturbance before abandonment (minutes)	Closest approach (meters)	Wind direction relative to haulout	Estimated Wind speed (knots)
Small boat	16	75	Crosswind	11
Small boat	16	40	Crosswind	11
Large boat	28	100	Upwind	13
Large boat	43	400	Upwind	19
Small boat	65	30	Upwind	9
Small boat	115	60	Upwind	15

Small boat < 11 m
Large boat > 11 m
Crosswind: prevailing wind blowing parallel to walrus and approaching boat
Upwind: prevailing wind blowing from the approaching boat towards the walrus

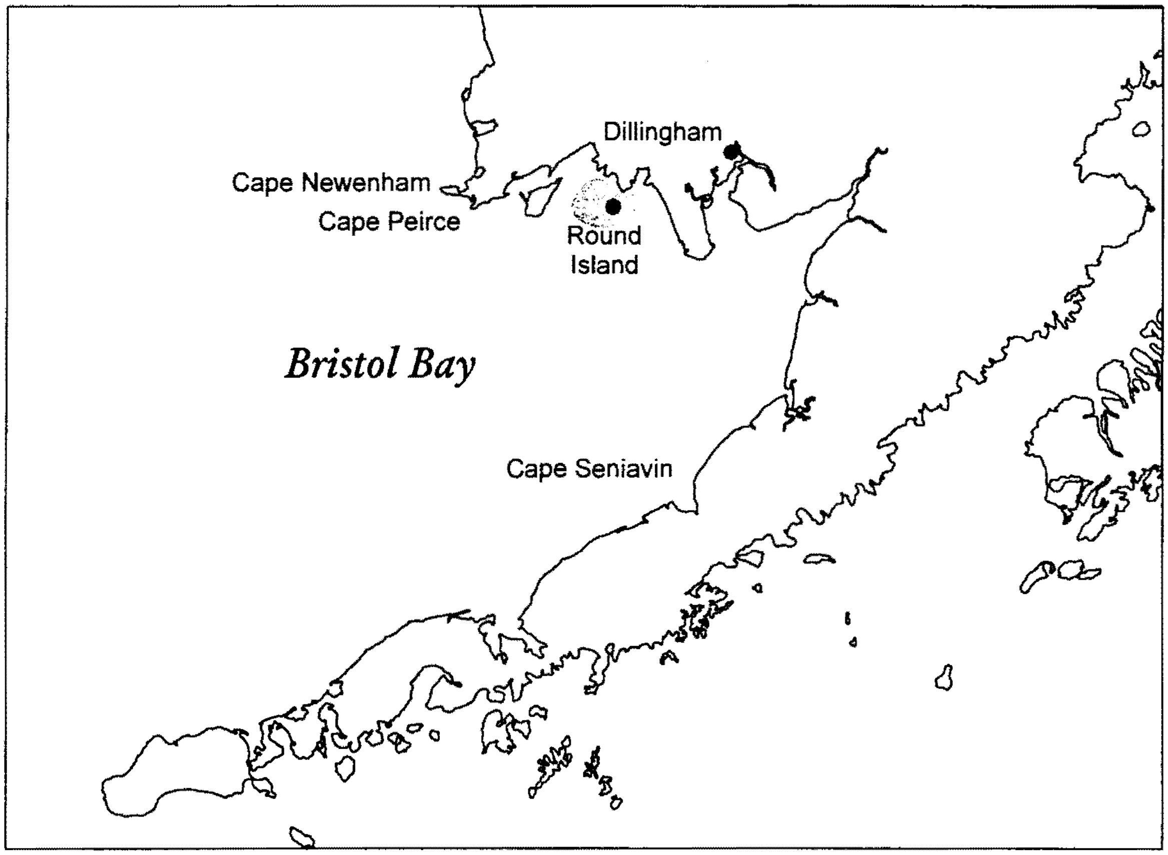

Figure 1. Locator map of Round Island and the Walrus Islands State Game Sanctuary (shaded area), Bristol Bay, Alaska.

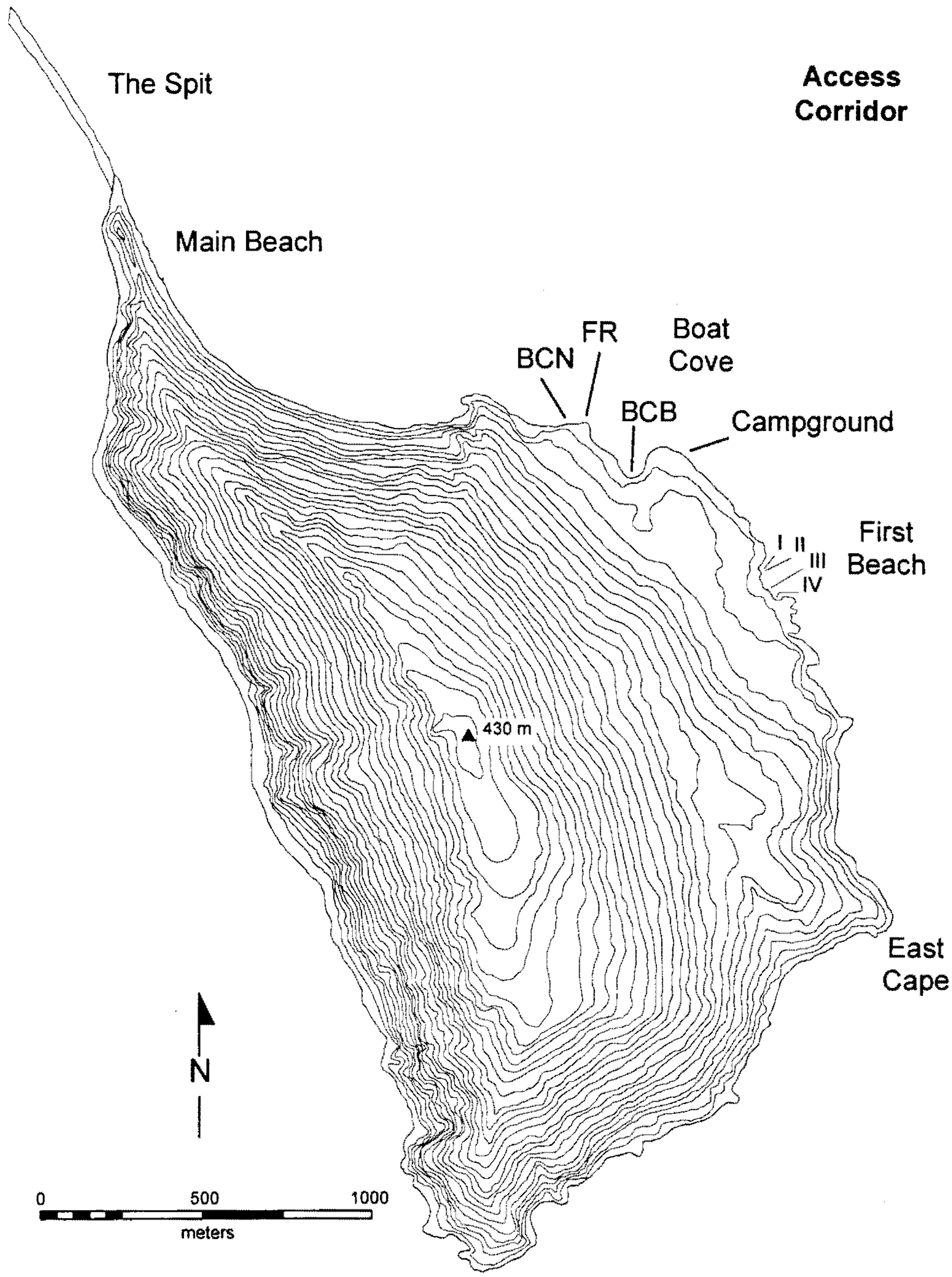

Figure 2. Area map of Round Island, including site locations of event sampling studies, summer 1993. Topographic contours = 15 meters (50 feet). BCN = Boat Cove North, FR = Flat Rock, BCB = Boat Cove Beach (visitor staging area). Roman numerals I - IV refer to observation areas identified on First Beach.

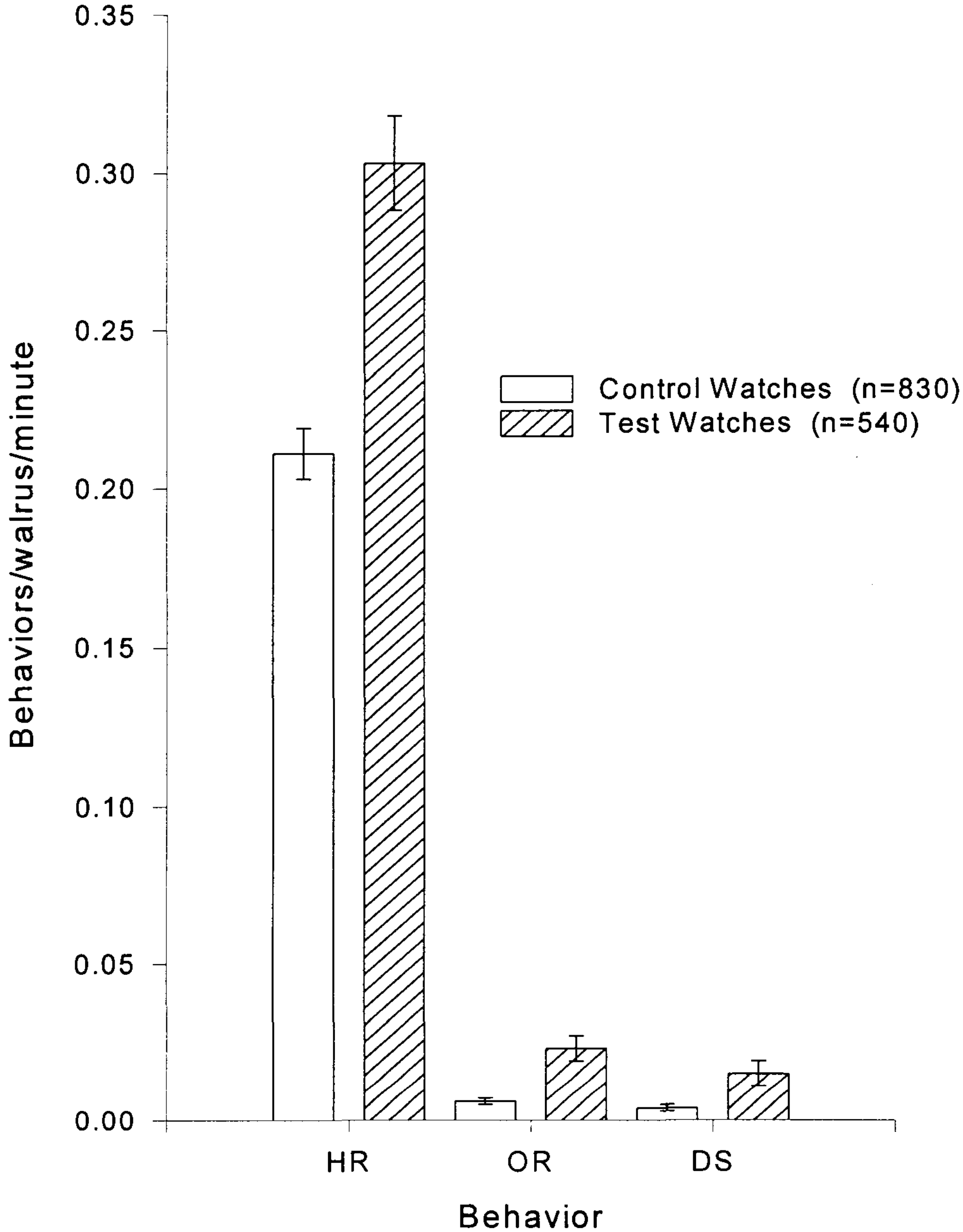

Figure 3. Rates of walrus behaviors observed at Round Island, May - August 1993. Test = anthropogenic stimulus detected during event sampling studies. Control = no anthropogenic stimuli detected during observations. HR = Head Raise, OR = Orientation, DS = Displacement.

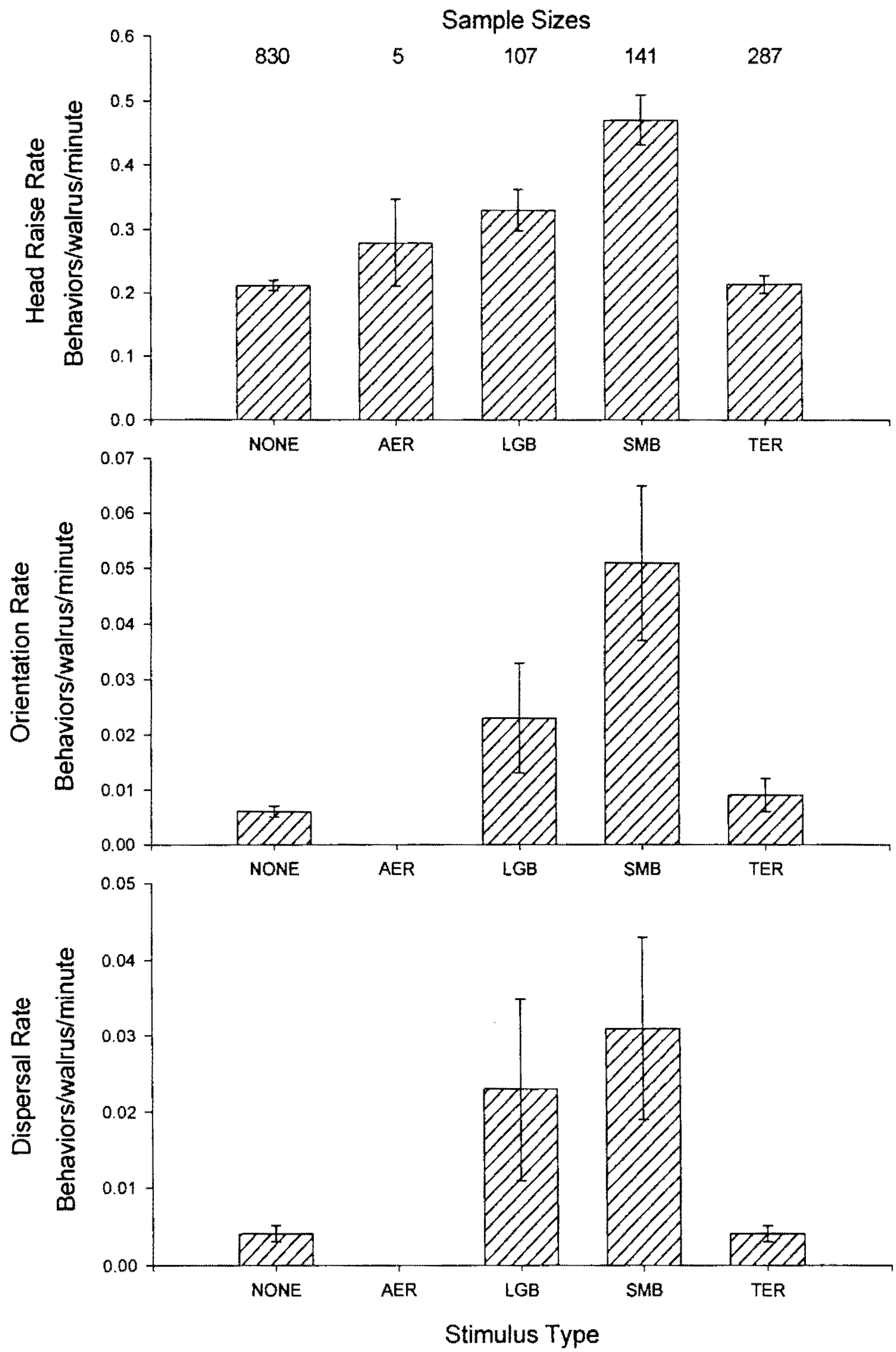

Figure 4. Rates of walrus behaviors relative to stimulus type observed at Round Island, May - August 1993. AER = Aerial, LGB = Large Boat (>11 meters long), SMB = Small Boat (<11 meters), TER = Terrestrial. Bars = 95% confidence interval.

APPENDIX 1. ANECDOTAL OBSERVATIONS OF WALRUS DISTURBANCES, ROUND ISLAND, 7 MAY-25 AUGUST, 1993.

Anecdotal reports resulted from off-effort observations by the authors and contributions of observations made by island visitors.

Codes: KK = Kiana Koenen, SK = Susan Kruse, FR = Flat Rock, BC = Boat Cove, FB = First Beach, CG = Campground, MB = Main Beach

May 7, 10:00, Boat Cove/Campground
Revenge, 1 of 2 fishing boats day visiting. Animals left haulout below campground as boat approached to within 60 m. Apparently, 3 of an undisclosed number of animals were disturbed.

May 15, 15:30, Main Beach.
Coast Guard C-130 passed east side of the island from NW to SE (altitude est. 250-300 m). P. Hessing reports seeing 80 of approximately 160 animals leave main beach as a result of the aircraft's passing.

May 18, 10:00, Flat Rock
D. Winkleman brought his boat into the cove. Seven walrus hauled out on FR displayed a graded increase in alertness. All 7 left when KK and SK launched the skiff (approximate time elapsed = 15 minutes).

May 30, 22:30 (est.), Flat Rock
Unidentified airplane passed high overhead. Campers reported that walrus hauled on flat rock looked up when plane was audible.

May 30, 22:30 (est.), Campground
An unidentified airplane passed at high altitude (est. >1500 m). Campers reported that an unspecified number of animals left the campground haulout during the overflight

June 16, 18:18, Second/Second Prime
SK was looking at 4 animals hauled out when an unidentified airplane passed high overhead. One animal repeatedly lifted its head (2-3 times). Eventually, the animals settled down. At 1818 she walked to 2nd Beach and observed that the 6-8 animals that had been hauled out prior to the overflight had entered the water.

June 16, 18:28, Main Beach
KK noted loud aircraft engine noise at 1812. She did not notice any obvious reactions by 2 animals on flat rock. She hiked to Main Beach lookout and at 1828 observed "a mass exodus" of an estimated 200 animals streaming off the spit area. Smaller groups of walrus along the cliffs to the east did not show any increase in activity.

June 18, First Beach
KK reported that during her daily counts, 10 animals were in nearshore water and 6 on the shoreline. As she began her counts from the path above FB, the 6 animals on the shoreline bolted for the water, joined the group of 10 and swam off. She felt that the animals oriented towards her prior to their departure from the beach.

June 19, 16:20, Main Beach
A high-wing, twin engine aircraft passed the west side of the island at roughly 760 m above the ground. SK immediately went to "garbage hill" and used 10X binoculars to observe walrus at Main Beach. She did not observe any noticeable reaction or atypical activities by the estimated 40 animals on the haulout.

June 20, 16:40, Flat Rock/ Main Beach
SK noted that a commercial jet passed at high altitude, making considerable noise and leaving a vivid contrail. She had been watching 3 animals hauled out on FR and did not not observe any change in their activities during the overflight. She turned to watch the est. 500 animals hauled out on the MB spit area and did not notice any obvious change in behaviors.

June 21, Main Beach
L. Van Daele witnessed 2 humans shooting at a group of walrus hauled out on MB. Animals remained on the beach until the hunters had approached within 20-30 m (on foot). After shots were fired, all of the animals fled into the water. Several hundreds were observed milling in nearshore waters of the spit or in small, cohesive groups of 8-15, swimming steadily towards the eastern beaches. Obs. made by KK and SK shortly after the shooting: groups of animals began to stream into nearshore waters of 1st and 2nd Beaches. This influx of animals caused a great deal of social disturbance as animals fought to reposition themselves or get onshore (about 100 animals joined the 1st beach haulout during the first 3 hours following the shooting incident).

July 3, 17:30, First Beach
Visitors reported all animals hauled out on first beach (no group size estimate) cleared the area, presumably as a result of a small rock fall. The animals left in an "orderly" manner and swam off in small, (<10 anim.) tightly cohesive groups.

July 4, 20:58, First Beach
SK was doing beach counts when 3 animals became agitated and increasingly vigilant in her direction. She froze, and 2 of the 3 settled down. The third remained vigilant, and as SK remained still, it began to leave, and caused the following cascade of events: The first animal's departure caused the dispersal of all of the walrus hauled out on the rocks along the cliff edge on the east end of the beach, a concommitant increase in vocalizations (especially bellows) resulted in a beach-

wide increase in vigilance, and all animals on the S end of the beach oriented to sea and began to leave the beach. At 2100, 8 animals left as a cohesive group. 2101: 15 more left. Animals on the north end of the beach calmed down. 2102: 2 more left from the south end of the beach. 2103: 8 animals remained in chest-deep water. 2105: 2 more animals left beach. 2106: 5 animals left beach. SK left to try to minimize further disturbance. She returned at 2128 to find that several animals had hauled out again, the whole group quiescent, and a group of 8 resting offshore in shallow water.

July 10, 09:00 (est.), Campground
Two visitors reported that they were standing above campground haulout watching animals for nearly 5 minutes when an animal appeared to look their way. This animal appeared to startle, which caused all 21 animals to leave the beach.

July 10, 14:58, Main Beach
KK was at Boat Cove when she heard a commercial jet pass high overhead (>1500 meters). At 1508 she noticed a large influx of animals (no counts available) in the water and at the shoreline of the MB spit.

July 10, 15:00, Second Prime
SK was observing a group of 20 animals on the flat rocks on the west end of 2nd Prime Beach. She noted a particularly loud jet flying high over the island. She did not see any change in the walrus' behavior during or immediately following the overflight.

July 11, 16:10-16:32, Main Beach
During this 18 minute period, 7 commercial jets passed high over Crooked Island. Their noise was obvious on Round Island. KK watched animals hauled at MB through a spotting scope located at "garbage hill." She noted that during a 5-minute period, numbers of animals on the beach dropped from an estimated 800 to about 500. She observed many heads-up and movement of animals on the beach and nearshore.

July 14, 15:30 (est.), First Beach
A camper reported causing a disturbance on FB by setting up a tripod to photograph himself with a walrus back drop. He noted that after "making a fast movement" 5 animals left the beach. Over the next half-hour, groups of 3-5 animals left every 5-8 minutes. He estimated that a total of 20-21 animals departed before the rest of the group settled back down.

July 16, 15:00 (est.), Main Beach
SK was near flat rock and heard a loud, unidentifiable roar (land slide?). She immediately went to obs. pt. and noted that many birds were flushed off nest sites near the spit. Nearly 90 walrus were in nearshore waters and an additional 15

animals bolted off of the beach (making splashes as they entered the water). The animals milled about in the shallow water and no additional dispersals were observed.

July 16, 20:10, Second Beach
KK had finished her counts (225 animals) and paused to take photos. As she fished her camera out of her pack, she was alerted by the sound of rocks sliding under moving animals. She looked down at the haulout and observed an unreported number of animals entering the water. A single walrus was looking up towards an empty cliff face, as if it had been alarmed by a rock falling from the cliff.

July 17, 20:08, First Beach
KK was doing behavioral observations and saw a single animal move towards the water. She did not notice any stimulus which may have alarmed the walrus. It left a bit faster than usual, and alerted or disturbed several animals lying at the water's edge. Ten animals originally at the water's edge made a "panic" dispersal into deeper water. Animals lying nearby did not respond to these activities.

July 24, 11:30 (est.), Flat Rock
Camper reported that he caused a disturbance by carelessly approaching FR obs pt. One animal reacted by rearing up, 8 animals immediately left the rock. A single animal remained on the rock for an additional 10 minutes before it finally went into the water and swam off.

July 24, 13:18, First Beach
SK was counting animals on quad IV of FB (est. 23 animals). One animal spied her and started for the water. It paused and another animal began to head for the water, bellowing as it went. At 1319, 4 animals were queued up to leave the beach. Shortly after that, another 11 lined up to go. Ten animals near the east wall of the beach remained quiescent. At 1321, 13 animals were leaving the area in a cohesive group; one following closely behind the next. This movement was accompanied by increased vocalizations, especially bellows. By 1322 the animals were quiet again; the disturbed animals were dispersing in groups of 2-3 to areas II and III of FB.

July 30, 18:41, Main Beach
Cessna 185 made repeated low (<300 meters) over-flights of west end. 350-450 walrus left the MB haulout.

July 31, 15:40, First Beach
SK noted that a commercial jet flew high over the island, causing loud engine noise. She watched 7 animals on quad IIB of FB and observed' 3 head raises, 2 orientations and 1 dispersal. At 1541 3 more animals left their quad for the water's edge. 1543: one animal left beach. 4 of 7 animals remained.

August 02, 15:55, Main Beach
Low flying, single prop plane made 1 pass over the west end. There was a massive bird disturbance- 100's were flushed from their nests, but there was no noticeable reaction by hauled out walrus.

August 08, 13:53, Main Beach
KK completed counts at MB (425 animals) when she heard aircraft flying at high altitude towards the southeast. At 1354 she watched approximately 150 animals on the beach below traverse trail stand up and orient towards the water. An estimated 30 animals left the beach and milled in shallow water directly offshore of the haulout. KK did not notice any change in animals hauled out on the spit.

August 09, 10: 34, Main Beach
E. Bowlby and KK heard aircraft flying at high altitude over the island to the northwest. The sound was audible until 1037. None of the estimated 150 walrus hauled out on MB made noticeable reactions to the noise.