Western Gray Whale Behavior and Movement Patterns: Shore-Based Observations off Sakhalin Island, July-September 2004

Photo taken from shore Station 07, G. Gailey

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INTRODUCTION, RATIONALE, AND BRIEF OVERVIEW OF RESULTS

The western population of gray whale (*Eschrichtius robustus*) is remnant and in danger of extinction (USFWS 1997, Red Book of the Russian Federation 2000, Hilton-Taylor 2000). Approximately 100 individuals habitually feed off the northeastern area of Sakhalin Island in summer-fall of every year; and considerable research on occurrence patterns, foraging and other behaviors, behavior relative to industrial activities, and genetics has taken place in the past seven years (summaries in Blokhin *et al.* 2003 a, b, LeDuc *et al.* 2002, Meier *et al.* 2002, Weller *et al.* 1999, 2002 a, b, Würsig *et al.* 1999, 2002, 2003, Yakovlev and Tyurneva 2003, Yazvenko *et al.* 2002, Gailey *et al.* 2004).

In 2004, we investigated spatial and temporal occurrence patterns and aspects of behavior of nearshore gray whales in proximity to potential oil/gas development by Exxon Neftegas Limited (ENL) and Sakhalin Energy Investment Company (SEIC). Similar to 2002 and 2003, the absence of industrial activity during most of the 2004 field season provided an opportunity to observe and quantify baseline information about the natural behavior, movement, and respirations of western gray whales in their feeding grounds. Only towards the end of the 2004 field season (after 15 September), a seismic survey was conducted (by DalMorNefteGas) nearshore (approximately 5-10 km) north of Station 07 (53° 07' N). Unfortunately the sample size was too small to evaluate potential disturbance of the animals to the seismic activity as was done in 2001 (Würsig *et al.* 2002). As had been the case for the effort in 2001-2003, it was decided to gauge whale behaviors to provide long-term observations of habitat use, distribution, and behavior of gray whales nearshore. This onshore platform had the advantage that it was some distance from the whales, thereby avoiding the possibility of the observing station(s) to be a source of disturbance. We chose three main observation techniques: 1) scan sampling to obtain relative abundance estimates, distribution, and group sizes of gray whales along shore; 2) theodolite tracking of focal groups to describe locations, orientations, speeds, and habitat use; and 3) focal group or focal animal observations to describe surfacing-respiration-dive parameters and other surface-visible behaviors. Data were analyzed by parametric and nonparametric statistical methods. Ultimately, it is our intent to describe the basic biology, behavior, and habitat utilization of western gray whales in the Piltun area, and the amount of variability that can exist annually, seasonally, and geographically. We understand that such baseline information will be used during project design and implementation to help realize effective management strategies to protect the whales and their habitat.

The 2004 field season was successful by providing information about movement patterns, behavioral observations, and relative numbers of whales at six geographic locations along the northeastern coast of Sakhalin Island. The field season commenced on 28 July 2004 and ended on 22 September 2004. The season had 24 days of effort (384 hrs), 196 scan samples with 1,101 sightings, 162 theodolite tracklines, and 71 focal behavior follows of individual gray whales.

METHODS

Methods used in 2004 were consistent with those implemented in 2001-2003, and much of this section is repeated from Würsig *et al.* (2002, 2003) and Gailey *et al.* (2004), with the addition of two observation stations and some analyses, as detailed below. Due to the activity of a seismic survey late in the field season and the potential for inclusion of a variable amount of disturbance data in the results, all data were removed from the analyses that were collected after 15 September 2004. Information gathered during the seismic survey was limited to only three days and lacked sample size for evaluating potential disturbance of the animals to the activity.

Study Area

Shore-based observations were conducted along 66 km of coastal region in the northeastern portion of Sakhalin Island, Russia (Figure 1). The study area encompasses a nearshore part of the Piltun feeding area, one of the two currently known feeding grounds off northeastern Sakhalin Island utilized by the western (or Korean-Okhotsk) stock of gray whales, with an apparent nutrient-rich habitat that may be influenced by a local lagoon ecosystem, known as Piltun lagoon (see also Johnson 2002). The nearshore waters of the Sea of Okhotsk are characterized by sand substrate with a gradually sloping continental shelf.

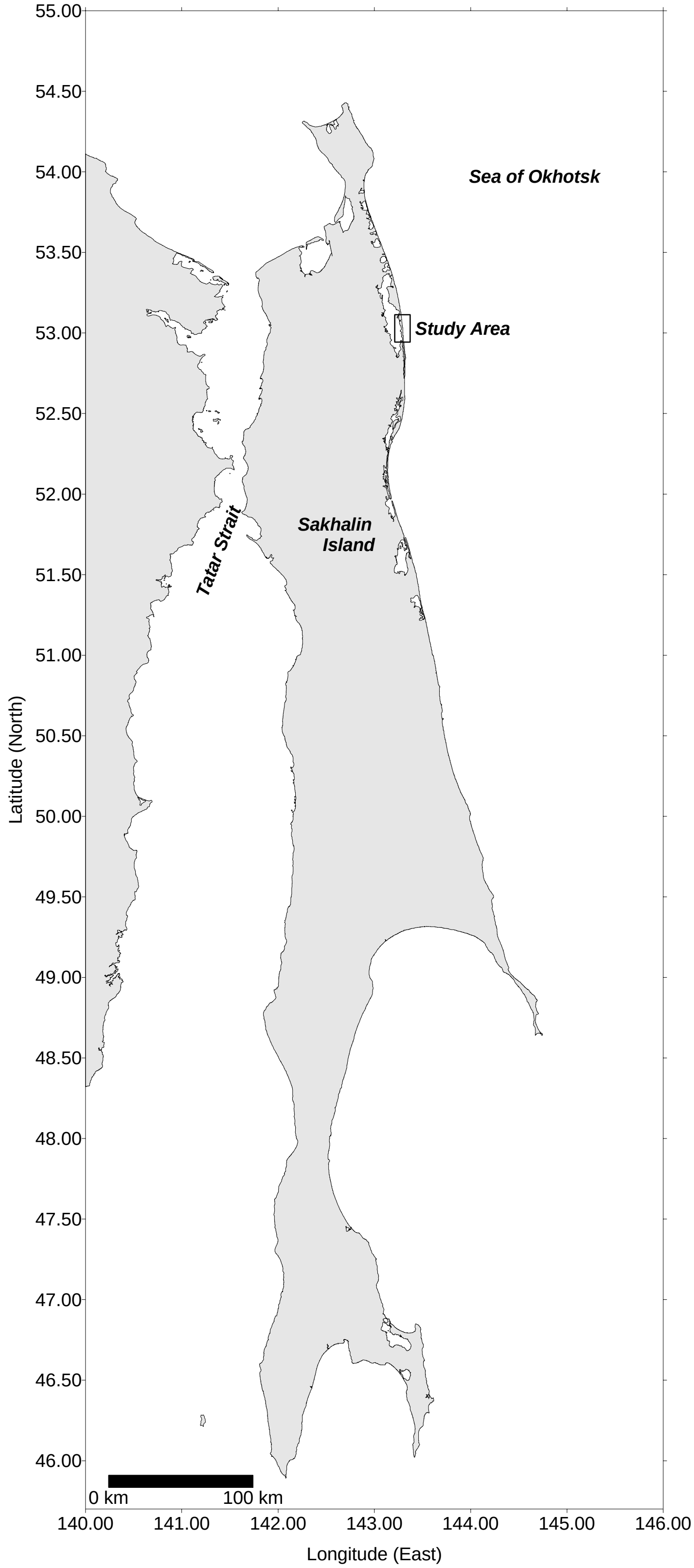


Figure 1. Study area in the northeastern portion of Sakhalin Island in Far East Russia. Figure 2 shows details of the study area.

Shore-Based Observations

Six geographic locations were chosen to conduct behavioral observations on western gray whales during the summer of 2004 (Table 1). Each station was selected based on its height above sea level relative to the generally low dunes of the area (Table 1), and adjacent overlapping area to the next shore-based stations (approx. 5 km along the shoreline, Figure 2). The position of each station allowed the shore-based team to monitor gray whale behaviors along approximately 66 km of coastal region. Two separate observation teams conducted research at two adjacent stations on each day of effort. Due to the logistic difficulty of moving between stations, one day of effort was usually dedicated to one pair of shore-based stations. Station selection proceeded systematically from south to north. Once the northern-most station was reached (North Station & Odoptu Station), then the next day of effort would continue at the most southern stations (South Station & 1st Station). Therefore, the observation teams conducted research at each of the six stations after three favorable weather days. Two stations (2nd Station and Station 07) had also been used since the 2001 seismic study; 1st Station and Odoptu Station were incorporated in 2002, and North Station and South Station were added in 2004.

Table 1. Six shore-based vantage points along the northeastern coast of Sakhalin Island, Russia. Station height is at mean low water.

Station	Latitude	Longitude	Height (m)
North Station	53° 18' 02.9"	143° 12' 42.6"	19.6
Odoptu Station	53° 12' 33.0"	143° 14' 51.2"	17.5
Station 07	53° 07' 29.8"	143° 16' 12.5"	9.0
2nd Station	53° 03' 08.9"	143° 17' 04.4"	8.0
1st Station	52° 58' 27.6"	143° 18' 07.6"	9.9
South Station	52° 53' 23.8"	143° 19' 06.3"	7.7

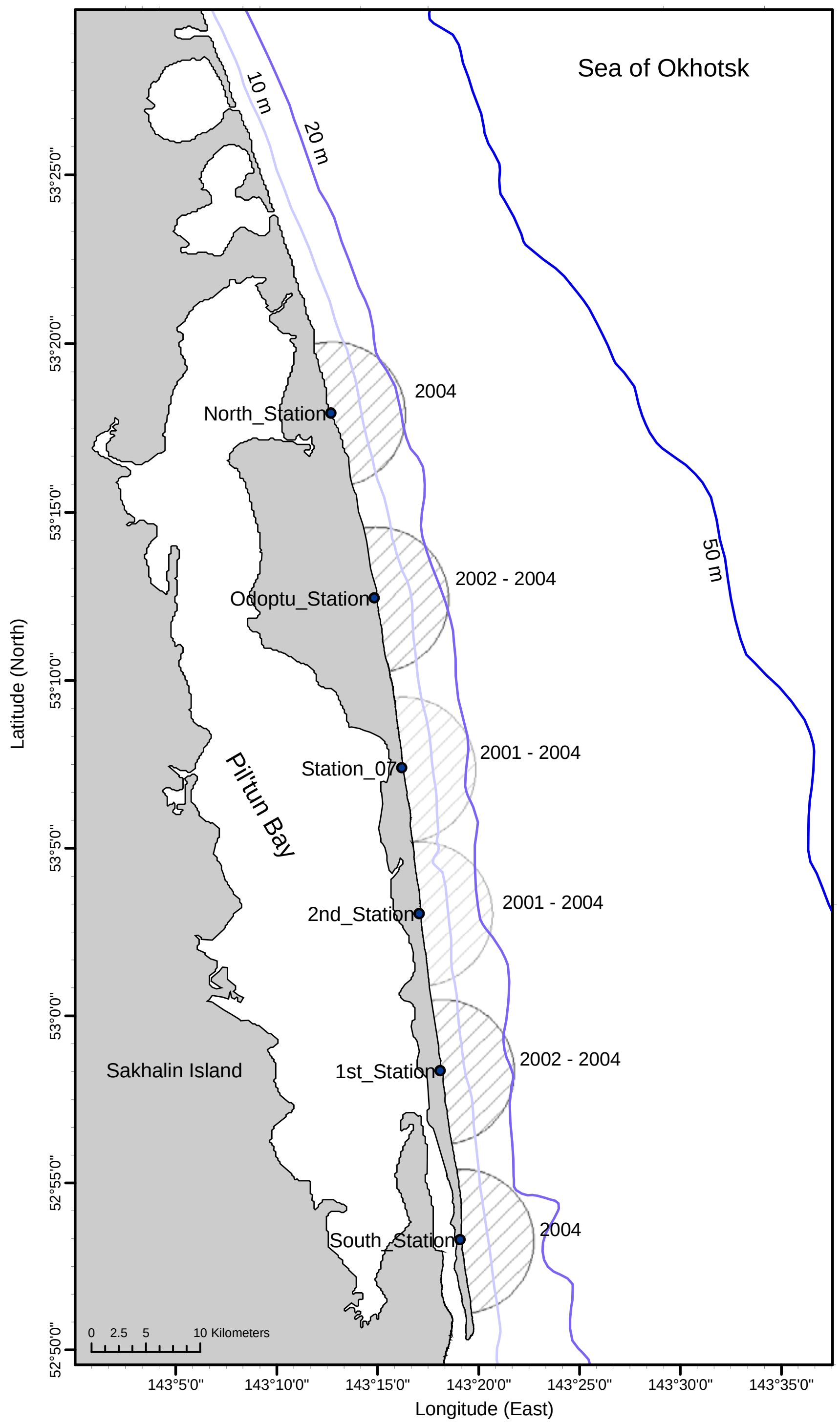


Figure 2. Geographic positions of six shore-based stations in the northeastern coastal region of Sakhalin Island, Russia. Semi-circular grids illustrate approximate viewable range (4 km) from each shore-based station. Dates indicate years when data were collected at each station.

Environmental Parameter Measurements

Environmental conditions were recorded several times per day to ensure consistent and reliable results for all three methodological techniques employed by the shore-based monitoring teams (see below). The relative visibility, glare concentration and horizontal angles, sea state (Beaufort scale values 0-4 were recorded in this study, with 3 being small whitecaps and > 3 generally unacceptable for most analyses except for movement patterns and when whales were < 2 km from the observation point), wind direction, cloud cover, and swell conditions were recorded. Two hand-held weather stations were utilized to automatically record temperature, barometric pressure, wind speed, wind direction, humidity, and several other environmental parameters at 10-min intervals throughout each day of effort at each observation station. After each field day, the environmental data were downloaded to a PC and stored for later use. If any of the above-mentioned environmental parameters hampered observations, then research effort was discontinued until conditions were acceptable.

Scan Sampling

To monitor the relative number and distribution of gray whales in the study area, scan sampling methods were conducted hourly when focal behavior sessions were not being conducted. Two observers used hand-held binoculars (7x50) to progressively scan a predetermined section of the study area ranging from 0° to 180° magnetic North (magnetic declination relative to true North =12.19° West in summer of 2004). Each scan was initiated from the northern portion of the study area and proceeded to the southern portion, with a maximum of one scan per hour. The duration of each scan was determined based on the rate of scan (i.e. °/min) in 2001-2003 (20° to 160° = 140°/15 min = 9.33 °/min). Due to the increased coverage area in 2004 and the need to be consistent with previous data, the duration was calculated to be 19.28 min (180° / (9.33 °/min) = 19.28 min). Once an observer sighted a whale or whales, then the number of whales, angular distance between the whale and the horizon (based on binocular reticles), magnetic bearing, and estimated distance from the station were recorded.

Theodolite Tracking

The spatial and temporal movement patterns of gray whales were monitored with Lietz/Sokkisha Model DT5A & DT5 theodolites with 30-power monocular magnification and 5-

sec precision. The theodolite tracking technique converts horizontal and vertical angles into geographic positions of latitude and longitude for each theodolite recording. The tracking of individuals over time provides information about the animals' relative speeds and orientations, alone or in relation to seismic or other human activity on the water (see Würsig *et al.* 1991, Gailey 2001, Gailey and Ortega-Ortiz 2002, and Gailey *et al.* 2004, for further description and mathematical calculations). A theodolite tracking session was initiated when a single or an individually recognizable gray whale in a group could be identified and the individual was within a relatively close distance (~ 4-5 km) from the station. Each individual was continually tracked until the animal was lost, moved beyond the 4 km critical distance, or when environmental conditions hampered further tracking. For each theodolite recording, subsequently referred to as a fix, the date, time, and vertical and horizontal angles were stored in a Microsoft Access database with the relative distance, bearing referenced to true North, and geographic position calculated in real-time by the theodolite computer program *Pythagoras* (Gailey and Ortega-Ortiz 2002). Due to the relatively low elevations of each station, a maximum of 4 km distance from the station was used for a critical distance to ensure reliable data for analysis of speeds, orientations, and displacement (see page 4, Table 1, for station elevations and Würsig *et al.* 1991 for height-related errors).

Focal Behavior Observations

Focal behavior sessions (Altmann 1974, Martin and Bateson 1993) were conducted on individual gray whales to determine if any behavioral or respiration changes occurred in relation to environmental variables. However, a complete set of environmental data was not available for analysis in this report, and such analysis is not conducted here. A focal behavior session was initiated when all observers determined that a single whale could be monitored continuously and reliably enough so that respiration and critical behavioral events would not be missed. The reason for choosing a single or individually recognizable whale was that it was generally impossible to distinguish known individuals, due to our low vantage point and distance from whales. A focal session would be terminated once the whale moved out of the study area or when the above conditions were not met. At least one behavioral observer would follow individuals with the aid of hand-held binoculars (7x50). The behavioral observer verbally stated each behavioral event, and a computer operator recorded this into a laptop computer with

Pythagoras (Gailey and Ortega-Ortiz, 2002). To minimize inter-observer variability, the behavioral observer's observations were periodically evaluated by other observers. In most "focal follow" sessions, behavior and respiration events were recorded simultaneously with spatial and temporal movements provided by theodolite tracking of the focal animal.

Shore-Based Photography

In 2004, we explored the feasibility of taking identification photographs of whales particularly close to shore, generally less than 500 m. We used a Nikon D1x digital camera and a 100-400 mm lens with a 2x extender. While preliminary evaluations of the technique are encouraging, we are presently analyzing the technique with the best quality photographs gained and will report the relative success, recommendations of the lens-camera system to be used for future work, and the data obtained in a separate report.

Data Analysis

Scan Data – For a broad overview, the relative number of whales and number of pods were analyzed. All scan-based data were evaluated for the entire coastal region observed throughout the six shore-based stations and within and between each station. An estimation of the distribution using the fixed kernel method was conducted to graphically evaluate potential areas where animals were most frequently seen along the coastal region during scans (Worton 1989). The number of whales/pods per station were evaluated at different time periods for each day of effort. Due to non-normal distribution of scan data, both number of whales and pods were transformed (log (# whales or pods +1)) for analytical purposes. Based on the observed height above sea level, geographic bearing, and reticle readings of each sighting, distance from observer and geographic location were calculated (see Lerczak and Hobbs, 1998 for distance equations). In addition, a refraction index was used to correct for potential errors in line-of-sight estimation within the distance approximation (Leaper and Gordon, 2001). Due to differences in observation heights at the six stations, a threshold, determined by evaluating the frequency distribution of sightings in relation to distance from station and the station's relative height, of ≤ 6 km distance from the station was used for some analyses (i.e. comparing relative abundance values between stations) in order to fairly compare between different stations (Figure 3). For other analyses that were dependent on geographic location, such as distance from shore, a threshold of 10 km from the observation station was taken. The rationale for the increased threshold for the distance from shore analysis was to increase the coverage area to incorporate sightings further from shore to be represented in the analysis.

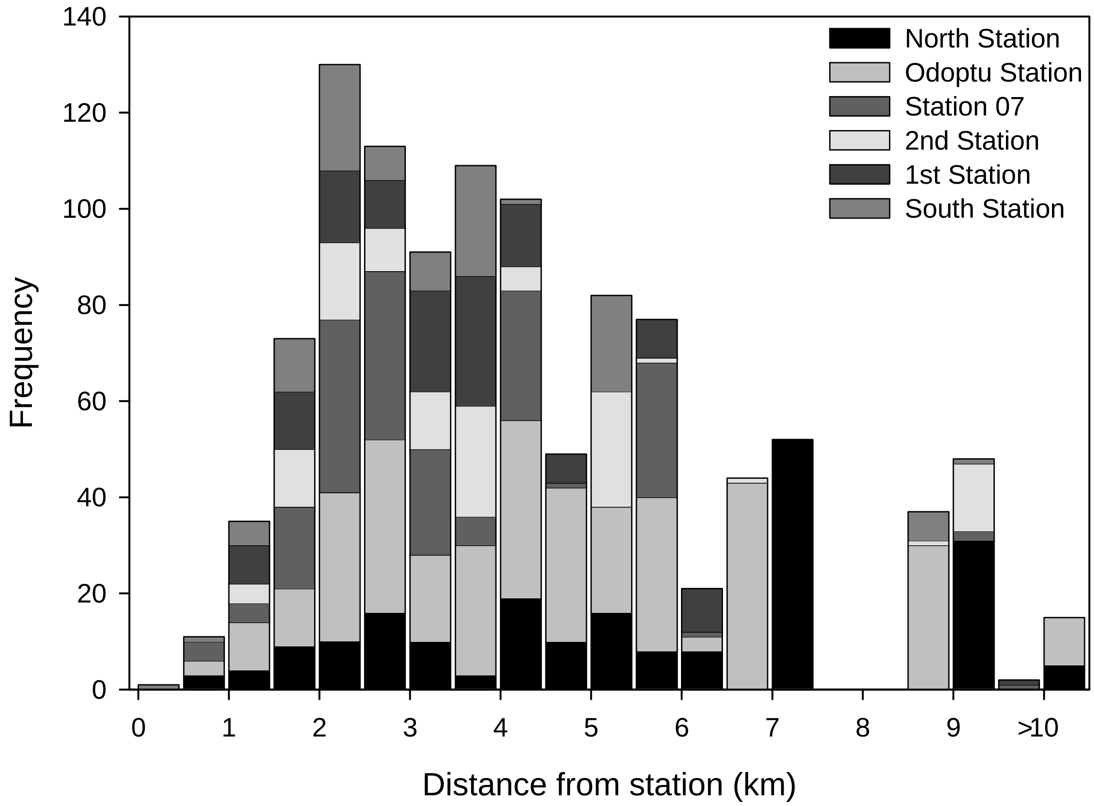


Figure 3. Sighting distances of western gray whales from six shore-based vantage points.

Theodolite Data – Theodolite tracking information was evaluated in terms of each animal's relative speeds, orientations, and displacement. Due to potential issues of over- or under-sampling and to ensure that fixes within a single track were uncorrelated, each trackline was interpolated temporally, as suggested by Turchin (1998). The temporal component was based on evaluating the entire trackline dataset in terms of step lengths, turning angles, number of fixed data points, and fix rate. A 90-sec interpolation criterion was based on an autocorrelation analysis performed on movement patterns (see Würsig *et al.* 2002). The iterative interpolation strategy started by focusing on the first whale position in a track, and then interpolating a geographic position based on the actual fix data 90-sec apart. The result of the interpolation procedure yielded tracklines with pairs of fix points (steps) separated by time intervals of approximately 90 seconds.

For each interpolated trackline, the calculated leg speed, acceleration, linearity, reorientation rate, ranging index, and mean vector length were analyzed. Leg speed is estimated by calculating the distance traveled between two sequential fixed points within a trackline divided by the time interval between the two points. Acceleration evaluates changes within leg speed to determine if an animal is generally increasing or decreasing speeds within a trackline. Linearity is an index of deviation from a straight line, calculated by dividing the net geographic distance between the first and last fix of a trackline by the cumulative distances along the track. Linearity values range between 0 and 1, with 0 indicating no net movement and 1 indicating a straight line (Batschelet 1980). In addition to linearity, another directionality index r (mean vector length; Cain 1989) was incorporated due to its dependence on angular change within a trackline as opposed to distances. Mean vector length values range from 0 (great scatter) to 1 (all movements in the same direction) (Cain 1989). Reorientation rates represent a magnitude of bearing changes along a trackline. This rate is calculated as the summation of absolute values of all bearing changes along a trackline divided by the entire duration of the trackline in minutes (Smultea and Würsig 1995).

A ranging index was included to measure the minimal diagonal area of the whale's track incorporating its course and track duration (Jahoda *et al.* 2003). Furthermore, a "displacement" analysis was conducted to evaluate natural movement patterns among different behavioral states of western gray whales. Displacement is defined as a straight-line distance an animal moved spatially from the start of the track (i.e. step 0) to the n^{th} step. Confidence intervals for the displacement analysis were based on bootstrap methods. The bootstrap was conducted by randomly selecting (with replacement) i_n paths (where i_n was defined as the number of paths that have n moves), and calculating the mean squared displacement. After 1,000 iterations of the bootstrap, the 95% confidence interval for each step were selected from the 26^{th} and 975^{th} values as the lower and upper limits, respectively. Due to the nature of this analysis, all paths were used for low n steps (i.e. step 0), but as n increases, the number of paths decrease. The consequence of this is greater error bars at higher n steps (Turchin 1998).

Behavioral/Respiration Data – To evaluate potential behavioral changes, focal behavioral data were quantified by six variables: 1) blow interval (times less than 60 s between subsequent exhalations per surfacing); 2) number of blows per surfacing; 3) surface time (duration the animal remains at or near the surface); 4) dive time (logged whenever a submerged whale did not blow for > 60 s); 5) surface blow rate (mean number of exhalations per minute during a surfacing); and 6) surface-dive blow rate (number of exhalations per minute averaged over the duration of a surfacing-dive cycle, using the dive previous to the surfacing). The determination of a 60 s dive criteria was based on evaluating the bi-modal frequency distribution and survivorship analysis of all subsequent blows (regardless of time between blows), where the 60 s threshold was between the two (blows and dives) different distributions. One approximately 10 min long bin was randomly selected per each behavioral observation session to address independence (a measure of autocorrelation), and one mean calculated per each of the six variables per ten minute bin (see next section).

Theodolite and Focal Behavior Data Bins – Due to variation in track duration between tracklines, all tracks were binned into 10-min intervals per tracking/focal follow session. "Binning" involved combining locations within intervals of time lasting approximately 10 min, and viewing the interval of time as the basic observation unit upon which responses and explanatory variables were measured. Each 10-min interval of time was called a *bin*, and ended at an actual or interpolated geographic location. Due to non-constant track lengths, one or multiple bins were obtained for each track. For each bin, the above-mentioned tracking and behavioral values of interest were calculated. Due to variation in the number of bins per tracking session, and to avoid pseudoreplication in analyses, one 10-min bin was randomly selected from each trackline or focal behavior session. Therefore, the sampling unit used was one 10-min bin representative per trackline or focal behavior session.

Transformations - Histograms were evaluated for each of the response variables. Transformations for each non-normal distribution were performed to approximate normal distributions for analytical purposes. The distributions of linearity and mean vector length were highly skewed, non-normal in shape, and contained values that ranged from 0 to 1. The empirical logit transformation was applied to linearity and mean vector length using the following equation,

$$Y_i' = \log_e\left[\frac{Y_i - 0.003}{1-(Y_i - 0.003)}\right],$$

where Y_i' was the transformed response for observation *i*, and Y_i was the original response. The constant 0.003 was subtracted from each observation to avoid division by zero when the original response was 1.0. Back-transformation to the scale of the original response was accomplished using the equation,

$$Y_i = \frac{1.003 \times \exp\{Y_i'\} + 0.003}{1 + \exp\{Y_i'\}}.$$

The distributions of leg speed, reorientation rate, blows per surfacing, range, and surface time were also highly non-normal. Each of these variables was log-transformed using the equation,

$$Y_i' = \log_e(Y_i).$$

Again, Y_i' was the transformed response for observation *i*, and Y_i was the original response. Back-transformation to the scale of the original response was accomplished by raising *e* to the Y_i' power.

RESULTS

Effort

The 2004 field season commenced on 28 July 2004 and ended on 22 September 2004. A total of 47 (with both stations, 24 actual) days (348 hrs) of effort was spent at the six shore-based stations (Table 2, Appendix 1). The first day of data collection started on 31 July at South and 1st Stations. The last field day of effort was 21 September at Odoptu and North Stations.

Table 2. Total amount of effort at six shore-based stations during 28 July to 21 September, 2004.

Station	Days	Effort (hrs)
South Station	7	53.87
1st Station	7	66.8
2nd Station	8	59.86
Station 07	9	68.14
Odoptu Station	8	52.85
North Station	8	46.67
Total	47	348.19

Scan Data

General – A total of 196 scans with 1,579 whales from 1,101 sightings were accumulated for the duration of the study (Table 3). Distribution of sightings from the six stations is shown in Figure 4 and Figure 5; this demonstrates graphically, but also quantified in Figure 3, that although whales could be sighted up to about 10 km distance from the station with the highest elevation (North Station, 19.5 m), they were generally < 5 km from shore (Figure 6; Table 4).

Table 3. Summary of scans during 2004 at six shore-based stations.

Station	Scans	Sightings	Individuals
North Station	23	204	304
Odoptu Station	26	347	490
Station 07	33	184	258
2nd Station	32	121	179
1st Station	45	140	203
South Station	37	105	145
Total	196	1101	1579

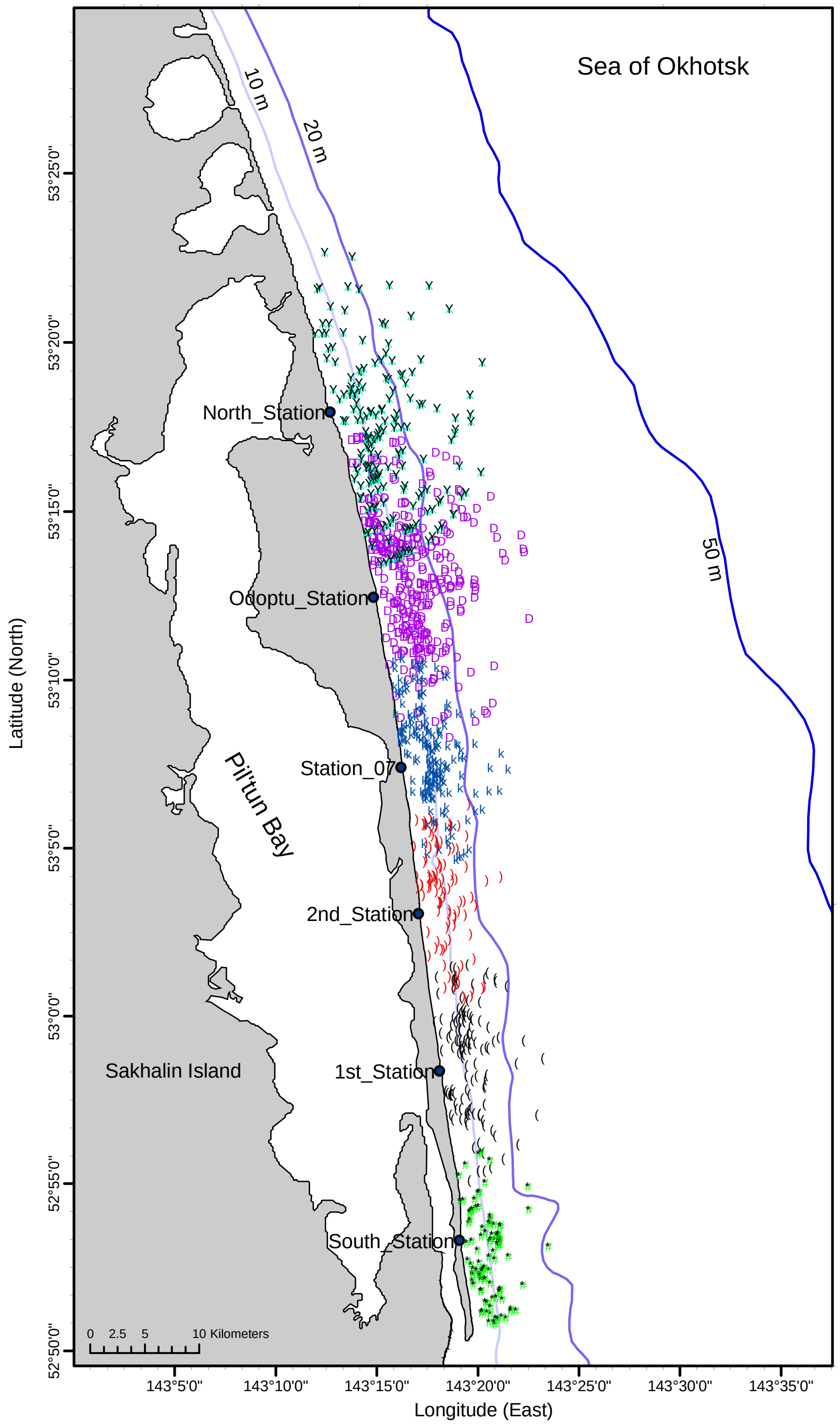


Figure 4. Geographic positions of sightings of western gray whales at six shore-based stations on Sakhalin Island, summer 2004.

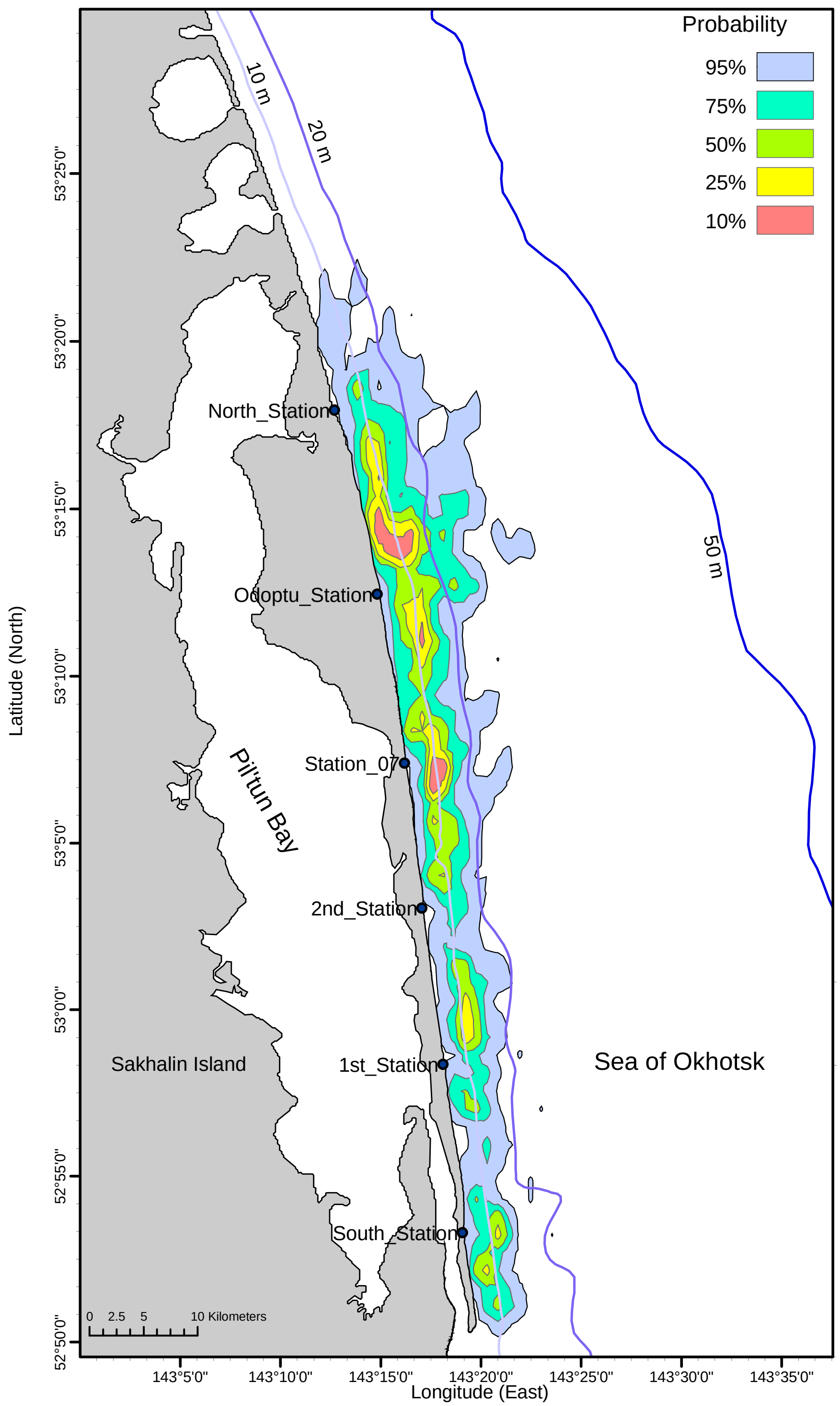


Figure 5. Distribution of western gray whales during the summer of 2004. Blue – red represents the kernel density probability contours.

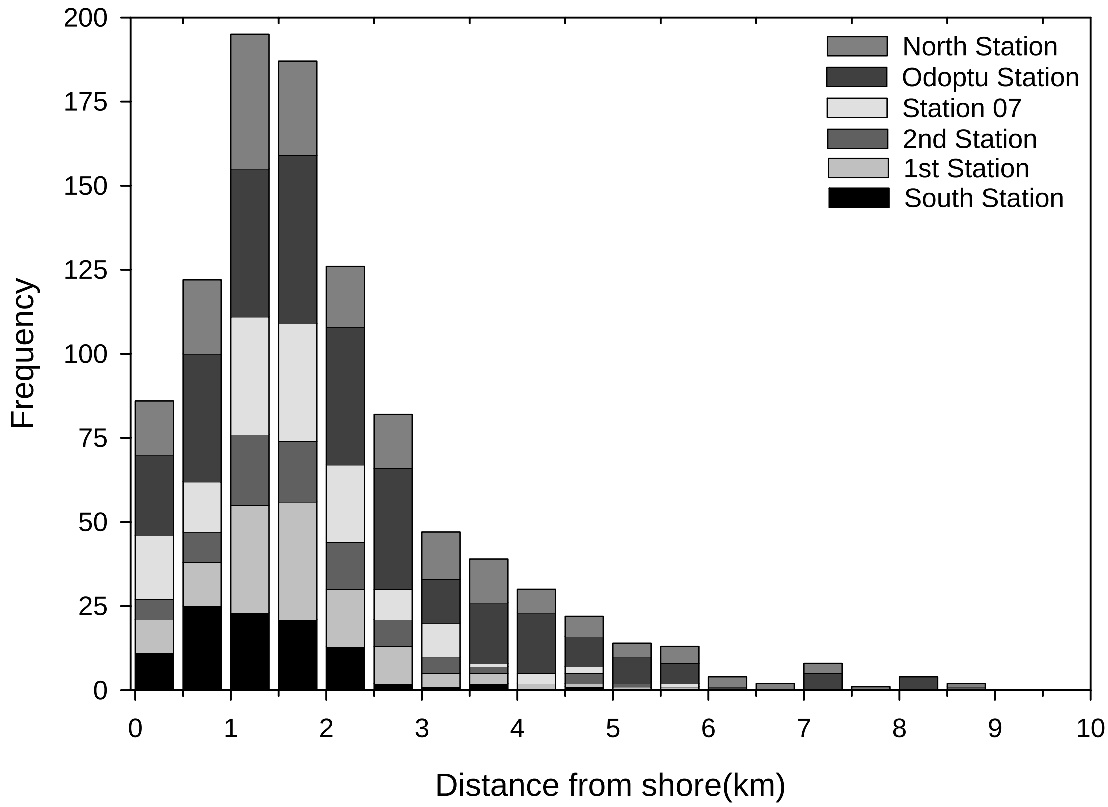


Figure 6. Distance of western gray whale sightings from shore off Sakhalin Island, summer 2004.

Table 4. Distance of western gray whales from shore at six shore-based stations. Sample size represents number of sightings of gray whales (117 sightings were removed due to distance and time criteria, see methods).

Stations	Mean(km)	Median (km)	SD (km)	N
North Station	2.4	1.8	1.74	199
Odoptu Station	2.4	2.0	1.65	315
Station 07	1.7	1.6	1.01	153
2nd Station	1.9	1.6	1.28	88
1st Station	1.8	1.6	0.99	130
South Station	1.4	1.3	0.81	99
Total	2.1	1.7	1.45	984

Gray whales were present on each day of effort, with a mean of 6.4 ± 5.43 SD (Median = 5, Range: 0-25, N = 188) whales and 4.5 ± 3.56 (4, 0-16, 188) pods in the study area per scan. The mean pod size detected was 1.4 ± 0.75 (1, 1-6, 837) whales per pod throughout the duration of this study (Figures 7 - 9).

A.

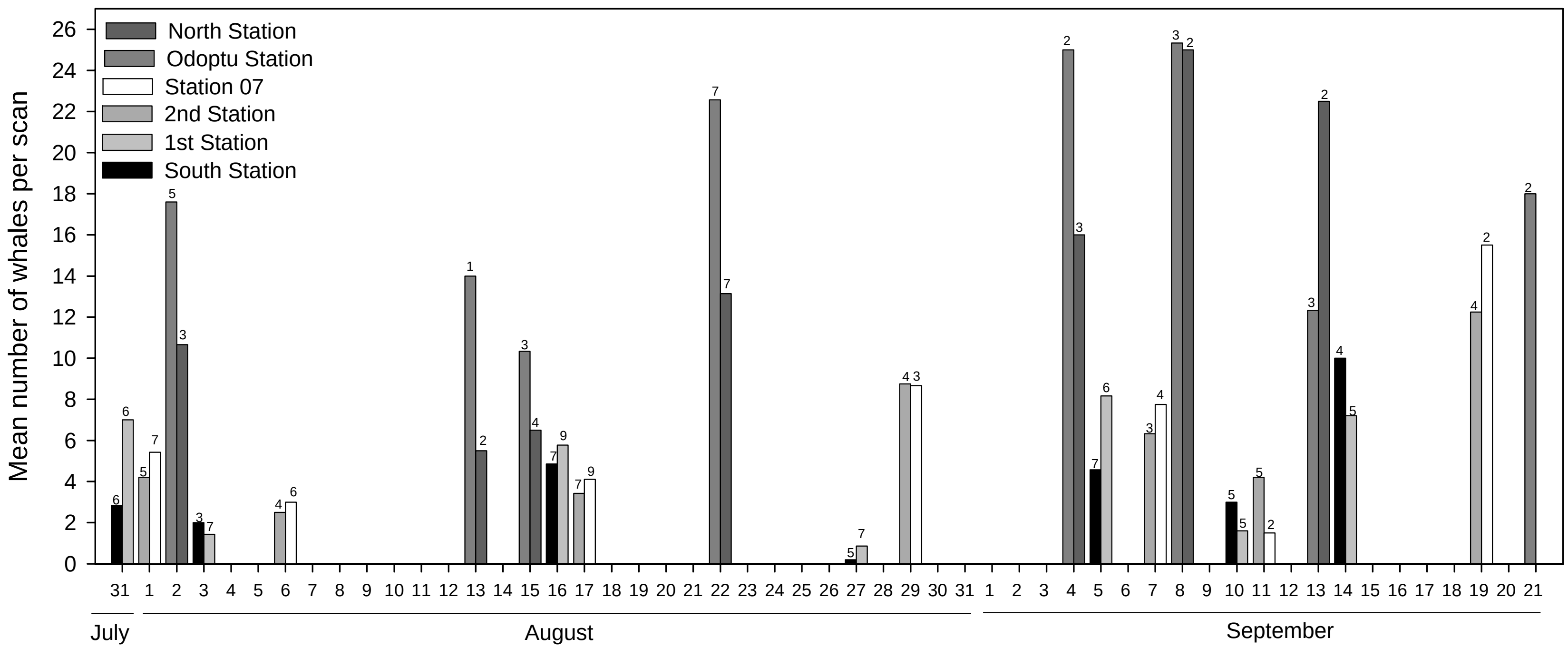


Figure 7. Mean numbers of whales detected per scan at each of the six shore-based stations. The number of scans performed per day at each station is indicated at the top of each bar.

B.

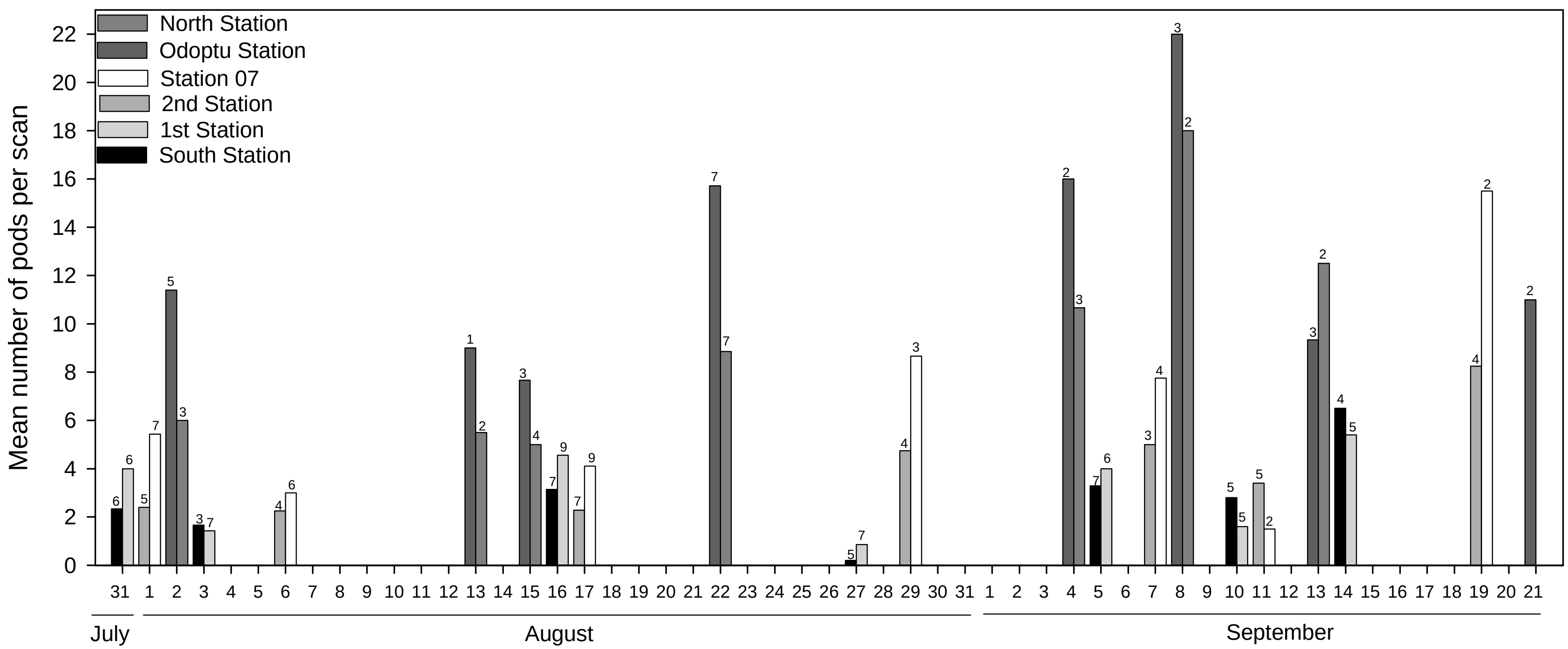
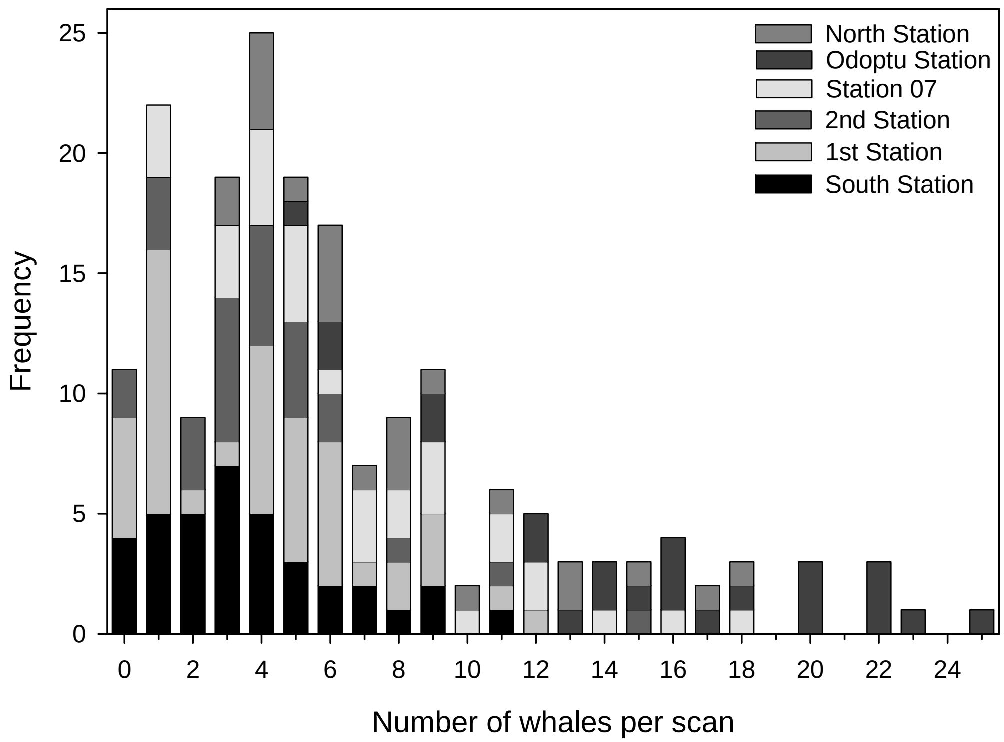
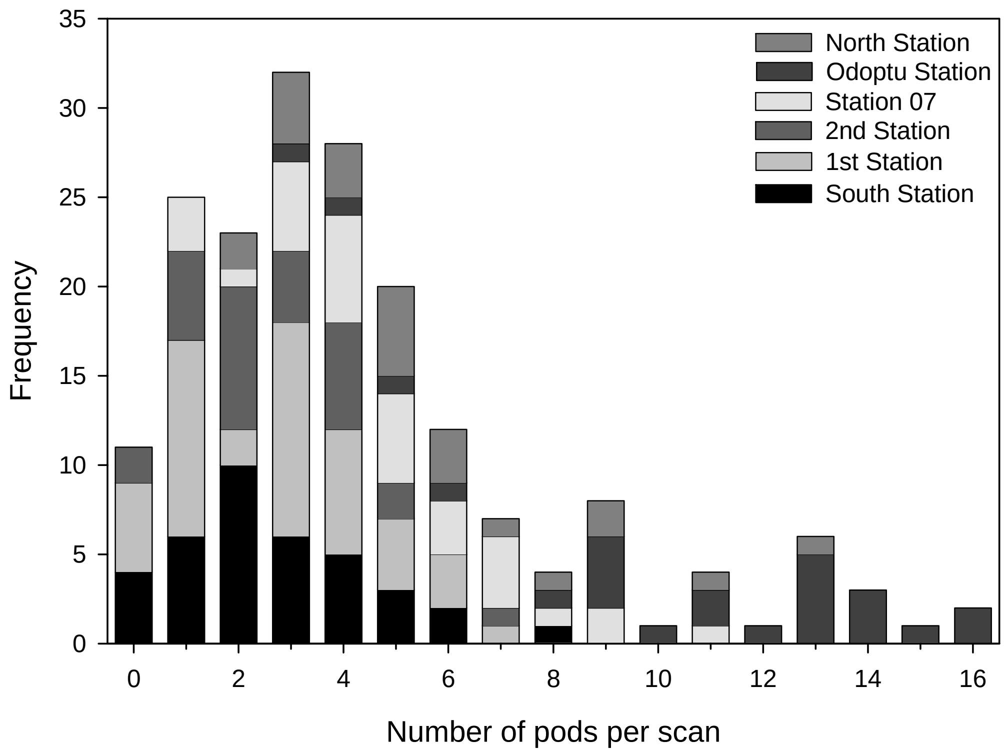


Figure 8. Mean numbers of pods detected per scan at each of the six shore-based stations. The number of scans performed per day at each station is indicated at the top of each bar.

A.



B.



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C.

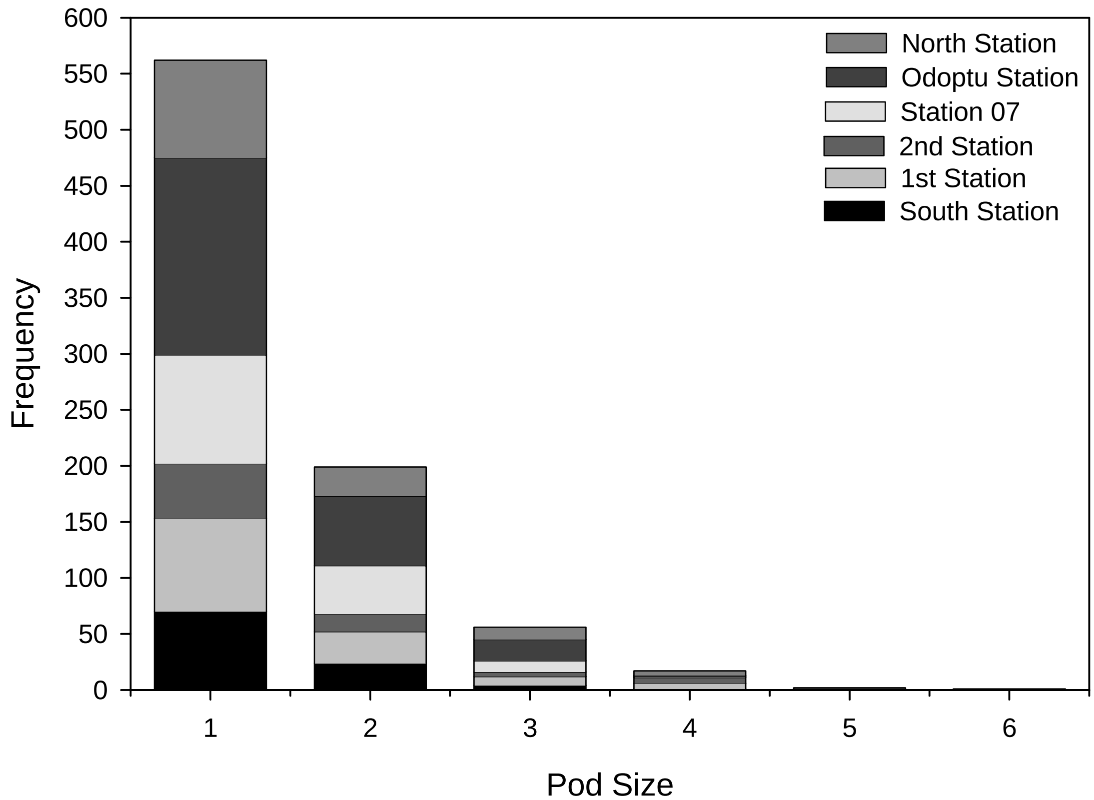
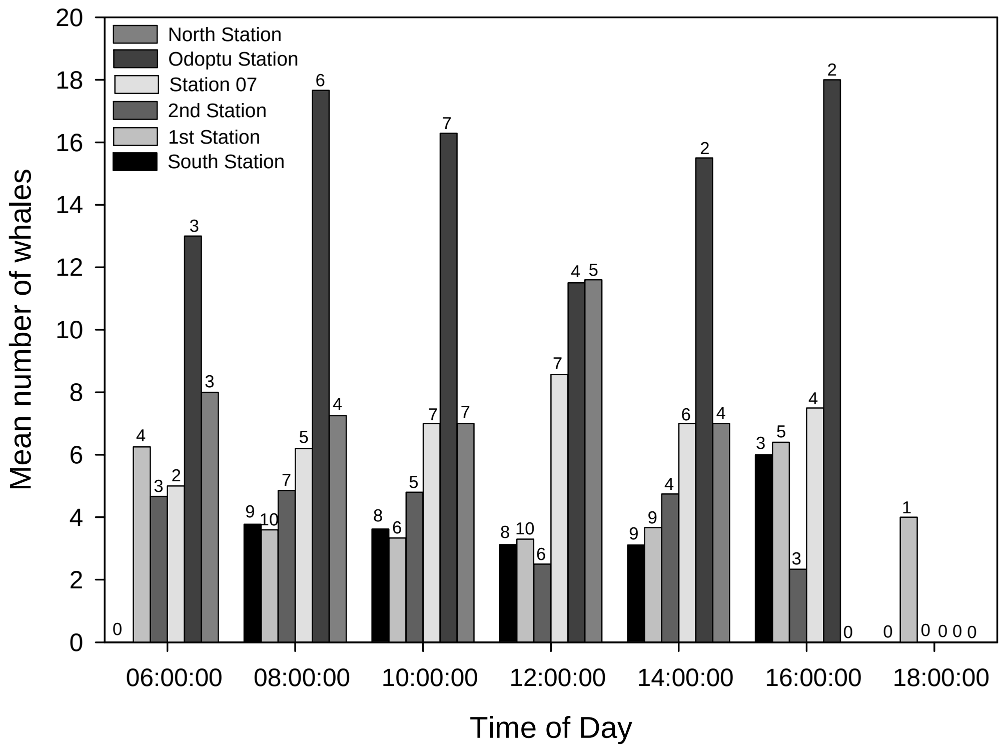


Figure 9. Frequency histograms of numbers of whales (A) and pods (B) detected per scan throughout the study period, and pod size (C). Only the numbers of whales and pods ≤ 6 km were included.

Morning vs Afternoon - No significant difference in the number of whales (Z = 1.15, P = 0.25) or pods (1.28, 0.20) were detected in the morning and afternoon periods of each day (Figure 10). In the morning, the mean number of whales was 6.9 ± 5.76 SD (Median = 5, Range: 0-23, N = 96); and in the afternoon, the mean number of whales was 5.9 ± 5.03 (4.5, 0-25, 92). In the morning, the mean number of pods was 4.8 ± 3.83 (4, 0-16, 96); and in the afternoon, the mean number of pods was 4.1 ± 3.24 (3, 0-16, 92).

A.



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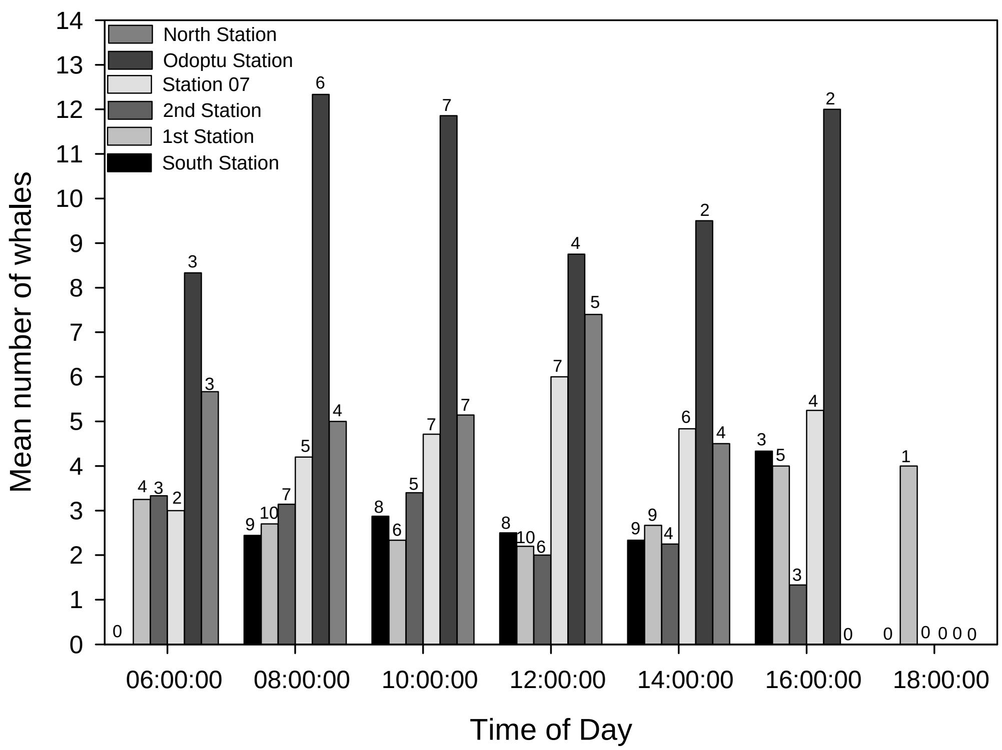

Figure 10. Mean number of whales (A) and pods (B) per time of day at six shore-based stations.

Stations – The mean numbers of whales and pods observed for the season among stations were significantly different (whales $F = 21.55$, $df = 5$, $P < 0.001$; pods 26.73, 5, <0.001), with more whales and pods at the northern shore-based station (Odoptu Station, $\overline{\chi}$ =15.5 ± 5.73 SD whales and 10.8 ± 3.69 pods) on average for the season (see Figure 8 and Table 5). Post-hoc comparisons found that:

- Odoptu Station was significantly higher in numbers of whales and pods than all other stations;
- North Station and Station 07 were similar in numbers of whales and pods, but significantly different from the remaining four stations; and
- 2^{nd} Station, 1^{st} Station, and South Station had similar number of whales and pods among each other, but were significantly different from Odoptu Station, North Station, and Station 07.

Although observers are likely to see more whales at higher elevations due to increased visible range and Odoptu Station had one of the highest vantage points among the six stations, the difference in number of whales and pods is unlikely to be affected by elevation differences since we removed sightings beyond the critical 6 km distances, within which all stations have similar probabilities of detecting whales (see methods). In fact, the highest vantage point at North Station (19.5 m) did not find a significant difference from a lower vantage point (8.9 m) at Station 07. If this distance criterion had not been taken, the only difference in significance pattern would be between the similar numbers found at North Station and Station 07 (i.e. North Station, Odoptu Station, and Station 07 would be significantly different among all other stations, and 2^{nd} Station, 1^{st} Station, and South Station would provide similar numbers of whales and pods); therefore this significance would have been due to the observer being able to see further from the higher vantage point and not relative to the abundance of animals within a defined area.

Table 5. Number of whales (A) and pods (B) detected at six shore-based stations. Sample size is represented by the number of scans per station. Similar shading of rows indicates stations not found to be different among each other.

A.

Station	Mean	Median	SD	Range	N
North Station	8.2	7.5	4.44	3-18	23
Odoptu Station	15.5	16	5.73	5-25	24
Station 07	7.2	7	4.34	1-18	31
2nd Station	4.0	4	3.19	0-15	28
1st Station	4.1	4	3.17	0-12	45
South Station	3.6	3	2.76	0-11	37
Total	6.4	5	5.43	0-25	188

B.

Station	Mean	Median	SD	Range	N
North Station	5.6	5.0	2.84	2-13	23
Odoptu Station	10.8	12.0	3.69	3-16	24
Station 07	4.9	5.0	2.44	1-11	31
2nd Station	2.6	2.0	1.64	0-7	28
1st Station	2.8	3.0	1.87	0-7	45
South Station	2.7	2.0	1.87	0-8	37
Total	4.5	4.0	3.56	0-16	188

Theodolite Tracklines

Gray whales were tracked for at total of 119 hours ($\bar{\chi}$ = 44.2 min./track), ranging from 5 min to 4.27 hrs of continuous monitoring of movement patterns (Table 6). We recorded a total of 162 different tracklines with 7,987 geographic positions (Figure 11).

Table 6. Summary of trackline data gathered at six shore-based stations.

Station	# Tracklines	Mean Duration (min.)	Range (min.)
North Station	25	42.62	5 - 101
Odoptu Station	42	41.61	6 - 197
Station 07	35	42.27	5 - 256
2nd Station	21	44.19	6 - 156
1st Station	22	47.53	9 - 175
South Station	17	42.1	7 - 135
Total	162	44.18	5 - 256

The analytical data set, consisting of only recognizable or single individuals before the seismic survey was conducted, yielded 116 tracklines that were suitable for analysis (Table 7). On average, gray whales observed during the duration of the study were moving 2.2 ± 1.30 SD kph (Median = 1.9, Range = 0.3-6.4; Figure 12), accelerating -0.05 ± 0.221 kph (-0.03,-0.82– 0.81; Figure 13), reorienting 19.1 ± 15.17 °/min (13.8, 0.5 – 64.4; Figure 14), and ranging 32.9 ± 22.31 m/min (28.0, 3.0 – 106.7; Figure 17). The mean vector length and linearity index were 0.79 ± 0.217 (0.89, 0.20 – 1.00; Figure 15) and 0.81 ± 0.232 (0.91, 0.10 – 1.00; Figure 16), respectively. These directional indices indicate a more straight-line path movement as opposed to a non-directional feeding type behavior.

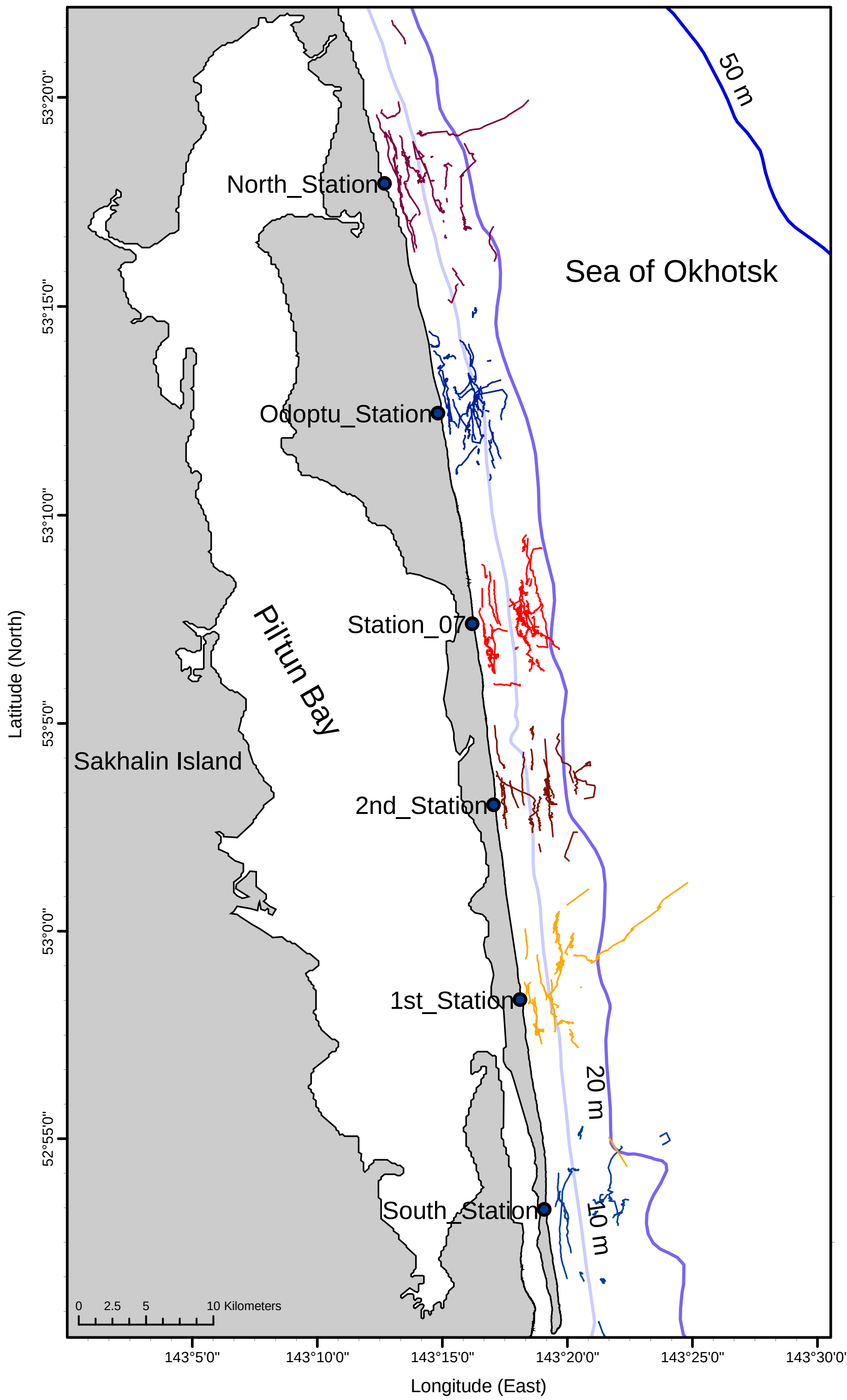

Figure 11. Tracklines of western gray whales at six shore-based positions on Sakhalin Island during summer 2004 (N = 162).

Table 7. Summary data for trackline analysis of western gray whales during summer 2004.

N = 116	Mean	Median	Min	Max	SD
Leg Speed (kph)	2.2	1.9	0.3	6.4	1.30
Reorientation Rate (°/min.)	19.1	13.8	0.5	64.4	15.17
Acceleration (kph)	-0.05	-0.03	-0.82	0.81	0.221
Mean Vector Length	0.79	0.89	0.20	1.00	0.217
Linearity Index	0.81	0.91	0.10	1.00	0.232
Ranging Index (m/min.)	32.9	28.0	3.0	106.7	22.31

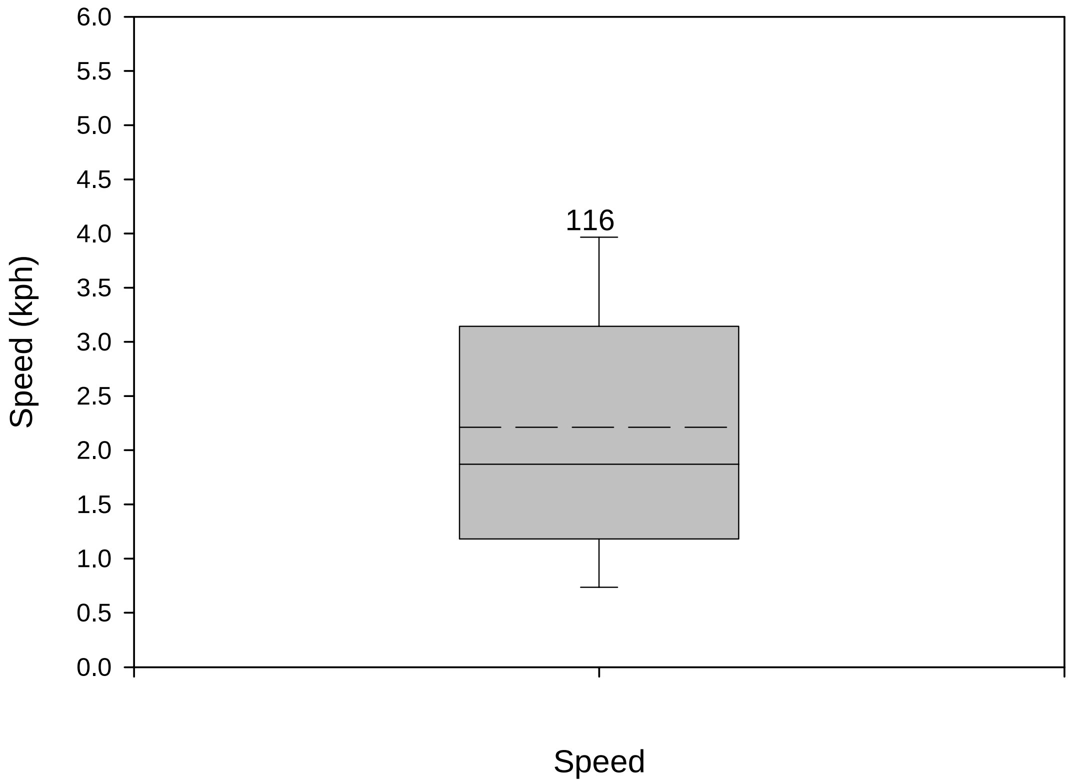

Figure 12. Leg Speed for all single or recognizable individual gray whales observed at six shore-based stations. For each box-plot the whiskers represent the 10th and 90th percentile, the box represents the 25th and 75th percentile, the solid bar represents the 50th percentile, and dashed bars represent mean values.

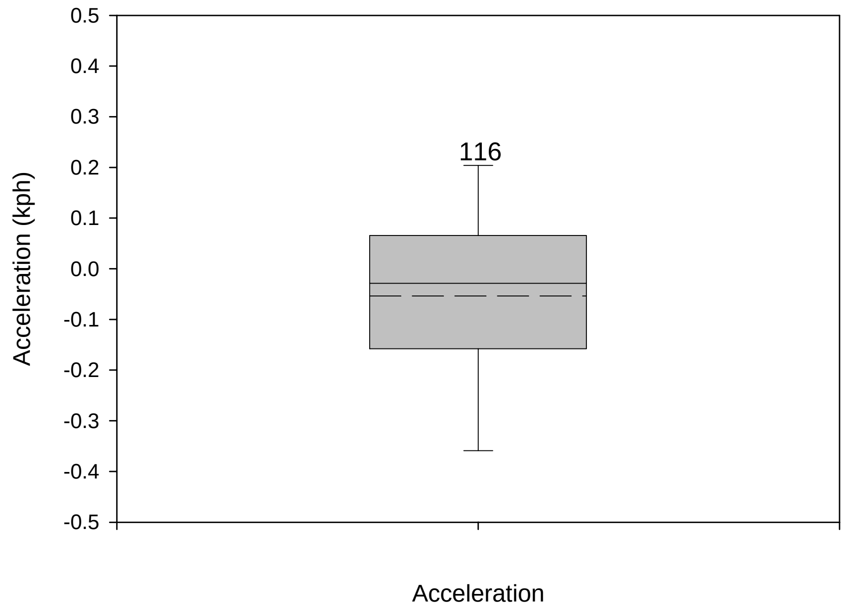

Figure 13. Acceleration for all single or recognizable individual gray whales observed at six shore-based stations. The negative values of acceleration represent deceleration. Display as in Figure 12.

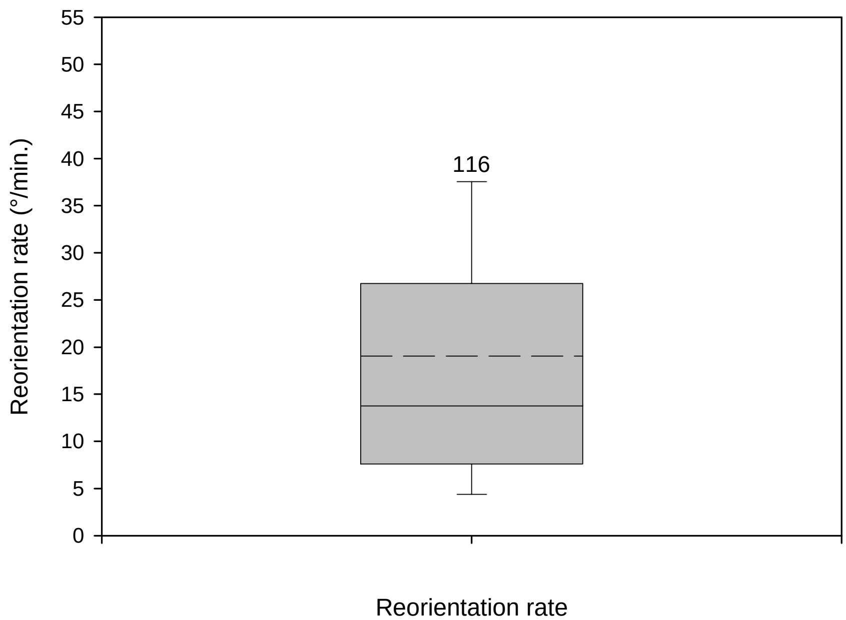

Figure 14. Reorientation rate for all single or recognizable individual gray whales observed at six shore-based stations. Display as in Figure 12.

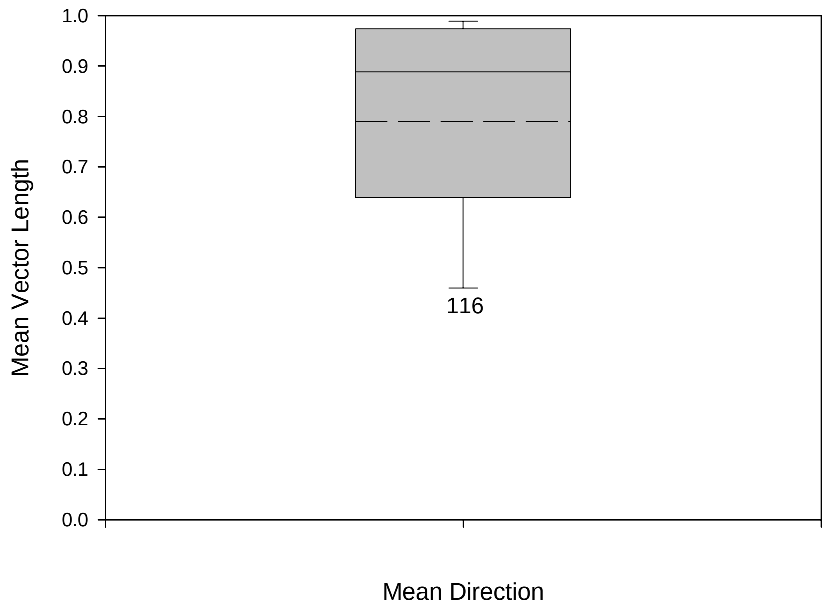

Figure 15. Mean vector length for all single or recognizable individual gray whales observed at six shore-based stations. Display as in Figure 12.

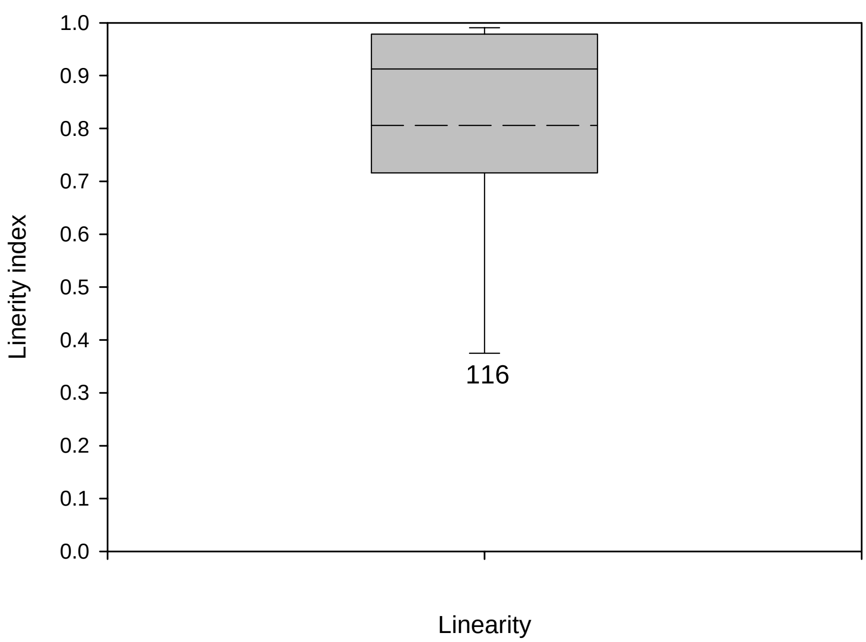

Figure 16. Linearity index for all single or recognizable individual gray whales observed at six shore-based stations. Display as in Figure 12.

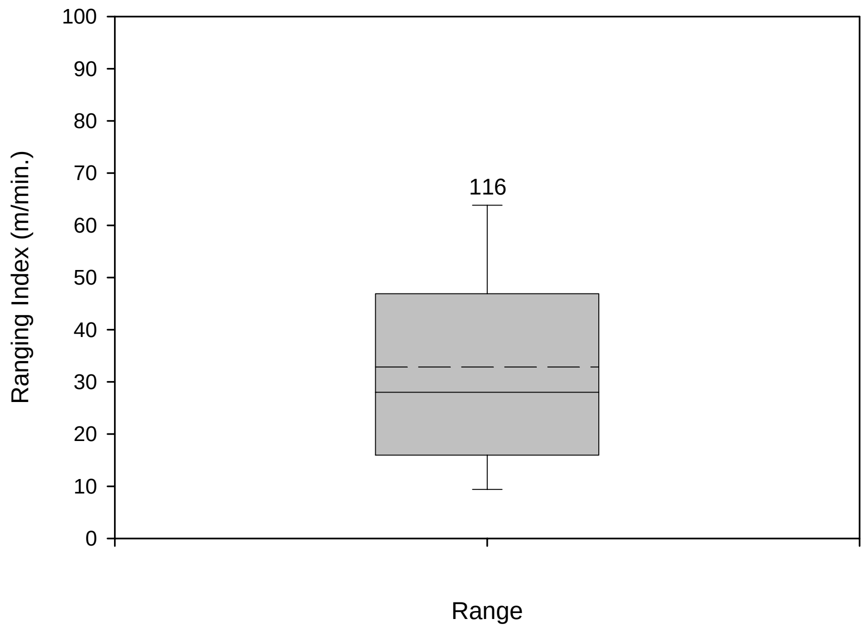

Figure 17. Ranging index for all single or recognizable individual gray whales observed at six shore-based stations. Display as in Figure 12.

Focal Behavior Observations

Focal behavioral observations were conducted for a total of 47 hrs, on 71 individual gray whales from 31 July to 21 September 2004 (Table 8). The mean duration of a focal session lasted approximately 39 min, and a total of 4,369 behavior events were collected.

Table 8. Summary of focal behavior data gathered at four shore-based stations.

Station Name	# Focals	Mean Duration (min)	Range (min)
North Station	10	30.41	7 - 61
Odoptu Station	15	45.69	5 - 105
Station 07	17	35.55	6 - 152
2nd Station	8	51.6	7 - 106
1st Station	11	44.4	12 - 144
South Station	10	29.92	8 - 61
Total	71	39.35	5 - 152

The analytical data set, consisting of data before the initiation of the seismic survey, yielded 64 focal follows. On average, individual gray whales had a blow interval of 0.41 ± 0.169 SD blows per minute (Median = 0.37, Range = 0.20 – 0.93; Figure 18), with 4.16 ±

1.628 (4.00, 2 – 5; Figure 19) blows per surfacing. The time that individuals were observed at the surface was 1.78 ± 1.730 (1.13, 0.37 – 7.77; Figure 18) minutes, while individuals dove for 2.38 ± 0.796 (2.27, 1.03 – 4.60; Figure 18) minutes. The dive surface blow rate and surface blow rate were 1.21 ± 0.315 (1.23, 0.49 – 1.95, Figure 19) blows per minute and 4.28 ± 0.315 (4.00, 1.33 – 4.60, Figure 19) blows per minute, respectively (Table 9).

Table 9. Summary statistics for surface-respiration-dive parameters of individual western gray whales.

N = 70	Mean	Median	Min	Max	SD
Blow Interval (per min.)	0.41	0.37	0.20	0.83	0.169
Blows/Surfacing	4.16	4.00	2.00	5.00	1.628
Surface Time (min.)	1.78	1.13	0.37	7.77	1.730
Dive Time (min.)	2.38	2.27	1.03	4.60	0.796
Surface Blow Rate	4.28	4.00	1.33	8.00	1.493
Dive-Surface Blow Rate	1.21	1.23	0.49	1.95	0.315

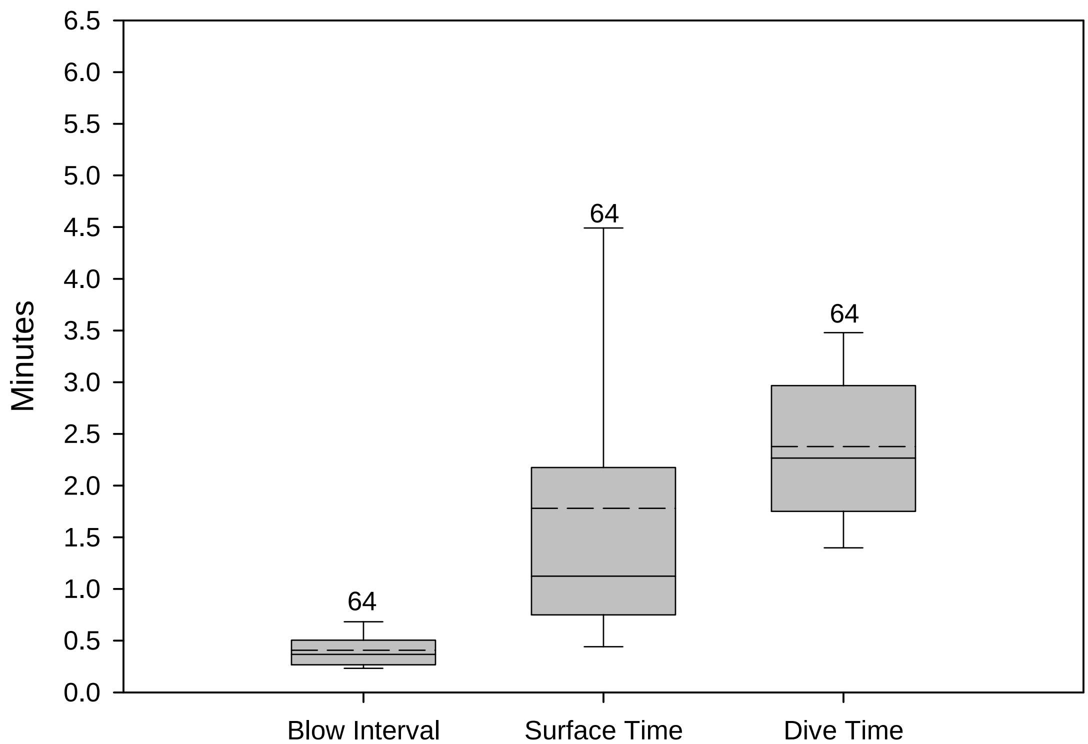

Figure 18. Blow interval, surface time, and dive time parameters of western gray whales. Display as in Figure 12.

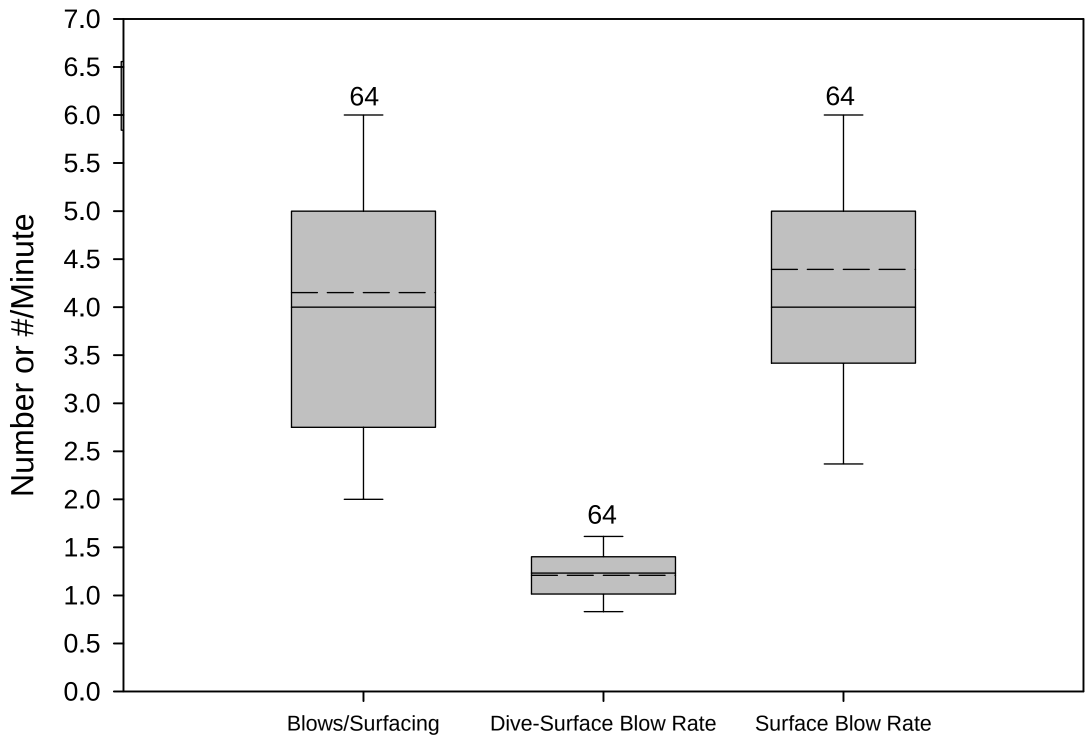

Figure 19. Number of blows per surfacing, dive-surface blow rate, and surface blow rate of western gray whales. Display as in Figure 12.

Behavior

Three main behavioral states were observed during the 2004 field season: 1) Feeding – whale(s) generally remain in one localized area with non-directional movement and consistent periods of diving; 2) Feeding/Traveling – whale(s) swim in one general direction at relatively slow speeds with consistent periods of diving; and 3) Traveling – whale(s) swim in one general direction and often remain at the surface without consistent dives. Although other behavioral states were observed, such as milling, socializing, and resting, there are too few occurrences of these behavioral states to provide a detailed analysis.

The gray whales' speeds ($F = 35.47$, $df = 2$, $P = <0.01$), reorientation rates (31.69, 2, <0.01), ranging indices (35.13, 2, <0.01), linearity (32.85, 2, <0.01) and mean vector length (28.07, 2, <0.01) were significantly different among the three behaviors. Respiration interval (8.32, 2, <0.01) was significantly different between feeding and traveling and between feeding/traveling and traveling; but not between feeding/traveling and feeding. Acceleration, distance-to-shore, surface time, dive time, dive-surface blow rate, and surface blow rate were all non-significant among the three behavioral states (Table 10, Figure 20 - Figure 31). The "displacement" of whales among the three behavioral states also revealed significant differences with individuals displacing 0.03 km^2 (95% Confidence interval: 0.01 – 0.04 km^2), 0.45 km^2 (0.35 - 0.68 km^2), and 1.56 km^2 (1.16 – 2.05 km^2) during feeding, feeding/traveling, and traveling behavioral states, respectively, after 20 steps (i.e. 30 minutes) (Figure 32).

Table 10. Movement and respiration variables of western gray whales during feeding, feeding/traveling, and traveling behavioral states. Post-hoc significance is denoted by F (Feeding), FT (Feeding/Traveling), and T (Traveling).

Variable	Feeding	Feeding/Traveling	Traveling	F (df = 2)	P	Post-hoc Significance
Speed (kph)	0.9 ± 0.53 (19)	1.7 ± 0.97 (43)	3.2 ± 1.62 (51)	35.48	< 0.001	F-T, FT-T, FT-F
Reorientation rate (/min)	42.5 ± 18.26 (19)	17.8 ± 9.549 (43)	11.9 ± 11.27 (51)	31.70	< 0.001	F-T, FT-T, FT-F
Linearity Index	0.4 ± 0.21 (19)	0.8 ± 0.14 (43)	0.8 ± 0.16 (51)	32.85	< 0.001	F-T, FT-T, FT-F
Mean vector length	0.5 ± 0.20 (19)	0.8 ± 0.15 (43)	0.8 ± 0.14 (51)	28.08	< 0.001	F-T, FT-T, FT-F
Acceleration (kph)	0.0 ± 0.13 (19)	0.0 ± 0.18 (43)	0.01 ± 0.27 (51)	0.15	0.858	
Ranging index (m/min)	10.4 ± 5.329 (19)	27.0 ± 16.31 (43)	50.6 ± 27.80 (51)	42.87	< 0.001	F-T, FT-T, FT-F
Distance to shore	1.4 ± 0.80 (19)	1.4 ± 0.66 (43)	1.2 ± 0.93 (51)	0.63	0.532	
Respiration Interval (min)	0.36 ± 0.169 (11)	0.32 ± 0.146 (25)	0.48 ± 0.151 (29)	8.37	< 0.001	F-T, FT-T
Surface Time (min)	1.38 ± 1.082 (11)	1.52 ± 1.716 (25)	1.82 ± 1.490 (29)	0.30	0.745	
Dive Time (min)	2.45 ± 1.302 (11)	2.47 ± 0.788 (25)	1.94 ± 0.682 (29)	2.86	0.065	
Dive-surface blow rate	1.29 ± 0.324 (11)	1.27 ± 0.328 (25)	1.21 ± 0.333 (29)	0.22	0.802	
Surface blow rate	4.98 ± 1.784 (11)	4.87 ± 2.693 (25)	4.01 ± 2.022 (29)	1.89	0.161	

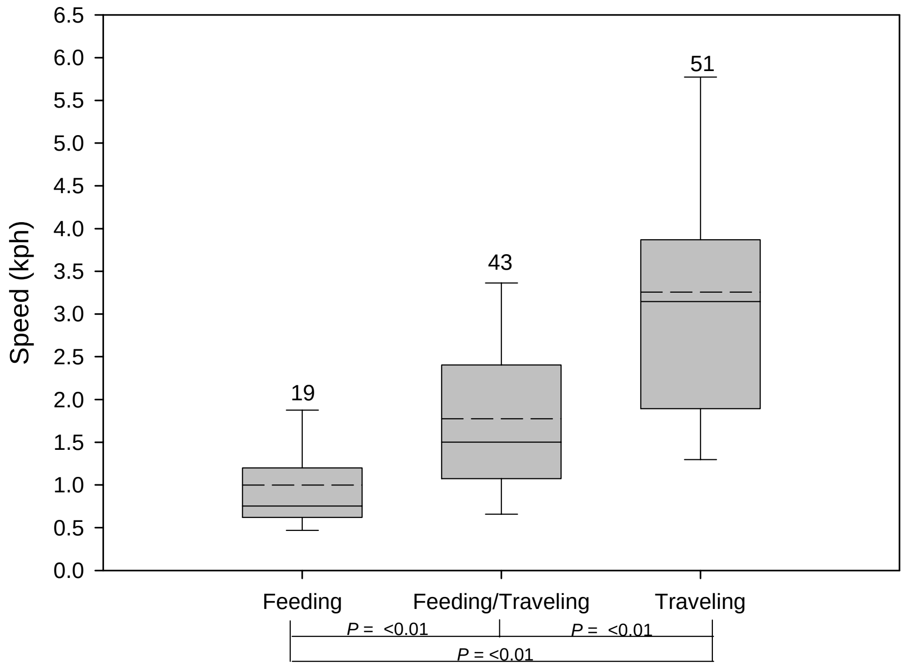

Figure 20. Speed of western gray whales during three behavioral states. Display as in Figure 12.

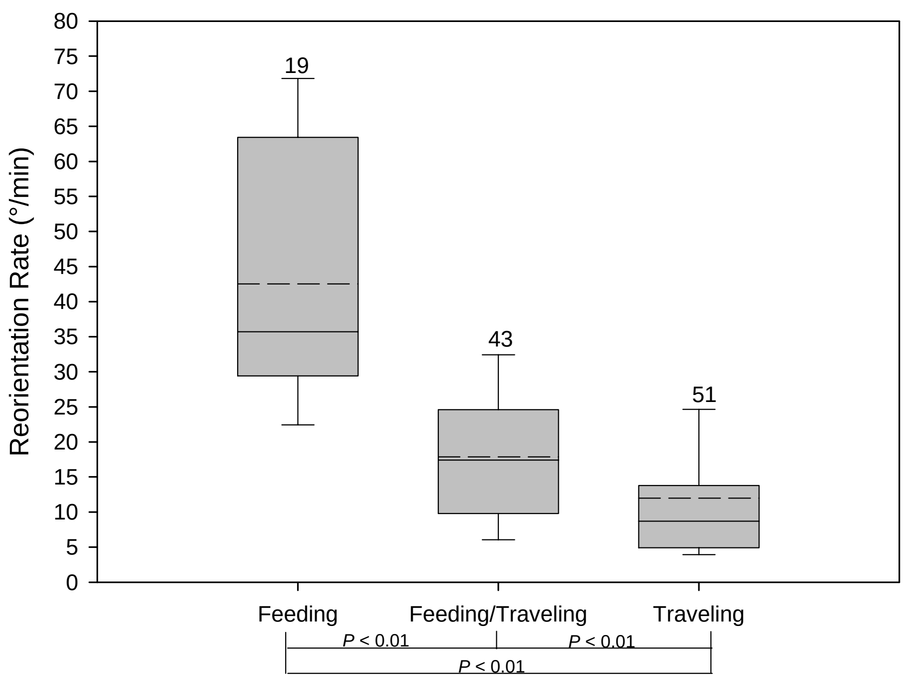

Figure 21. Reorientation rate of western gray whales during three behavioral states. Display as in Figure 12.

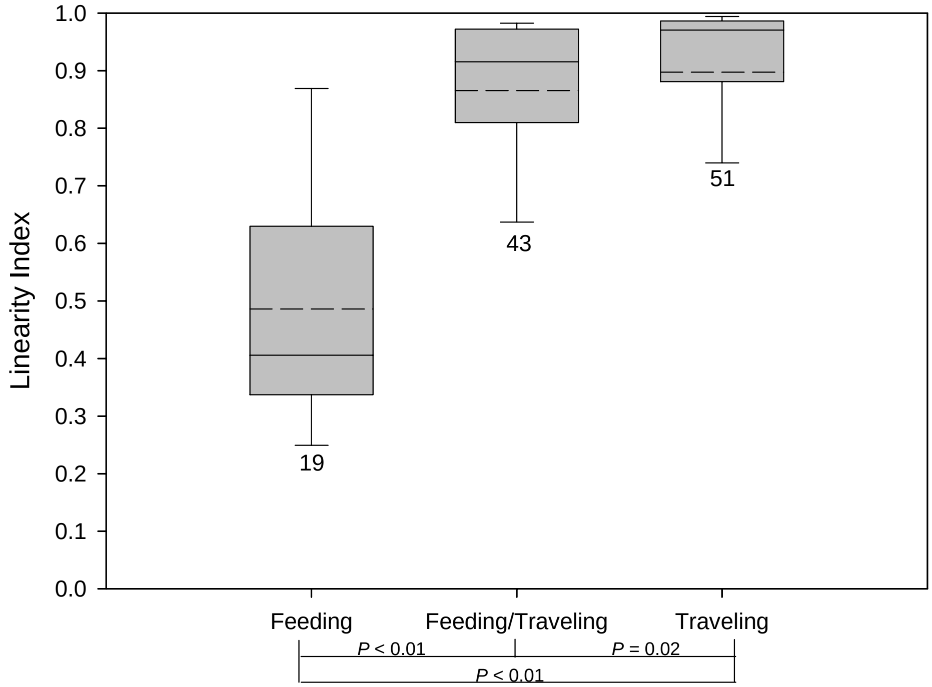

Figure 22. Linearity index of western gray whales during three behavioral states. Display as in Figure 12.

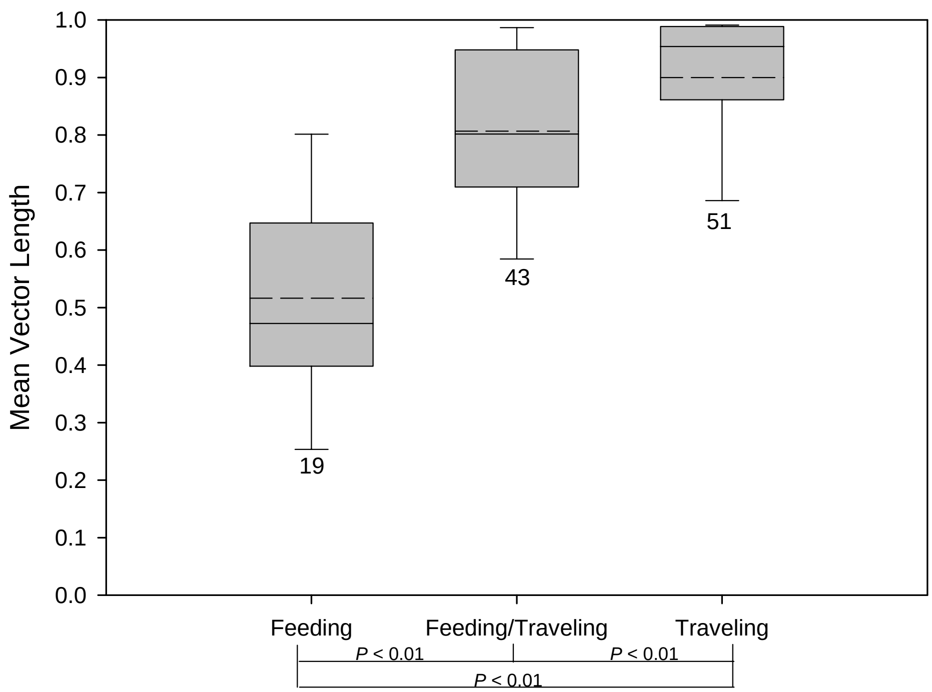

Figure 23. Mean vector length of western gray whales during three behavioral states. Display as in Figure 12.

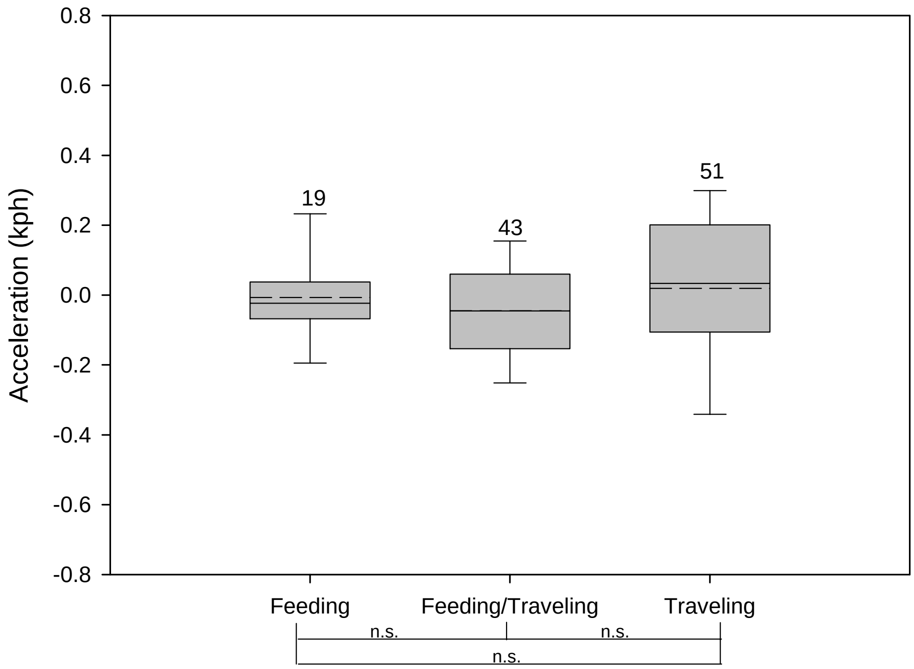

Figure 24. Acceleration of western gray whales during three behavioral states. Display as in Figure 12.

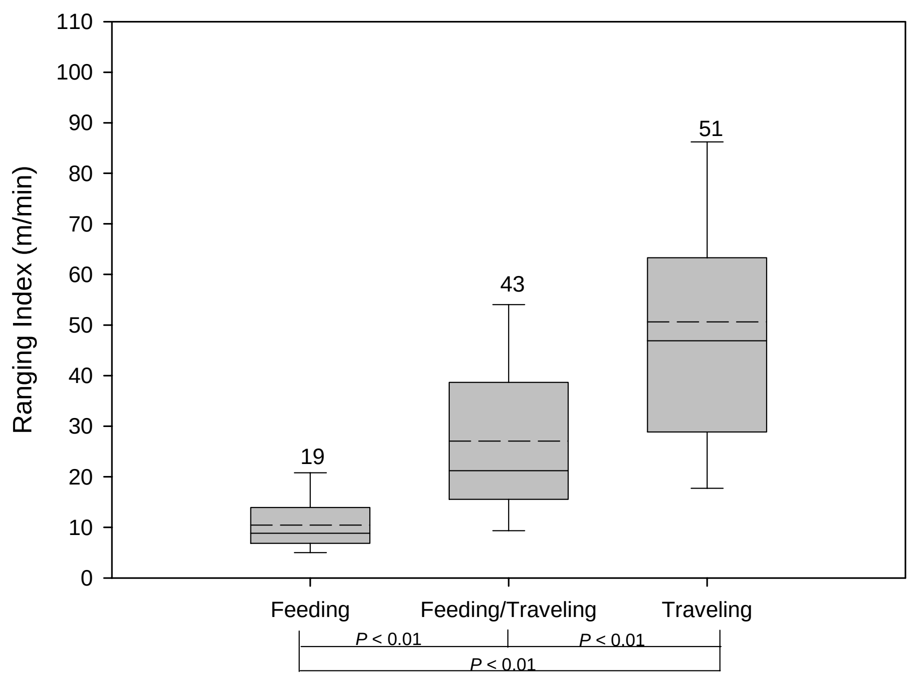

Figure 25. Ranging index of western gray whales during three behavioral states Display as in Figure 12.

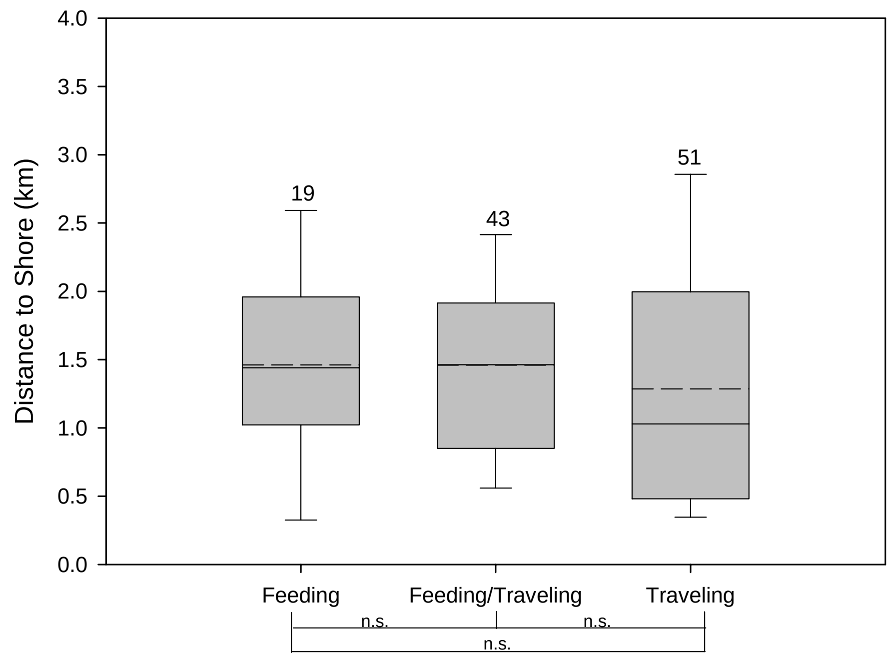

Figure 26. Distance to shore of western gray whales during three behavioral states. Display as in Figure 12.

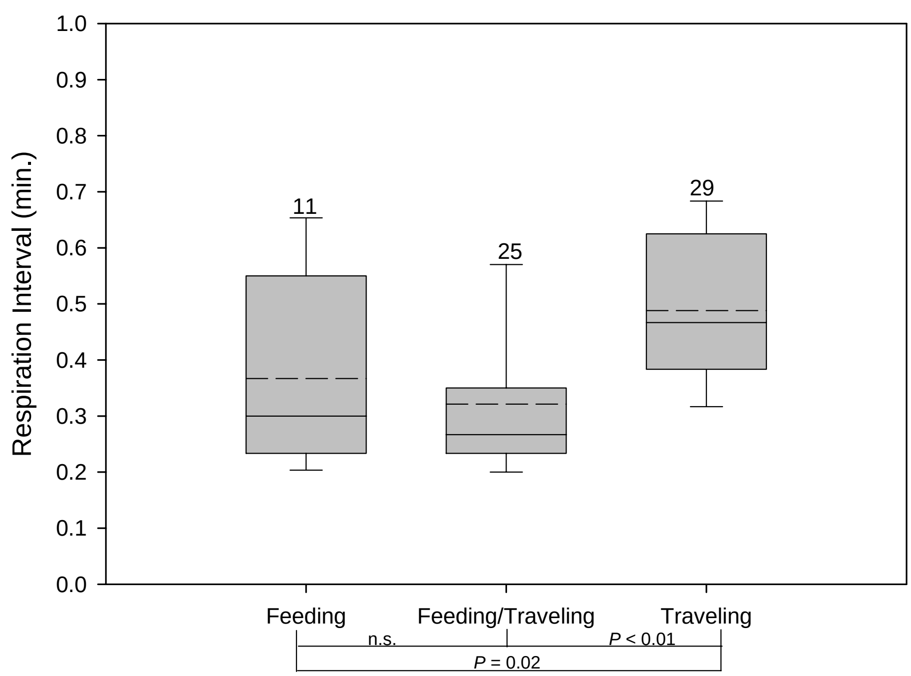

Figure 27. Respiration interval of western gray whales during three behavioral states. Display as in Figure 12.

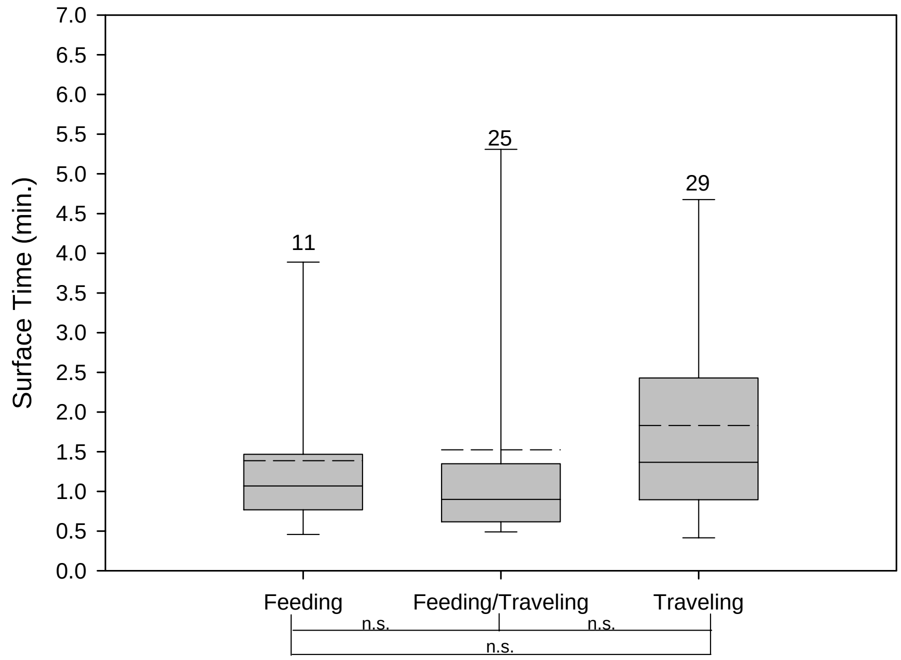

Figure 28. Surface time of western gray whales during three behavioral states. Display as in Figure 12.

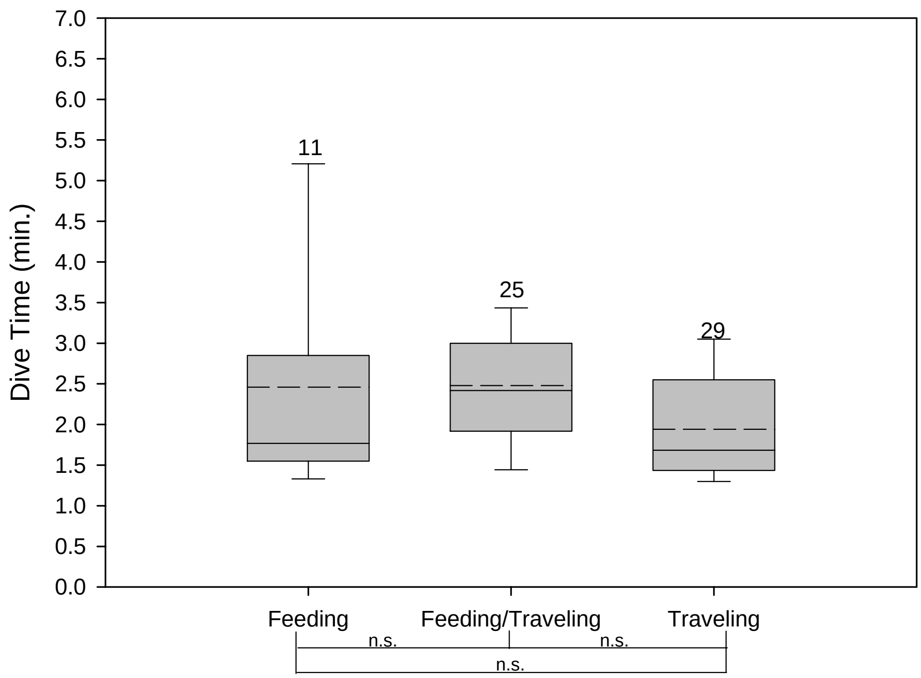

Figure 29. Dive time of western gray whales during three behavioral states. Display as in Figure 12.

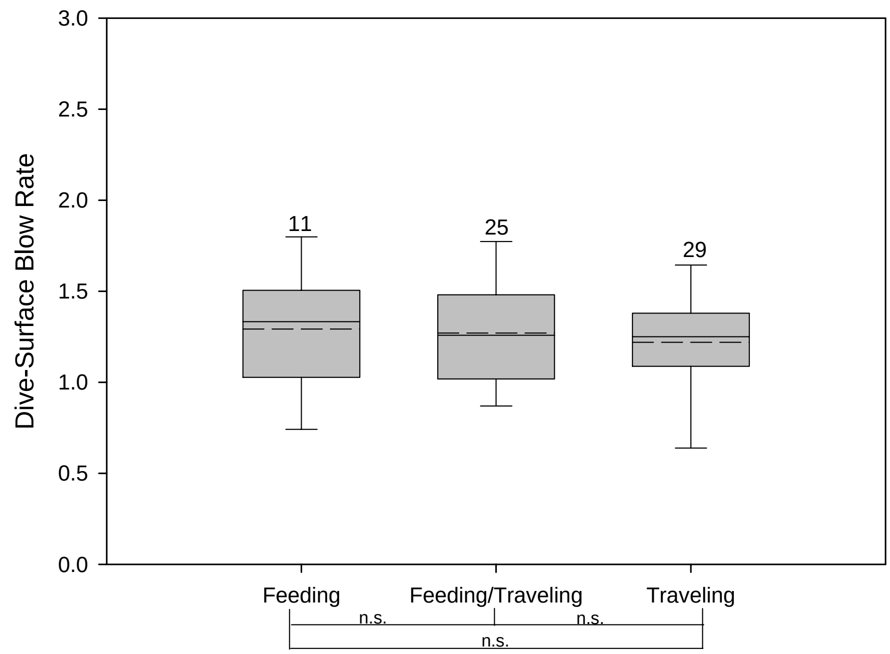

Figure 30. Dive-surface blow rate of western gray whales during three behavioral states. Display as in Figure 12.

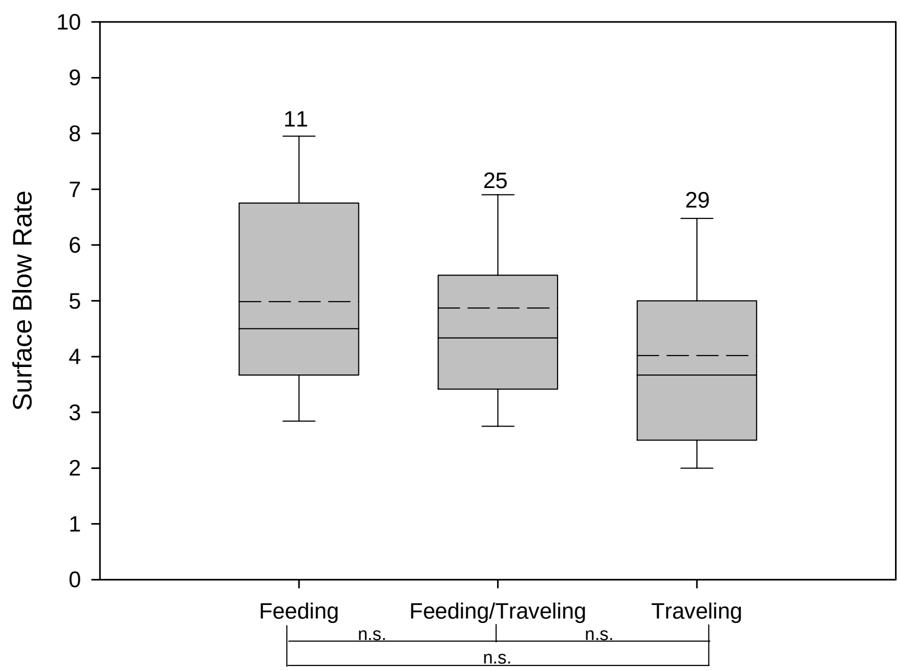

Figure 31. Surface blow rate of western gray whales during three behavioral states. Display as in Figure 12.

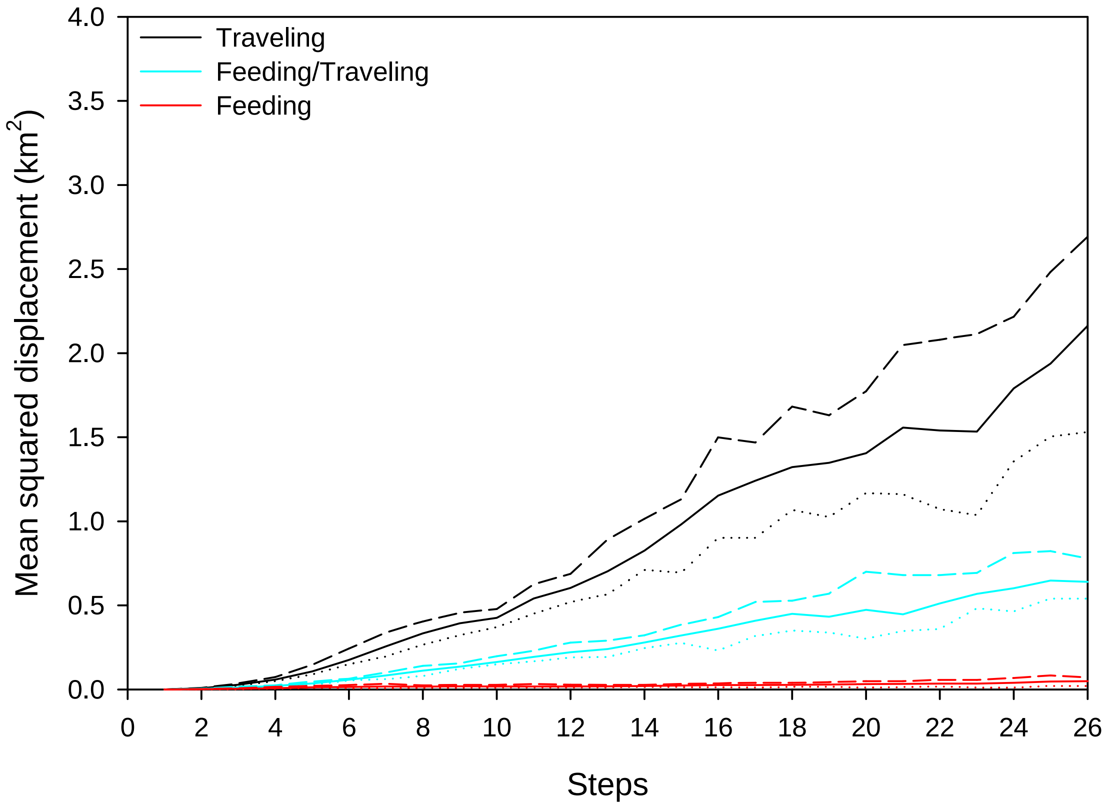

Figure 32. Mean squared displacement of western gray whales during three behavioral states. The upper and lower 95% confidence intervals are represented by dashed and dotted lines, respectively.

Social Activity – During the end of August and early September, more occasions of social activity were observed. During two (22 August and 7 September 2004) of the four occasions of social activity, the penis of at least one male was observed at the surface multiple times. During each of these occasions, the animals' behavioral and movement activities were similar. There were periods of surface-active behavior with flukes, pectorals, heads, and other parts of an animal's body above the surface of the water, and periods of apparent "chasing" where one animal would rapidly move away from the group and the rest of the social group would move after this animal. Once the other individuals "caught up" with the one that moved away, the surface activity would continue and similar active events were repeated. A mom-calf pair was engaged in this activity during one observation with the mom-calf pair being the first individuals moving away from the social group.

Killer Whales

Four groups of killer whales were observed in the study area during the 2004 field season. On 1 August 2004, two groups consisting of three and three-five individuals were sighted at 2nd Station, socializing and traveling north. The same group of 3-5 individuals was observed on the same day at Station 07. Another sighting of three killer whales traveling south was made at 2nd Station on 7 September. On 14 September, a single male killer whale was sighted at South and 1st Stations, traveling north. Gray whales were present in the study area (range: six-eleven gray whales in the study area based on scan information) during all four killer whale sightings. The closest approach observed between killer whale(s) and gray whales was approximately 1 km. During such occasions, gray whales did not appear to change their behavior, such as moving away from the killer whales or discontinue feeding, due to the killer whale(s) presence. No mom-calf pairs or alone calves were observed in the study area during the periods of killer whale(s) presence.

DISCUSSION

With the exception of the seismic survey late in the field season, the 2004 observations were relatively free of anthropogenic activity; therefore, we believe that these data represent good "baseline" information to be used towards understanding the biology, behavior, and habitat utilization of western gray whales on a daily, seasonal, and annual basis. As in the summers of 2001 thru 2003 (see Würsig *et al.* 2002, 2003 and Gailey *et al.* 2004 for all comparisons), gray whales were present on each day of the 24 days of observations and, on average, were 2.1 km from shore, indicating strong site fidelity to the study area which is most likely due to high concentrations of prey availability (114.1 g/m^2 concentrations for Amphipods; Fedeev 2002, 2003). Such fidelity for feeding gray whales has also been described for the eastern population (for example, Pike 1962, Hatler and Darling 1974, Würsig *et al.* 1986, Dunham and Duffus 2002), as well as the present one (Weller *et al.* 1999).

The numbers of whales and pods per scan observed in 2004 presented many changes from past years. The mean numbers of whales and pods were two-three times higher than had been sighted in the past three years. However, this increase could be partially due to the increased area of coverage (i.e. from 20° to 160° in 2001-2003 to 0° to 180° in 2004). Since the rate of the scan (area observed per time) remained consistent, the removal of sightings observed between 0° to 19° and 161° to 180° still yielded an increase in the number of whales and pods observed at stations in previous years (Table 11). The addition of our South Station was expected to yield higher concentrations of whales due to potential aggregation near the mouth of the Piltun lagoon area (Weller *et al.* 1999); however, relatively few numbers of whales and pods were observed there in 2004. During 2001-2003, the number of whales and pods at Station 07 provided similar numbers to 2nd Station and 1st Station, but, in 2004, the numbers of whales was found to be greater at Station 07. In 2001, considerably more whales occurred at the southern-most station, Mt. Kiwi, than at the four other more northerly stations. However, in 2002 - 2004, it was the northern-most station, Odoptu (just north of the 2001 northern station, Muritai) that had substantially more whales than any other station. In the earlier part of the 2001 field season, seismic surveys were conducted in the

Odoptu Block, and some whales may have avoided this area during that period (Yazvenko *et al.* 2002).

In summary, the number of whales and pods nearshore dramatically increased from the past three years of observations, with the highest concentration near the northern stations at Odoptu Station, North Station, and Station 07 (Table 11). The increase in the number of whales in the study area may be partially related to the observed (based on aerial surveys) decrease in the number of whales in the offshore feeding area (Yazvenko pers. comm.). Although we do not know the factors relating to the apparent distribution shift, we speculate that prey distribution was likely a key factor. If prey concentrations were much higher in the nearshore area or lower in the offshore area, it would be more energetically efficient and therefore preferential for the whales to feed nearshore. In addition, the nearshore area may offer some protection, especially for young calves, from potential predators such as killer whales.

Table 11. Summary of number of whales and pods per scan for 2001-2004. Stations proceed from highest latitude (North Station) to lowest latitude (South Station).

	Number whales			
Staion	2001	2002	2003	2004
North Station	-	-	-	5.7 ± 3.49 (23)
Odoptu Station	-	8.4 ± 4.59 (16)	5.6 ± 4.31 (29)	12.2 ± 5.77 (24)
Muritai	2.3 ± 1.49 (34)	-	-	-
Station 07	1.8 ± 1.35 (41)	3.3 ± 2.74 (29)	2.3 ± 3.32 (55)	5.9 ± 4.13 (31)
Midway	2.7 ± 1.87 (40)	-	-	-
2nd Station	2.3 ± 1.88 (34)	2.0 ± 1.83 (37)	1.8 ± 1.75 (37)	3.7 ± 2.95 (28)
Mt. Kiwi	4.0 ± 2.7 (42)	-	-	-
1st Station	-	1.9 ± 1.98 (35)	1.2 ± 1.84 (46)	3.1 ± 3.00 (45)
South Station	-	-	-	2.3 ± 2.35 (37)
	Number pods			
North Station	-	-	-	3.8 ± 2.10 (23)
Odoptu Station	-	5.7 ± 2.85 (16)	4.4 ± 3.01 (29)	8.4 ± 3.83 (24)
Muritai	1.6 ± 1.05 (34)	-	-	-
Station 07	1.3 ± 0.94 (41)	2.2 ± 1.75 (29)	1.7 ± 2.22 (55)	4.1 ± 2.35 (31)
Midway	2.0 ± 1.25 (40)	-	-	-
2nd Station	1.7 ± 1.29 (34)	1.5 ± 1.37 (37)	1.3 ± 1.22 (37)	2.4 ± 1.47 (28)
Mt. Kiwi	2.6 ± 1.43 (42)	-	-	-
1st Station	-	1.5 ± 1.40 (35)	1.0 ± 1.50 (46)	2.2 ± 1.89 (45)
South Station	-	-	-	1.7 ± 1.61 (37)

Despite an increase in the overall numbers of whales in the study area, the animal's movement patterns appeared similar to past movements. Speed of movement was a median of about 1.9 and mean of 2.2 kph. These speeds are consistent with the 2.3 and 1.9 mean speeds observed in 2003 and 2001, respectively, and those observed (albeit with limited data) in the eastern stock of gray whales in the Bering Sea (Würsig *et al.* 1986). However, these speeds are slower than those of 2002 (mean = 3.2 kph). In 2002, gray whales were observed traveling more throughout the study area. In fact, the overall speed in 2002 was very similar to the behavioral traveling speeds of 3.6 and 3.2 kph observed in 2003 and 2004, respectively. Although more data are needed to understand the "normal" movement patterns inter-annually, speeds and observations in 2002 indicate that animals were traveling more and spending less time in one area in that year. This could be representative of a different foraging strategy such as feeding on prey in the water column more as opposed to benthic feeding. Although the general speed of movement appeared to have been different in 2002, linearity, acceleration, reorientation rate, and mean vector length were all remarkably similar in 2001 thru 2004 (Table 12). Table 12 also presents data from off Piltun from the two years prior to the beginning of present work in 2001. We do not regard these earlier data to be closely comparable, since they were taken from a very different vantage point (the Piltun lighthouse), by different people than in the most recent four years, and by different categorizations and analytical approaches.

The surface-respiration-dive parameters observed in 2004 were similar to those observed in 2001 and 2003. In 2002, however, blow interval and dive time appear to be higher and lower, respectively, than observed in 2001, 2003, and 2004. The overall blow interval (mean = 0.5 ± 0.19)) and dive time (1.8 ± 0.80) observed in 2002 appear more indicative of the traveling behavioral states (blow interval = 0.5 ± 0.14 and dive time = 1.7 ± 0.64 for 2003 and 0.5 ± 0.15 and 1.9 ± 0.68 for 2004) of 2003 and 2004. Blow intervals, blows per surfacing, and surface times in 2001, 2003, and 2004, were comparable to those of bottom-feeding eastern gray whales in the northern Bering Sea (Würsig *et al.* 1986) and off Vancouver Island, Canada (Guerrero 1989). Dive times were generally lower than those of eastern gray whales reported to date, which is likely a factor of the shallow depth of the present study area. For example, Würsig *et al.* (1986) found a general increase in dive time in deeper (> 20 m) water.

Theodolite tracking demonstrated three major behavioral types: 1) feeding; 2) feeding/traveling; and 3) traveling through the area, often parallel to the coastline. Unlike 2001 and 2002, but similar to 2003, more social activity was observed towards the end of August and early September, which corresponds with the apparent seasonal increase of social activity. Our observation of an increase in social behavior in late summer is remarkably similar to what was described off St. Lawrence Island, with eastern gray whales socializing more in September than in July (Würsig *et al.* 1986). Our descriptions are especially similar to the precopulatory and apparent copulatory activities described earlier by Sauer (1963) and Fay (1963). While we do not know whether the observed activities represent "serious" copulation among animals, it is of interest that a tendency exists for more such social/sexual play in the late than in the early feeding season, in both gray whale populations. It is presently unknown whether the behavior is due to gray whales having successfully fed and are now able to engage in other activities, this marks the early beginning of the mating season, or for some other reason. Given the gestation period of gray whales (11-13 months), it is likely that such social/sexual behavior observed in the feeding grounds serves some unknown non-reproductive purpose.

Speed, reorientation rate and ranging index were significantly different between each of the behavioral states of feeding, traveling, and feeding/traveling in 2003 and 2004. Linearity and mean vector length were significant between all behavioral states in 2004. However, these parameters were not different between feeding/traveling and traveling in 2003 (see Gailey *et al.* 2004). This difference is potentially due to the smaller sample size ($N_{traveling} = 11$, $N_{feeding/traveling} = 22$, $N_{feeding} = 20$) in 2003 than in 2004 ($N_{traveling} = 51$, $N_{feeding/traveling} = 43$, $N_{feeding} = 19$). In 2004, respiration interval was also different between feeding and traveling, and feeding/traveling and traveling, but non-significant between feeding and feeding/traveling. Time between subsequent blows was longer when individuals were traveling and similar when individuals were feeding. In 2003, respiration interval was only different between feeding and traveling behavioral states, but sample size was smaller in 2003 ($N_{traveling} = 8$, $N_{feeding/traveling} = 13$, $N_{feeding} = 16$) than in 2004 ($N_{traveling} = 29$, $N_{feeding/traveling} = 25$, $N_{feeding} = 11$). An examination of different activities in conjunction with knowledge of potential prey types and concentrations may provide further insights into different foraging strategies and habitat utilization.

In summary, the observations of western gray whales on their feeding grounds in 2004 showed an increase in the number of whales and pods throughout the study area compared to data collected in 2001-2003. Despite this increase, the movement and respiration parameters monitored were comparable to data collected in 2001 and 2003. Some parameters, such as speed, dive time, and respiration interval, appear to be different in 2002 (although proper inter-annual analyses need to be conducted), potentially indicating a different foraging strategy or change in prey availability in the study area. While more data are needed to explore inter-annual, seasonal, and geographic patterns of western gray whales, we believe that the information collected in 2002 thru 2004 provides a good baseline of information to explore the "natural" variability in their behavior, and better understand habitat utilization throughout the observed study area. Since the primary reason that gray whales migrate to this area each summer is to forage, our interpretation of behavioral observations would be greatly enhanced from an incorporation of data on prey concentrations in the study area, gathered since 2002 (Fadeev 2003, 2004, 2005). Therefore, additional analyses will be conducted to overlay prey densities with behavioral observations. Furthermore, due to the likely increase in anthropogenic activity related to oil/gas project development and the concern of possible cumulative impacts, acoustic information would be desirable to evaluate potential behavioral disturbances of gray whales. We believe that combinations of behavioral observations, acoustic data, and benthic studies would provide an excellent monitoring strategy to identify problems, and to suggest alternatives to management practices that may be impacting this critically endangered population of gray whales, while filling in basic information on their life history, behavior, and habitat utilization.

Table 12. Summary statistics for theodolite and focal behavior data collected during 1997, 1998, and 2001 - 2004. Dashes (-) separate numbers that indicate ranges; plus/minus (±) separate means and standard deviations, and numbers in parentheses are sample sizes.

Variable	1997 (Würsig et al. 1999)	1998 (Würsig et al. 2000)	2001 (Würsig et al. 2002)	2002 (Würsig et al. 2003)	2003 (Gailey et al. 2004)	2004 (Present Report)
Leg Speed (kph)	1.5-2.0	1.7± 1.4	1.9 ± 1.49 (510)	3.2 ± 2.06 (74)	2.3 ± 1.04 (47)	2.2 ± 1.30 (116)
Linearity	0.70 - 0.90	0.78± 0.40	0.8 ± 0.23 (482)	0.8 ± 0.24 (74)	0.8 ± 0.29 (47)	0.8 ± 0.23 (116)
Acceleration (kph)	-	-	0.0 ± 0.71 (506)	0.1 ± 0.50 (74)	0.0 ± 0.23 (47)	0.0 ± 0.22 (116)
Reorientation Rate (°/min.)	8 – 13	7.0± 6.12	17.4 ± 13.72 (506)	21.0 ± 19.32 (74)	26.0 ± 18.76 (47)	19.1 ± 15.17 (116)
Distance to Shore (km)	1 – 3	<1 – 2	1.1 ± 0.66 (510)	-	2.3 ± 1.23 (283)	2.1 ± 1.45 (984)
Mean Vector Length	-	-	0.8 ± 0.26 (482)	0.8 ± 0.27 (74)	0.7 ± 0.29 (47)	0.8 ± 0.22 (116)
Ranging Index	-	-	-	-	31.1 ± 18.06 (47)	32.9 ± 22.31 (116)
Blow Interval (blows/min.)	0.46± 0.17	0.37± 0.196	0.4 ± 0.14 (271)	0.5 ± 0.19 (46)	0.4 ± 0.13 (34)	0.4 ± 0.17 (64)
Blows per Surfacing	4.7± 4.33	3.7± 2.24	5.2 ± 3.93 (234)	4.9 ± 4.45 (42)	4.2 ± 1.38 (34)	4.2 ± 1.63 (64)
Surface Time (min.)	1.8± 2.48	1.0± 1.03	1.6 ± 1.84 (241)	1.7 ± 1.50 (42)	1.7 ± 1.78 (34)	1.8 ± 1.73 (64)
Dive Time (min.)	1.7± 0.53	2.3± 0.99	2.5 ± 0.92 (239)	1.8 ± 0.80 (44)	2.2 ± 0.77 (34)	2.4 ± 0.80 (64)
Dive-Surface Blow Rate	1.2± 0.40	1.1± 0.43	1.2 ± 0.34 (236)	1.3 ± 0.32 (42)	1.3 ± 0.42 (34)	1.2 ± 0.32 (64)

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APPENDIX 1. Daily summary of theodolite, focal behavior, and scan data collected during the summer of 2004.

Station	Date	Start Day	End Day	Effort (hrs)	# Tracklines	# Focal Follows	# Scans
South_Station	31-Jul-04	9:09:26	17:26:16	8.28	2	0	6
1st_Station		6:30:00	17:34:00	11.07	6	1	6
2nd_Station	1-Aug-04	8:18:41	17:18:05	8.99	2	2	5
Station_07		9:11:36	18:10:46	8.99	4	2	7
Odoptu_Station	2-Aug-04	7:05:51	14:09:46	7.07	2	1	5
North_Station		8:16:04	13:36:03	5.33	3	0	3
South_Station	3-Aug-04	10:20:20	16:36:51	6.28	2	1	3
1st_Station		9:34:00	17:29:22	7.29	0	3	7
2nd_Station	6-Aug-04	7:36:14	13:25:13	5.82	2	0	4
Station_07		7:53:56	16:03:22	8.16	5	3	6
2nd_Station	8-Aug-04	8:28:52	12:10:38	3.7	1	0	0
Station_07		8:52:23	13:17:37	4.42	0	0	0
Odoptu_Station	13-Aug-04	8:39:15 11:11:30	10:56:51 11:52:37	2.98	2	0	1
North_Station		9:19:44	16:31:31	7.2	4	2	2
Odoptu_Station	15-Aug-04	10:00:30	16:13:03	6.21	5	1	3
North_Station		11:04:10	16:01:13	4.95	1	0	4
South_Station	16-Aug-04	8:14:11	17:24:34	9.17	3	2	7
1st_Station		7:21:18	18:35:40	11.24	4	3	9
2nd_Station	17-Aug-04	7:39:28	16:57:24	9.3	1	1	7
Station_07		6:55:31	18:13:26	11.3	4	2	9
Odoptu_Station	22-Aug-04	7:33:49	17:18:47	9.75	13	3	7
North_Station		7:37:07	15:58:33	8.36	4	3	7
South_Station	27-Aug-04	8:37:57	16:29:00	7.85	0	0	5
1st_Station		8:15:50	17:20:52	9.08	1	0	7
2nd_Station	29-Aug-04	7:47:33	15:56:50	8.15	2	0	4
Station_07		7:35:41	16:27:51	8.87	5	1	3
Odoptu_Station	4-Sep-04	8:04:42	16:21:07	8.27	5	2	2
North_Station		7:39:15	15:00:43	7.36	4	1	3
South_Station	5-Sep-04	8:22:37	16:28:01	8.09	4	2	7
1st_Station		7:42:48	18:00:58	10.3	5	3	6
2nd_Station	7-Sep-04	8:53:22	17:01:09	8.13	5	1	3
Station_07		8:22:53	17:18:32	8.93	6	3	4
Odoptu_Station	8-Sep-04	8:25:16	15:40:08	7.25	7	4	3
North_Station		10:04:02	14:22:02	4.3	3	2	2
South_Station	10-Sep-04	9:02:51	15:45:33	6.71	2	1	5
1st_Station		8:46:24	16:23:18	7.62	2	2	5
2nd_Station	11-Sep-04	8:15:33	17:52:51	9.62	6	4	5
Station_07		7:51:48	18:30:33	10.65	3	2	2
Odoptu_Station	13-Sep-04	7:51:56	14:35:06	6.72	5	3	3
North_Station		7:24:04	13:18:39	5.91	4	0	2
South_Station	14-Sep-04	8:23:34	15:52:47	7.49	4	4	4
1st_Station		7:52:24	17:26:42	9.57	4	2	5
2nd_Station	19-Sep-04	11:16:49	17:26:03	6.15	2	0	4
Station_07		11:45:00 13:13:38	13:00:08 16:40:50	4.71	6	4	2
Station_07	20-Sep-04	9:36:19	11:43:57	2.13	2	0	0
Odoptu_Station	21-Sep-04	8:59:22	13:35:47	4.61	3	1	2
North_Station		9:20:31	12:36:20	3.26	2	2	0
TOTAL				348.19	162	71	196