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Sakhalin Energy Investment Company LTD.

Western Gray Whale Behavior, Movement, and Occurrence Patterns off Sakhalin Island, 2005

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Western Gray Whale Behavior, Movement, and Occurrence Patterns off Sakhalin Island, 2005

Photo taken from shore at North Station, G. Gailey

Glenn Gailey, Olga Sychenko, and Bernd Würsig

March 2006

FAR EAST BRANCH OF THE RUSSIAN ACADEMY OF SCIENCES

MARINE BIOLOGY INSTITUTE

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REPORT
ON SCIENTIFIC RESEARCH

PHOTOGRAPHIC IDENTIFICATION OF GRAY WHALES (*ESCHRICHTIUS ROBUSTUS*) OF THE KOREAN-OKHOTSK POPULATION ON THE NORTHEAST SHELF OF SAKHALIN ISLAND, RUSSIA, 2005

Final report

Research Supervisor,
Candidate of Biological Sciences Yu. M. Yakovlev

VLADIVOSTOK
2006

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INTRODUCTION, RATIONALE, AND BRIEF OVERVIEW OF RESULTS

The western stock of gray whales (*Eschrichtius robustus*) is one of the most critically endangered large baleen whale populations in the world (USFWS 1997, Red Book of the Russian Federation 2000, Hilton-Taylor 2000). The current population size is likely to be slightly over 110 individuals that feed off the northeastern area of Sakhalin Island in the summer-fall (Yakovlev and Tyurneva 2006). For the past eight years, considerable research on occurrence patterns, foraging and other behaviors, behavior relative to industrial activities, and genetics has taken place in order to understand and monitor the population during their summer-fall (June – October) foraging period (summaries in Blokhin *et al.* 2003 a, b, Fedeev 2002, 2003, 2004, 2005, LeDuc *et al.* 2002, Meier *et al.* 2002, Vladimirov *et al* 2005, Weller *et al.* 1999, 2002 a, b, Würsig *et al.* 2002, 2003, Yakovlev and Tyurneva 2003, 2004, 2005, Yazvenko *et al.* 2002, Gailey *et al.* 2004, 2005). It is currently unknown where western gray whales spend winter and spring, but it is assumed that mating, calving, and early calf rearing take place in or near coastal waters of the South China Sea (Jones and Swartz 2002).

The primary feeding grounds of western gray whales overlap with existing and planned oil and gas development being conducted by the operators of the Sakhalin II (Sakhalin Energy Investment Company (SEIC)) and Sakhalin-1 (Exxon Neftgas Limited (ENL)) projects. Sakhalin II and Sakhalin-1 have sponsored several monitoring programs to understand natural variation and potential impacts that their activities may have on western gray whale behavior, movement, abundance and population trends. Such continual monitoring and active mitigation provide a better understanding of the population, and minimize stress and potential effects of industrial activity.

One of the primary concerns in the short- and long-term is the amount and levels of sound in relation to oil and gas project development and operation (vessel traffic, drilling, dredging). The effects of marine sounds on baleen whales have been documented for a number of species, such as bowhead whales (Ljungblad *et al.* 1988; Reeves *et al.* 1984; Richardson *et al.* 1999; Richardson *et al.* 1986), humpback whales (McCauley *et al.* 2000; McCauley *et al.* 1998), and gray whales (Malme and Miles 1985; Malme *et al.* 1986). For eastern gray whales, Malme *et al.* (1986) found that ~10% of the whales stopped feeding and moved away from seismic sounds when received sound levels near the whales exceeded 163 dB re 1μPa (rms). For more continuous sounds, Malme *et al.* (1986) observed 10-50% of feeding eastern gray whales avoiding an area exposed to industrial noise levels of 120 dB. Western gray whales have also been documented to respond to sounds produced during seismic surveys (Gailey *et al.* Submitted; Johnson *et al.* Submitted; Weller *et al.* 2002; Würsig *et al.* 1999; Yazvenko *et al.* Submitted).

During the summer of 2005, SEIC initiated construction of the Piltun Astokh-B (PA-B) platform with the placement of a Concrete Gravity Based Structure, or CGBS. The PA-B platform is located near-shore (~13 km from shore in 30 m water depth) and in close proximity to the Piltun feeding area. Placement of the CGBS consisted of four main phases: 1) Installation of anchor stations by two anchor handling tug supply vessels (AHTS), 2) CGBS tow-in with five AHTS's, 3) CGBS positioning and placement, and 4) scour protection. Anchor installation commenced on 27 July and after placement of the CGBS on 1 August offshore activities continued (including scour protection) throughout our observation time until 7 September. Because of the proximity of the PA-location to the Piltun feeding area and the potential impact on whales from sounds generated during the CGBS installation, SEIC had developed a noise mitigation strategy that was implemented prior to the placement of the CGBS, in conjunction with acoustic and behavior monitoring programs before and during the offshore activities.

The data on whale locations, movements, and behaviors were analyzed using univariate techniques comparing a "control" area to a potential impact area. The control area consisted of all observations prior to 27 July when installation activities began and data from the four northern-most stations that would have a lower likelihood of disturbance by the installation throughout the observation period. The potential impact area consisted of stations in closer proximity to the installation from the time anchors were installed through scour protection, or the time of PA-B activity.

A more detailed multivariate analysis is currently being conducted that will incorporate environmental, temporal, and sound level information to examine potential impacts the construction activity may have had on western gray whales and these analyses will be submitted in a later report (Gailey *et al.* proposal, January 2006). No effects on whale behavior were noted using univariate statistical techniques for whales exposed to sounds from seismic activity during 2001 whereas 5 of 11 behavioral parameters were statistically correlated to sound energy levels using multivariate techniques, while six parameters were not correlated with sound level. For example, at higher received sound energy exposure levels, whales traveled faster, changed directions of movement less, were recorded further from shore, and stayed under water longer between respirations (Gailey *et al.* Submitted).

As had been the case for the effort in 2001-2004, we monitored gray whale behaviors to provide long-term observations of habitat use, distribution, movement, and behavior of individuals and groups in the Piltun feeding area. The onshore platform used had the advantage that it was some distance from the whales, thereby avoiding the possibility of the observing station(s) being a source of disturbance. We conducted three primary observation methods: 1) scan sampling to obtain relative abundance estimates, distribution, and group size information; 2) theodolite tracking of individuals or groups to describe spatial movement, orientations, speeds, and habitat use; and 3) focal animal observations to monitor 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 feeding area, and the amount of variability that can exist annually, seasonally, and geographically. Such information will be used during project design and implementation to help realize effective management strategies to protect the whales and their foraging habitat.

The 2005 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. We provided data on behavior of whales in locations well removed from the construction activity and from locations in closer proximity to the operations starting before construction commenced and continuing until 7 September. Potential disturbance activities investigated included those related to CGBS installation, small research vessels in the area to photo-identify whales, and the occasional presence of killer whales (*Orcinus orca*). The field season commenced on 12 July 2005 and ended on 7 September 2005. The season had 26 days of effort, 92 scan samples with 509 sightings of 697 whales, 172 theodolite tracklines encompassing 9,106 geographic positions in 154 hours of tracking, and 67 focal animal follows of individual gray whales, for 56 hours of behavior.

METHODS

Research methods used in 2005 were generally consistent with those implemented in 2001-2004, and much of this section is repeated from Würsig *et al.* (2002, 2003) and Gailey *et al.* (2004, 2005). Data analyses also followed similar protocols as used before, but with inclusion of some new techniques, identified below.

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 north of the mouth of Piltun Bay, 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.

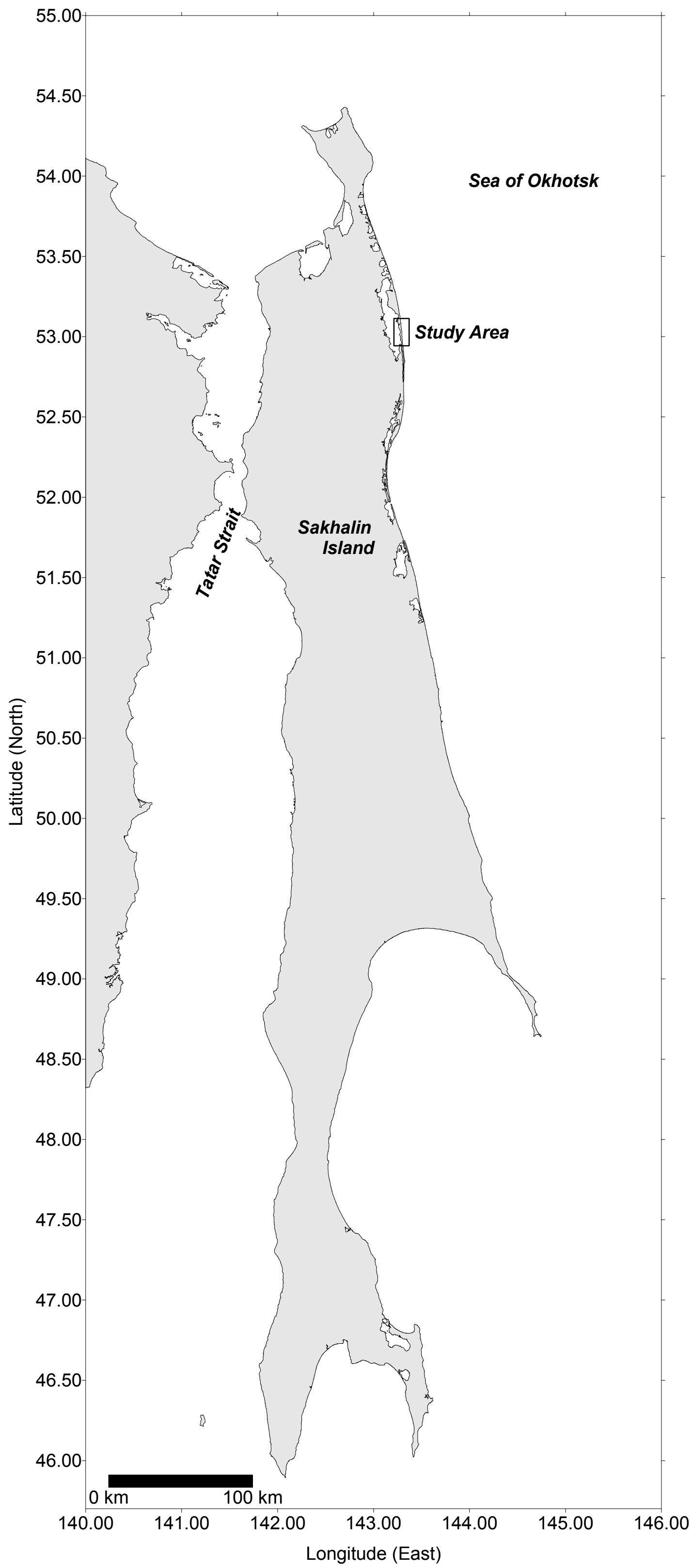


Figure 1. Study area in the northeastern portion of Sakhalin Island in Far East Russia. Figure 2 shows details of the study area.

Shore-Based Observations

Six geographic locations were chosen to conduct behavioral observations on western gray whales during the summer of 2005 (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 logistical difficulty of moving between stations, one day of effort was dedicated to one pair of shore-based stations. Station selection proceeded systematically from south to north. Once the northern-most stations were 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 covered all six stations after three favorable weather days. Two stations (2nd Station and Station 07) had 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 Name	Latitude	Longitude	Height (m)
North Station	53°18'22.8"	143°12'35.3"	18.82
Odoptu Station	53°12'33.1"	143°14'51.2"	16.37
Station 07	53°07'29.8"	143°16'12.5"	7.39
2nd Station	53°03'08.8"	143°17'04.5"	8.39
1st Station	52°58'27.2"	143°18'07.5"	9.75
South Station	52°53'23.1"	143°19'06.2"	7.14

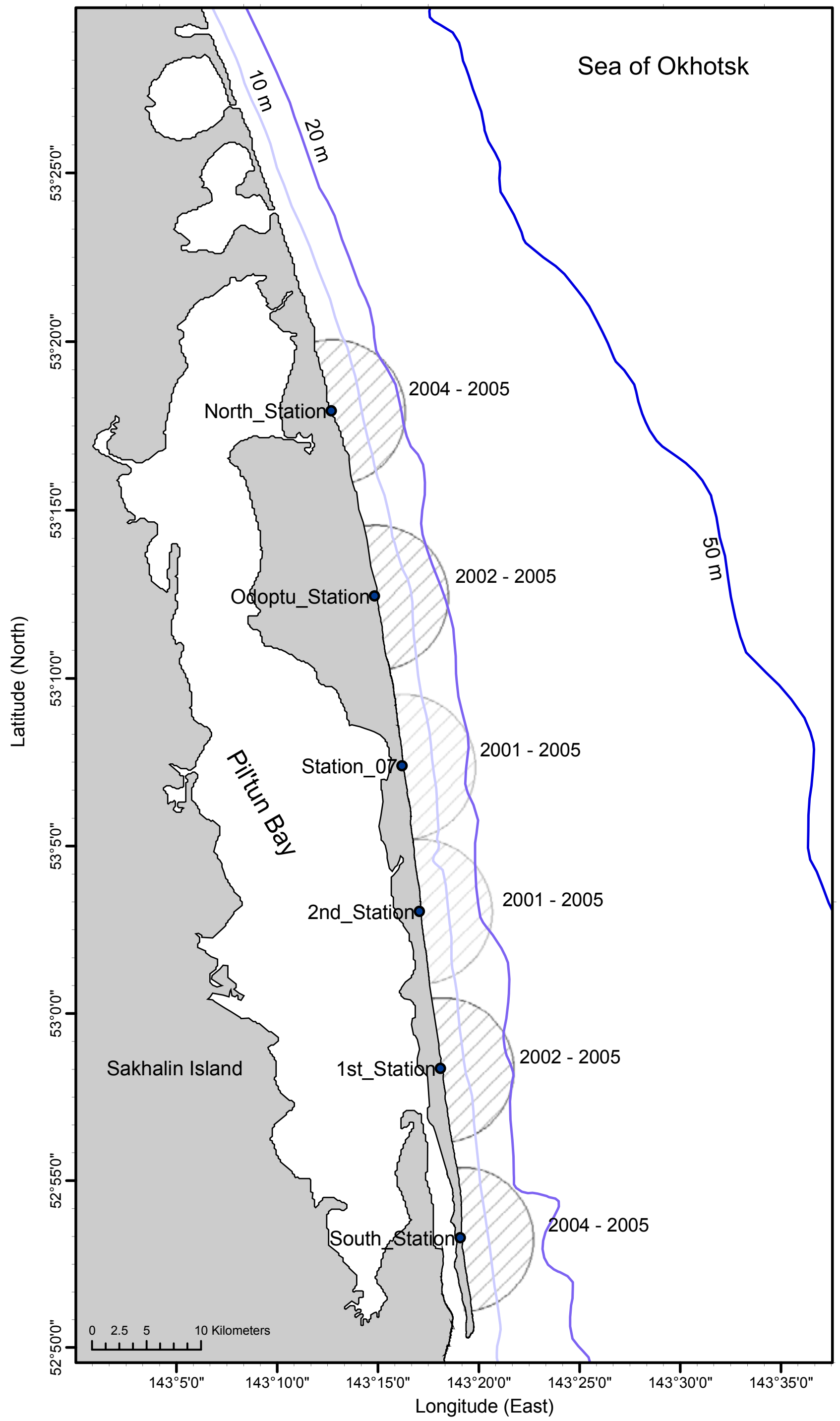


Figure 2. Geographic positions of six shore-based stations in the northeastern coastal region of Sakhalin Island, Russia. Semi-circular grids illustrate approximate viewable range (4 km) from each shore-based station. Dates indicate years when data were collected at each station.

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 =12.21° West in summer of 2005). 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 - 2005 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 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 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 to monitor behavioral and surface-respiration-dive parameters of individual gray whales. 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.

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, the detection range probabilities between different stations are likely to be an influencing factor when comparing relative abundance values between different stations. For example, the theoretical distance to the horizon of the highest observation point (North Station, 18.84 m) is 15.5 km, while the lowest vantage point (South Station, 7.14 m) distance to the horizon is 9.5 km. Therefore, an observer could potentially detect a whale 6 km further at North Station than at South Station and the relative number of whales could potentially be higher at North Station, simply due to increased detection ranges. To fairly compare relative abundance values between different stations, a threshold distance of $\leq$ 6 km was chosen based on evaluating the frequency distribution of sightings in relation to distance from station (i.e. distance from the observer) and the station's relative height (Figure 3). At the stations with lower elevations, relatively few sightings were observed beyond 6 km from the observer, while more frequent sightings occurred at the stations with higher elevations (North and Odoptu Stations). For other analyses that were dependent on geographic location and not relative abundance estimates, such as distance from shore, a greater threshold distance of 10 km from the observation station was taken. The rationale for the increased threshold distance for the distance from shore analysis was to increase the coverage area to incorporate sightings further from shore to be represented in the analysis.

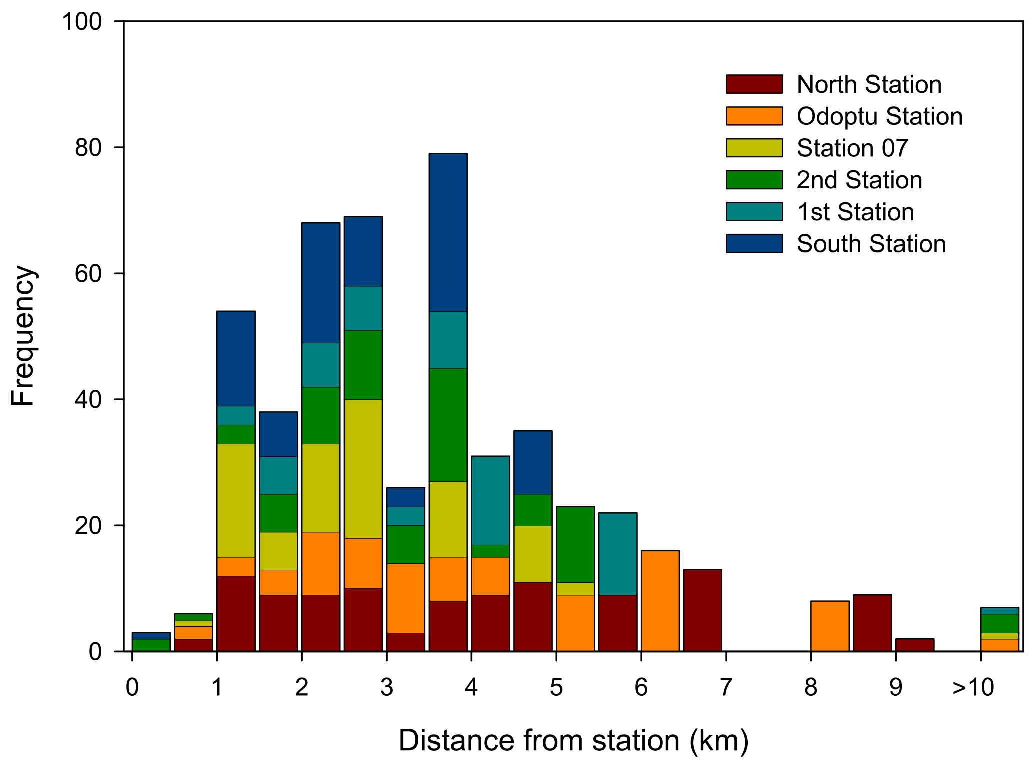


Figure 3. Sighting distances of western gray whales from six shore-based vantage points.

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 western gray whale 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 criterion 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 10.5 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 10.5-min intervals per tracking/focal follow session. "Binning" involved combining locations within intervals of time lasting approximately 10.5 min, and viewing the interval of time as the basic observation unit upon which responses and explanatory variables were measured. Each 10.5-minute 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 bin was randomly selected from each trackline or focal behavior session. Therefore, the sampling unit used for analyses was one bin representative per trackline or focal behavior session.

Vessels – Scan sampling, focal behavior and movement variables were examined in relation to vessel activity in the study area. To evaluate if the number of whales changed in response to the number of vessels observed during each scan, a correlation analysis was conducted. To directly evaluate the movements of gray whales in relation to vessel activities, the distance and relative orientation of each trackline were analyzed. The relative orientation is estimated with a scheme devised by Bejder (1999) to interpret directional movements of one object in relation to another. This technique allows for a quantifiable description of approaches and avoidances between objects at known distances, and can be used to describe potential impacts of anthropogenic activity on marine mammals (Gailey 2001). Two different distance criteria were taken to examine zodiac research vessels were approaching gray whales photo-identification purposes and other vessels that were not intentionally approaching gray whales. For the Photo-ID vessels, bins were selected based on the closest distance approach between the zodiac and whale with a minimum distance criteria of 0.5 km. Due to limited sample size, non-photo-identification vessel (referred to as "other" vessels) close approach distance criterion was taken at 2 km from the whale. Each above-mentioned movement and focal behavior variable was examined in relation to these close vessel-whale approaches. A Mann-Whitney U statistical test was used to examine potential differences in movement and respiration parameters during vessel approaches, compared to data when no vessel activity (i.e. "normal" variation) was observed in the study area. Because of the different distance criteria between zodiacs and larger vessels, we cannot make direct comparisons of disturbance between the two.

<u>CGBS Installation</u> – To broadly assess potential disturbance of gray whales during the CGBS installation, movement and respiration data were partitioned into two categories: 1) Control and 2) PA-B Activity. These categories were defined with the assumption that any potential observable impact would likely occur at the observation stations closest to the installation activity. Therefore, the control category consisted of all data prior to any construction activity (before 27 July) and data during construction at the four most northern stations (stations furthest away from the activity). The PA-B Activity category consisted of all data at the two closest stations (South Station and 1st Station) during anchor installation and scour protection activity (27 July to 7 September). Unfortunately, weather conditions (primarily fog) hampered observations during the CGBS tow-in and placement. A one-way analysis of variance was used for movement and focal follow analyses.

For scan sampling analyses, data were partitioned into before and during the construction activity for each station to determine if potential shifts in relative abundance occurred between different stations prior to and during the construction activity. A two-way analysis of variance test was conducted to evaluate potential differences in the number of whales before and during activity at the different observation stations.

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 2005 field season commenced on 12 July 2005 and ended on 7 September 2005. A total of 51 (with both stations, 26 actual) days (332 hrs) of effort was spent at the six shore-based stations (Table 2, Appendix 1). The first day of data collection started on 12 July at South and 1st Stations. The last field day of effort was 7 September at Odoptu and North Stations.

Table 2. Total amount of effort at six shore-based stations during 12 July to 7 September, 2005.

Station	Days	Effort (hrs)
North Station	7	35.39
Odoptu Station	7	40.09
Station 07	8	51.88
2nd Station	9	72.66
1st Station	11	75.18
South Station	9	57.53
Total	51	332.73

Scan Data

General – A total of 92 scans with 697 whales from 509 sightings were accumulated for the duration of the study (Table 3). Distribution of sightings from the six stations is quantified in Figure 3 and shown in Figure 4 and 5; although whales could be sighted more than 10 km distance from the station with the highest elevation (North Station, 18.9 m), sightings were generally < 5 km from shore (Figure 6; Table 4).

Table 3. Summary of scans during 2005 at six shore-based stations.

Station	# Scans	# Sightings	# Individuals
North Station	10	106	151
Odoptu Station	11	86	116
Station 07	21	85	118
2nd Station	18	78	109
1st Station	16	63	76
South Station	16	91	127
Total	92	509	697

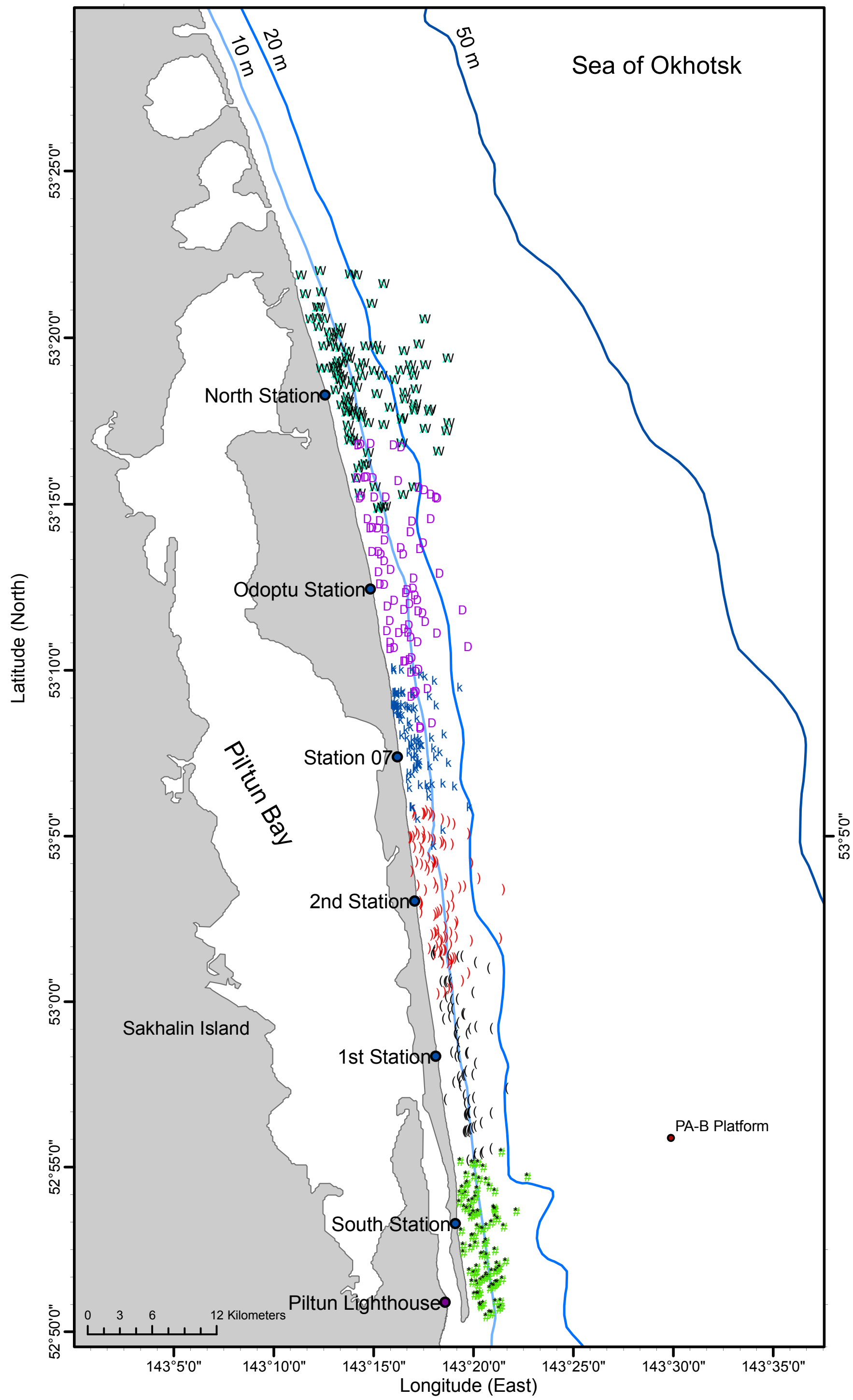


Figure 4. Geographic positions of all sightings of western gray whales at six shore-based stations on Sakhalin Island, summer 2005.

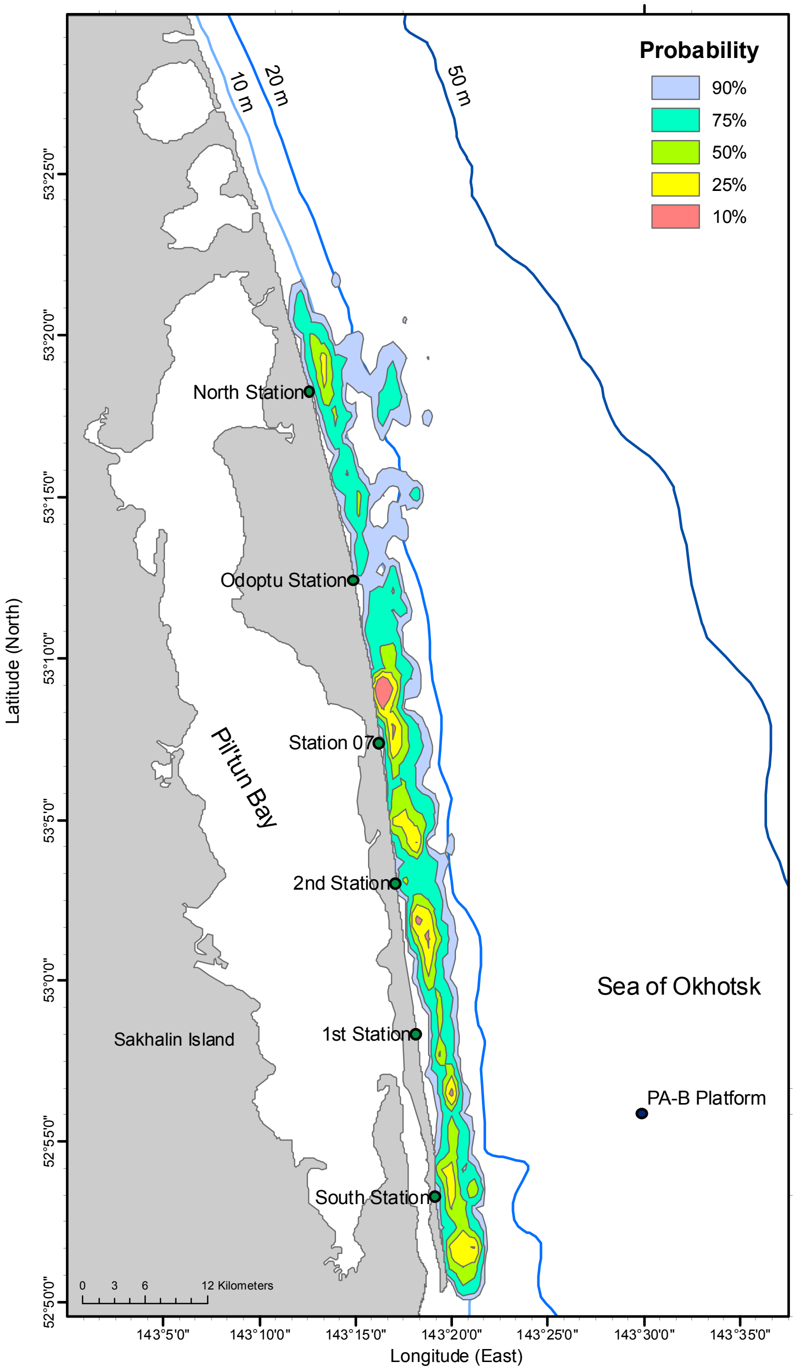


Figure 5. Distribution of western gray whales during the summer of 2005. Blue – red represents the kernel density probability contours.

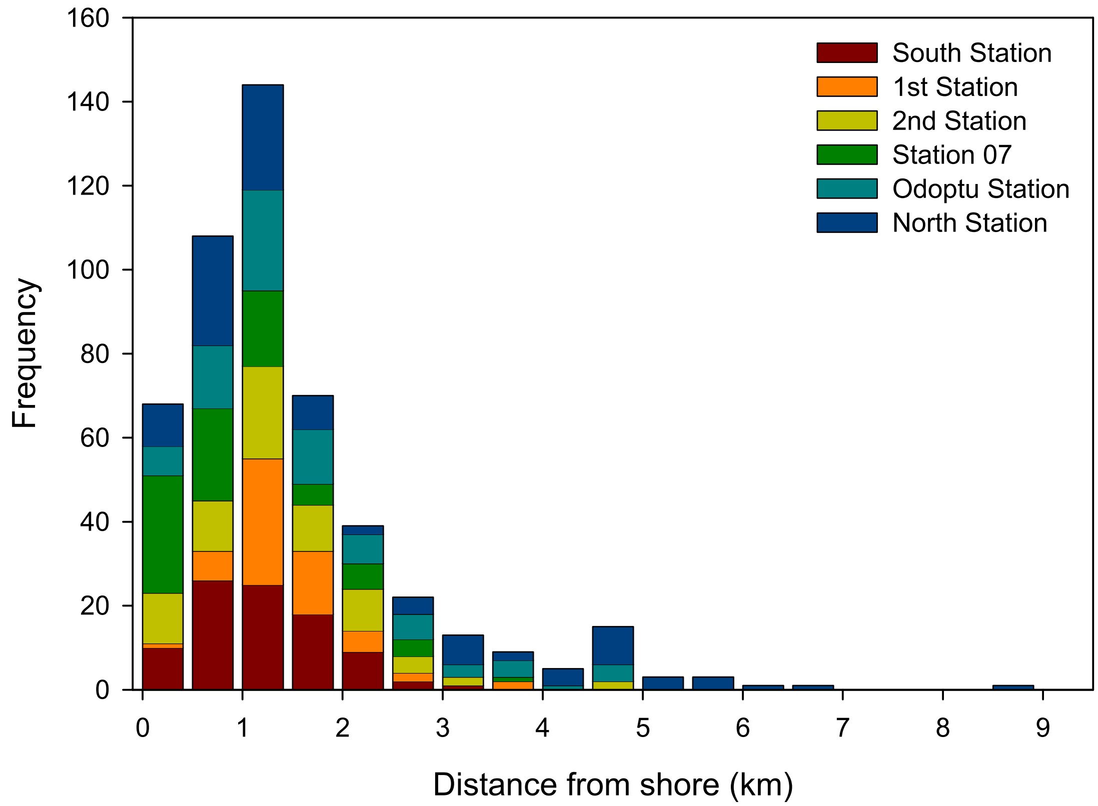


Figure 6. Distance of western gray whale sightings from shore off Sakhalin Island, summer 2005.

Table 4. Distance of western gray whales from shore at six shore-based stations. Sample size represents number of sightings of gray whales (7 sightings were removed due to distance criteria, see methods).

Station	Mean (km)	Median (km)	SD (km)	N
North Station	2.1	1.3	1.84	106
Odoptu Station	1.8	1.4	1.14	84
Station 07	1.0	0.8	0.75	84
2nd Station	1.4	1.3	0.94	75
1st Station	1.5	1.4	0.63	62
South Station	1.3	1.2	0.65	91
Total	1.5	1.3	1.19	502

Gray whales were present on each day of effort, with a mean of 6.8 ± 4.36 SD (Median = 5, Range: 0-20, N = 92) whales and 4.9 ± 3.00 (4, 0-13, 92) pods in the study area per scan. The mean pod size detected was 1.4 ± 0.74 (1, 1-8, 454) whales per pod throughout the duration of this study (Figures 7 – 9).

A.

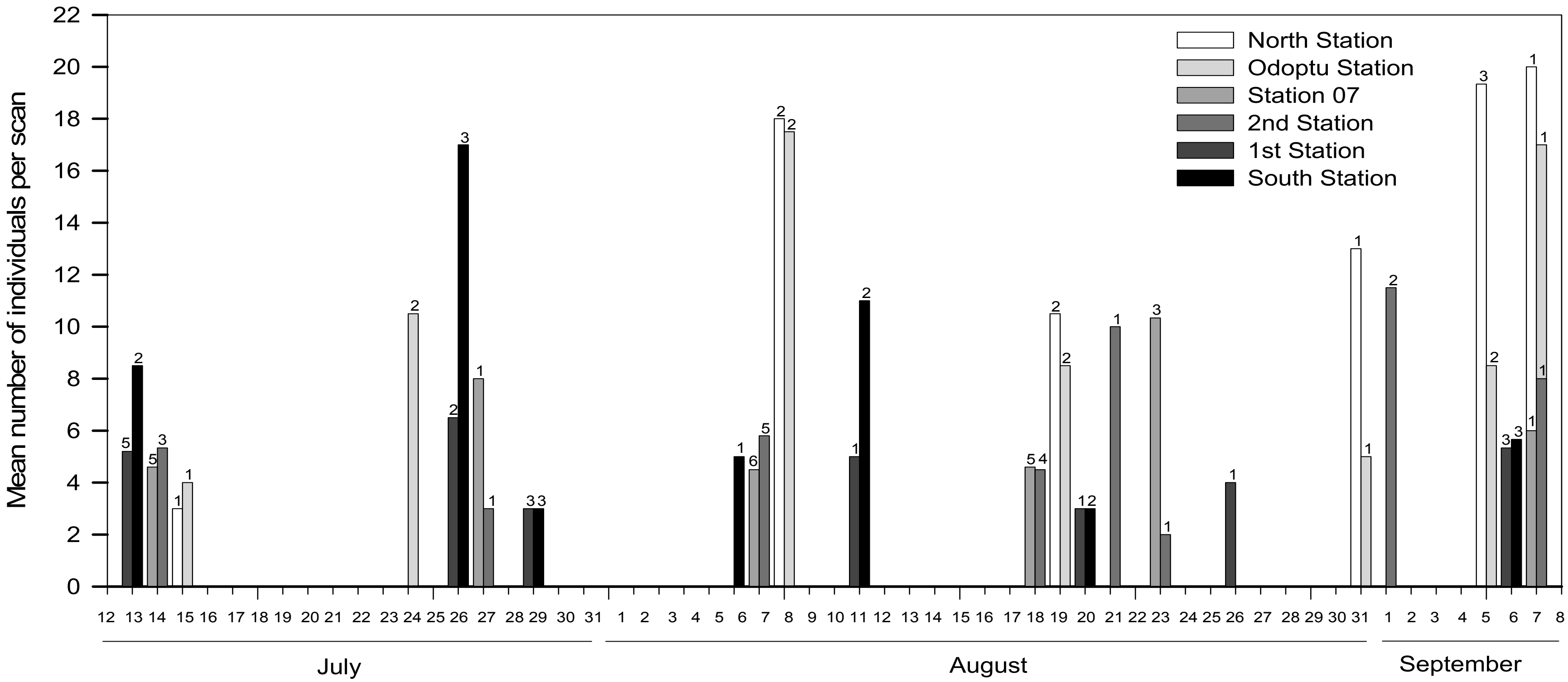


Figure 7. Mean numbers of whales detected per scan at each of the six shore-based stations. The number of scans performed per day at each station is indicated at the top of each bar.

B.

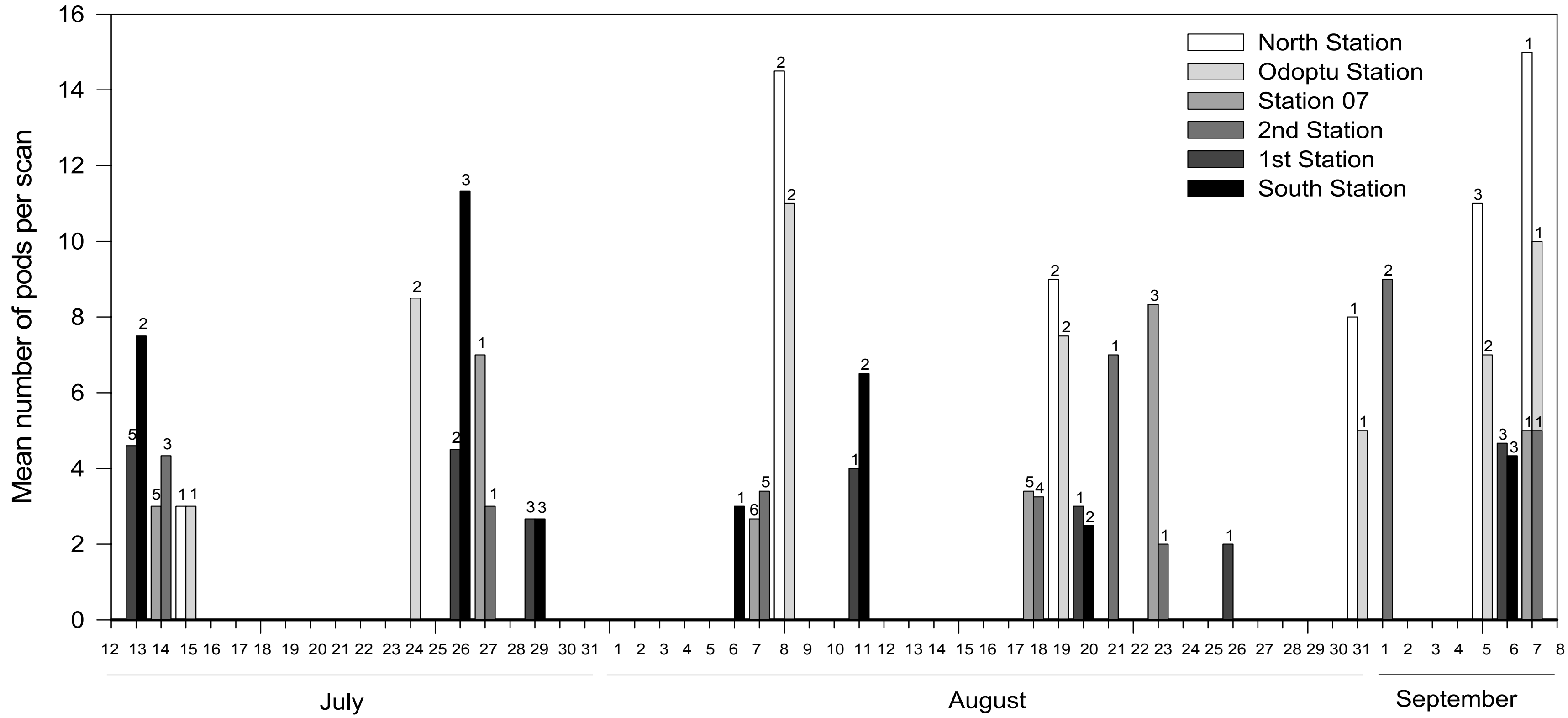
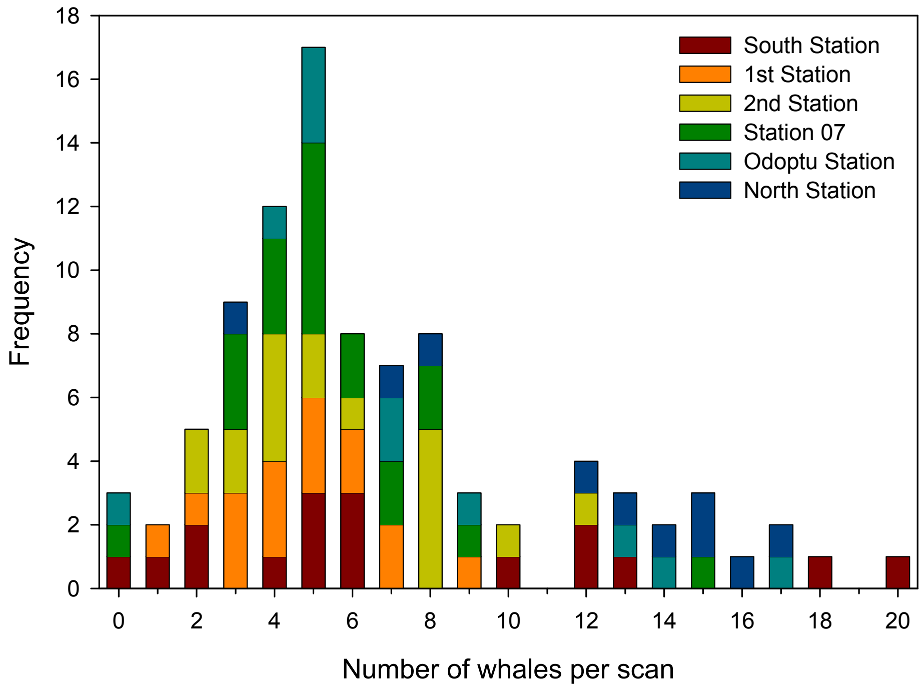


Figure 8. Mean numbers of pods detected per scan at each of the six shore-based stations. The number of scans performed per day at each station is indicated at the top of each bar.

A.



B.

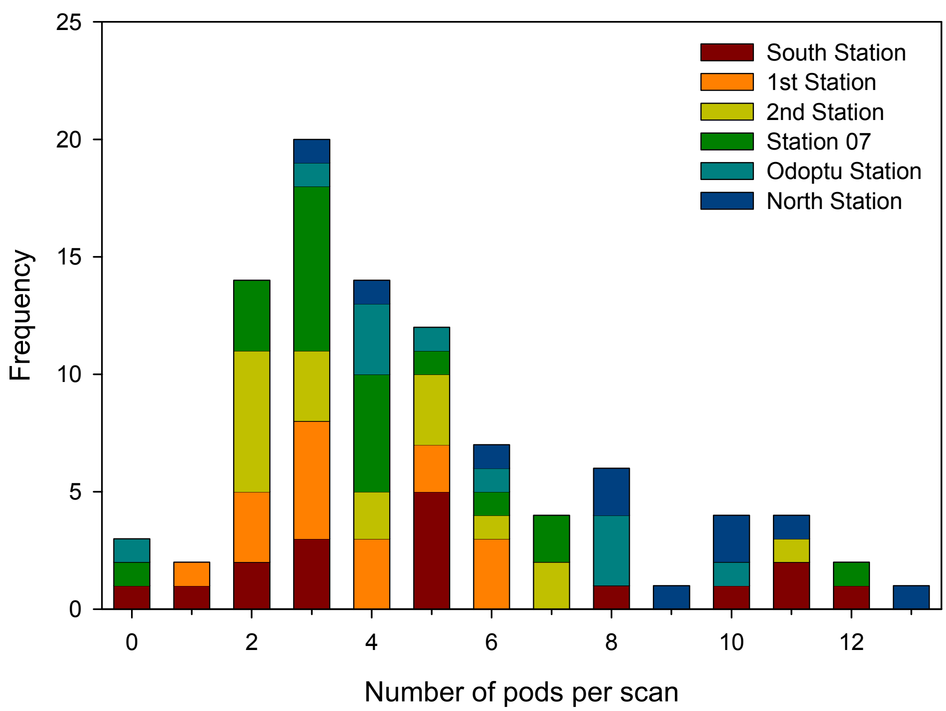


Figure 9. Frequency histograms of numbers of whales (A) and pods (B) detected per scan throughout the study period, and pod size (C). Only the numbers of whales and pods ≤ 6 km were included.

C.

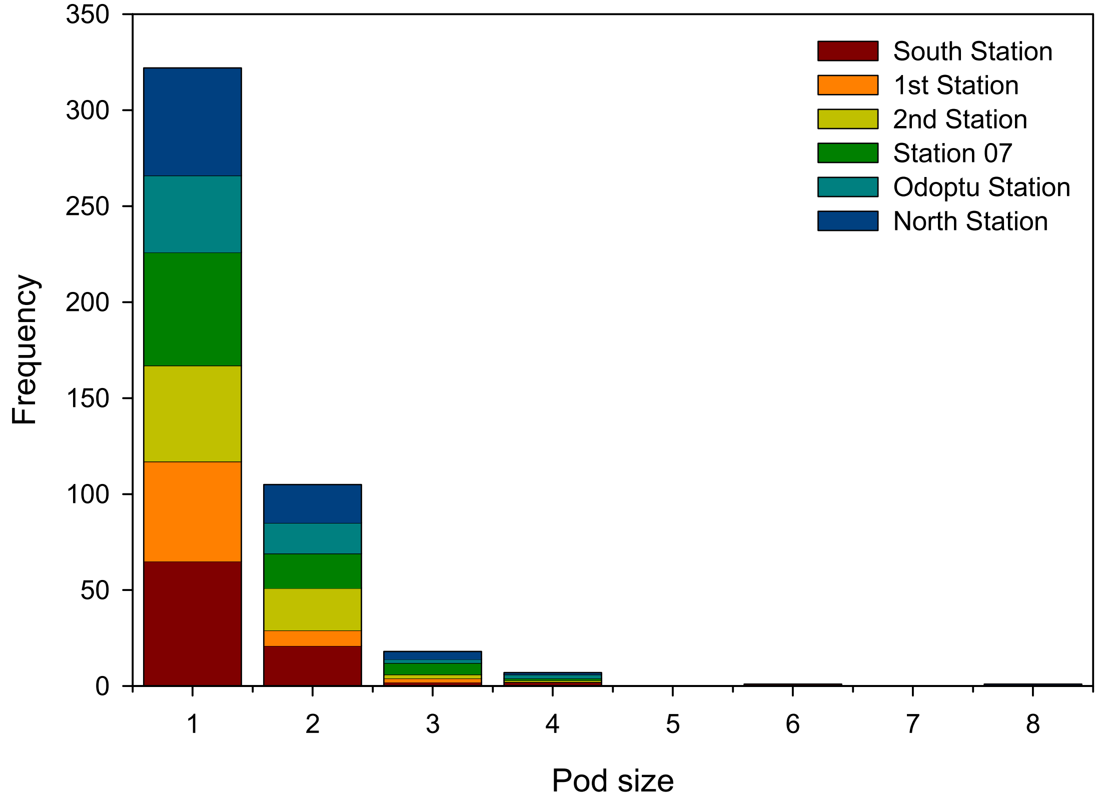
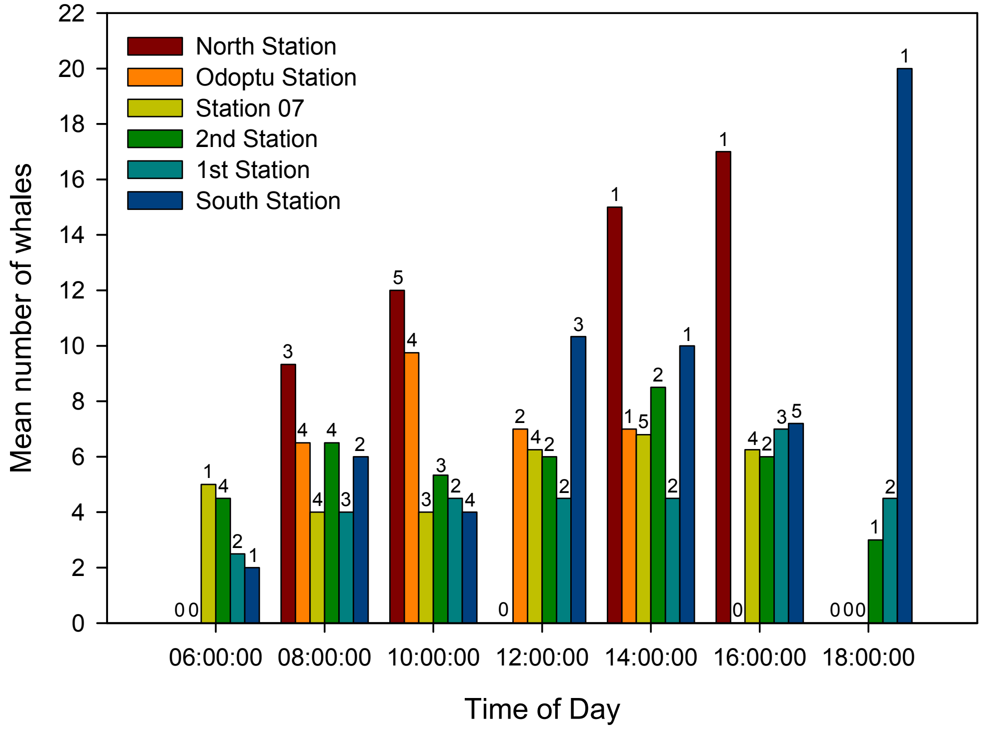


Figure 9 continued from previous page.

Morning vs Afternoon - No significant difference in the number of whales (t = -1.57, P = 0.21) or pods (-1.03, 0.31) were detected in the morning and afternoon periods of each day (Figure 11). In the morning, the mean number of whales was 6.2 ± 4.23 SD (Median = 5, Range: 0-17, N = 49); and in the afternoon, the mean number of whales was 7.6 ± 4.42 (6, 1-20, 43). In the morning, the mean number of pods was 4.6 ± 2.93 (4, 0-13, 49); and in the afternoon, the mean number of pods was 5.3 ± 3.06 (4, 1-12, 43).

A.



B.

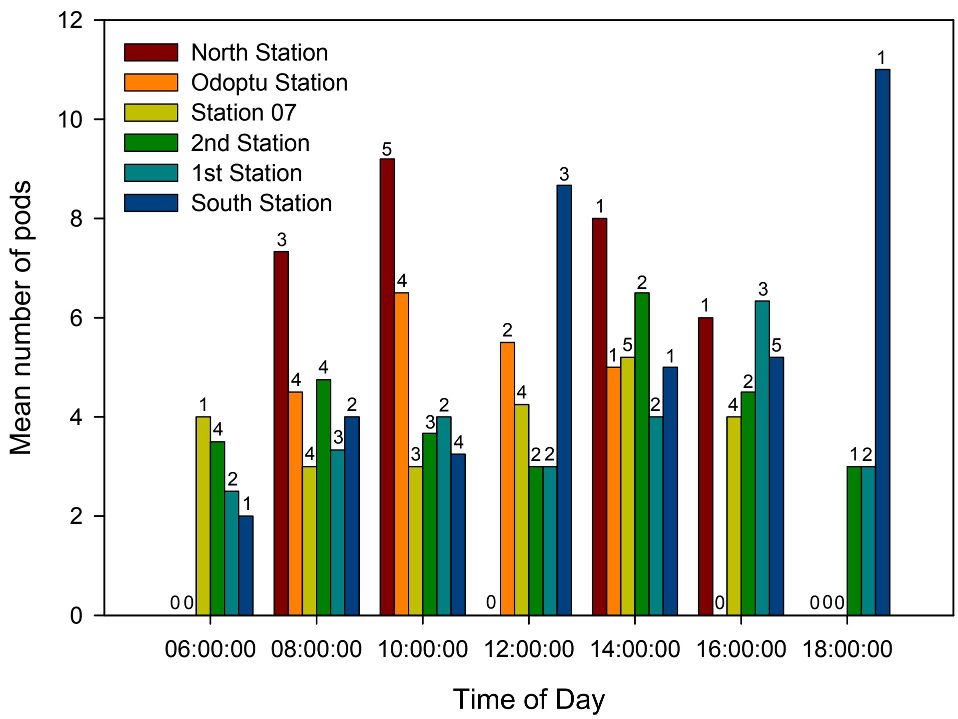


Figure 11. Mean number of whales (A) and pods (B) per time of day at six shore-based stations.

Stations – The mean numbers of whales and pods observed for the season among stations were significantly different (whales F = 5.32, df = 5, P < 0.001; pods 4.54, 5, <0.001), with more whales and pods at the northern most shore station (North Station, $\overline{\chi}$ =12.0 ± 4.55 SD whales and 8.2 ± 3.12 pods) on average for the season (see Figure 8 and Table 5). Post-hoc comparisons found that:

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

Although there tended to be more whales to the north, there was also a great degree of daily variation within each station (Figure 8). In early July, the southern most station had higher number of whales than seen in the previous year (Table 17). These numbers also varied considerable throughout the field season. There also appear to be shifts in area use, where decreases in number of whales (for example North Station and Odoptu Station after 8 August) corresponded with an increase in number of whales/pods at the adjacent station (Station 07).

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	Stdev	Min	Max	N
North Station	12.0	13.5	4.55	3	17	10
Odoptu Station	7.8	7.0	5.02	0	17	11
Station 07	5.6	5.0	2.98	0	15	21
2nd Station	5.8	5.0	2.86	2	12	18
1st Station	4.6	4.5	2.06	1	9	16
South Station	7.9	6.0	5.66	1	20	16

B.

Station	Mean	Median	Stdev	Min	Max	N
North Station	8.2	8.5	3.12	3	13	10
Odoptu Station	5.5	5.0	2.88	0	10	11
Station 07	4.0	3.0	2.47	0	12	21
2nd Station	4.2	3.5	2.43	2	11	18
1st Station	3.9	3.0	2.06	1	9	16
South Station	5.7	5.0	3.59	1	12	16

Theodolite Tracklines

Gray whales were tracked for at total of 154 hours ($\overline{\chi}$ = 54 min./track), ranging from 5 min to 5.7 hrs of continuous monitoring of movement patterns (Table 6). We recorded a total of 172 different tracklines with 9,106 geographic positions (Figure 12).

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

Station	# Tracklines	Mean Duration (min.)	Range (min.)
North Station	21	52.2	11 - 172
Odoptu Station	28	44.7	5 - 107
Station 07	24	66.8	8 - 177
2nd Station	36	53.3	8 - 213
1st Station	38	59.0	9 - 344
South Station	25	46.3	8 - 181
Total	172	54.0	5 - 344

The analytical data set, consisting of only recognizable or single individuals, yielded 124 tracklines that were suitable for analysis (Table 7). On average, gray whales were observed moving 2.2 ± 1.58 SD kph (Median = 1.8, Range = 0.3-7.8; Figure 13), accelerating -0.01 ± 0.230 kph (-0.03,-0.89– 0.52; Figure 14), reorienting 21.4 ± 17.25 °/min (15.9, 1.3 –

69.5; Figure 15), and ranging 32.8 ± 17.25 m/min (24.7, 2.9 – 127.7; Figure 18). The mean vector length and linearity index were 0.79 ± 0.236 (0.91, 0.16 – 1.00; Figure 16) and 0.73 ± 0.270 (0.85, 0.09 – 1.00; Figure 17), respectively. These directional indices indicate a more straight-line path movement as opposed to a non-directional feeding type behavior.

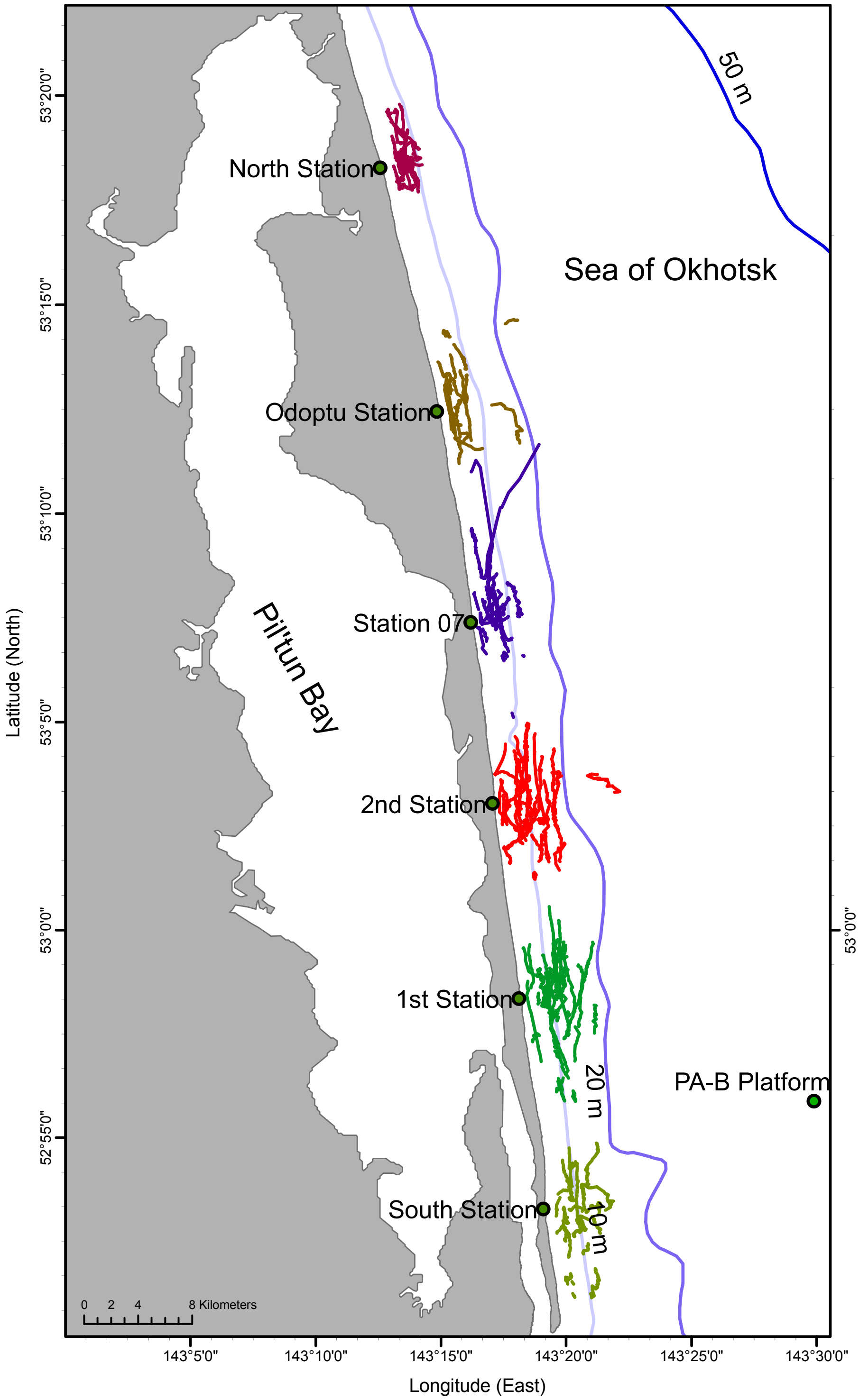


Figure 12. Tracklines of western gray whales at six shore-based positions on Sakhalin Island during summer 2005 (N = 172).

Table 7. Summary data for trackline analysis of western gray whales during summer 2005.

N = 124	Mean	Median	Min	Max	SD
Leg Speed (kph)	2.2	1.8	0.3	7.8	1.58
Reorientation Rate (°/min.)	21.4	15.9	1.3	69.5	17.25
Acceleration (kph)	-0.01	-0.03	-0.89	0.52	0.230
Mean Vector Length	0.73	0.85	0.09	1.00	0.270
Linearity Index	0.79	0.91	0.16	1.00	0.236
Ranging Index (m/min.)	32.8	24.7	2.9	127.7	26.67

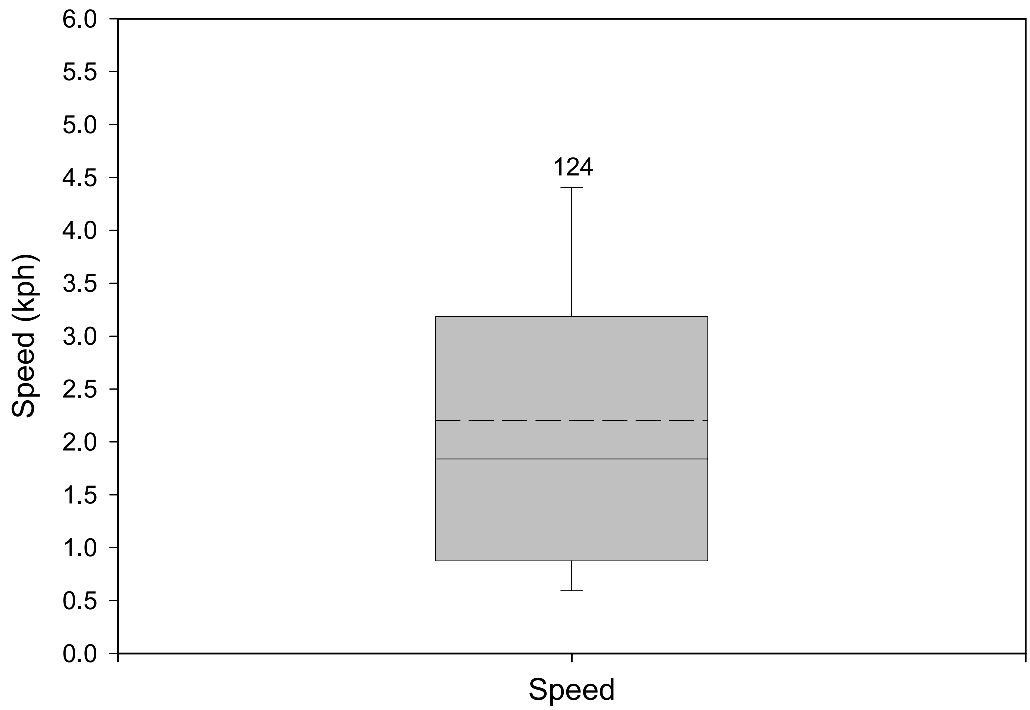


Figure 13. Leg Speed for all single or recognizable individual gray whales observed at six shore-based stations. For each box-plot the whiskers represent the 10th and 90th percentile, the box represents the 25th and 75th percentile, the solid bar represents the 50th percentile, and dashed bars represent mean values.

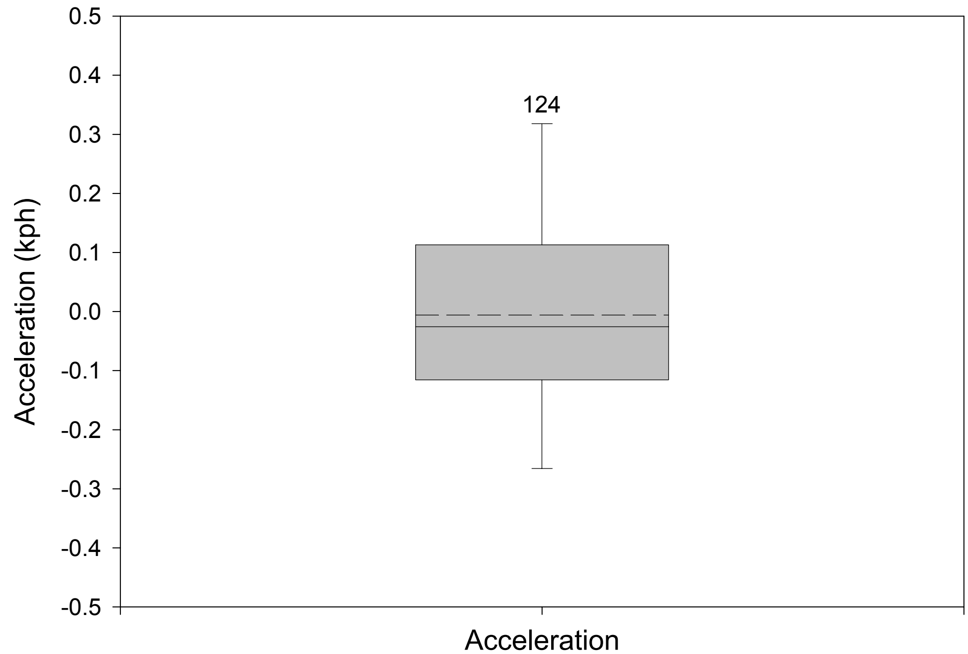


Figure 14. Acceleration for all single or recognizable individual gray whales observed at six shore-based stations. The negative values of acceleration represent deceleration. Display as in Figure 13.

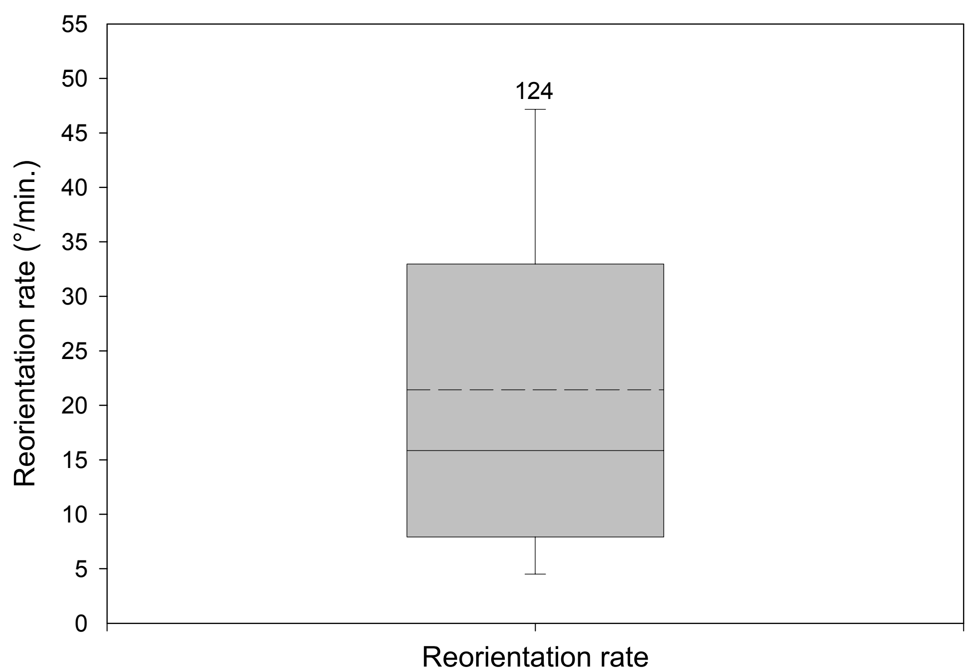


Figure 15. Reorientation rate for all single or recognizable individual gray whales observed at six shore-based stations. Display as in Figure 13.

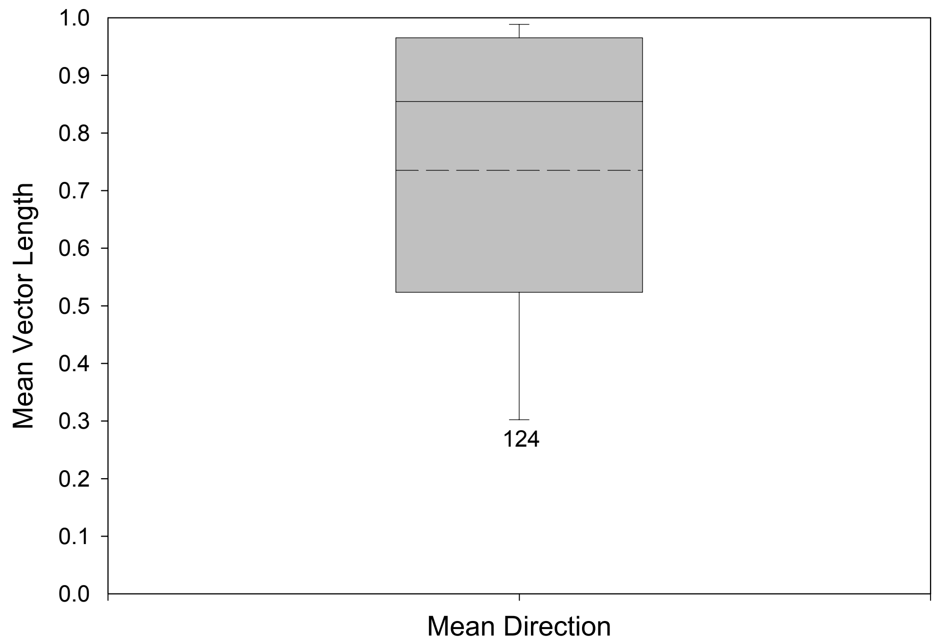


Figure 16. Mean vector length for all single or recognizable individual gray whales observed at six shore-based stations. Display as in Figure 13.

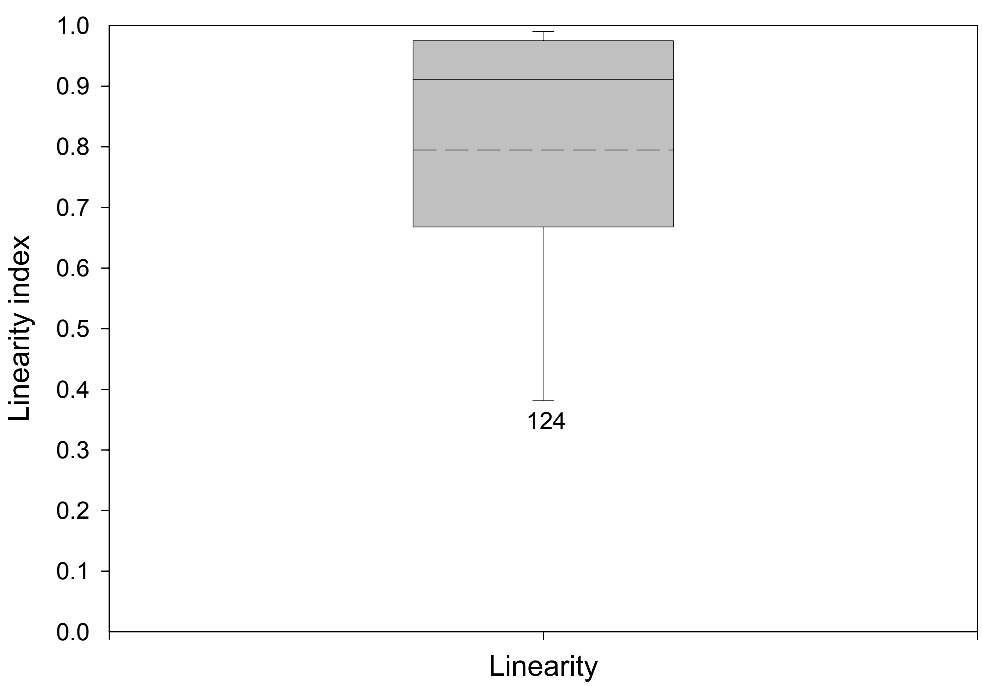


Figure 17. Linearity index for all single or recognizable individual gray whales observed at six shore-based stations. Display as in Figure 13.

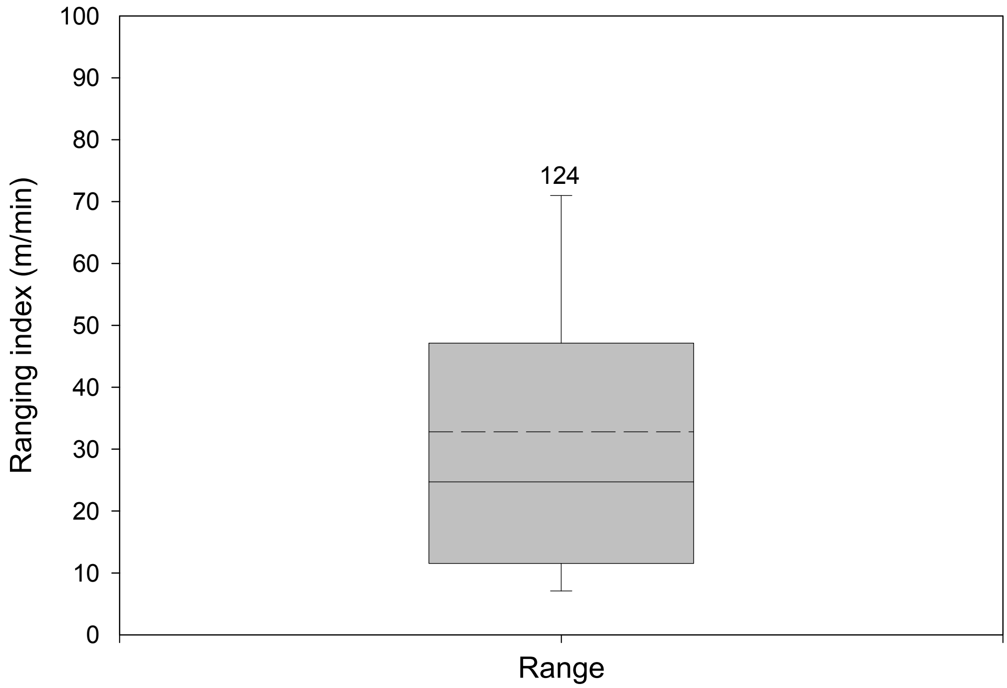


Figure 18. Ranging index for all single or recognizable individual gray whales observed at six shore-based stations. Display as in Figure 13.

Focal Behavior Observations

Focal behavioral observations were conducted for a total of 56 hrs, on 67 individual gray whales from 13 July to 6 September 2005 (Table 8). The mean duration of a focal session lasted approximately 50 min, and a total of 5,196 behavior events were recorded.

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

Station	# Focals	Mean Duration (min.)	Range (min.)
North Station	7	34.49	12. - 76
Odoptu Station	12	50.15	16 - 93
Station 07	11	50.93	7 - 173
2nd Station	14	52.55	10 - 157
1st Station	13	60.47	14 - 172
South Station	10	41.3	16 - 82
Total	67	49.83	7 - 173

The analytical data set yielded 66 focal follows. One focal follow was removed due the short duration of the focal session that provided limited information. On average, individual gray whales had a blow interval of 0.39 ± 0.149 SD blows per minute (Median =

0.37, Range = 0.19 – 0.79; Figure 19), with 5.11 ± 2.858 (4.29, 1.20 – 16.33; Figure 20) blows per surfacing. The time that individuals were observed at the surface was 1.60 ± 1.734 (1.05, 0.18 – 9.66; Figure 19) minutes, while individuals dove for 2.20 ± 0.835 (2.02, 1.05 – 4.11; Figure 19) minutes. The dive surface blow rate and surface blow rate were 1.32 ± 0.416 (1.24, 0.72 – 2.80, Figure 20) blows per minute and 4.38 ± 1.571 (4.34, 0.72 – 2.80, Figure 20) blows per minute, respectively (Table 9).

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

N = 66	Mean	Median	Min	Max	SD
Blow Interval (per min.)	0.39	0.37	0.19	0.79	0.149
Blows/Surfacing	5.11	4.29	1.20	16.33	2.858
Surface Time (min.)	1.60	1.05	0.18	9.66	1.734
Dive Time (min.)	2.20	2.02	1.05	4.11	0.835
Surface Blow Rate	4.38	4.34	1.33	7.30	1.571
Dive-Surface Blow Rate	1.32	1.24	0.72	2.80	0.416

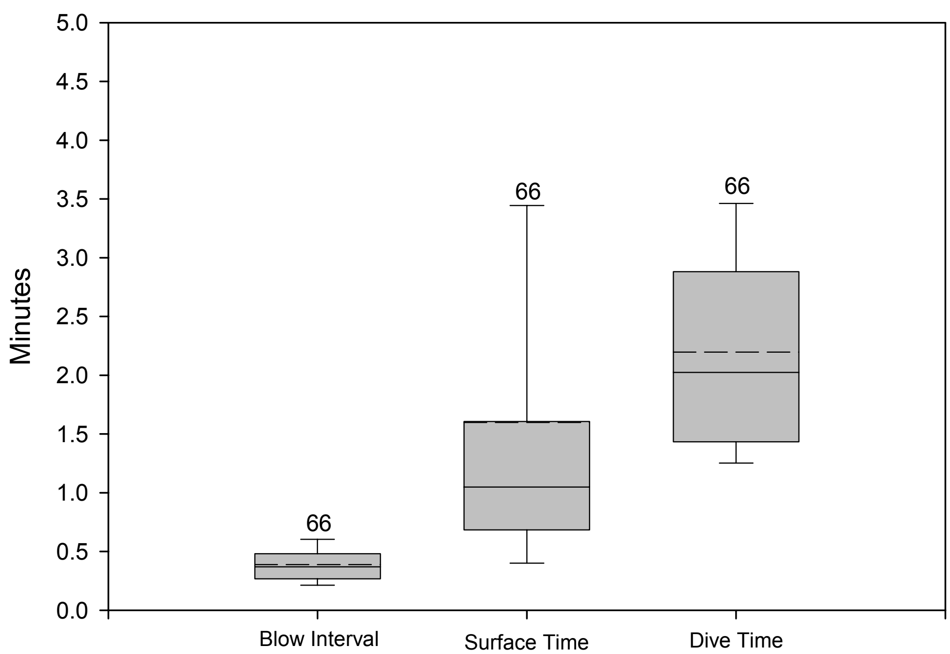


Figure 19. Blow interval, surface time, and dive time parameters of western gray whales. Display as in Figure 13.

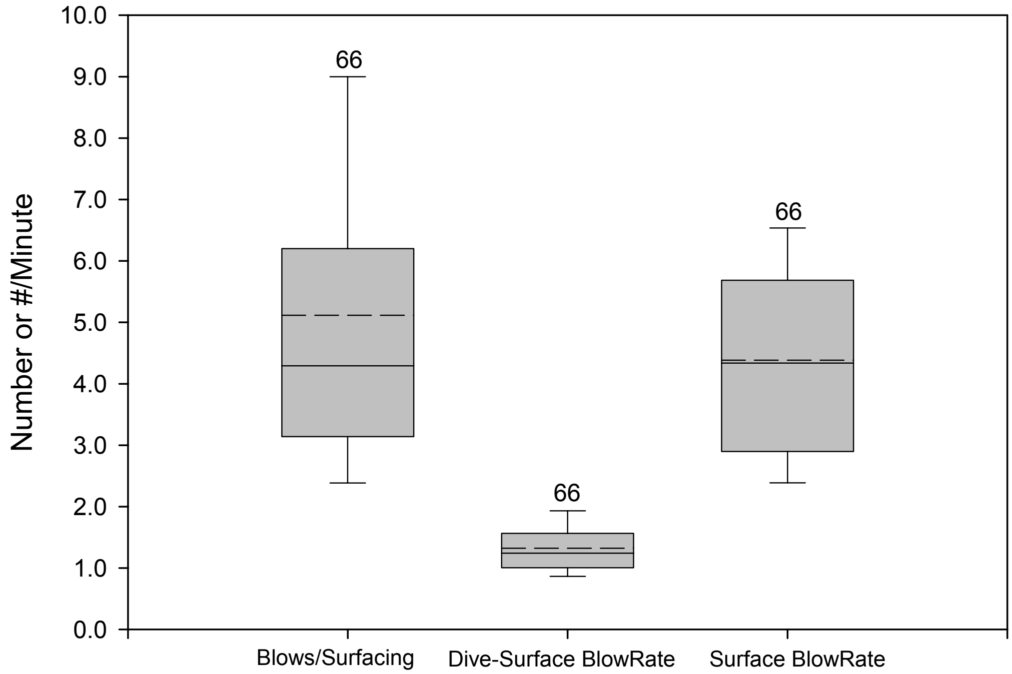


Figure 20. Number of blows per surfacing, dive-surface blow rate, and surface blow rate of western gray whales. Display as in Figure 13.

Behavior

Three main behavioral states were observed during the 2005 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 ($F = 39.61$, $df = 2$, $P = <0.01$), reorientation rates (33.91, 2, <0.01), ranging indices (53.84, 2, <0.01), linearity (42.46, 2, <0.01) and mean vector length (31.70, 2, <0.01) were significantly different among the three behaviors. Respiration interval (11.38, 2, <0.01) was significantly lower during feeding than traveling and between feeding/traveling and traveling; but not between feeding/traveling and feeding. Gray whales were observed to spend significantly less time at the surface (3.34, 2, 0.04) while feeding compared to traveling behavior. The surface-blow rate was also found to be significantly different (9.85, 2, <0.01) among all three behaviors. Acceleration, distance-from-shore, dive time, and dive-surface blow rate were all non-significant among the three behavioral states (Table 10, Figure 21 - Figure 33). The mean squared displacement of whales among the three behavioral states also revealed significant differences with individuals covering 0.05 km^2 (95% Confidence interval: 0.03 – 0.07 km^2), 0.65 km^2 (0.48 - 0.81 km^2), and 2.01 km^2 (1.43 – 2.59 km^2) during feeding, feeding/traveling, and traveling behavioral states, respectively, after 20 steps (i.e. 30 min) (Figure 34).

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 ± 0.50 (45)	1.8 ± 1.04 (49)	3.6 ± 1.74 (56)	39.61	<0.01	F-T, FT-T, FT-F
Reorientation rate (/min)	34.6 ± 14.29 (45)	21.2 ± 12.11 (49)	9.15 ± 6.497 (56)	33.91	<0.01	F-T, FT-T, FT-F
Linearity Index	0.6 ± 0.24 (45)	0.8 ± 0.11 (49)	0.9 ± 0.10 (56)	42.46	<0.01	F-T, FT-T, FT-F
Mean vector length	0.5 ± 0.24 (45)	0.7 ± 0.21 (49)	0.9 ± 0.11 (56)	31.70	<0.01	F-T, FT-T, FT-F
Acceleration (kph)	0.0 ± 0.19 (45)	0.0 ± 0.23 (49)	0.04 ± 0.25 (56)	1.55	0.22	
Ranging index (m/min)	11.0 ± 6.638 (45)	27.2 ± 17.38 (49)	58.2 ± 29.55 (56)	53.84	<0.01	F-T, FT-T, FT-F
Distance to shore	1.1 ± 0.40 (45)	1.2 ± 0.57 (49)	1.2 ± 0.61 (56)	0.84	0.43	
Respiration Interval (min)	0.29 ± 0.064 (16)	0.34 ± 0.111 (25)	0.46 ± 0.159 (29)	11.38	<0.01	F-T, FT-T
Surface Time (min)	0.9 ± 0.61 (16)	1.2 ± 0.57 (25)	1.9 ± 2.19 (29)	3.34	0.04	F-T
Dive Time (min)	2.7 ± 0.77 (16)	2.3 ± 0.78 (25)	2.1 ± 1.03 (29)	2.04	0.14	
Number Surfacings	4.1 ± 1.730 (16)	4.8 ± 1.73 (25)	5.2 ± 3.3 (29)	0.91	0.56	
Dive-surface blow rate	1.1 ± 0.28 (16)	1.4 ± 0.45 (25)	0.5 ± 0.48 (29)	1.95	0.15	
Surface blow rate	5.5 ± 1.13 (16)	4.6 ± 1.28 (25)	3.7 ± 1.54 (29)	9.85	<0.01	F-T, FT-T, FT-F

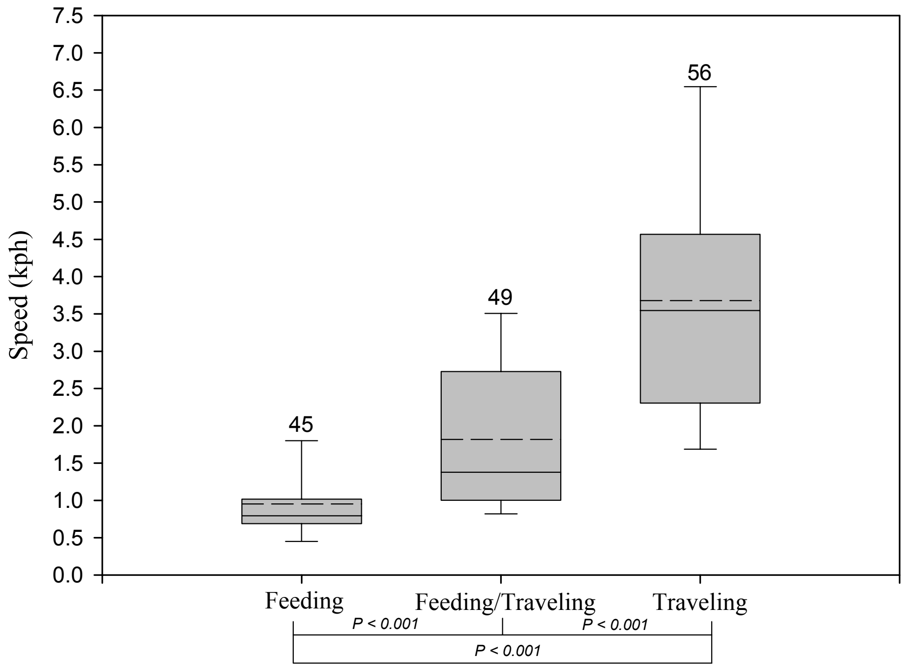


Figure 21. Speed of western gray whales during three behavioral states. Display as in Figure 13.

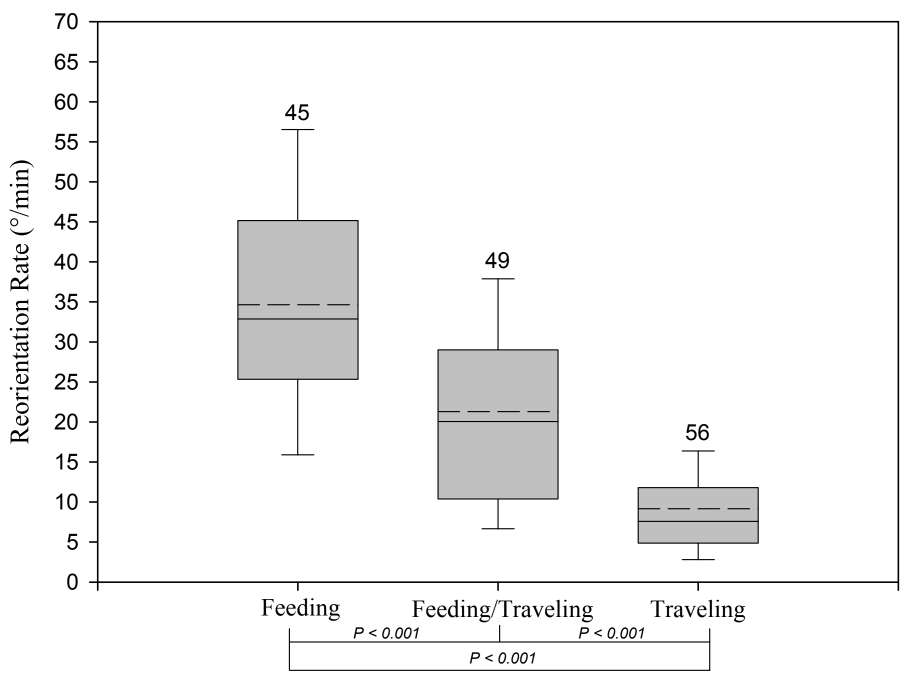


Figure 22. Reorientation rate of western gray whales during three behavioral states. Display as in Figure 13.

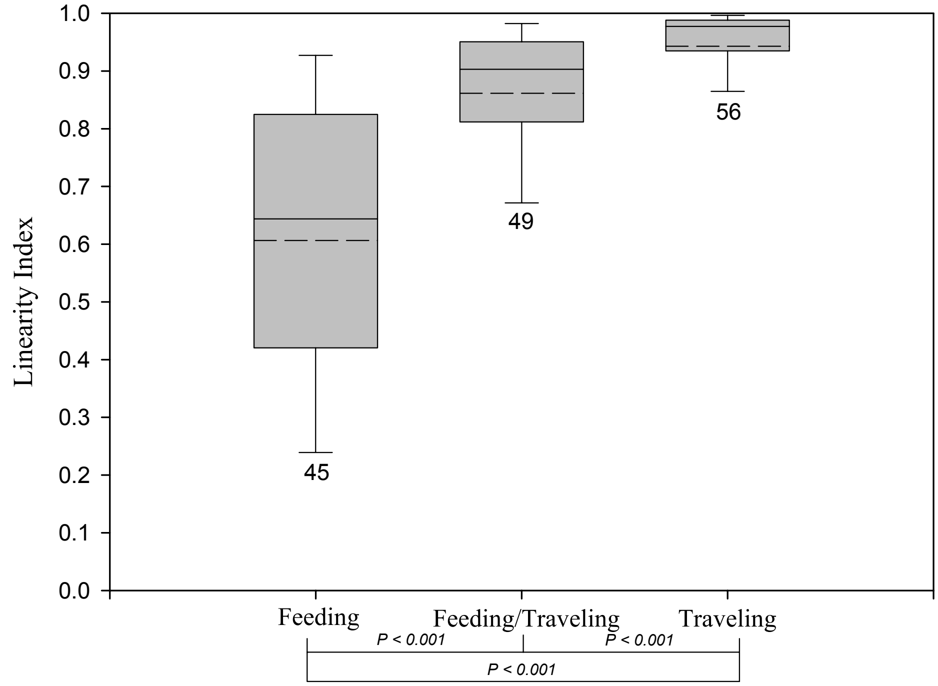


Figure 23. Linearity index of western gray whales during three behavioral states. Display as in Figure 13.

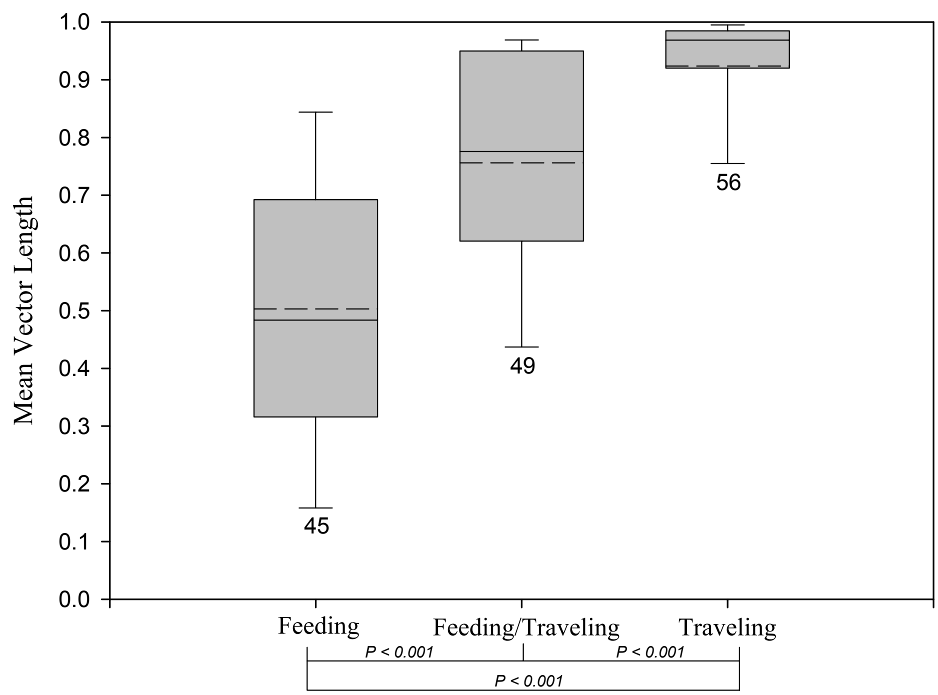


Figure 24. Mean vector length of western gray whales during three behavioral states. Display as in Figure 13.

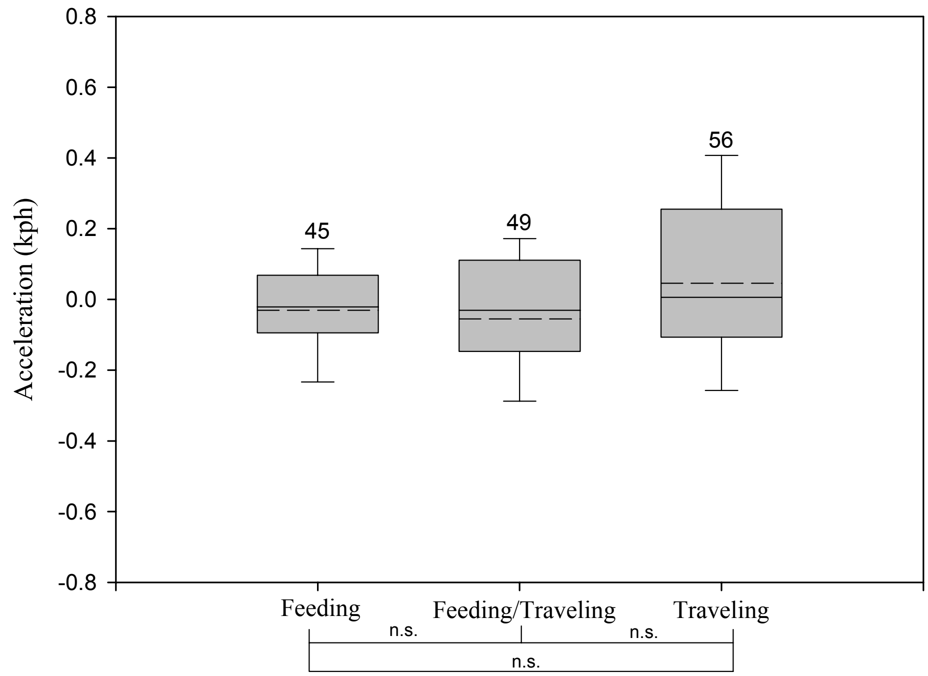


Figure 25. Acceleration of western gray whales during three behavioral states. Display as in Figure 13.

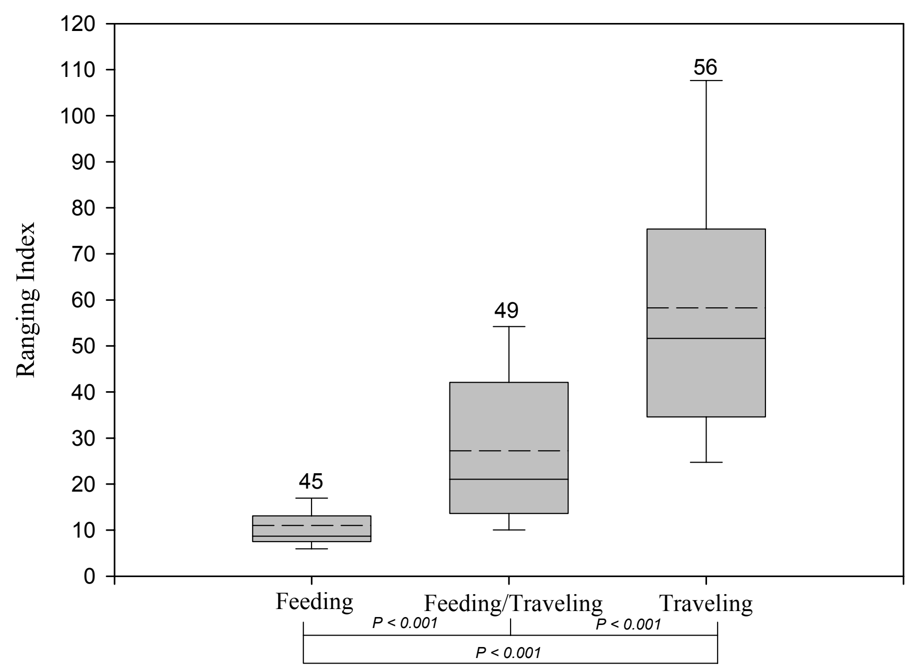


Figure 26. Ranging index of western gray whales during three behavioral states Display as in Figure 13.

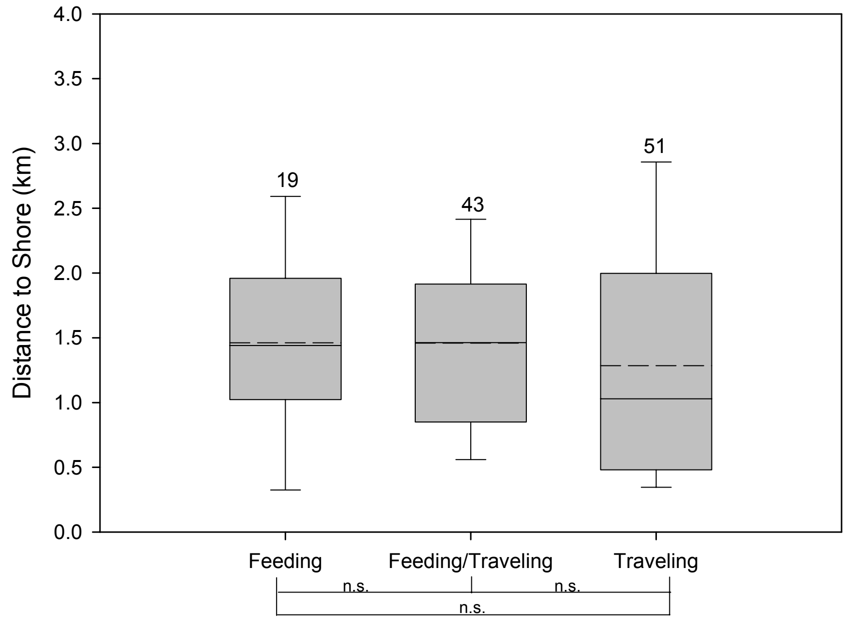


Figure 27. Distance to shore of western gray whales during three behavioral states. Display as in Figure 13.

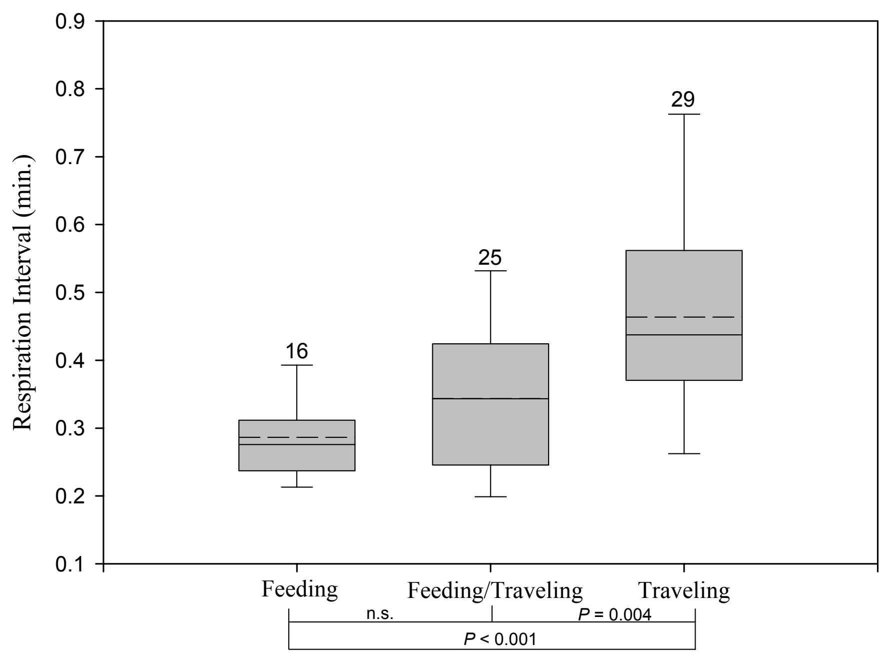


Figure 28. Respiration interval of western gray whales during three behavioral states. Display as in Figure 13.

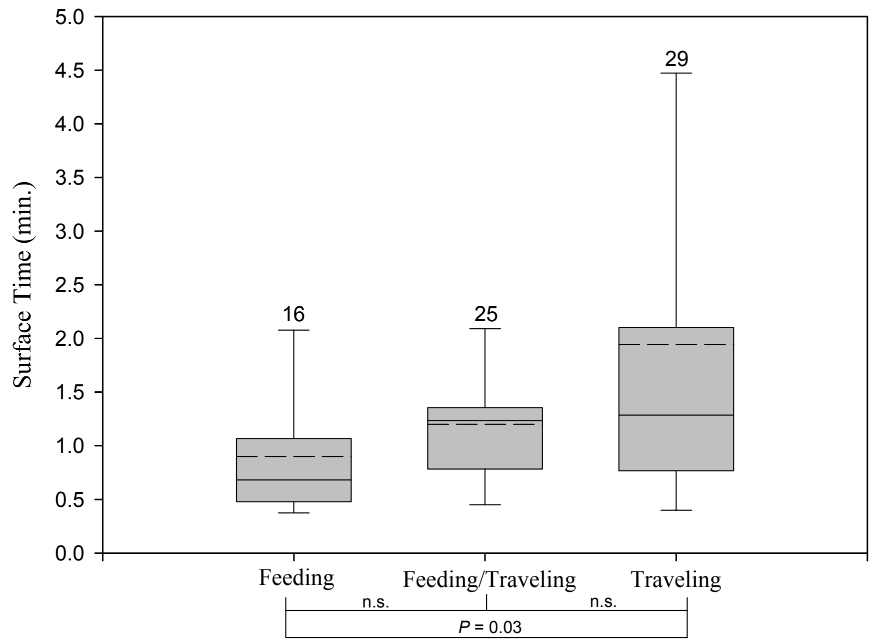


Figure 29. Surface time of western gray whales during three behavioral states. Display as in Figure 13.

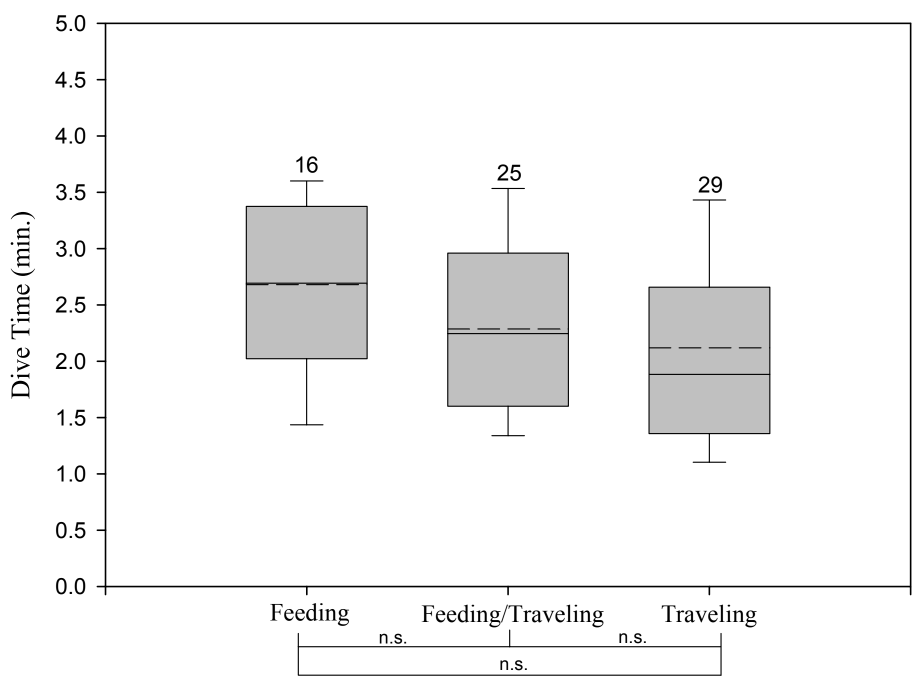


Figure 30. Dive time of western gray whales during three behavioral states. Display as in Figure 13.

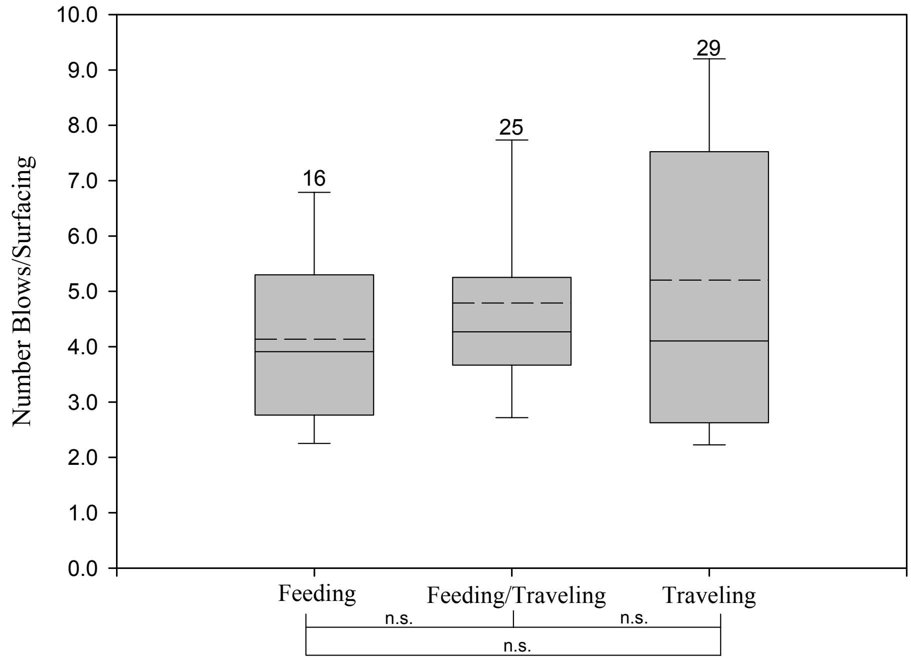


Figure 31. Number of blows per surfacing of western gray whales during three behavioral states. Display as in Figure 13.

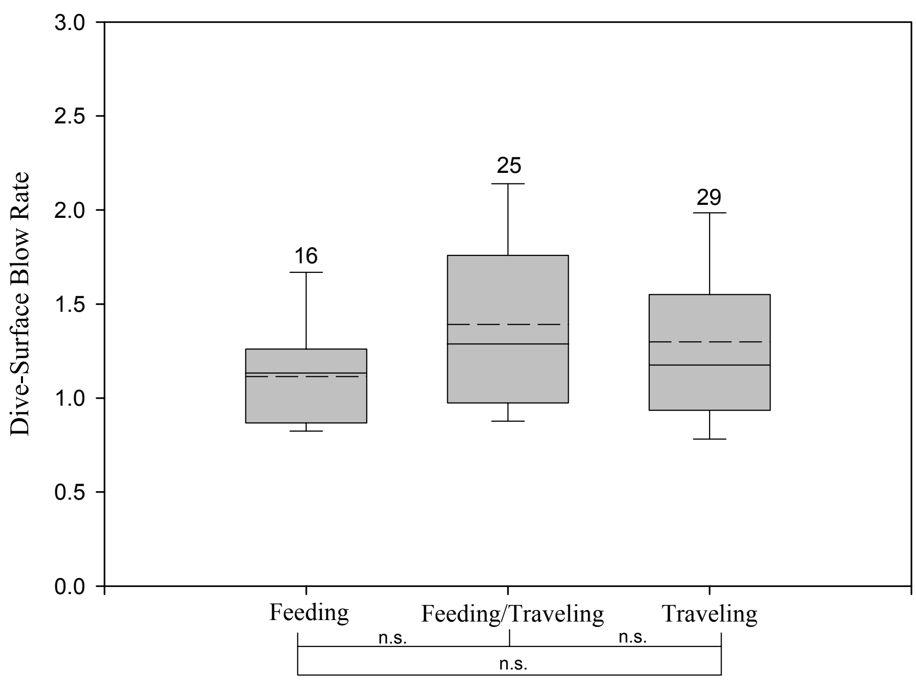


Figure 32. Dive-surface blow rate of western gray whales during three behavioral states. Display as in Figure 13.

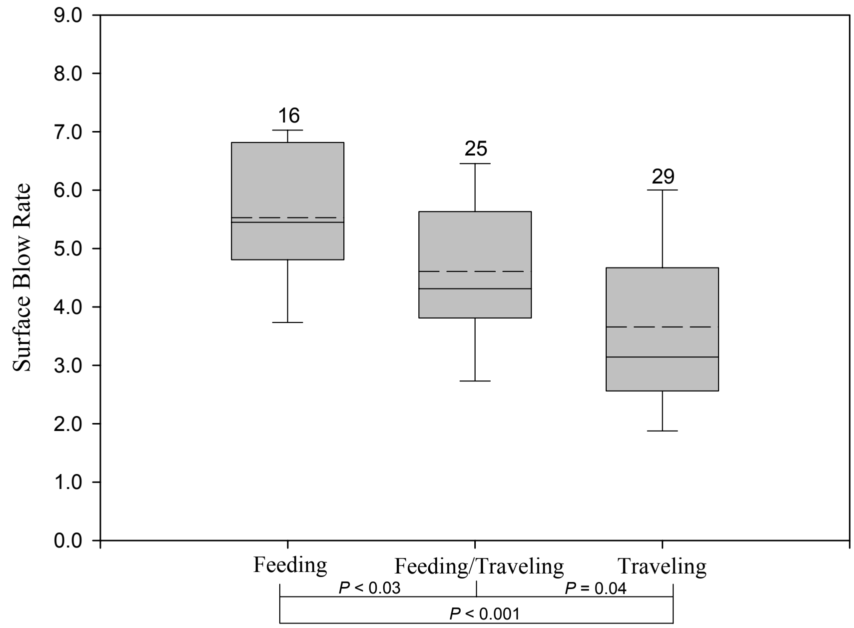


Figure 33. Surface blow rate of western gray whales during three behavioral states. Display as in Figure 13.

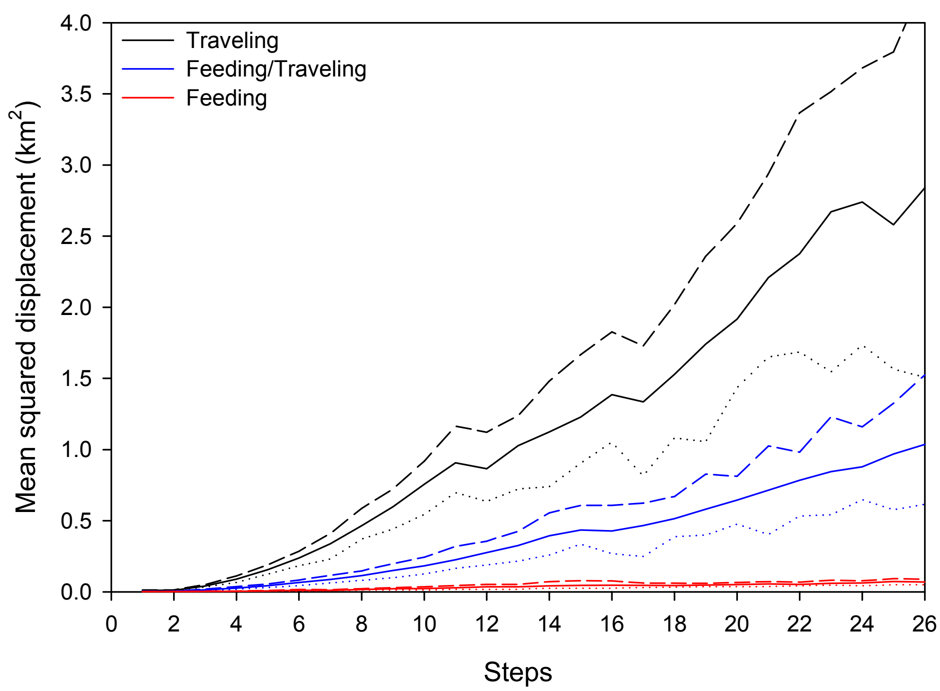


Figure 34. Mean squared displacement of western gray whales during three behavioral states. The upper and lower 95% confidence intervals are represented by dashed and dotted lines, respectively.

Social Activity – Three occasions of social activity were observed towards the end of the 2005 field season. The first observation of social activity occurred on 23 August (Station 07), the penis of one whale was observed at the surface. A group of four individuals appeared to be the subgroup of a larger group (about 8 individuals), which separated potentially due to vessel activity in the area, with two nearby vessels (a Photo-ID boat and a larger research vessel). Later, the social behavior was observed within one of the separated groups. The other two observations of social behavior were recorded on 1 and 5 September (2nd and North Stations, respectively). 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 individual that moved away, the surface activity would continue and similar active events were repeated. On 5 September, the group of eight individuals included three calves. On 1 September, the group consisted of three adults.

Killer Whales

Two groups of killer whales were observed in the study area during the 2005 season. On 11 August, a group of four individuals were observed traveling south at 1st Station and later at the southern most station (South Station). Another group of killer whales (2 individuals) was sighted on 1 September at our 2nd Station during a scan. During each killer whale sighting, gray whales were present in the study. On 11 August, killer whales approached within 4.2 km from a mother-calf pair that were feeding in the area, 1.3 km from an individual feeding/traveling, and 0.8 km from a sighting during a scan session. On 1 September, the closest observed approach was 7 km during a scan session. During each observation, no obvious changes were observed in gray whale behavior due to the presence of killer whales in the area.

Vessels

The number of vessels in the study area was not found to be statistically correlated with the number of whales during scan sessions ($P = 0.81$, $R^2 = 0.006$, Figure 35).

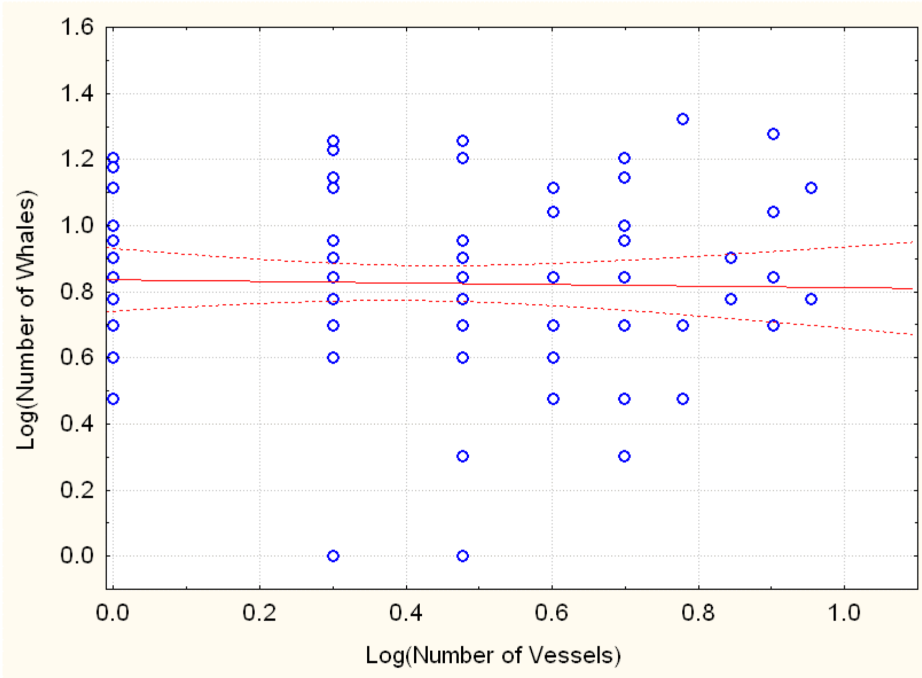


Figure 35. Correlation between the number of vessels and relative abundance of whales during scan sampling sessions.

During vessel approaches (within 0.5 km) with Photo-ID zodiacs, gray whale's speed (U = 495, P = 0.57), reorientation rate (492, 0.55), linearity (506, 0.64), mean vector length (485, 0.52), and ranging index (522, 0.75) were not found to be statistically different compared to gray whale movement patterns during no boat activity in the area. Acceleration was, however, significantly higher (337, 0.04) indicating animals were increasing their speed when the vessel approached within 0.5 km of the animal. Gray whale movement patterns when approached within 2 km from other vessels in the area were not found to be significantly different compared to "normal" behavioral observations (speed (U=443, P=0.61), acceleration (304, 0.06), reorientation rate (342, 0.14), linearity (422, 0.48), mean vector length (389, 0.31), and ranging index (430, 0.53)) (Table 11).

Table 11. Movement of western gray whales during vessel approaches.

Variable	No Vessel	Other Vessels	Photo-ID
Speed	2.2 ± 1.58 (124)	1.7 ± 0.92 (8)	3.4 ± 3.16 (9)
Acceleration	0.0 ± 0.23 (124)	0.1 ± 0.22 (8)	0.2 ± 0.53 (9)
Reorientation Rate	21.4 ± 17.25 (124)	35.3 ± 27.55 (8)	22 ± 23.99 (9)
Linearity	0.8 ± 0.24 (124)	0.7 ± 0.25 (8)	0.8 ± 0.24 (9)
Mean Vector Length	0.7 ± 0.27 (124)	0.6 ± 0.28 (8)	0.7 ± 0.29 (9)
Range	32.8 ± 26.67 (124)	24 ± 15.77 (8)	51.4 ± 53.93 (9)

Gray whales' relative orientation to the vessel was more frequently observed moving "away" from the vessel as it approached within 500 m to conduct a Photo-ID session. The most frequently observed relative orientation during other vessel approaches was equivocal (Table **12**).

Table 12. Relative orientation of western gray whales during close vessels approaches.

Relative Orientation	Other Vessels	Photo-ID
Away	1	5
Equivocal	6	3
Towards	1	1

Unfortunately, focal follow observations were not conducted during approaches with Photo-ID zodiacs. During other vessel approaches to gray whales, only four focal follows were being carried out, which provides limited sample sizes for statistical analyses (Table 13).

Table 13. Respiration parameters of western gray whales during other vessel approaches.

Variable	No Vessel	Other	Photo-ID
Respiration Interval	0.4 ± 0.15 (66)	0.3 ± 0.12 (4)	n.a.
Surface Time	1.6 ± 1.73 (66)	1.6 ± 0.32 (4)	n.a.
Dive Time	2.2 ± 0.84 (66)	2.7 ± 0.74 (4)	n.a.
Blows/surfacing	5.1 ± 2.86 (66)	7.3 ± 0.5 (4)	n.a.
Surface Blow Rate	4.4 ± 1.47 (66)	4.8 ± 1.02 (4)	n.a.
Dive Surface Blow Rate	1.3 ± 0.42 (66)	1.8 ± 0.11 (4)	n.a.

PA-B Offshore Activities

The relative numbers of whales at the different observations stations (F = 1.19, df = 9, P = 0.32) were not found to be statistically different before and during construction activity in relation to installation of the concrete gravity based structure and associated scour protection. However, sample sizes for all stations were relatively low (Table 14). North station was excluded from this analysis due to only one scan sampling observation being conducted prior to construction.

Table 14. Relative number of whales per scan prior and during construction activity in relation to the installation of a concrete gravity based structure.

	Before CGBS	CGBS	Anchor	Scour
North Station	3 ± 0 (1)	13 ± 3.46 (9)	-	13 ± 3.46 (9)
Odoptu Station	4.7 ± 4.51 (3)	9 ± 4.93 (8)	-	9 ± 4.93 (8)
Station 07	4.6 ± 0.89 (5)	5.9 ± 3.34 (16)	8 ± 0 (1)	5.7 ± 3.41 (15)
2nd Station	5.3 ± 2.52 (3)	5.9 ± 3 (15)	3 ± 0 (1)	6.1 ± 3 (14)
1st Station	5.6 ± 1.99 (7)	3.9 ± 1.9 (9)	3 ± 1 (3)	4.3 ± 2.16 (6)
South Station	13.6 ± 5.86 (5)	5.4 ± 3.32 (11)	3 ± 2.64 (3)	6.3 ± 3.24 (8)

Western gray whales' speed (F = 1.49, df = 1, P = 0.22), acceleration (2.69, 1, 0.10), reorientation rate (0.06, 1, 0.80), linearity (0.50, 1, 0.48), mean vector length (0.19, 1, 0.66), and ranging index (1.85, 1, 0.18) were not found to be significantly different between the control and PA-B Activity categories. (Table 15 and Figure 36 and Figure 37). Distance from shore was, however, significantly different (12.85, 1, < 0.001), with gray whales on average being further from shore (i.e. closer to the construction activity) during the offshore activities. This result could be due to potential sampling bias towards preferentially tracking gray whales closest to the construction activity. The significant differences observed could also be a result of geographic differences. Therefore, distance from shore was re-analyzed while considering "station" as a covariate. The result was no significant difference (0.35, 1, 0.55) in distance from shore after considering station as a covariate when comparing between the control and PA-B offshore activity categories.

Table 15. Movement variables during control and PA-B offshore activity categories.

	Speed		Acceleration		Reorientation Rate		Linearity	
Station	Control	PA-B Activity	Control	PA-B Activity	Control	PA-B Activity	Control	PA-B Activity
North Station	1.81 ± 1.792 (18)		0 ± 0.17 (18)		19.8 ± 15.8 (18)		0.8 ± 0.21 (18)	
Odoptu Station	1.82 ± 1.021 (23)		0 ± 0.19 (23)		22 ± 16.21 (23)		0.8 ± 0.19 (23)	
Station 07	1.94 ± 1.266 (15)		-0.1 ± 0.15 (15)		19.9 ± 18.52 (15)		0.8 ± 0.25 (15)	
2nd Station	2.14 ± 1.357 (25)		-0.1 ± 0.28 (25)		22.9 ± 14.38 (25)		0.8 ± 0.24 (25)	
1st Station	3.21 ± 2.337 (6)	2.77 ± 2.22 (25)	-0.1 ± 0.29 (6)	0.1 ± 0.27 (25)	22.6 ± 11.9 (6)	23.5 ± 22.07 (25)	0.8 ± 0.21 (6)	0.8 ± 0.2 (25)
South Station	1.93 ± 1.4 (4)	2.27 ± 1.336 (13)	-0.2 ± 0.36 (4)	0 ± 0.28 (13)	17.2 ± 18.34 (4)	19.3 ± 9.3 (13)	0.9 ± 0.14 (4)	0.9 ± 0.11 (13)
All Stations	2.02 ± 1.446 (91)	2.6 ± 1.958 (38)	-0.1 ± 0.23 (91)	0 ± 0.27 (38)	21.3 ± 15.54 (91)	22.1 ± 18.66 (38)	0.8 ± 0.22 (91)	0.8 ± 0.17 (38)

	Mean Vector Length		Range		Distance from Shore	
	Control	PA-B Activity	Control	PA-B Activity	Control	PA-B Activity
North Station	0.7 ± 0.26 (18)		26.4 ± 30.36 (18)		1.1 ± 0.34 (18)	
Odoptu Station	0.8 ± 0.23 (23)		27.1 ± 17.72 (23)		0.9 ± 0.6 (23)	
Station 07	0.7 ± 0.31 (15)		29.9 ± 22.21 (15)		0.9 ± 0.46 (15)	
2nd Station	0.7 ± 0.27 (25)		30.5 ± 22.51 (25)		1.2 ± 0.51 (25)	
1st Station	0.7 ± 0.24 (6)	0.7 ± 0.27 (25)	48.1 ± 39.65 (6)	42.3 ± 36.59 (25)	1.3 ± 0.79 (6)	1.5 ± 0.5 (25)
South Station	0.8 ± 0.3 (4)	0.8 ± 0.18 (13)	29.5 ± 24.53 (4)	34.4 ± 22.37 (13)	1.6 ± 0.96 (4)	1.4 ± 0.54 (13)
All Stations	0.7 ± 0.26 (91)	0.8 ± 0.24 (38)	29.8 ± 24.43 (91)	39.6 ± 32.33 (38)	1.1 ± 0.55 (91)	1.5 ± 0.51 (38)

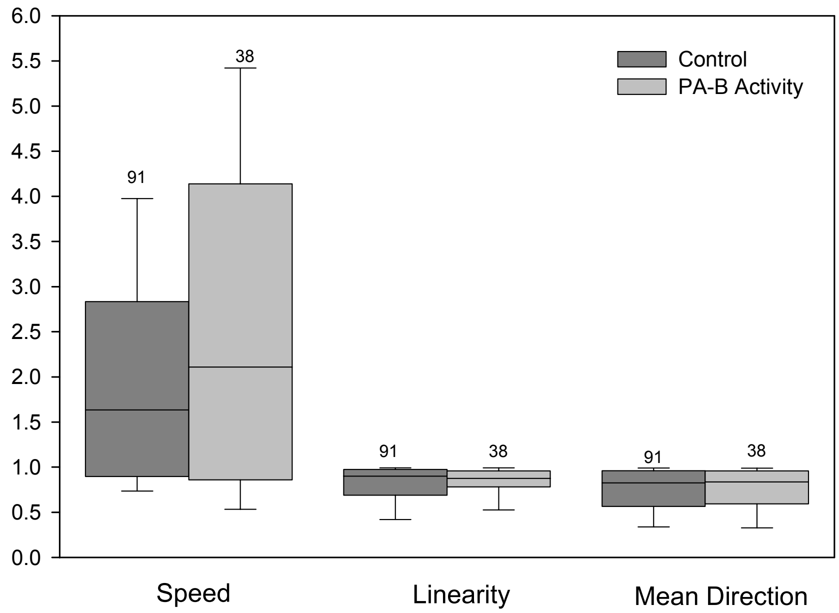


Figure 36. Western gray whale speed, linearity, and mean vector length during control and PA-B offshore activity categories.

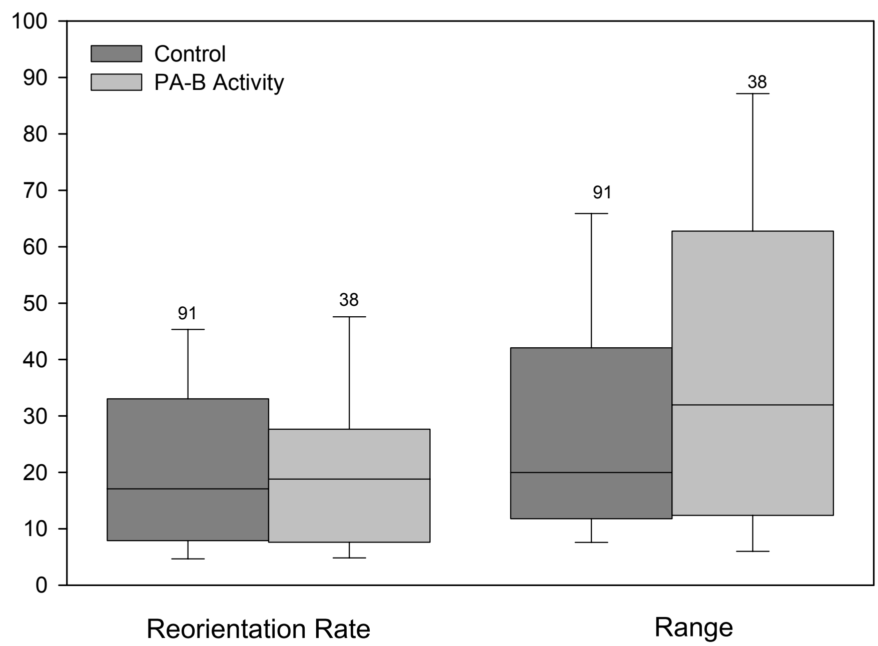


Figure 37. Western gray whale reorientation rate and ranging index during control and PA-B offshore activity categories.

The general (Figure 38) and behavioral (Feeding, feeding/traveling, and traveling, Figure 39 - 40) displacement of western gray whales during the offshore construction at PA-B location were observed to be within the confidence intervals of the control category.

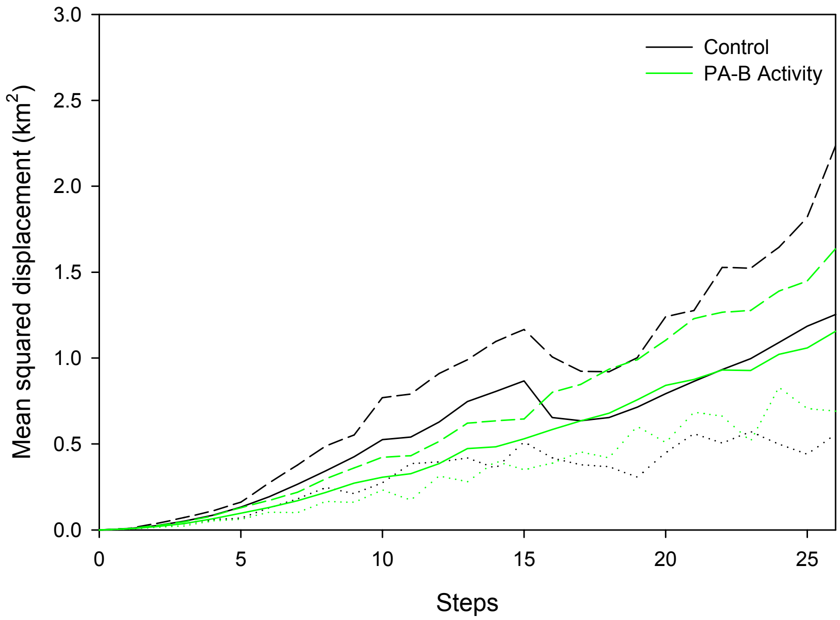


Figure 38. Western gray whale overall displacement during control and PA-B offshore activity categories. The upper and lower 95% confidence intervals are represented by dashed and dotted lines, respectively.

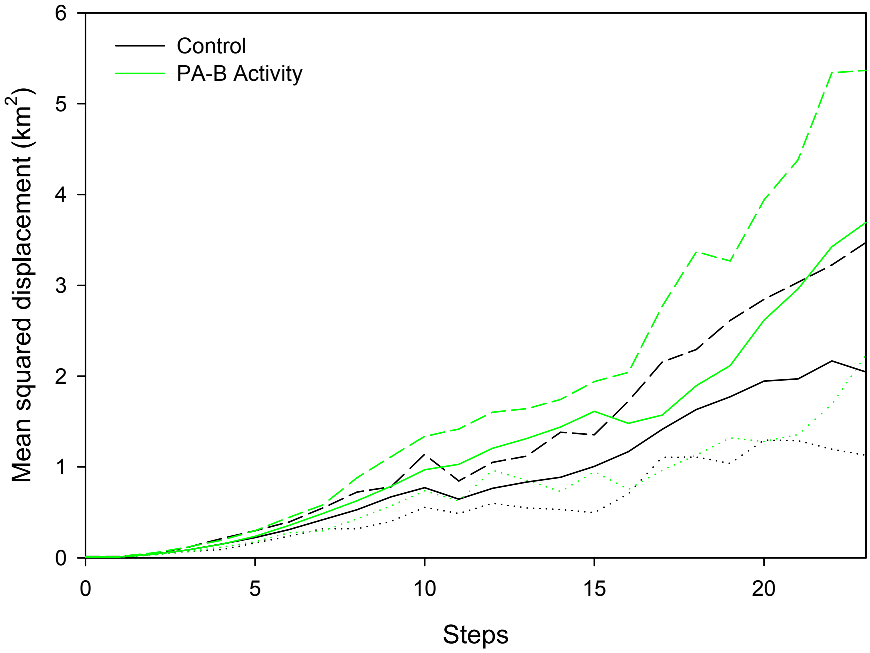


Figure 39. Displacement of western gray whales during observations of traveling behavior in relation to control and PA-B offshore activity categories. The upper and lower 95% confidence intervals are represented by dashed and dotted lines, respectively.

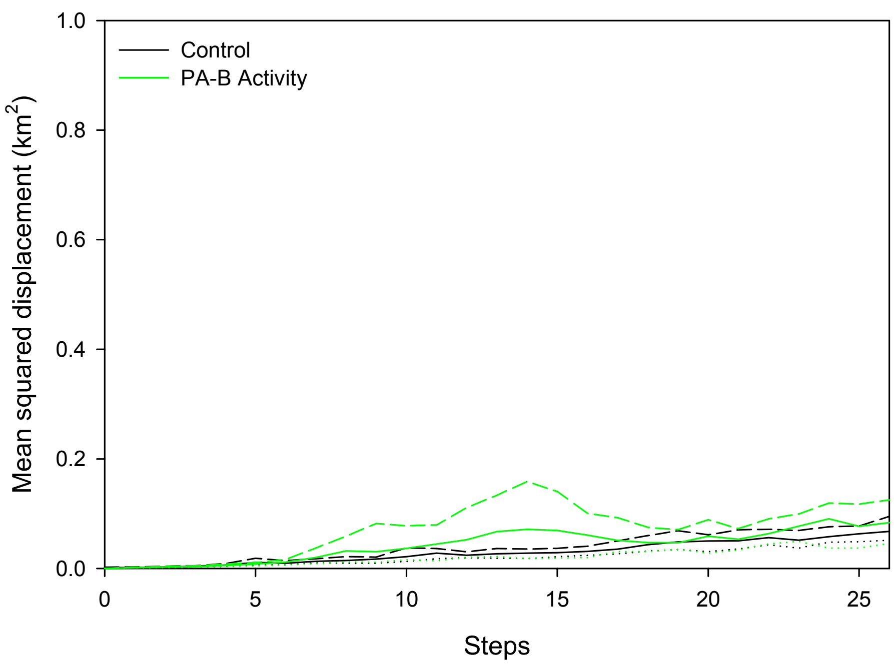


Figure 40. Displacement of western gray whales during observations of feeding behavior in relation to control and PA-B offshore activity categories. The upper and lower 95% confidence intervals are represented by dashed and dotted lines, respectively.

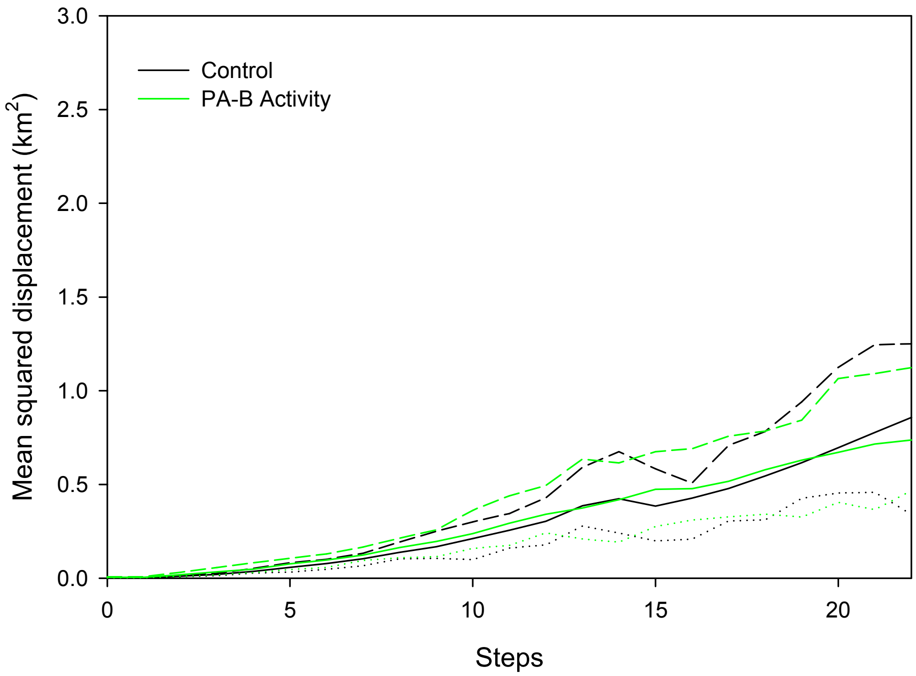


Figure 41. Displacement of western gray whales during observations of feeding/traveling behavior in relation to control and PA-B offshore activity categories.

There were no significant differences found between impact and control categories for all respiration parameters monitored (Blow interval (F = 0.02, df = 1, P = 0.83), surface time (0.39, 1, 0.54), dive time (1.55, 1, 0.22), number blows/surfacing (0.88, 1, 0.35), surface blow rate (0.49, 1, 0.62), and dive-surface blow rate (0.13, 1, 0.72), (Table 16 and Figure 42 - Figure 43).

Table 16. Respiration parameters of western gray whales during control and PA-B offshore activity categories.

Station	Blow Interval		Surface Time		Dive Time	
	Control	PA-B Activity	Control	PA-B Activity	Control	PA-B Activity
North Station	0.35 ± 0.093 (7)		1.5 ± 0.99 (7)		2.2 ± 0.67 (7)	
Odoptu Station	0.4 ± 0.101 (12)		1.4 ± 1.04 (12)		1.8 ± 0.79 (12)	
Station 07	0.37 ± 0.149 (10)		1.6 ± 1 (10)		2 ± 0.75 (10)	
2nd Station	0.41 ± 0.175 (14)		1.4 ± 1.61 (14)		2.2 ± 0.8 (14)	
1st Station	0.33 ± 0.171 (2)	0.36 ± 0.144 (11)	1.1 ± 0.35 (2)	1.3 ± 0.78 (11)	3.4 ± 1.27 (2)	2.5 ± 1.32 (11)
South Station	0.34 ± 0 (1)	0.42 ± 0.218 (9)	0.6 ± 0 (1)	2.5 ± 3.33 (9)	2.3 ± 0 (1)	2.5 ± 1.05 (9)
All Stations	0.38 ± 0.135 (46)	0.39 ± 0.179 (20)	1.4 ± 1.16 (46)	1.8 ± 2.28 (20)	2.1 ± 0.81 (46)	2.5 ± 1.18 (20)

	Number Blows/Surfacing		Surface Blow Rate		Dive-Surface Blow Rate	
	Control	PA-B Activity	Control	PA-B Activity	Control	PA-B Activity
North Station	5.2 ± 2.36 (7)		4.4 ± 1.08 (7)		1.4 ± 1.37 (7)	
Odoptu Station	4.4 ± 2.08 (12)		3.9 ± 1.28 (12)		1.4 ± 1.38 (12)	
Station 07	5.4 ± 2.2 (10)		4.1 ± 1.45 (10)		1.4 ± 1.42 (10)	
2nd Station	4.7 ± 2.9 (14)		4.6 ± 1.54 (14)		1.2 ± 1.24 (14)	
1st Station	4.5 ± 0.71 (2)	5 ± 2.13 (11)	4.7 ± 2.21 (2)	4.8 ± 2.06 (11)	1 ± 1.04 (2)	1.4 ± 1.44 (11)
South Station	2.8 ± 0 (1)	6.2 ± 5 (9)	4 ± 0 (1)	4.3 ± 2.05 (9)	0.8 ± 0.84 (1)	1.3 ± 1.26 (9)
All Stations	4.8 ± 2.33 (46)	5.5 ± 3.62 (20)	4.3 ± 1.36 (46)	4.6 ± 2.01 (20)	1.3 ± 1.32 (46)	1.4 ± 1.36 (20)

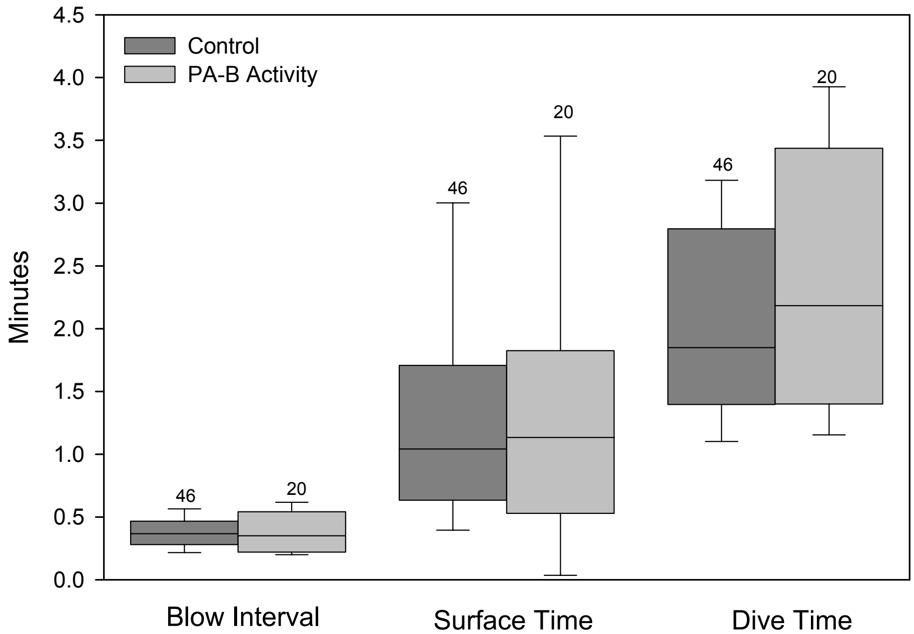


Figure 42. Western gray whale blow interval, surface time, and dive time during control and PA-B offshore activity categories.

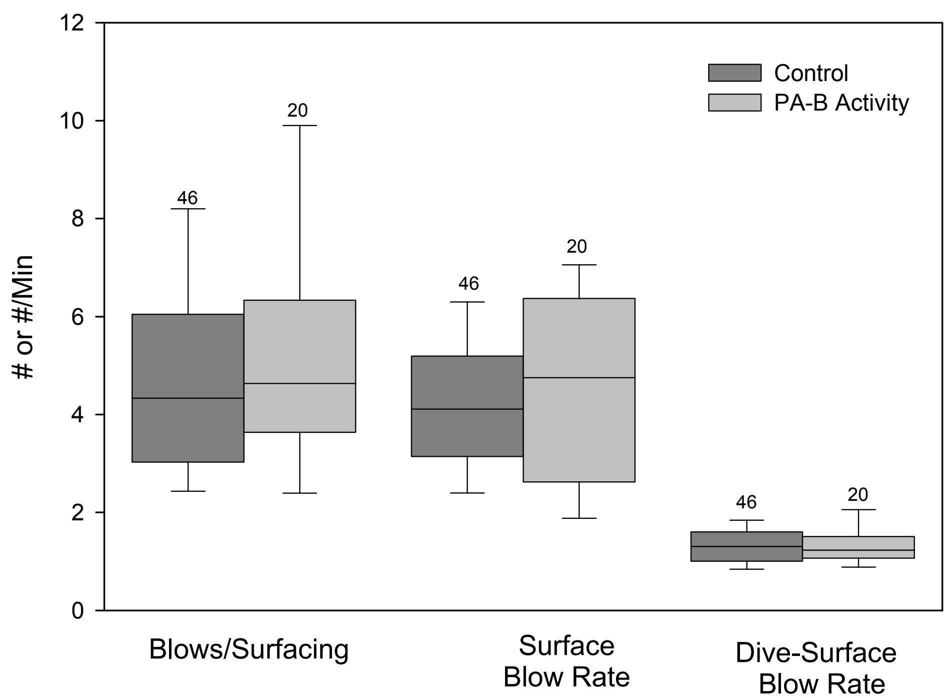


Figure 43. Western gray whales' surface blow rate, dive-surface blow rate, and number of blows per surfacing during control and PA-B offshore activity categories.

DISCUSSION

In 2001, our first year of dedicated shore-based observations (with five stations, spaced closer together than in later years) resulted in initial baseline descriptions as well as examination of potential effects of whale behavior during a seismic survey in that summer (Würsig *et al.* 2002, Gailey *et al.* Submitted). With the exception of a seismic survey late in the 2004 field season, the 2002-2004 observations were relatively free of anthropogenic activity; [hrm1]therefore, we believe that data from those years 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. Due to the potential impact of the seismic activity in 2004 on western gray whales, all data were removed after seismic operations commenced late in that field season and are not included nor analyzed in any representation in this or previous reports (see Gailey *et al.* 2005). While we can compare 2005 whale movement and behavior information to the preceding four years, it is especially informative to compare our present information with that gathered in 2004, because the number of observation stations (6) and two teams working concurrently at adjacent sites were the same. In addition, the field leaders (Gailey at one and Sychenko at the adjacent site) were the same. Unfortunately, we did have reduced researcher numbers between the two years, with two per team in 2005 vs. three per team in 2004; this latter difference resulted in fewer scans in 2005 than in 2004. In this past year, the placement of the CGBS provided a counter-point to the relatively “undisturbed” intervening years.

As in the summers of 2001 thru 2004 (see Würsig *et al.* 2002, 2003 and Gailey *et al.* 2004, 2005 for all comparisons), gray whales in 2005 were present on each day of the 26 days of observations indicating strong habitat utilization in the Piltun feeding area, which is most likely due to high concentrations of prey availability (e,g 114.1 g/m^2 concentrations for Amphipods; Fadeev 2002, 2003, 2004, 2005, 2006). Such repeated habitat use 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 western population (Weller *et al.* 1999). Although distance thresholds allowed for sightings of up to 10 km from the station to be included, the mean distance from shore in 2005 was 1.5 km, as compared to 2.1 km in 2004; overall, whales on average were closer to shore in 2005 than in all years except for 2001. One exception was at the northernmost station, where kernel density probability contours show a consistent feeding area in waters >1.5 km from shore and >20 m deep. In addition, gray whales tended to be further from shore, on average, at these northern stations (mean distance = 2.1 and 1.8 km at North and Odoptu Stations, respectively) than at the four southern stations (1.0, 1.4, 1.5, 1.3).

From 2005 data, as in all previous years, it is apparent that there is much day-to-day variability in numbers of whales and pods per station, even when sighting conditions are similar among several days. Gray whales are highly mobile animals, and can traverse several of our observation areas within one day. Nevertheless, there are certain apparent trends. In 2005, the northernmost station, North Station, had significantly more whales and pods than stations further south (Table 17). This pattern of greater abundance of animals in the northern locations has been consistent for the past four years and consistent with aerial and vessel distribution studies (Vladimirov 2005, 2006). 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 more northerly (presently second-to northernmost) station, Odoptu (~5 km 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, in the central part of our present study area, and some whales may have avoided this area during that period (Yazvenko *et al.* 2002). However, scan observations were not conducted at the northern areas of Odoptu and North Station, which are north of the Odoptu Block, in 2001; therefore, the relative abundance of animals in these areas in 2001 compared to later years is unknown.

There may have been an intra-seasonal trend of shifting abundance in 2005 with decreases (after 8 August) at the two northernmost stations and concurrent increases at the approximate geographic center of the study area, Station 07 and 2nd Station. After early September, relative abundance values from the northern station increased compared to August with concurrent decreases at Station 07. The two southernmost stations tended to be lower than others throughout the season. We caution that great care must be taken in interpretation of these results, as sample sizes within the season were not adequate enough for reliable statistical analyses, and we simply do not know whether the apparent shifts are spurious due to great mobility overall. These data are also collected during the primary feeding period (July to early September) of western gray whales and does not encapsulate seasonal information in relation to arrival and departure of whales to/from the feeding grounds. Vladimirov *et al.*'s(2005, 2006) distribution study provides further details in relation to broad scale distribution patterns that were collected throughout the feeding season (June – October, 2005) by shore-based scans, aerial, and vessel methods.

There was no significant difference in numbers of whales or pods by time of day (AM vs. PM), although it could be instructive (if sample sizes were sufficient) to conduct a multivariate analysis taking tide, weather conditions, seasonality, and temporal considerations into account. As Table 17 indicates, there has been a tendency in the past two years of overall increase in numbers of whales and pods near-shore compared to observations conducted in 2001-2003. This increase could be related to the corresponding decrease of gray whales observed in the offshore feeding area in the past two years (Vladimirov 2005, 2006). The relative number of whales at Odoptu station also appears to shift inter-annually with higher numbers observed in 2002 and 2004 and lower numbers in 2003 and 2005. Potential inter-annual shifts of area use also appear in the kernel density analyses where relatively few whales were observed north of North Station in 2004, while in 2005 this area was more extensively utilized. One explanation for these inter-annual changes could be in relation to size and concentration of prey availability in different areas (Fadeev 2006).

Table 17. Summary of number of whales and pods per scan for 2001-2005. Stations proceed from highest latitude (North Station) to lowest latitude (South Station). Different shading indicates significant differences between stations within each year. Sightings between 0-20 and 160-180 where removed from 2004 & 2005 data sets to properly compare relative abundance of gray whales to the methods of 2001-2003 (see methods).

	Number whales				
Station	2001	2002	2003	2004	2005
North Station	-	-	-	5.7 ± 3.49 (23)	9.1 ± 4.70 (10)
Odoptu Station	-	8.4 ± 4.59 (16)	5.6 ± 4.31 (29)	12.2 ± 5.77 (24)	5.6 ± 4.52 (11)
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)	3.6 ± 1.96 (21)
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)	3.94 ± 2.18 (18)
Mt. Kiwi	4.0 ± 2.70 (42)	-	-	-	-
1st Station	-	1.9 ± 1.98 (35)	1.2 ± 1.84 (46)	3.1 ± 3.00 (45)	2.8 ± 1.83 (16)
South Station	-	-	-	2.3 ± 2.35 (37)	5.5 ± 3.77 (16)
	Number pods				
North Station	-	-	-	3.8 ± 2.10 (23)	6.1 ± 3.44 (10)
Odoptu Station	-	5.7 ± 2.85 (16)	4.4 ± 3.01 (29)	8.4 ± 3.83 (24)	3.9 ± 2.55 (11)
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)	2.4 ± 1.47 (21)
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)	2.9 ± 1.67 (18)
Mt. Kiwi	2.6 ± 1.43 (42)	-	-	-	-
1st Station	-	1.5 ± 1.40 (35)	1.0 ± 1.50 (46)	2.2 ± 1.89 (45)	2.5 ± 1.75 (16)
South Station	-	-	-	1.7 ± 1.61 (37)	2.6 ± 2.68 (16)

In 2005, we had the highest number of theodolite tracks of focal whales, and also the longest track recorded (5.7 hrs) of a mother/calf pair remaining near our 1st Station. This observation occurred during scour protection activities; with the mother-calf pair continually milling throughout the day and then starting to travel south during the end of the observation period. Despite an increase in the overall numbers of whales in the study area in the past two years, the animal's movement patterns in 2005 were generally similar to previous observations. Speed of movement was a median of 1.8 and mean of 2.2 kph, remarkably similar to the median of 1.9 and mean of 2.2 kph of 2004. 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, in which there was little anthropogenic activity being conducted in the study area. 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 2005 (Table 18).

The surface-respiration-dive parameters observed in 2005 were also similar to those observed in 2001, 2003, and 2004. In 2002, however, blow interval and dive time appear to be higher and lower, respectively, than observed in other years, indicative of the greater amount of travel in that year (Gailey *et al.* 2005, Table 18). Blow intervals, blows per surfacing, and surface times in 2001, 2003, 2004 and 2005, 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.

Unlike 2001-2002 but similar to 2003-2004, in 2005 more social activity was observed towards the end of August and early September (on three days: 23 August, 1 and 5 September). Our observation of an increase in social behavior in late summer is 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 involve 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 more energetic activities such as social/sexual “play”, or perhaps as a precursor to physiological sexual readiness. Given the gestation period of gray whales (11-13 months), it is likely that such social/sexual behavior on the feeding grounds is non-reproductive.

Killer whales were sighted within 0.8 and 7 km of focal whales on 11 August and 1 September, but no discernable behavioral shifts were noted for gray whales. We do not know whether the whales were unaware of the killer whales, or were simply unconcerned by their presence.

The behavioral states of western gray whales were recorded in the field along with movement and respiration data. These data demonstrated three primary behavioral types: 1) feeding, 2) feeding/traveling; and 3) traveling through the area, often parallel to the coastline. There were significant differences between movement parameters of speeds of travel, reorientation rates, ranging indices, linearity, mean vector length, and several of the respiration parameters (respiration interval, surface time, surface blow rate) among these behavior states. We recognize some circularity between behavioral categorizations and the variables used in the analyses: for example, a whale classified in the field as feeding ("remains in one localized area with non-directional movement and consistent periods of dives") would be expected to show lowered speeds and higher reorientation rates and dive times than one classified as traveling ("swimming in one general direction and often remaining at the surface without consistent dives"). Behavioral consideration in movement and respiration parameters is, however, an important factor when monitoring an animal's activity in the field and evaluating these data can allow us to rapidly and accurately identify aberrant behavior in the field compared to known baseline information [hrm2](Gailey proposal, January 2006).Differences in movement and respiration patterns during feeding and feeding/traveling behavior may also represent different foraging strategies (i.e. feeding in one area with high concentration of food, while feeding/traveling in areas of lower prey availability or on different prey types).

Without the incorporation of knowledge of underwater sound levels, our designations and analyses of potential disturbance were broadly assessed in the present preliminary report. We addressed three conditions of potential disturbance: industry operation vessels within 2 km of focal whales, small "zodiac" type inflatable vessels with outboard motors that tend to travel rapidly and target whale locations for photo-identification purposes, within 500 m of focal whales, and the CGBS installation.

The CGBS installation analyses were categorized as "before" (previous to 27 July) and "during" comparisons for relative abundance information. Unfortunately, sample sizes for "before" are especially low, as we arrived in the study area only several weeks prior to the onset of construction activities. For movement and respiration analyses, data were partitioned into control (consisting of all data prior to construction and data collected at the four observation station furthest from the construction activity during construction) and PA-B activity (all data at the two closest observation stations during the construction period) categories..

We found no significant differences in numbers of whales or pods before and during construction of the CGBS and associated scour protection activities nor in any respiration or movement variables at the two southernmost stations during construction activity compared to the control category. However, these analyses are univariate and not in relation to the industrial sounds produced by the activity nor do they consider other environmental factors that may affect the variables. During the 2001 seismic survey study, we also found non-significant results for our univariate approach relative to sounds produced during the seismic survey, but after accounting for environmental and temporal variables in a multivariate analysis, several variables were found to be significantly associated with several sound variables (Würsig *et al.* 2002, Gailey *et al.* Submitted). A multivariate approach also has the added advantage of accounting for autocorrelation between subsequent bins of the same track or focal-follow observation allowing for increased sample sizes for analysis. For the univariate analyses conducted here, it was chosen to randomly select one representative bin to avoid autocorrelation issues.

There were no significant differences in occurrence, respiration, or movement parameters due to large vessels within 2 km of focal whales. However, we found a statistical significant increase in acceleration when photo-ID vessels approached within 500 m, indicating that target whales increased speed as the vessel approached. As well, there was an apparent, but not statistically significant, tendency for speeds to be higher and more variable in the presence of the photo-ID vessels (3.4 ± 3.16 kph, n=9) as compared to other vessels (1.7 ± 0.92 kph, n=8) and no vessels (2.2 + 1.58, n=124). These results are manifestations of what can be quite apparent in the field: whales appear somewhat habituated to those vessels that merely travel by without targeting the whales, and that show no apparent danger. These vessels also tend to stay on one course at a relatively constant speed with little erratic movement. The smaller vessels that target whales often change gray whale behavior at least in the short term, especially if these small vessels are driven with rapid shifts in engine speeds and by rapid approach towards whales.

Observations of western gray whales on their feeding grounds in 2004-2005 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, when no construction activities were occurring, potentially indicating a different foraging strategy or change in prey availability in the 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, 2006). This will allow for additional analyses to be conducted to overlay prey densities with behavioral observations. Furthermore, due to the likely increase in anthropogenic activity related to oil/gas project development in 2006 and the concern of possible cumulative impacts, continual acoustic information is essential towards evaluating potential behavioral disturbances of gray whales. We believe that combinations of behavioral observations, acoustic data, and benthic information provide an excellent monitoring strategy to understand potential interactions of these whales and anthropogenic activities 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 18. Summary statistics for theodolite and focal behavior data collected during 2001 - 2005. Dashes (-) separate numbers that indicate ranges; plus/minus (±) separate means and standard deviations, and numbers in parentheses are sample sizes.

Variable	2001	2002	2003	2004	2005
Leg Speed (kph)	1.9 ± 1.49 (510)	3.2 ± 2.06 (74)	2.3 ± 1.04 (47)	2.2 ± 1.30 (116)	2.2 ± 1.58 (124)
Linearity	0.8 ± 0.23 (482)	0.8 ± 0.24 (74)	0.8 ± 0.29 (47)	0.8 ± 0.23 (116)	0.8 ± 0.24 (124)
Acceleration (kph)	0.0 ± 0.71 (506)	0.1 ± 0.50 (74)	0.0 ± 0.23 (47)	0.0 ± 0.22 (116)	0.0 ± 0.23 (124)
Reorientation Rate (°/min.)	17.4 ± 13.72 (506)	21.0 ± 19.32 (74)	26.0 ± 18.76 (47)	19.1 ± 15.17 (116)	21.4 ± 17.25 (124)
Distance to Shore (km)	1.1 ± 0.66 (510)	-	2.3 ± 1.23 (283)	2.1 ± 1.45 (984)	1.5 ± 1.19 (502)
Mean Vector Length	0.8 ± 0.26 (482)	0.8 ± 0.27 (74)	0.7 ± 0.29 (47)	0.8 ± 0.22 (116)	0.7 ± 0.27 (124)
Ranging Index	-	-	31.1 ± 18.06 (47)	32.9 ± 22.31 (116)	32.8 ± 26.67 (124)
Blow Interval (blows/min.)	0.4 ± 0.14 (271)	0.5 ± 0.19 (46)	0.4 ± 0.13 (34)	0.4 ± 0.17 (64)	0.4 ± 0.15 (66)
Blows per Surfacing	5.2 ± 3.93 (234)	4.9 ± 4.45 (42)	4.2 ± 1.38 (34)	4.2 ± 1.63 (64)	5.1 ± 2.86 (66)
Surface Time (min.)	1.6 ± 1.84 (241)	1.7 ± 1.50 (42)	1.7 ± 1.78 (34)	1.8 ± 1.73 (64)	1.6 ± 1.73 (66)
Dive Time (min.)	2.5 ± 0.92 (239)	1.8 ± 0.80 (44)	2.2 ± 0.77 (34)	2.4 ± 0.80 (64)	2.2 ± 0.84 (66)
Dive-Surface Blow Rate	1.2 ± 0.34 (236)	1.3 ± 0.32 (42)	1.3 ± 0.42 (34)	1.2 ± 0.32 (64)	1.3 ± 0.42 (66)

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APPENDIX 1. Daily summary of theodolite, focal behavior, and scan data collected during the summer of 2005.

Station	Date	Start Day	End Day	Effort (hrs)	# Tracklines	# Focal Follows	# Scans
1st_Station	12-Jul-05	11:31:55	14:49:57	3.30	0	0	0
1st_Station	13-Jul-05	11:20:27	18:32:59	7.21	3	1	5
South_Station		13:20:17	17:43:20	4.38	2	0	2
2nd_Station	14-Jul-05	7:29:10	17:45:56	10.28	4	1	3
Station_07		8:06:17	16:36:00	8.50	4	2	5
North_Station	15-Jul-05	9:47:53	10:57:28	1.16	0	0	1
Odoptu_Station		9:44:16	12:19:43	2.59	1	0	1
North_Station	24-Jul-05	11:31:22	15:31:23	4.00	2	0	0
Odoptu_Station		11:53:02	16:15:54	4.38	3	0	2
1st_Station	26-Jul-05	9:10:51	19:02:20	9.86	4	1	2
South_Station		10:25:00	18:26:20	8.02	5	1	3
2nd_Station	27-Jul-05	9:38:45	18:33:40	8.92	4	1	1
Station_07		10:11:51 14:02:01 15:22:43	11:46:07 14:15:59 18:06:18	4.53	3	0	1
2nd_Station	28-Jul-05	10:54:25	18:06:15	7.20	5	3	0
1st_Station	29-Jul-05	7:41:13	18:51:34	11.17	8	3	3
South_Station		7:56:59	18:00:22	10.06	3	2	3
1st_Station	31-Jul-05	7:24:46	8:31:49	1.12	0	0	0
South_Station		7:42:08	10:28:49	2.78	0	0	0
1st_Station	6-Aug-05	7:07:35 15:02:22	14:52:48 15:12:33	7.92	7	2	0
South_Station		7:19:50	15:03:34	7.73	1	0	1
2nd_Station	7-Aug-05	7:40:11	17:59:05	10.32	3	2	5
Station_07		8:16:24	17:32:23	9.27	3	1	6
North_Station	8-Aug-05	8:47:46	16:48:59	8.02	8	3	2
Odoptu_Station		8:11:36	16:33:03	8.36	4	3	2
1st_Station	11-Aug-05	10:58:23	18:42:01	7.73	2	0	1
South_Station		11:35:29	18:21:47	6.77	5	2	2
2nd_Station	18-Aug-05	7:39:08	18:04:26	10.42	5	2	4
Station_07		7:44:42	17:36:43	9.87	3	2	5
Odoptu_Station	19-Aug-05	9:04:23	16:44:41	7.67	8	3	2
North_Station		9:06:53 16:43:06	16:26:06 16:59:53	7.6	3	0	2
1st_Station	20-Aug-05	7:23:34	14:15:51	6.87	3	1	1
South_Station		7:30:21	14:00:11	6.50	1	1	2
2nd_Station	21-Aug-05	7:26:38	14:03:14	6.61	2	0	1
Station_07		8:08:24	12:27:58	4.33	2	2	0
2nd_Station	23-Aug-05	7:36:36 11:07:44	10:23:22 17:59:32	9.64	5	2	1
Station_07		8:21:54 11:04:56	8:30:35 18:35:41	7.66	3	1	3
1st_Station	25-Aug-05	13:13:06	18:13:16	5.00	4	2	0
1st_Station	26-Aug-05	10:27:41	16:44:48	6.29	2	1	1
South_Station		11:23:08	16:38:09	5.25	5	2	0
North_Station	31-Aug-05	10:06:45	17:15:34	7.15	4	3	1
Odoptu_Station		9:36:31	17:34:00	7.96	4	2	1
2nd_Station	1-Sep-05	8:41:02	17:35:33	8.91	8	3	2
Station_07		9:33:08	16:56:33	7.39	6	3	0
North_Station	5-Sep-05	10:52:01	17:54:19	7.04	4	1	3
Odoptu_Station		9:51:44	17:59:31	8.13	8	4	2
1st_Station	6-Sep-05	8:15:25	16:58:19	8.72	5	2	3
South_Station		8:17:23	14:19:59	6.04	3	2	3
2nd_Station	7-Sep-05	8:23:00	8:45:00	0.37	0	0	1
North_Station		11:00:30	11:25:45	0.42	0	0	1
Odoptu_Station		10:06:20	10:26:40	1.01	0	0	1
Station_07		9:14:40	9:35:30	0.35	0	0	1
TOTAL				332.73	172	67	92