WESTERN GRAY WHALE ADVISORY PANEL **WGWAP 5/18**
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ENGLISH

Comparison of shore-based scan counts

Comparison of Shore-Based Scan Counts

Background

As part of the recommendations of the WGWAP-4 report, the panel agreed … *that a dedicated comparison of scan and count methods as well as the analytical approaches used to calculate distance for data from the two teams would be a valuable contribution to proper integration of the distribution and behaviour data sets* (Recommendation 008, WGWAP-4 report).

This document aims to address this recommendation by:

1) Outlining and comparing the scan methodologies between the distribution and behaviour teams
2) Providing differences in distance estimation approaches
3) Comparing differences in whale counts between the shore teams
4) Comparing differences in whale counts on a daily and single scan basis

Study Area and Methods

The behavioural and distribution scan collection aim to monitor the relative abundance and distribution of western gray whales at both a broad and fine scale resolution. The shore based distribution scans are conducted once per day at each of the 13 locations (Figure 1). The behavioural teams are located at two of their six observation stations on any good weather day (Figure 1). Behavioural teams conduct multiple scans throughout the day to monitor finer scale temporal and spatial changes (natural and in relation to anthropogenic activities) in distribution and abundance within their observation regions.

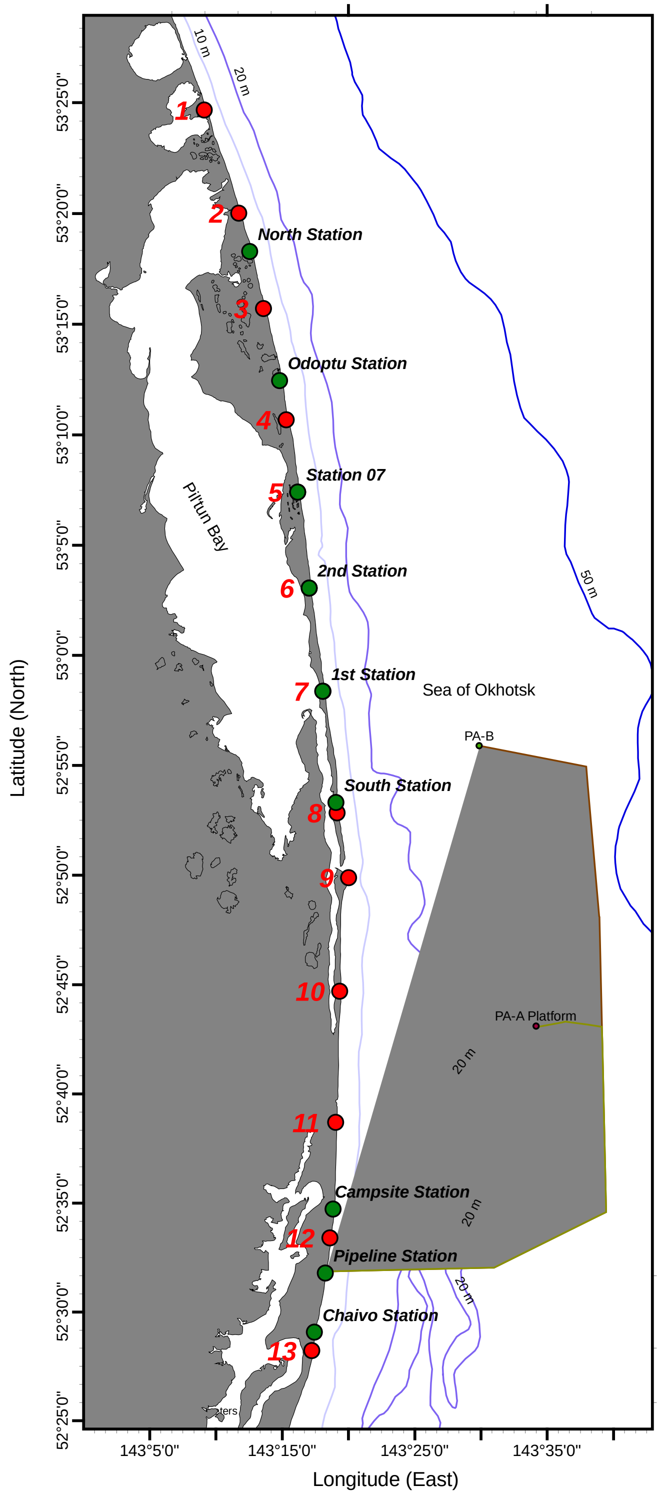

Figure 1. Map of distribution and behaviour survey points along the northeastern portion of Sakhalin, Island. Red numbers indicate distribution team survey locations and black names (green dots) indicate behavioural observation locations.

Distribution survey methods summary **-** The distribution survey points are classified into two regions – the Odoptu-Piltun (north, stations 1-8, Figure 1) section and the Astokh-Chayvo (south, stations 9-13, Figure 1). Two survey teams, one for the Odoptu-Piltun area and one for the Astokh-Chayvo area, conduct scans along ~120 km of coastal region. The two surveys are coordinated and conducted concurrently. During each survey, the two teams synchronize the survey time at the nearest stations near the mouth of Piltun Bay (Stations 8 and 9). Therefore, if the north team conducted a survey from Station 1 to Station 8, the south team conducts surveys moving in the opposite direction, from Station 13 to Station 9, and the teams synchronize the end of the survey at Station 8 and Station 9. In similar fashion, if the north team starts a survey from Station 8 in the morning, the south team starts its survey from Station 9 at the same time.

Upon arrival at each observation station, the distribution team conducts one scan. The scan proceeds from north to south or south to north depending on the direction of the survey route (i.e. if the distribution team is surveying from station 1 to station 8 (north to south), then scans proceed north to south). Each survey team consists of three members: Two scan observers and one data recorder. The two observers use hand-held binoculars (7x50 Fujinon FMTRC-SX or Steiner Commander V binoculars (used only in 2007)). The scan continues progressively at a rate of 10º per minute with a duration ranging from 17-20 minutes. All sighting and environmental data are recorded on datasheets. Scan surveys are not conducted with > 3 Beaufort sea state, wind speed > 10 m/s, heavy participation, and/or presence of fog.

Behavioural scan survey methods summary **–** The behavioural observations are conducted at six stations in the northern (Odoptu-Piltun) region (Figure 1). Two separate behavioural teams conduct research at two of the six observation stations on every possible "good" weather day. Scans are conducted hourly when focal follow observations are not being conducted. During each scan, two observers use hand-held binoculars (7x50 Fujinon FMTRC-SX with reticle and compass) to progressively scan a predetermined section of the study area ranging from 0° to 180° magnetic North (magnetic declination relative to true North = 11.81° West in summer of 2007). Each scan is initiated from the northern portion of the study area and proceeds 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 - 2007 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. The *Pythagoras* software, developed by Gailey and Ortega-Ortiz (2002), was used to 1) inform the observers of the approximate region they should be scanning for every 10° magnetic North, 2) provide a data entry form to record sighting information, and 3) calculate geographic position and visually display sightings in real-time.

Comparison of behavioural and distribution scan methods – The methods of the behavioural surveys are designed to remain in one region per day of effort and monitor changes in the distribution of whales throughout the day. Distribution surveys aim to provide a “snap” shot of the distribution and abundance of western gray whales at a larger geographic range. Of the six behavioural observation points, three (Station 07, 2nd Station, and 1st Station) overlap at the same location with the vehicle observation sites. The behavioural southern location (South Station) is, however, relatively close to the northern distributions most southern observation site (Station 8).

The scan protocols between the distribution and behaviour teams are similar with some differences in scan rate, scan duration, and scan direction. Recorded environmental and sighting information are also similar with the exceptions that behavioural records do not include horizon visible and precipitation variables, while distribution records do not record temperature, pressure, estimated swell height, and observer’s who initially makes a sighting (Appendix 1). The most problematic difference in data recording is the difference in categorization of visibility, an important parameter when assessing the relative number of whales during different environmental conditions. This lack of compatibility in definition leads to difficulties when attempting to combine these data for analyses, such as the multivariate analyses being conducted by Gailey et al.

Distance Approximation

The estimation of distances to a marine mammal from an observation point is a critical part of determining distribution. Both shore-based observation teams have adopted the Lerczak and Hobbs (1998) distance approximation equation to estimate the distance and geographic location of western gray whales from binocular reticle readings. However, the line-of-sight estimation does not account for possible bending due to environmental conditions that cause refraction as light rays curve when passing through an atmospheric density gradient (Lerczak and Hobbs 1998). Therefore, the behavioural distance approximation included a refraction correction proposed by Leaper and Gorden (2001) that considers both temperature and pressure at the time of observation.

To evaluate the accuracies in the two distance estimation approaches, estimated vessel positions that were observed during scans in 2006 were calculated and compared to the actual location recorded by the ship's Global Positioning System (GPS). Both distance functions tend to underestimate the actual distance of the vessel. However, the refracted corrected distance does tend to compensate for part of the underestimation (Table 1). These results are similar to those published in Kinzey and Gerrodette (2003).

Upon review of the Leaper and Gorden (2001) and Kinzey and Gerrodette (2003), distribution sightings have been recalculated using the refraction correction approach and therefore all shore-based scan distance approximations have been standardized.

Table 1. Distance approximation of vessels observed during behavioural and distribution scans in 2006 compared to actual vessel distances.

Vessel	L&H Distance (km)	Refraction Corrected Distance (km)	Actual Distance (km)
Oparin	3.32	3.48	3.70
Oparin	8.76	11.13	11.49
Oparin	3.54	3.70	7.12
Oparin	2.47	2.55	3.67
Oparin	4.80	5.08	8.64
Oparin	3.94	4.10	8.75
Bogorov	4.49	4.74	5.50
Bogorov	3.11	3.24	4.31
Bogorov	3.67	3.83	4.98
Bogorov	3.69	3.86	5.11
Bogorov	5.26	5.46	8.41
Bogorov	3.44	3.56	5.47
Bogorov	5.71	6.05	11.94
Bogorov	8.17	10.45	7.95
Bogorov	5.35	5.67	7.25
Bogorov	3.01	3.09	4.13
Bogorov	3.73	3.93	5.86
Bogorov	4.12	4.28	6.47
Bogorov	6.69	7.03	16.34

Cross Comparison between Shore-Based Scan Counts

To address the WGWAP-4-008 recommendation, scans that were conducted at the four overlapping stations during the 2006 and 2007 field seasons were evaluated. These stations were Station 07, 2nd Station, 1st Station, and South station for the behaviour team and stations 5 – 8 for the distribution team (Figure 1). Scans that were conducted within less than 30 minutes from one another were evaluated in terms of the two teams estimated number of whales per scan. The duration was chosen to provide meaningful sample size for evaluation purposes. Only scans conducted in good visibility and Beaufort Sea states less than 4 were used to evaluate comparisons of counts between the two observational teams.

There were a total of 31 (14 in 2006 and 17 in 2007) overlapping scans that were conducted on 26 different days during 2006 and 2007. The behavioural observers sighted a mean of 4 whales and a maximum of 10 whales, while the distribution team sighted a mean of 4 whales and a maximum of 11 whales.

Distributional and behavioural scan counts of western gray whales were the same 32% of the time. Approximately 13% of the overlapping scan counts differed by at least 4 whales. (Table 2, Figures 2-3). In both 2006 and 2007, differences in whale counts were not significantly different between the teams (t= -1.429, sig= 0.163), however, sample size is relatively low for analytical purposes.

Table 2. The absolute difference in the whale counts between the distribution and behaviour teams.

Absolute Difference	Frequency	Percent	Cumulative Percent
0	11	35.48	35.48
1	8	25.81	61.29
2	7	22.58	83.87
3	1	3.22	87.10
4	0	0	87.1
5	2	6.45	93.55
6	0	0	93.55
7	2	6.45	100

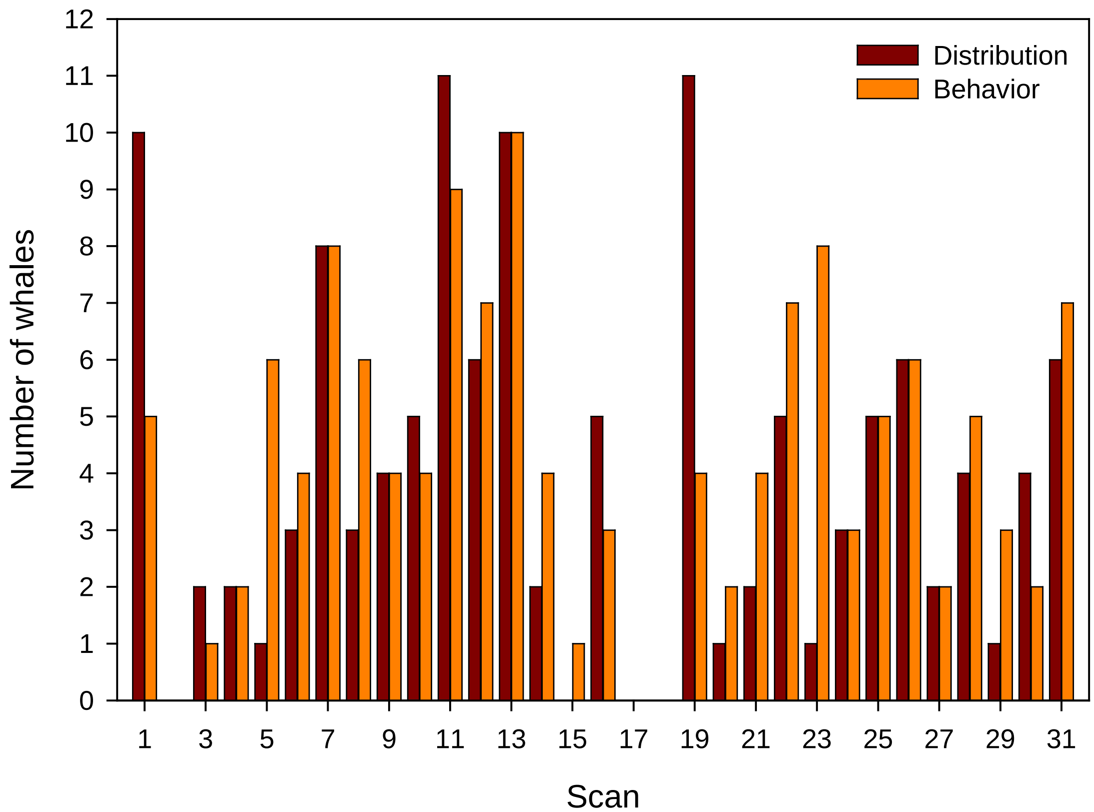

Figure 2. Number of whales sighted during overlapping scans by the shore-based distribution and behaviour teams during the summer of 2006 and 2007.

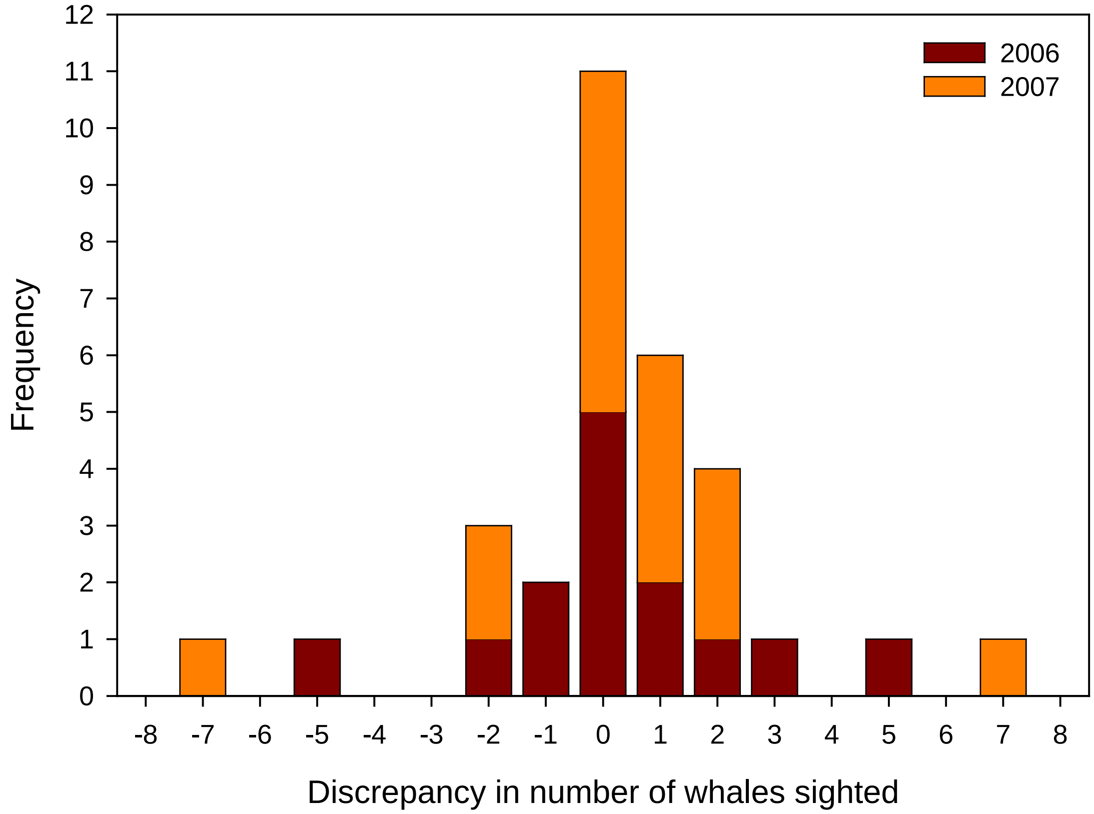

Figure 3. Number of whales observed during concurrent scans conducted by distribution and behaviour teams in 2006 and 2007. Negative values indicate that the distribution scan sighted more whales than the behavioural scan. Zero indicates perfect agreement and positive values indicate that behavioural scans yielded higher number of whales than the distribution scan.

Pod Size Discrepancy **-** One factor that may influence differences in the number of whales sighted is an observer's ability to estimate pod size. Therefore, pods that had similar sighting information (based on bearing, reticle readings, time, and separation from other whale sightings) were compared between the two teams. Figure 4 illustrates that the behavioural pod estimation tended to be higher than the distribution estimation. However, upon re-evaluation of the data, it is believed that these differences are not representative of the overall differences in the numbers of whales sighted. In fact, it is believed that the main differences in pod size estimation are more related to pod size definition. Multiple single whale sightings at minor differences in bearing for the distribution team were more likely to have one estimated bearing and group size estimate for the behavioural team. In other words, on some occasions when a pod had greater then 1 individual could be identified as the same between the two teams, the distribution team tended to give multiple different sightings at small differences in magnetic degrees (1-5° magnetic) but have the same reticle readings, while the behavioural observers tended to consider these as one group.

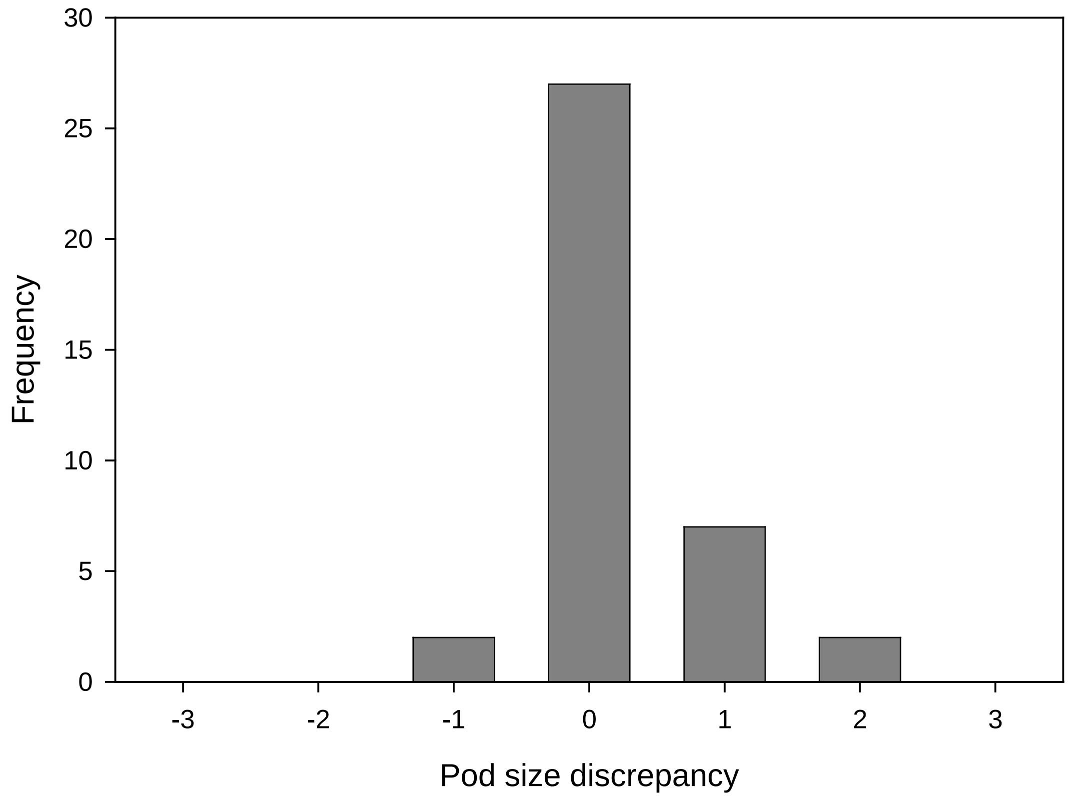

Figure 4. Discrepancies in pod size estimates between distribution and behaviour teams in 2006 and 2007. Negative values indicate that the distribution scan estimated larger pod sizes than the behavioural scan. Zero indicates perfect agreement and positive values indicate that behavioural scans yielded higher pod sizes than the distribution scan.

Single vs. Multiple Daily Scans

Distribution sightings are conducted once per day at each of the 13 observation station. These counts may or may not be representative of the mean or maximum number of whales that utilize a certain habitat on a daily basis. To examine these differences, the behavioural daily counts were compared to the distributional count at the four overlapping stations. Only behavioural counts consisting of 3 or more scans per day were used for this evaluation.

Mean Whales - There were 46 (18 in 2006 and 28 in 2007) instances on 25 days where behavioural observers completed at least three scans in good conditions and the distribution team conducted one scan in good conditions at the same location. The mean and maximum numbers of whales sighted by the behavioural observers were 4 and 20 whales, respectively. The distribution observers had a mean of 4 and a maximum of 16 whales. The mean count was similar to the distributional single count 26% of the time. Difference of >3 whales between the daily and single comparison occurred 9% of the time (Table 3, Figure 5).

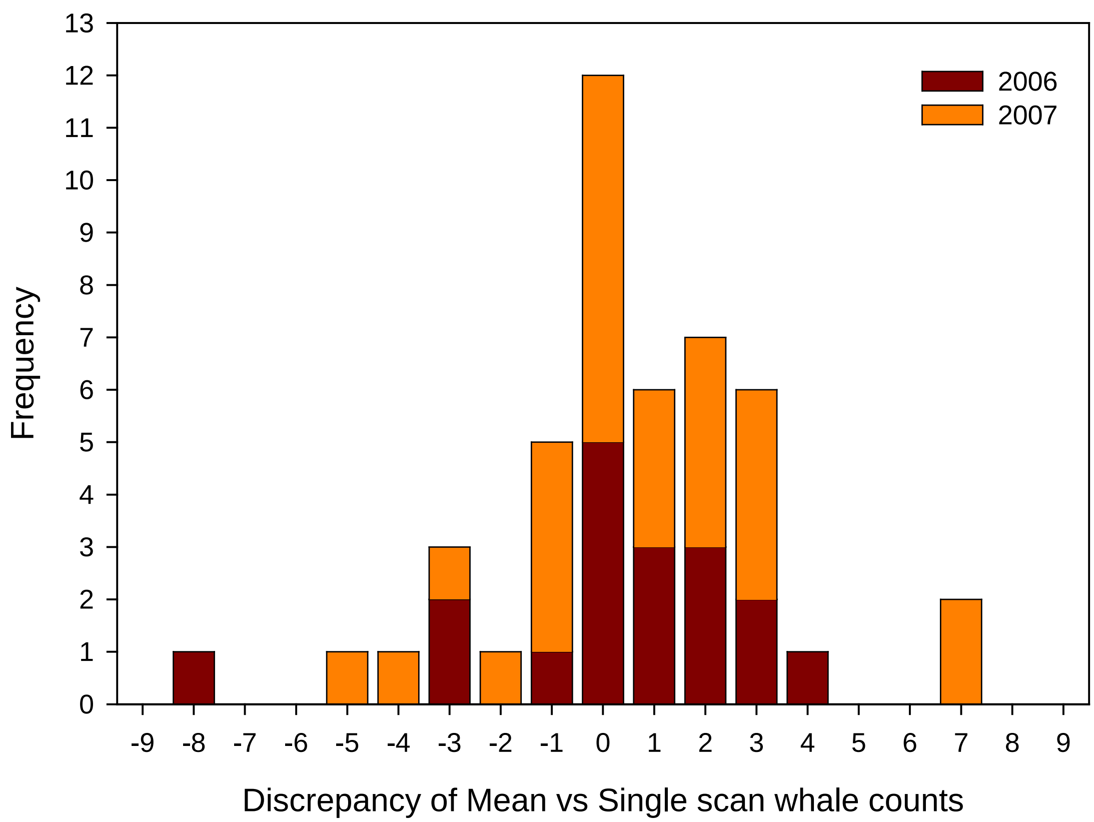

Figure 5. Mean difference of behavioural daily scan counts compared to single scans conducted by the distribution team at the same observation site. Negative values indicate that the distribution sighted more whales than the mean number of whales observed by

the behavioural observers. Zero indicates that the mean number of whales sighted agrees with the single scan count. Positive values indicate that the mean number of whales was higher than the single whale count.

Table 3. The absolute difference between the mean and maximum number of whales sighted by the behavioural observers during multiple scans and the distribution observers during one scan.

Absolute Difference In Whales Sighted	Daily Mean vs Single Count			Daily Maximum vs Single Count		
	Frequency	Percent	Cumulative Percent	Frequency	Percent	Cumulative Percent
0	12	26.09	26.09	6	13.04	13.04
1	11	23.91	50.00	12	26.09	39.13
2	8	17.39	67.39	6	13.04	52.17
3	9	19.57	86.96	6	13.04	65.22
4	2	4.35	91.30	3	6.52	71.74
5	1	2.17	93.48	7	15.22	86.96
6	0	0.00	93.48	2	4.35	91.30
7	2	4.35	97.83	1	2.17	93.48
8	1	2.17	100.00	1	2.17	95.65
9	0	0.00	100.00	1	2.17	97.83
10	0	0.00	100.00	0	0.00	97.83
11	0	0.00	100.00	1	2.17	100.00

Maximum whales - The maximum number of whales observed by the behavioural observers agreed with the single count of the distribution survey 13% of the time. The daily maximum tended to be greater than 3 whales from the single count 28% of the time. (Table 3, Figure 6). On average, the mean and maximum counts tended to observe more whales compared to the single count.

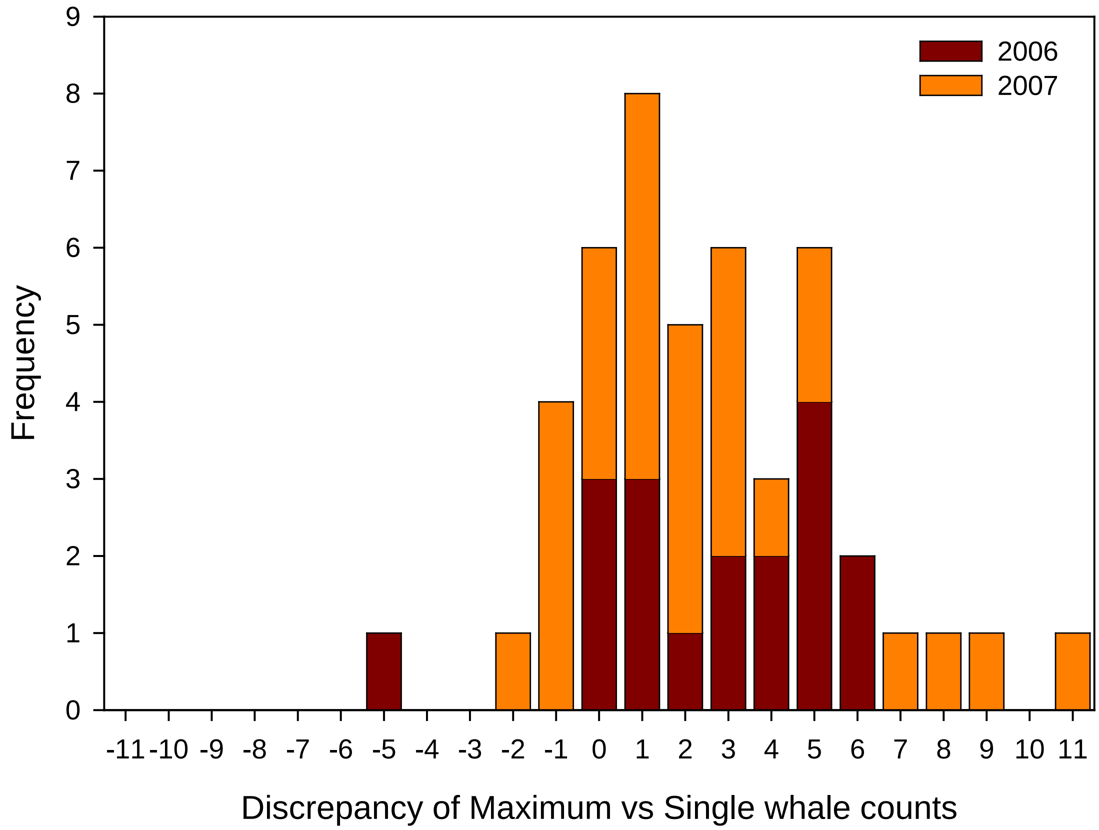

Figure 6. Difference in the maximum number of whales sighted during at least three scans per day compared to a single count of whales at the same station on the same day. Negative values indicate that the distribution single count observed more whales compared to the maximum number of whales seen during the multiple scans. Zero indicates that the maximum number of whales were similar to the single distributional whale count. Positive values indicate that the maximum number of whales sighted in a single day was greater than the number of whales counted during the single distributional scan.

Summary

Scan protocols between the distribution and behaviour teams are similar with some relatively small deviations in scan rate, scan direction, and overall duration of the scan. Environmental and sighting information being recorded by the two shore-based teams are also similar with exceptions of precipitation, horizon visible, swell height, atmospheric temperature, atmospheric pressure, and the observer who initially sights a whale(s) (Appendix 1). Lack of standard definition in the visibility assessment is likely to be the most problematic issue when attempting to integrate the two teams' datasets for analytical purposes. Lack of data collection of other variables, such as estimated swell height; also pose analytical issues if these variables are to be considered in the analyses.

Two different distance estimation approaches were evaluated and compared to actual ship positions observed in the field. Although both distance estimations tended to underestimate the true position of the vessel, the refracted corrected distance approach proposed by Leaper and Gorden (2001) compensated for part of the underestimation. Based on these results, all shore-based sightings have been re-calculated using the refraction correction distance equation.

There can be considerable amount of variability in the overall number of whales observed per scan at approximately the same time and location. These differences were not observed to be biased to one team who could have potentially identified more or less number of whales than the other shore based team. Given the limited sample size and lack of a proper design to test these differences, it remains unclear why the two teams have considerable amount of variation in whale counts. Pod size did not initially appear to have contributed to these differences, but the two teams do appear to define pod size differently, which may result in different results of average group sizes of western gray whales. In general, the whale counts were within at least 3 or less whales 87% of the time. The mean number of whales observed by the behaviour team was on average similar to the single count observed by the distribution team. However, the maximum number of whales observed in a specific region on a given day tended to be higher than the single count observed indicating the amount of variability in abundance and distribution of western gray whales on a daily basis.

In conclusion, these results provide an initial evaluation of comparisons between shore-based counts conducted by two separate teams (distribution and behaviour) and the amount of daily variation that can occur. These data were, however, not specifically designed or collected in a manner to address the question at hand. Scans performed by the two teams may not have occurred at exactly the same time. Alternately, if scans did occur simultaneously, sighting biases may have occurred due to the observers' proximity to one another during the scan. A more appropriate design with increased sample sizes may yield different results from those presented here.

Literature Cited

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Appendix 1. Environmental and sighting information recorded for behavioural and distribution scan surveys. X indicates variables that are recorded for each project.

Type	Variable Name	Behaviour	Distribution	Definition
Environmental	Station	x	x	Unique numerical or textual description of the observation point.
	Date	x	x	Date of observation
	Start Time	x	x	Start time of the scan
	Stop Time	x	x	Stop time of the scan
	Visibility	x	x	Visibility conditions of the survey*
	Cloud Cover	x	x	Estimated percent of clouds
	Horizon Visible		x	True/False indicator if horizon is visible
	Glare Present	x	x	Presence of glare in the scan region
	Glare (%)	x	x	Percent of scan region obscured by glare
	Glare Bearings	x	x	Range of magnetic bearings of glare
	Precipitation		x	Presence of rain during the scan
	Wind Direction	x	x	Estimated direction of the wind
	Wind Speed	x	x	Estimated speed of the wind (m/s or km/h)
	Sea State	x	x	Beaufort sea state scale
	Temperature	x		Atmospheric temperature during time of scan (º C)
	Pressure	x		Atmospheric pressure during time of scan (mB)
	Swell Height	x		Estimated height of swell (m)
Sighting	Species	x	x	Name of species or vessel observed during a scan
	Magnetic Bearing	x	x	Magnetic compass bearing to the observed species
	Reticle Estimate	x	x	Reticle value (divisions of 0.1) from the observed species from the horizon
	Individuals	x	x	Estimated number of sighted individuals
	Observer	x		Name of observer who initially sighted the species

* Distribution Visibility consists of an estimated distance (km). Behavioural Visibility classification is a subjective categorization of 1-5, where 1 = Excellent conditions with clear horizon line, 2 = good conditions with little to no haze at horizon, 3 = fair with some haze at the horizon, 4 = poor, no horizon, and 5 = low visibility, (< 5 km visibility).