WESTERN GRAY WHALE ADVISORY PANEL **WGWAP 3/INF.20-REV**

3rd Meeting **10 November 2007**

Agenda Item: 3 **ENGLISH**

MARINE MAMMAL OBSERVER PROGRAME

SEIC MMO Programme Effectiveness

Submitted by SEIC

SEIC MMO Programme Effectiveness

1. BACKGROUND

This document was prepared in response to recommendation WGWAP 2/009[1] specified in the Western Gray Whale Advisory Panel Report (IUCN 2007) of the second official meeting in April 2007, St. Petersburg, Russia. The SEIC MMO program was introduced in 2003 as one of the mitigation measures implemented for the Lunskoye seismic survey. During 2003, the main objective of the MMO program was to prevent marine mammal exposure to sound levels that could potentially result in hearing impairment. In subsequent years, when SEIC used MMOs on vessels that were involved in construction activities and site specific surveys, the MMO program focussed instead on prevention of vessel-whale collisions during whale migration and feeding periods.

A collision risk assessment was performed in 2006 as recommended by the ISRP (Gland meeting May 2005) to help identify SEIC vessel routes with highest risk of vessel-gray whale collisions that would benefit most from placing MMOs on board vessels transiting these routes. The MMO effectiveness as assessed in this report is a logical next step in determining how well the MMO program achieves its objective in preventing and reducing vessel-gray whale collisions.

The analysis of MMO effectiveness proposed by the WGWAP consists of the following components:

- Proportion of vessels/traverses with MMOs on board;
- Of those vessels with MMOs on board, the proportion of (1) time steaming and (2) nautical miles steamed during periods of daylight and reasonable visibility;
- Of that time/distance, the proportion in which the MMOs are operating effectively, given that the number of observers placed on each vessel (one or two) is insufficient to maintain effective watch continuously - this factor may be hard to quantify and thus need to be estimated roughly, based on the lengths of duty periods;
- An estimate of the mean detection probability while MMOs are on effective watch as a function of number of MMOs, visibility and sea state.

[1] The Panel **recommends** that the MMO dataset, in conjunction with the company's other records of vessel operations, be analyzed by Sakhalin Energy, with a view to evaluating each of the factors (specified in the report text) that contributes to overall effective coverage.

2. METHODS AND RESULTS

While MMO data were available from 2003 to 2007, only data from 2005 to 2007 were used in this analysis of MMO effectiveness. These data were selected partly because industrial activities in the Piltun area occurred mainly during this time period, but also because the rigor of data collection and QAQC of these data has improved over the years, with data from 2003 to 2004 considered to be less reliable for the purpose of the proposed analysis.

2.1. Proportion of vessels/traverses with MMOs on board

MMOs were stationed on vessels according to several criteria that included:

- How closely the vessel would approach the Piltun feeding area.
- Whether or not the vessel would be stationary for the majority of time.
- Whether the vessel was part of a group of vessels, i.e. a vessel spread, or would be operating independently. Examples of activities conducted with a vessel spread are pipe-laying, dredging, and installation of the concrete gravity based structure and topsides. The main vessels conducting these activities were accompanied by tugs, anchor handling vessels, and/or support and supply vessels. Typically 2 MMOs would be assigned to one vessel in a vessel spread.
- Accommodation available for MMOs on a vessel. Some vessels had limited berthing available that was fully occupied by the crew.

It was assumed that the proportion of vessels with MMOs on board should be calculated only for the Piltun area because proximity to this area was of vital importance in determining the necessity of MMOs on the vessel. This task was complicated by the following factors:

1. All vessels under contract by Sakhalin Energy were in principle assigned to specific tasks that could take place in different areas. This is especially the case in 2005 and 2006 when offshore construction activities were taking place in Aniva Bay, Lunskoye and Piltun.
2. The MMO database identifies the vessels that had MMOs assigned (Table 1) and the dates these vessels were in the field. We are experiencing difficulty, however, in determining the exact number of vessels sailing without MMOs in the Piltun area at any point in time because not all vessels under contract worked the entire season. The proportion of vessels with MMOs can therefore change over time. However, it should be possible to obtain the total number of vessels contracted by Sakhalin Energy for each year, and calculate a simple proportion of vessels with MMOs on board as requested by the Panel. SEIC is endeavouring to provide this information as soon as possible.

Table 1. Number of vessels with MMOs on board during 2005, 2006 and 2007.

Year	Number of vessels with MMOs	Total Number of Vessels in Field	Proportion of Vessels with MMOs
2005	19	35	0.54
2006	13	82	0.16
2007	6	30	0.20

2.2. Proportion of time steaming and nautical miles steamed during periods of daylight and reasonable visibility

During 2005 to 2007, SEIC conducted industrial activities related to platform and pipeline installation that involved multiple vessels. Each of these vessels was assigned to one or more specific tasks, with very different, and often very irregular movement patterns. The MMOs did not focus on obtaining exact data on distance traveled because this would have been difficult and time consuming, and would have reduced their effort for the main task, i.e., looking for marine mammals so that vessel-whale collisions could be avoided. Hence estimation of nautical miles steamed is not supported by the 2005 to 2007 MMO data.

MMOs began recording the vessel speed in 2007, so the proportion of time steaming during periods of daylight and reasonable visibility (visibility of at least 1 km and sea state less than Beaufort scale 4) could be determined for this particular year. Vessels travelling with speeds at least 1 km per hour were considered to be steaming for the purpose of this analysis. The proportion of time steaming could be approximated for 2005 and 2006 vessels by using the percentage of the total number of MMO records that represented moving vessels during periods of reasonable visibility, with the knowledge that one record was reported at least every 30 minutes. The MMO observations recorded by steaming vessels in 2005 and 2006 were identified by using the vessel activity attribute in the MMO data recording sheet. It was necessary to assume that the indicated vessel activity applied to all records for a given day during 2005 and 2006 because the vessel activity was recorded only daily in the MMO data sheets. Vessels conducting miscellaneous survey activities or in transit were assumed to be moving at sufficient speed to be classified as steaming.

Using this approach, the numbers of MMO records for steaming and stationary vessels were determined for each year during periods of reasonable visibility (including daylight) and poor visibility (Table 2). Vessels were steaming in good visibility conditions approximately 27 % of the time that MMOs were on both moving and stationary vessels under all weather conditions. Good visibility conditions occurred approximately 71 % of the time when MMOs were present on steaming vessels.

Table 2. The number of MMO records for stationary and moving vessels under conditions of poor and good visibility for each year of 2005 to 2007.

Year	**Poor Visibility**		**Good Visibility**		**Total**
	Stationary	*Moving*	*Stationary*	*Moving*	
2005	4973	2382	11633	5045	24033
2006	8219	3123	10730	7595	29667
2007	719	1206	1650	3606	7181
total	13911	6711	24013	16246	60881

2.3. Proportion of time/distance in which MMOs are operating effectively

Observations of marine mammals were conducted in daylight hours. The observation hours per day depend on longitude (area) and date (month), and range from 12 to 16 hours based on an analysis of modal values (start of observation/end of observation) (Table 3). Each MMO is on duty for no more than 4 consecutive hours, with two MMOs placed on most vessels. Consequently, one MMO is always on effective watch, with a maximum of 8 hrs (two rotations) on duty per MMO per day.

Only one MMO was placed on each crew change vessel in 2006-2007 because the vessels are quite small and have limited passenger capacity. Since the duration of the trip between Kaigon and PA-A is about four hours, and between Kaigon and PA-B approximately 5 hours, the maximum MMO watch duration is about four to five hours on a crew change vessel. After each voyage, the MMO is able to take a break for a minimum of several hours (or night).

Table 3. Average number of daylight hours available during June to October

Time Period	**Number of daylight hours**
June 1 – August 10	16
August 11 – 31	15
September 1 – 20	14
September 21 – October 15	13
October 16 – 31	12

2.4. Estimate of the mean detection probability while MMOs are on effective watch when a vessel is steaming during periods of reasonable visibility

There were 106 gray whale sightings recorded by MMOs when a vessel was steaming during periods of reasonable visibility using the criteria described in section 2.2, above. The bearing and distance to each gray whale sighting was used to calculate the perpendicular distance to the vessel heading at the time of the sighting. These perpendicular distances were then used in a line transect analysis (Buckland 2001, 2004) using the program Distance (Thomas et al. 2006) to estimate the mean detection probability for gray whales by MMOs on steaming vessels during periods of reasonable visibility. The mean detection probability was first estimated using all 106 sightings without covariates in order to determine a truncation distance that corresponded to a detection probability of approximately 0.15 (Buckland et al. 2001). The detection function without covariates was refit using only the 103 sightings within the truncation distance, and then the specific effect of each covariate (sea state and visibility) on mean detection probability was tested. The number of observers was 1 for all 103 sightings, and consequently the effect of this covariate could not be tested. Detection models were assessed and selected using Akaike's information criteria (AIC) values, supported by visual inspection of qq plots and the plots of histograms of perpendicular distances overlaid with detection function shapes. A covariate was only deemed to significantly contribute to gray whale detection probability when inclusion of the covariate reduced the Akaike's information criteria (AIC) value for the detection function. The effect of sea state was tested using two methods: a) stratification that fit a separate detection function to each level of the factor, and b) multiple covariate distance analysis (Buckland et al. 2004) that fit a single detection function with parameters for each covariate level. There were only eight sightings made at sea state 0 (Table 4), so these sightings were pooled with sightings of sea state 1 when analyzing the effect of sea state on mean detection probability. Visibility was tested using only multiple covariate distance analysis because there were only a few whale sightings in several of the visibility conditions (Table 5).

The analysis of mean detection probability assumed that the MMOs recorded a whale sighting when the animal was first observed. The analysis also assumed that the probability of detection for animals on the transect line is certain, i.e. 1. Whales are underwater part of the time, however it is assumed that vessels were travelling slowly enough so that there was ample time for a whale to resurface while the area occupied by the whale was being scanned by an MMO. The analysis was confounded by the following factors:

1. MMOs recorded only the approximate location of each whale sighting. The distances to gray whale sightings were estimated by eye, and the sighting bearing was recorded as a clock face, which rounds the bearing to the nearest 30 degrees.
2. Gray whale sightings were made by MMOs on a variety of vessels with different observation heights. This likely confounded estimates of detection probability.

Table 4. Number of gray whale sightings made by steaming vessels during 2005 to 2007 by sea state (Beaufort scale).

Sea State	Number of GW sightings
0	8
1	40
2	38
3	20

Table 5. Number of gray whale sightings made by steaming vessels during 2005 to 2007 by visibility (rounded to nearest integer). The percentage of time the visibility occurred was calculated over all MMO records. A visibility of 0 was recorded 24.3 % of the time. Visibility was unrecorded 0.9% of the time.

Visibility	Number of GW sightings	Percentage of Time Visibility Occurred over All MMO records
1	2	3.6
2	2	4.5
3	1	3.9
4	3	3.0
5	0	5.0
6	2	3.7
7	8	3.6
8	13	8.2
9	9	2.0
10	66	37.4

Hazard rate, half normal and uniform detection function models were initially fit to the 106 gray whale sightings. A truncation distance of 7000 m was selected that excluded 3 MMO records from the data set used in subsequent analyses. All three detection models provided a similar level of fit to the reduced data set (N = 103) as indicated by similar AIC values, and produced fairly similar estimates of mean detection probability (Table 6).

Figure 1 shows the detection function for the half normal (with cosine series expansion) model with no covariates included.

Table 6. Mean detection probability without covariates estimated by hazard rate, half normal with polynomial series and uniform with polynomial series detection function models.

Detection Function	AIC	Mean detection probability	Lower 95% CI	Upper 95% CI
Half normal (cosine series)	1773.68	0.42	0.33	0.54
Uniform (cosine series)	1773.62	0.45	0.38	0.54
Hazard rate (no series required)	1773.74	0.47	0.38	0.60

Sea state was not found to have a statistically significant effect on detection probability because AIC values for detection function models that included this factor were not improved. In addition, separate average detection probabilities estimated for sea state strata did not decrease at higher sea states. Inclusion of visibility as a covariate had a significant effect on detection probability, with detection probabilities decreasing as visibility decreased (Figure 2).

2.5. Absolute number of cases where vessel is diverted, slowed or stopped in response to MMO advice, and circumstances for those cases

MMOs advise the SEIC representative aboard a vessel (or the master) on practical measures to be taken when a marine mammal is sighted within the defined safety distance (<= 1 km) in order to prevent the animal's possible collision with the vessel (SEIC Marine Mammal Protection Plan 2007). In 2005-2007, 474 WGW sightings were recorded by MMOs on board the vessels involved in SEIC offshore activities. Fifty three of these sightings (11%) were within the defined safety distance. Of these 53 cases, mitigation measures were taken 15 times (Table 7). In 8 out of 22 cases the vessel was brought to a full stop, in 1 case the vessel was slowed down, and in 6 cases the vessel course was changed. No mitigation measures were taken in the remaining 38 cases for the following reasons:

- In 31 cases vessels were in a fixed position, being at anchor, adrift or in the state of dynamic positioning.
- In 4 cases the whales were moving parallel to the vessel at a distance of approximately 1 km, or were moving in a direction away from the vessel.
- In 3 cases vessels were sailing at low speed and, according to MMOs, posed no threat to gray whales.

Table 7. Mitigation response for 53 gray whale sightings made within the 1 km safety radius during 2005 to 2007.

Year	No of sightings at 1 km or less	Mitigation measures taken?					
		No			Yes		
		Stationary vessel	Whales moving away, parallel	Vessel at speed < 5 knots	Vessel stopped	Vessel slowed	Vessel diverted
2005	2		1				1
2006	47	28	2	3	8	1	5
2007	4	3	1				

3. SUMMARY

Vessels were steaming in good visibility conditions approximately 27 % of the time that MMOs were on both moving and stationary vessels under all weather conditions. Good visibility conditions occurred approximately 71 % of the time when MMOs were present on steaming vessels. One MMO was always on effective watch when a vessel was steaming during periods of reasonable visibility, with a mean detection probability that ranged from 0.42 to 0.47. Sea state was not found to significantly affect detection probability in good visibility conditions (defined as sea state < 4 and visibility of at least 1 km). However, visibility conditions did affect detection probability, with detection probabilities decreasing substantially as visibility conditions deteriorated.

Fifty three of 474 WGW sightings (11%) were within the defined safety distance during 2005-2007. Out of these 53 cases, mitigation measures were taken 15 times. No mitigation measures were taken for the remaining 38 cases because the vessel was stationary or moving at low speed, or the whale was moving parallel to, or away from the direction of vessel travel.

Table 8. Summary Table of results

Proportion of Vessels with MMOs	Proportion of Time Steaming in good visibility by all MMO Vessels	Proportion of MMO watches during vessel steaming during daylight/reasonable visibility	MMO Mean detection probability while on effective watch
0.16 – 0.54	0.27	1.0	0.42 – 0.47

4. LITERATURE CITED

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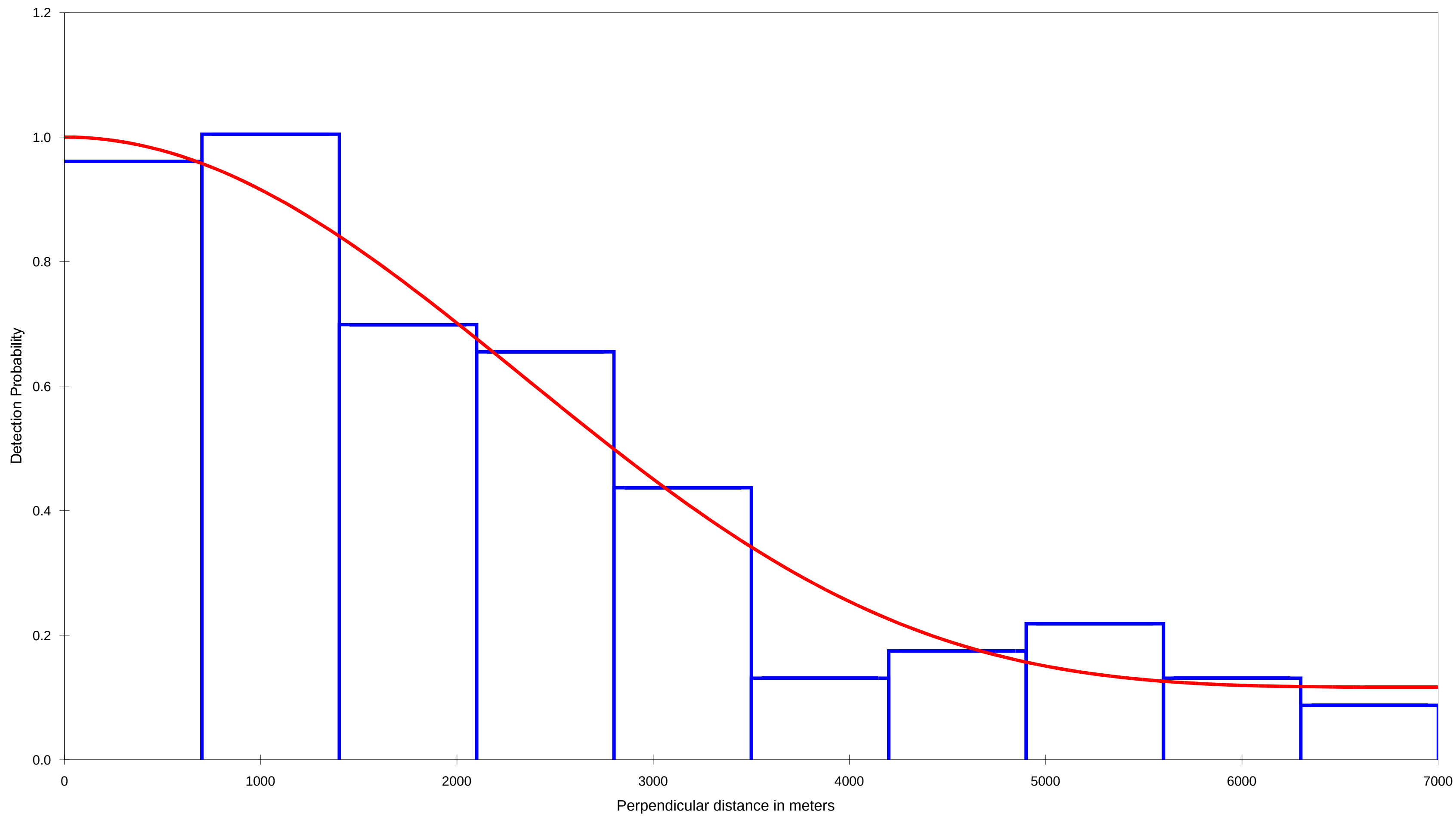

Figure 1. Global detection function for half normal with cosine series expansion model.

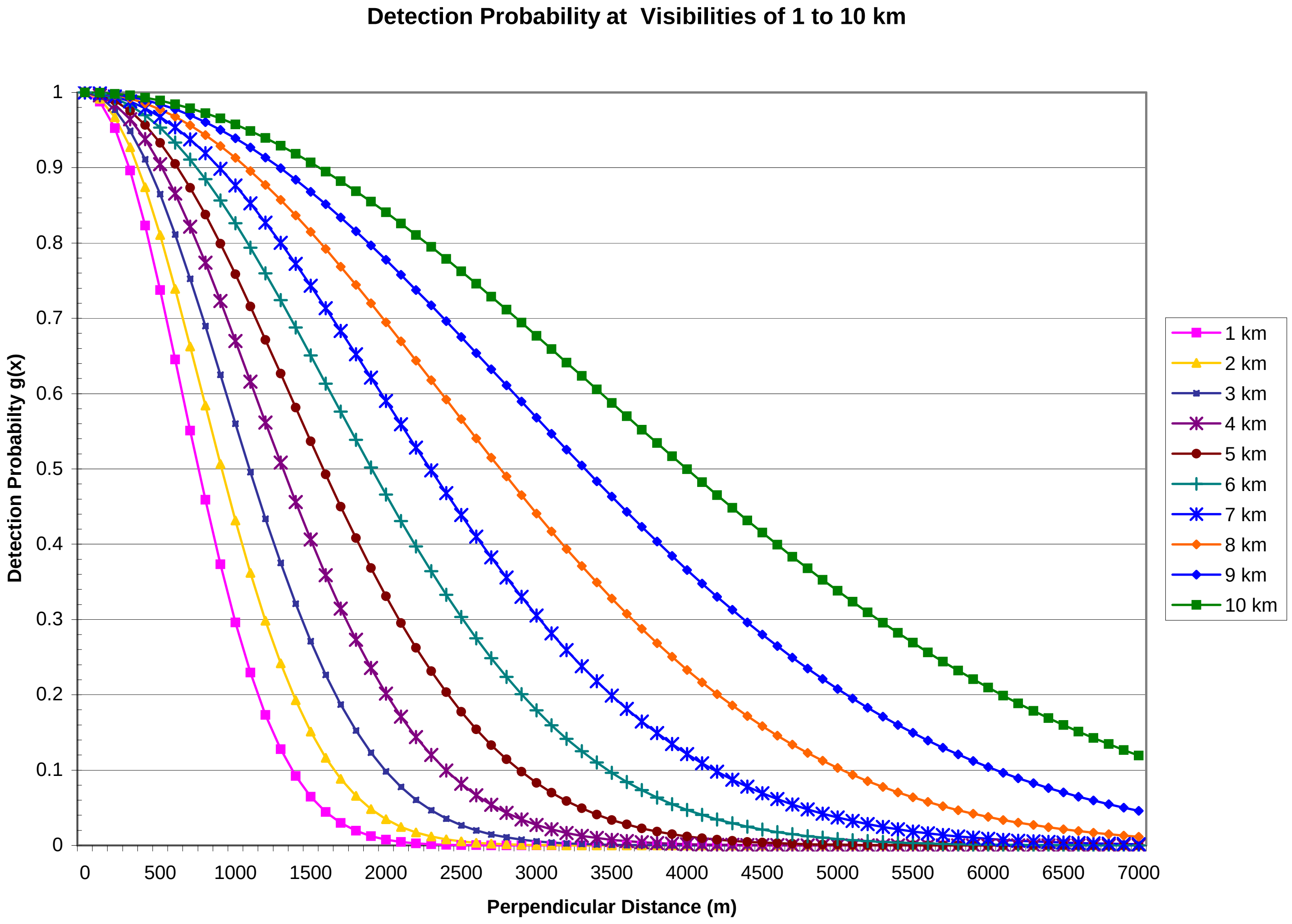

Figure 2. Detection probability calculated at 100 m steps for the half normal model with visibility included as a covariate.