WESTERN GRAY WHALE ADVISORY PANEL **WGWAP 3/INF.7**

3rd Meeting **1 November 2007**

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MONITORING AND MANAGEMENT OF CONTINUOUS NOISE

Western Grey Whale Daily Average Estimated Densities and Hourly Sound Level During 14 to 28 July 2006

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Sakhalin Energy Investment Company LTD.

Western Grey Whale Daily Average Estimated Densities and Hourly Sound Level During 14 to 28 July 2006

Оценка среднесуточной плотности охотско-корейской популяции серых китов и усредненные значения уровней шума за час в период с 14 по 28 июля 2006г.

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Revision 01

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WESTERN GRAY WHALE DAILY AVERAGE ESTIMATED DENSITIES AND HOURLY SOUND LEVELS DURING 14 to 28 JULY 2006

1. BACKGROUND

This document was prepared in response to recommendation WGWAP 2/013[1] specified in the Western Gray Whale Advisory Panel Report (IUCN 2007a) for the meeting held during April 2007 in St. Petersburg, Russia. Subsequent discussions with the panel (pers. comm. Doug Nowacek) in mid October 2007 led to a refinement of the requested reporting of noise levels and gray whale distribution data as follows:

i. Daily estimated densities of western gray whales (WGW) and hourly levels of underwater noise over the period from 14 to 28 July 2006 would be calculated separately for each of blocks 7, 8 and 9 instead of computing aggregate values for the entire area delineated by these blocks.

ii. Whale density would be calculated for grid cells of 1 km^2 (1 km parallel to shore x 1 km perpendicular to shore) instead of 10 km^2 grid cells because the density analysis sensitivity tests conducted for the WGWAP Seismic Task Force (IUCN 2007b) showed that the 1 km by 1 km grid cell size produces an adequate estimation of WGW density.

iii. Average whale densities would be calculated on two temporal scales:

   a) Daily.

   b) Using a 3 day moving window centered at each day of the requested period.

The motivation for this request from the WGWAP, as construed by Sakhalin Energy Investment Corporation (SEIC) and its contracted scientific advisors, is to enable the panel to perform a summary comparison between the distribution of whales and sound levels within the specified portion of the Piltun feeding area during 14 to 28 July 2006, when activities that included ice scour remediation and heavy module lifts were taking place in the vicinity of the PA-B platform. The authors of this report would like to emphasize that caution should be exercised in reaching any conclusions regarding correlation between sound levels and gray whale densities during this time period based on the information presented here because:

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[1] The Panel **recommends** that, for the period of 14-28 July 2006, the densities of whales and noise levels for a small area (blocks 7-9 from WGWAP 2/INF 11) be calculated and plotted together. Whale density should be calculated for grid cells of 10 km^2 (5 km parallel to shore x 2 km perpendicular) with a 1-day average and reported in whales/km^2. The noise should be calculated with hourly averages, and the two datasets overlain on plots of standard line type with time/date on the x-axis and two y-axes, one for whale density, and one for noise amplitude.

- Research conducted on eastern North Pacific gray whales (Bass 2000, Meier 2003) provides strong evidence that the distribution of gray whales (even in the presence of anthropogenic activities) is governed largely by the availability of prey. Recent studies by Fadeev (2005, 2006, 2007) on the prey resources of western gray whales on the northeast Sakhalin shelf suggests a similar link between prey and whale distribution, movements, and local abundance. Consequently prey/benthos distribution, along with other environmental factors including received sound level, would need to be taken into account to more fully understand variations in gray whale distribution and local abundance. A full multivariate statistical analysis would be the most appropriate means to understand this relationship.
- Gray whales show a preference for shallow waters less than 20 m deep in the Piltun feeding area, with most whales found in water depths of 5 to 15 m (Vladimirov et al. 2005, 2006, 2007). Consequently, gray whale densities are typically highest in block 7 that is close to shore, and very low in block 9 that is seaward of the 20m isobath. This fundamental trend in density has been confirmed by aerial and vessel surveys in the Piltun area, and is not an artefact of limited coverage in block 9 by shore-based surveys.
- Even with the finer subdivision in three blocks (near, mid and offshore) that has been adopted for this report, it must be kept in mind that the distribution of industrial noise in the alongshore (north-south) direction is far from being uniform, and any observed trends in the mean sound level for each block are generally driven by the larger component of industrial noise in the south portion of the blocks, closer to the PA-B construction activities.

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2. METHODS

WGW Density Analysis

Annual and seasonal distribution and abundance of WGW on the northeast Sakhalin shelf have been monitored by systematic aerial (2002-2005), vessel-based (2002 to present), and shore-based (behavioural team since 2002 and vehicle team since 2004) scan surveys (Würsig et al. 2002, 2003; Blokhin et al. 2003a, 2003b; Maminov 2004; Gailey et al. 2004, 2005, 2006, 2007; Vladimirov et al. 2005, 2006, 2007). These survey data have been analyzed to produce WGW density estimates for 1.0 km x 1.0 km grid cells within the surveyed area. A WGW density (whales/km^2) is estimated for each grid cell that is sampled during each systematic survey. Each density estimate incorporates the survey effort (area of the grid cell that was surveyed) into the calculation of the WGW density estimate for that grid cell. Before performing the density calculations, gray whale sightings are corrected for availability and perception bias that would typically result in an underestimation of animal abundance (Marsh and Sinclair 1989). An estimated density of zero is assigned to a grid cell if no WGWs were sighted within that grid cell during a particular survey. Density estimates are not calculated for grid cells with less than 0.1 km^2 surveyed area because of the high bias that would be associated with these estimates. The reader is referred to IUCN (2007b) for more details of the density analysis methodology.

The WGW grid cell density estimates for each survey are maintained in a database that allows them to be extracted for selected combinations of survey type and time period. Selected estimates can then be averaged within each grid cell to create WGW density surface maps at several temporal scales (e.g., monthly, yearly) that depict WGW spatial distribution and abundance. For example, Figure 1 shows the average WGW density in each surveyed grid cell in the Piltun area for the period 2002-2006, based on the available distribution data from aerial, vessel-based and shore-based surveys. Patterns of WGW distribution in the Piltun area can also be assessed by calculating average estimated densities at spatial scales larger than 1 km^2, because different distribution patterns are frequently evident at different scales (Wiens 1989). In this case, the grand mean of the grid cell density estimates from each survey that sampled an area delineated by a particular spatial scale is calculated for a time period of interest. These spatial scales include:

a) An 8 km swath along the coastline in the Piltun feeding area (approximately 968 km^2).
b) The region described in a) above subdivided into three blocks (north, central, south) – each approximately 323 km^2 - to stratify the region latitudinally.
c) The region described in a) above subdivided into 15 blocks, each approximately 64.5 km^2 (Figure 2).

Calculation of WGW density in blocks 7, 8 and 9 during 14 to 28 July 2006

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Four of the thirteen shore-based vehicle survey observation stations (stations 6 to 9) and three of the six shore-based behaviour observation stations (2nd, 1st and South) provide coverage of blocks 7 to 9. The effective coverage for the shore-based surveys is limited by the observation station height. Only whale sightings within a radial distance that corresponds to 0.1 reticle for an observer at a shore station, to a maximum of 8 km, are included in the WGW density analysis. This radial distance ranges from 4125 m to 6106 m for stations that sample blocks 7 to 9. Consequently, the shore-based surveys provide good coverage of block 7, limited coverage of block 8 and almost no coverage of block 9 (Figure 3). During the period from 14 to 28 July, only six survey days were possible for the shore-based vehicle team and five survey days for the behaviour team, with foggy weather or sea state preventing surveys from being conducted during the rest of this period (Table 1). Because the shore-based behaviour teams can only sample two of the six observation stations per day, the behaviour stations covering blocks 7 to 9 were not sampled at every good weather opportunity.

Vessel surveys in the Piltun area are planned once every month, and during the period of interest one vessel survey was conducted on 23 July 2006 along a transect parallel to shore approximately 2.5 km off the coastline. The detection function used to correct vessel survey sightings for perception bias has a truncation distance of 4.5 km. Consequently, survey coverage for vessel density estimates extends to the coastline on the shoreward side of the transect, and out to 4.5 km on the seaward side of the transect (Figure 4). This vessel survey provides complete coverage of blocks 7 and 8, and partial coverage of block 9.

For the purpose of this report, the grand mean of WGW density estimates were calculated daily, data permitting, during the period from 14 to 28 July 2006 for each of blocks 7, 8 and 9. The daily average estimated density for each block was computed using two methods:

a) Using only the density estimates for a given day to calculate the average estimated density for that day.

b) Using the density estimates within a three day sliding window centered on a given day to calculate the average estimated density for that day. For example, survey data for 16, 17 and 18 of July were used to calculate the average estimated density in each block for 17 July. If data were not available during any day of the three day window, the average was based only on the available days. For example, only estimates for 17 and 18 July were used in the calculation of average estimated density on 18 July because no survey was conducted on 19 July (Table 1).

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Table 1. Available survey data for blocks 7 to 9 by systematic surveys during 12 to 30 July. Survey data availability is shown for one extra day at each end of the time period of interest (14 to 28 July) because WGW average density calculations using a 3-day sliding window included these dates.

Date	Vehicle Scan	Behaviour Scan	Vessel
July 13	fog	fog	-
July 14	fog	fog	-
July 15	fog	fog	-
July 16	stations 6-9	South/1st	-
July 17	stations 6-9	2nd	-
July 18	stations 6-9	other stations (Odoptu/North)	-
July 19	fog	fog	-
July 20	fog	fog	-
July 21	fog	fog	-
July 22	fog	fog	-
July 23	fog	South/1st	Piltun
July 24	stations 6-9	2nd	-
July 25	stations 6-8	1st	-
July 26	fog (stations 6-8) Station 9 only	wind (sea state 5)	-
July 27	fog	wind (sea state 5)	-
July 28	fog	fog	-
July 29	fog	fog	-

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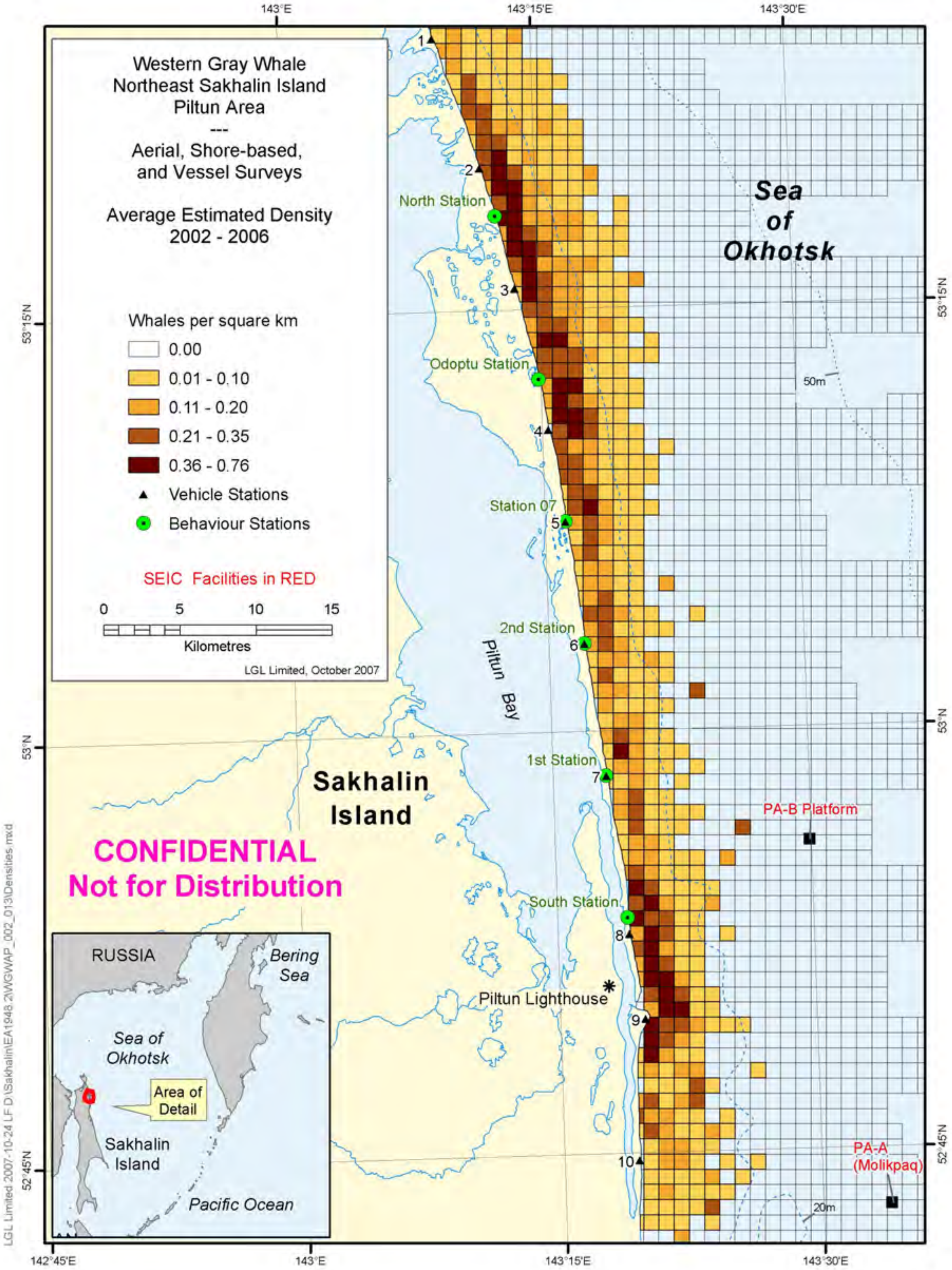

Figure 1. Average estimated WGW density based on 2002-2006 systematic survey data for the Piltun area of the northeast Sakhalin shelf.

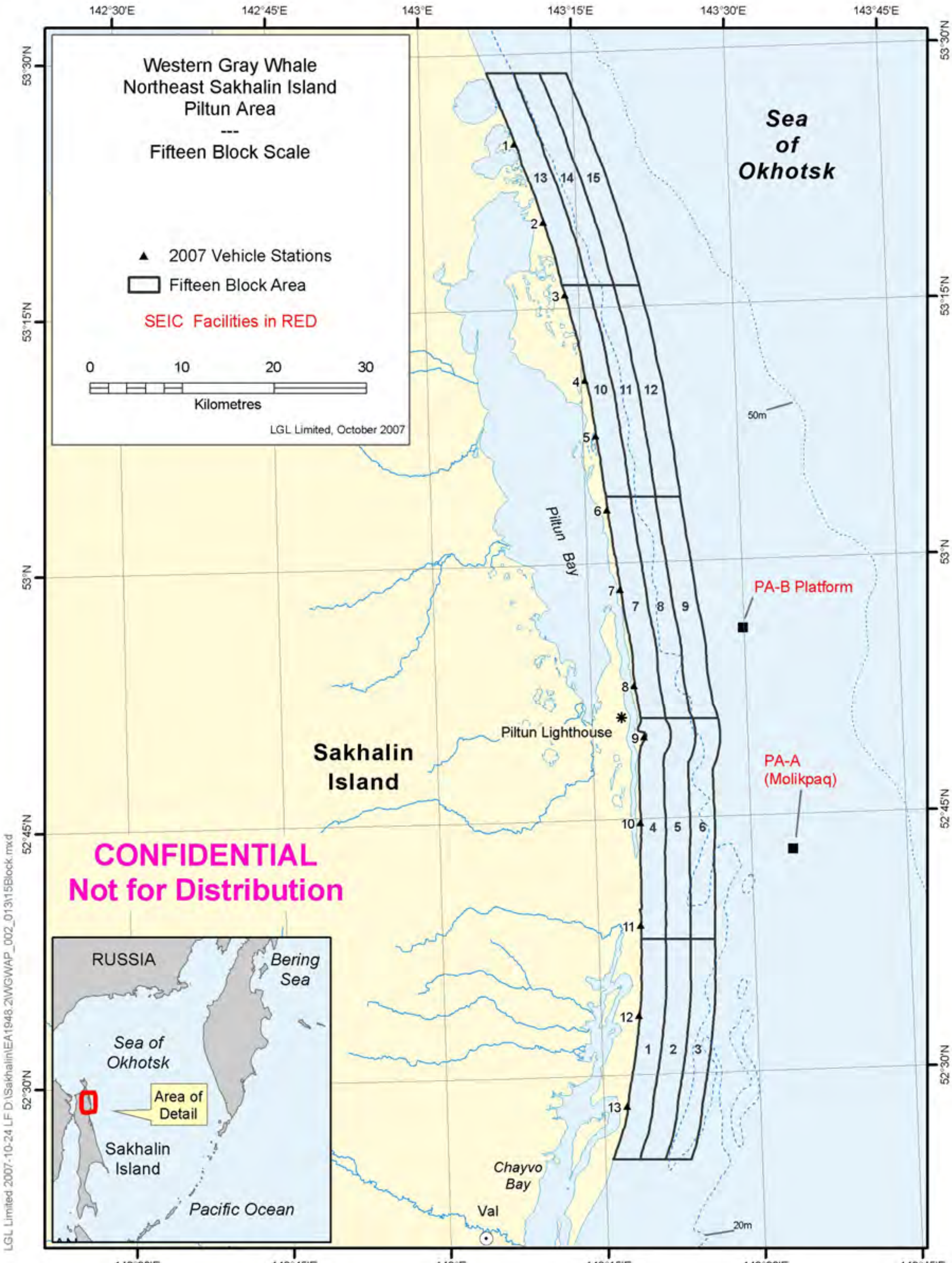

Figure 2. Fifteen block spatial scale of analysis for the Piltun area.

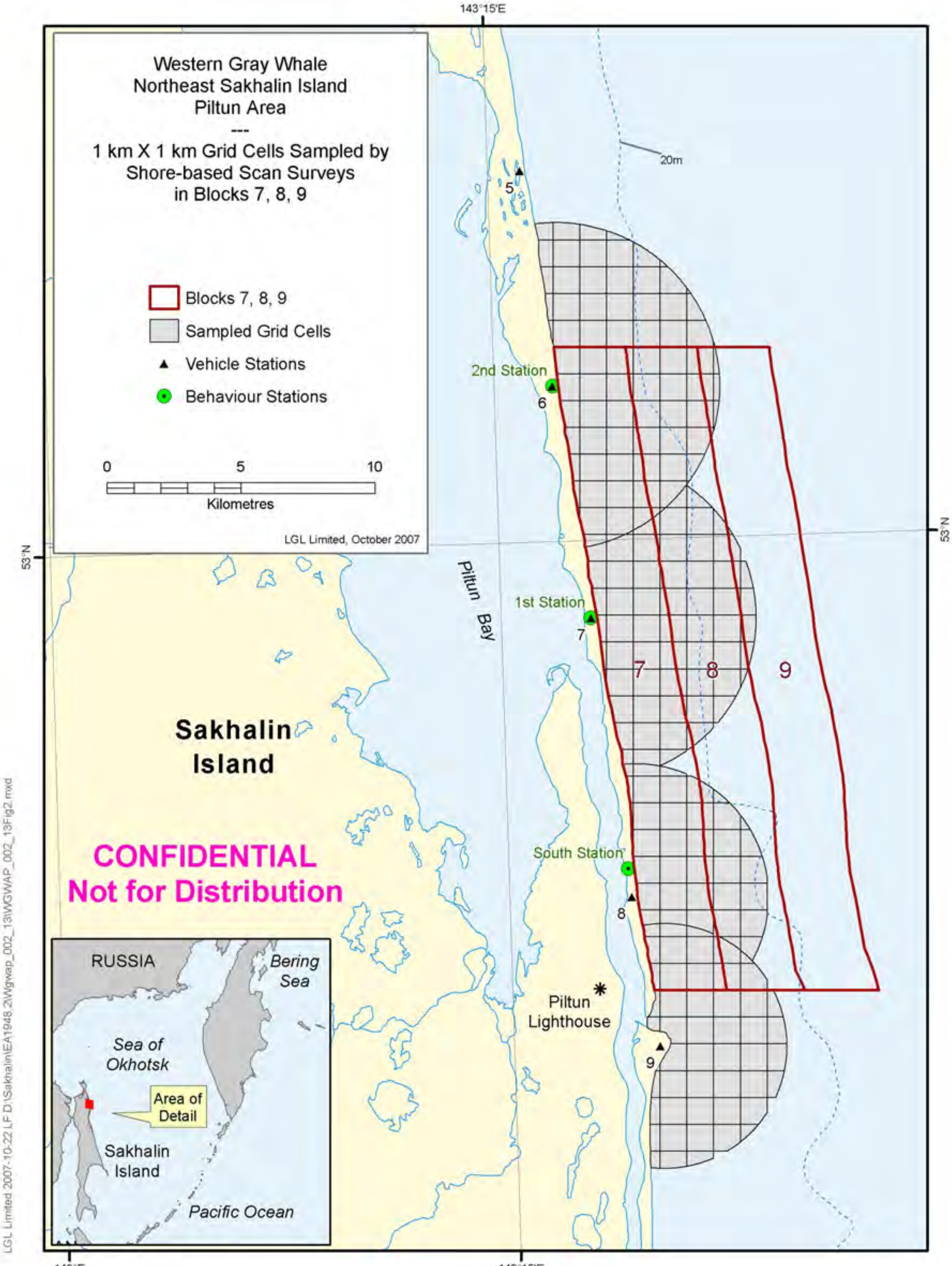

Figure 3. Shore-based survey coverage of blocks 7, 8 and 9.

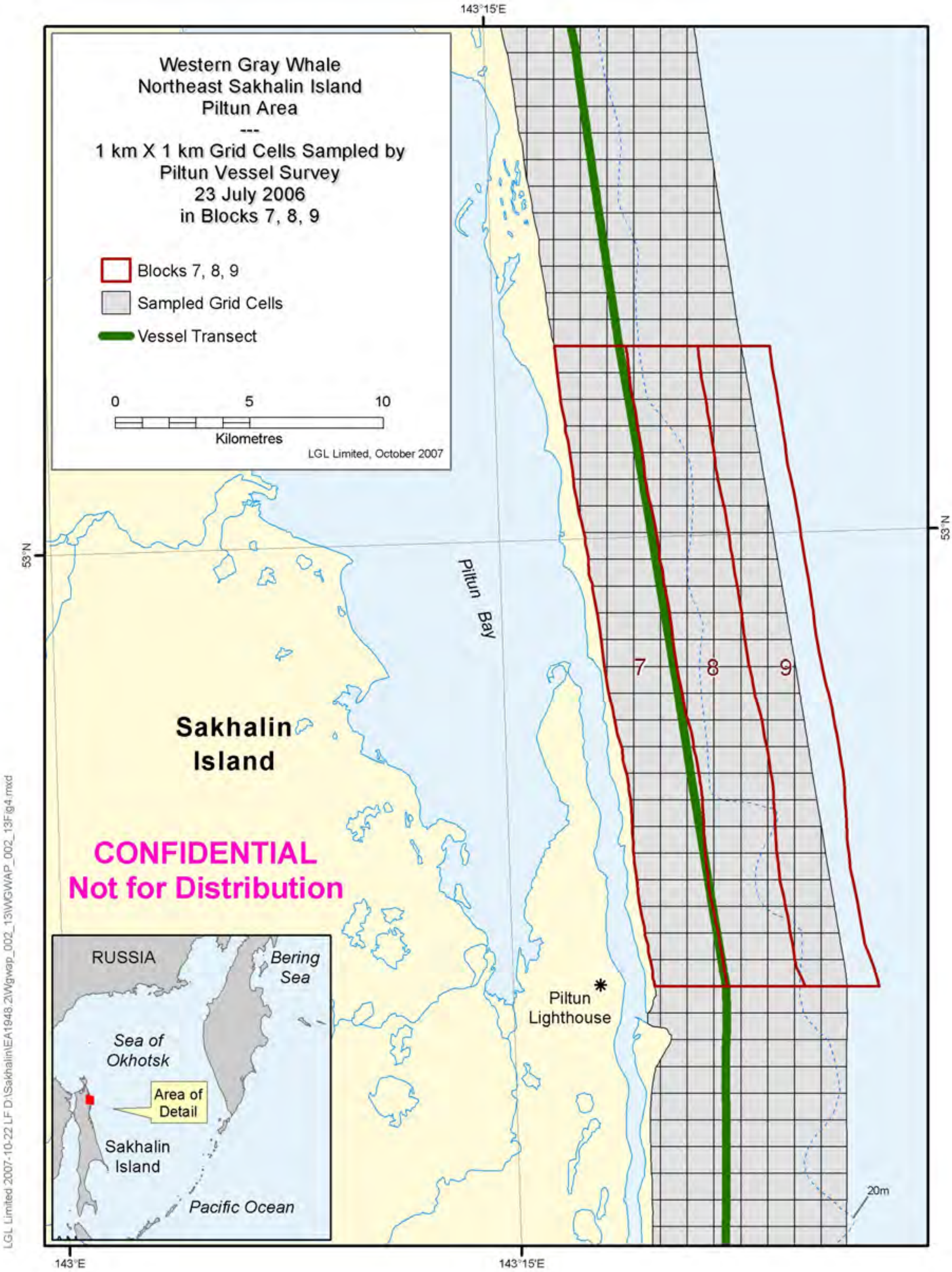

Figure 4. Vessel survey coverage of blocks 7, 8 and 9 at the fifteen block spatial scale of analysis for the Piltun area.

Calculation of Noise Levels

The calculation of mean acoustic levels at hourly intervals for the three area blocks considered in this analysis required first of all the estimation of acoustic levels on a regular grid from a sparsely described spatial distribution based on measurements from AUAR bottom-mounted recorders. The grid points were arranged in straight rows parallel to the coastline, at 1km separation, starting from 1km offshore to 8km offshore. Figure 5 shows the arrangement of the 200 grid points relative to the boundaries of the blocks, as well as the locations of AUAR recorders whose data were used in the analysis (Odoptu S-20, Odoptu PA-B, PA-B-10 and PA-B-20). Estimation of acoustic energy at grid points was based on a hybrid approach that combined numerical modelling of sound level distribution over the region of interest with the direct acoustic measurements. For the requested analysis interval of 14 July to 28 July 2008 two modelling scenarios were used, one for the period up to 20 July and one for the period past that date as per the post-season adjusted chronology. These correspond respectively to the operational phases “Lifts at PA-A” and “PA-A Pipelay – Early Phase and Lifts at PA-B” in the 2006 construction scheduling which are described in detail, including main vessels involved and their general location, in the acoustic monitoring report for that season (Racca et al. 2007). In either scenario, vessel activities taking place in the proximity of the PA-B CGBS constituted the dominant source of industrial noise in the region of interest. Having tabulated the modelling results at the grid points and AUAR locations, the 1-minute broadband levels from AUAR data were used to compute time-dependent differentials between modelled and measured levels at the AUAR locations. These were then used to adjust the modelled estimates for the grid locations. The detailed processing sequence for each grid point and 1-minute time step is as follows:

1. Identify the nearest AUAR to the grid point for which a data value is available at the time of interest (within a one-minute tolerance on either side). If none of the AUARs in the group can provide a data value, flag the estimate as missing (no further processing).
2. Look up the modelled sound level at the grid point for the active operational scenario at the time of interest and a receiver depth of 10m.
3. Look up the modelled sound level at the selected AUAR location as per step 1, for the active operational scenario at the time of interest and a receiver at seafloor depth.
4. Compute the dB difference between the modelled sound levels at the grid point and at the selected AUAR.
5. Retrieve the measured 1-minute average sound level at the selected AUAR as per step 1 at the time of interest.

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6. Adjust the level measurement at the selected AUAR by the difference in modelled levels as per step 4 to obtain the estimated sound level at the grid point.

The 1-minute estimates at individual grid points were averaged over hourly intervals, resulting in a map of hourly mean sound levels in 1-km spatial increments over the area of the specified blocks. Figure 6 presents an example of such a map, clearly showing the spatial variation of noise levels driven by range from the dominant sources (near PA-B) and bathymetry. The hourly estimates were then spatially averaged over all grid points within a block. The two most shoreward lines of the grid were used for Block 7, the next three for Block 8 and the three most seaward for Block 9. The final step consisted of culling from the hourly block average estimates those points that were clearly affected by the local presence of a vessel in the vicinity of one or more of the AUARs. Because the grid levels estimation process is based on the assumption that all anthropogenic sound originates at the construction vessels locations used in the modelling, any noise from a proximal source to the AUARs (such as a vessel used in their maintenance) would result in a greatly distorted level distribution map. Before any of the hourly estimates were discarded, however, the local origin of the elevated level had to be confirmed by matching the time of occurrence with field logs indicating vessel passages. A total of eight episodes of local vessel noise presence were recognized and culled, each lasting from one to four hours; their origin was traced to AUAR servicing visits by the acoustics monitoring support vessel Bogorov in all but two cases, the presence of the research vessel Nad'ezhda in one instance, and a brief pass by an unidentified vessel. The time series of block averaged hourly mean sound levels from this analysis are presented in the next section, overlaid on graphs of estimated daily WGW densities where available.

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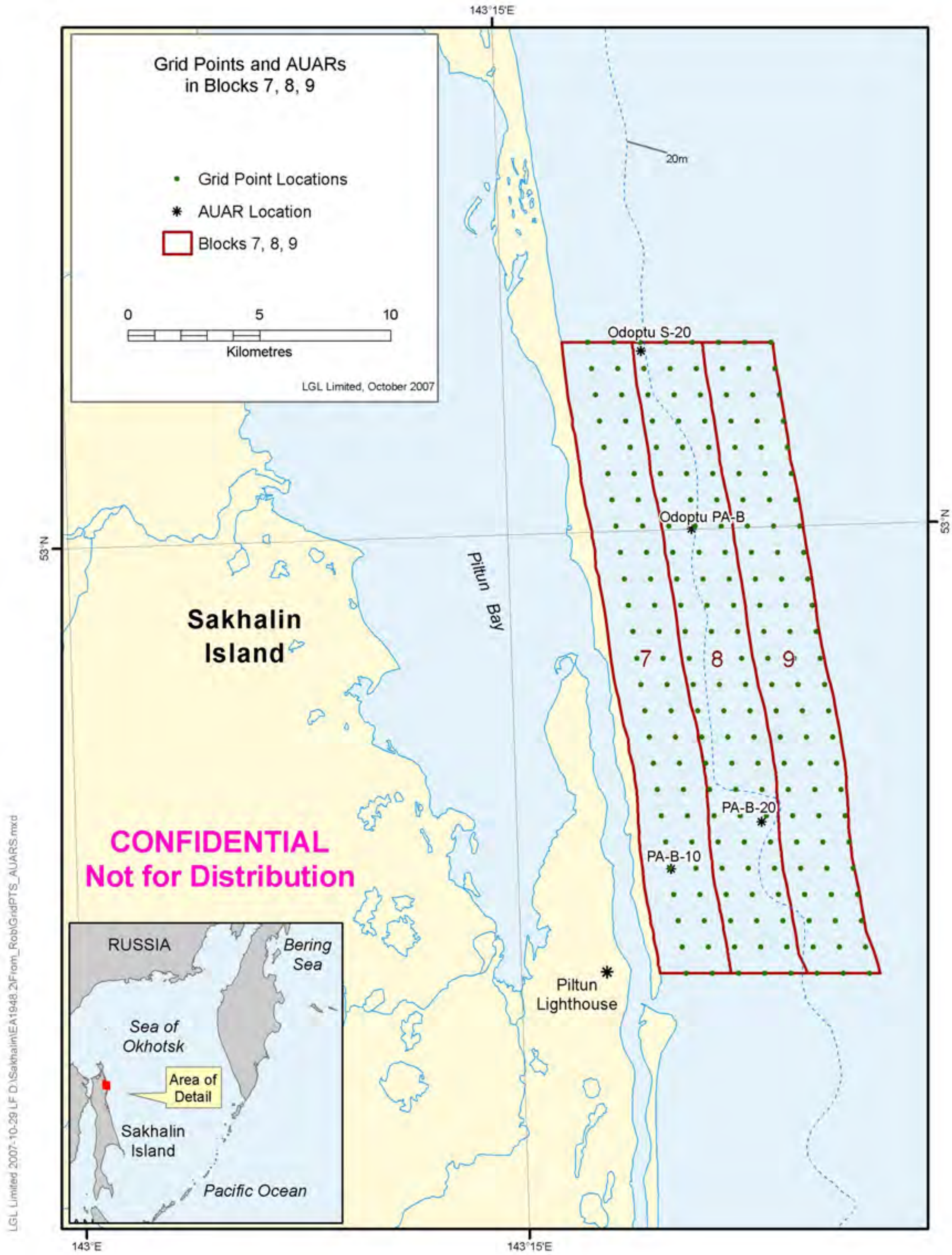

Figure 5. Location of noise level estimation grid points and active AUAR bottom mounted acoustic recorders relative to boundaries of WGW density estimation blocks 7, 8 and 9.

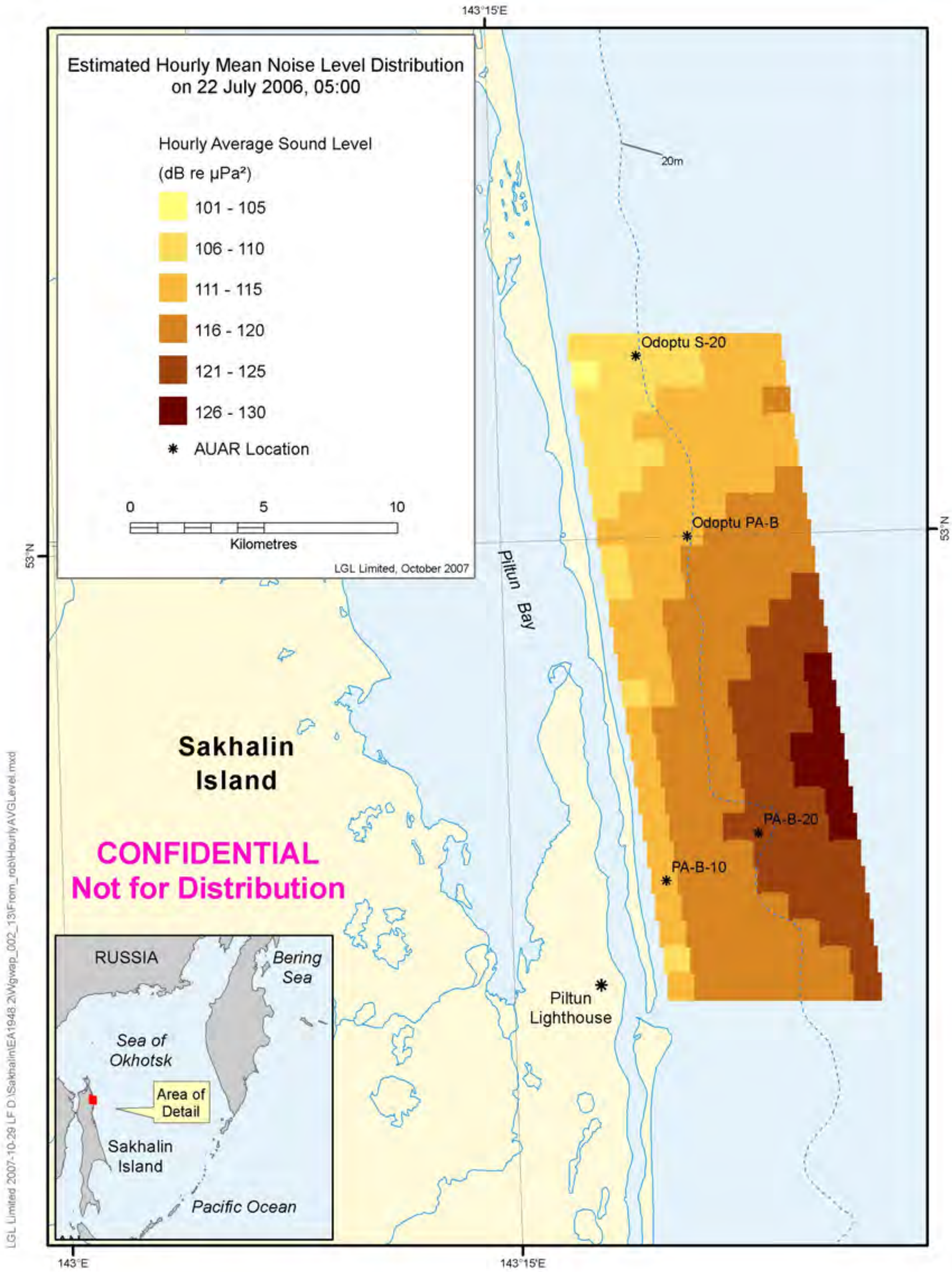

Figure 6. Example of estimated noise level distribution at 10m depth based on combination of modelled sound distribution from offshore construction sources and measurements at active AUAR bottom mounted acoustic recorders.

3. WGW ESTIMATED DENSITIES AND SOUND LEVELS FOR BLOCKS 7, 8 AND 9

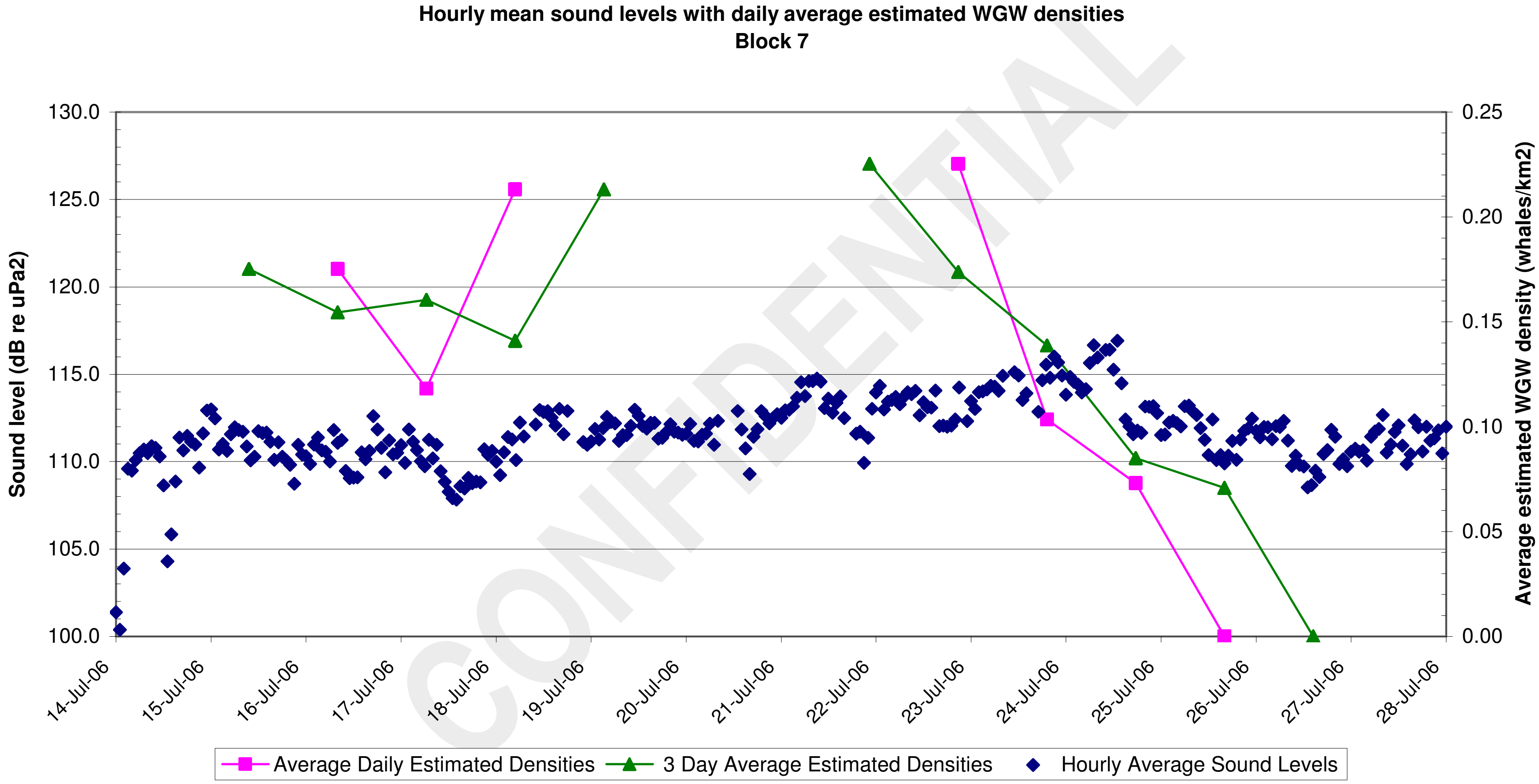

Figure 7. WGW estimated densities and sound levels for block 7.

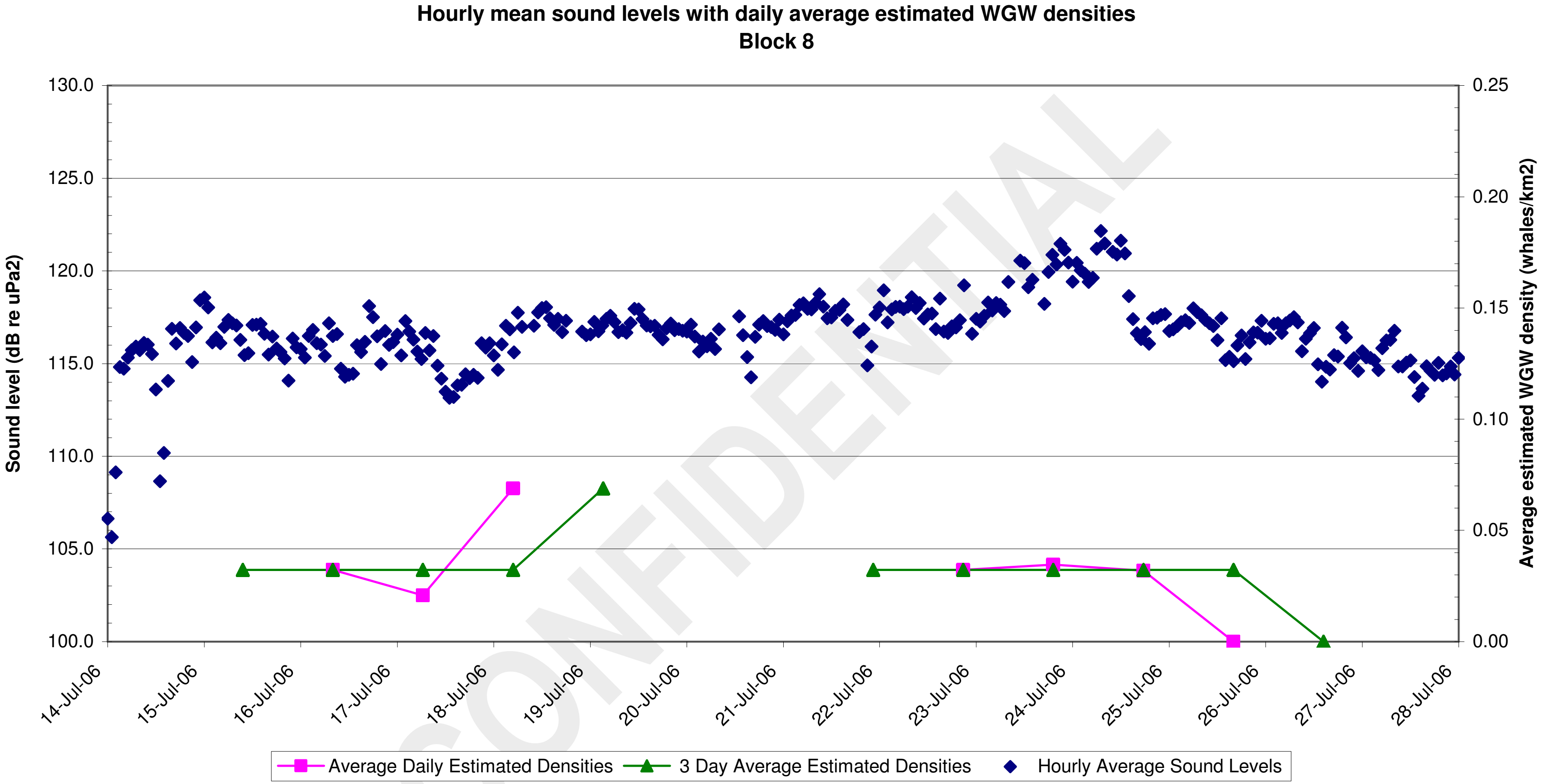

Figure 8. WGW estimated densities and sound levels for block .8

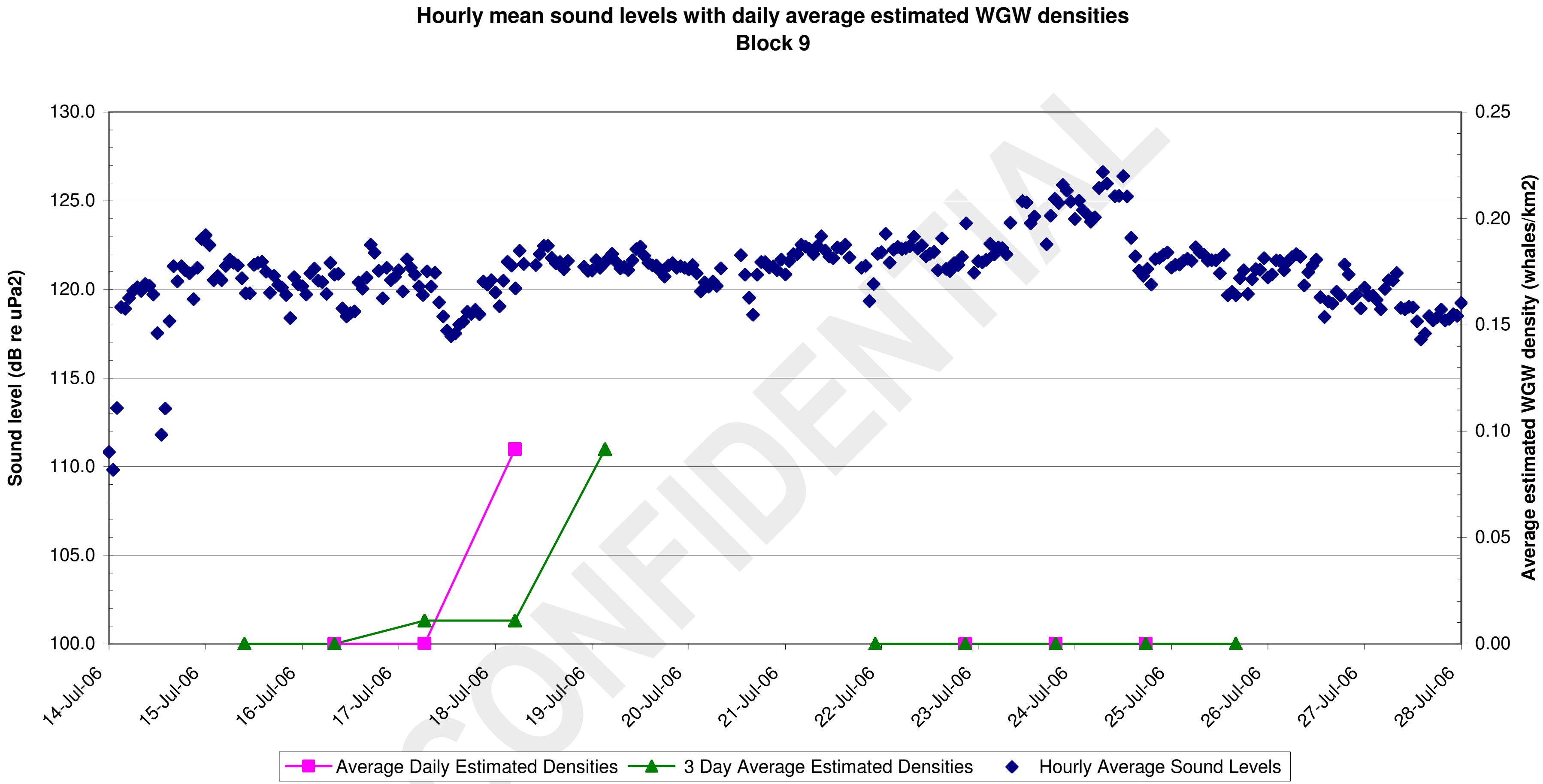

Figure 9. WGW estimated densities and sound levels for block .9

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