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Further information on available data and analysis used for blue whale abundance estimates south of Sri Lanka in Priyadarshana et al. (2016)

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Abstract

This short note provides some information regarding survey design and data collection in addition to the published results in in Priyadarshana et al. (2016). Two new estimates of blue whale abundance in an area south of Sri Lanka were calculated from the original data set for the periods of most intense survey effort in 2014 and 2015. These gave an abundance of 306 (155 – 599) in 2014 and 257 (159 – 416) in 2015.

Introduction

The information in this note is intended to supplement the published results in Priyadarshana et al. (2016) with respect to design based estimates of abundance. It should be noted that although Priyadarshana et al. (2016) do give an abundance estimate, this was not the primary focus of the study. These results use the original raw data set but were prepared during the IWC Scientific Committee meeting in 2021 to assist in the discussions of Northern Indian Ocean blue whale status.

Survey design

The surveys were designed specifically to examine average distribution patterns over a limited area to compare density along current shipping routes and possible alternatives. The survey area was 50km by 150km in a rectangle off the southern coast of Sri Lanka centred around Dondra Hd.

Parallel transects, each of ~46km in length were surveyed in pairs. Transects were parallel and approximately perpendicular to the coast and depth gradient.

Although data collected from two vessels were used in the spatial modelling, only data from the 'Raja and the Whales' vessel was used for the design based density estimate. Although this was a smaller vessel in length, it had a better viewing platform and covered greater effort.

Surveys were conducted over two years, 2014 and 2015, using the same vessel and mostly the same observer team.

Observers

The observers on the project were a mix of experienced whale researchers and an experienced whale watch skipper. The team on watch at any one time included two researchers and the whale watch skipper/crew. The platform height was 2.75m giving a mean eye height of ~4.3m. The researchers all had many years each of survey experience from small vessels.

Distance and angle estimation

The research team included several members (Calderan, Gordon, Leaper, Lewis) who spend a lot of time using real time video methods to measure distances and bearings to sightings. This gave them large sample sizes of measured distance estimates to actual whales under real survey conditions to compare with naked eye distance estimates. So arguably the team was better 'calibrated' than most observers in terms of distance estimation. The histogram of estimated distances was monotonic and a detection function was fitted in Distance with a low CV. Nevertheless, errors in distance and angle estimates were not included in the CV of the estimates (this is stated in the paper) and so overall variance would have been under estimated.

Angle estimation used compass binoculars (it was a fibreglass boat). These were felt to be preferable to angle boards because of the motion of the vessel. Transects were largely beam on to the prevailing swell and rolling was quite severe.

g(0)

The assumption of g(0)=1 will introduce some bias. Sea conditions off Sri Lanka can be challenging and the blue whales there are not particularly conspicuous. However, the combination of researchers and whale watchers appeared to be effective in detecting whales. The slow speed of the vessel (6 knots) also means that g(0) is likely to be closer to 1 than for many surveys from faster vessels. It would seem unlikely that the assumption of g(0)=1 would be a substantial source of bias compared to other factors.

Group size

Blue whales tended to occur in loose aggregations rather than well defined groups. Where possible, each individual was treated as a separate sighting, but sometimes these were classified as a group with a distance and angle to the group. The mean group size was 1.46. For the analysis in this paper I just used numbers of individuals on each transect. This will not affect the abundance estimates but the variance would be slightly different if observations of groups were used for the transect variance with an additional term for variance in group size.

Average density estimation

For the original paper, density was estimated using Distance. I can’t locate the original Distance project but have repeated the analysis based on the observed number of whales on each transect reported in Priyadarshana et al. 2016 (Table 1) which also match the raw data that I have. Data from two surveys (2014 and 2015) with the same vessel and mostly the same observer team were pooled to estimate a detection function. These surveys were carried out over two years with the intention of estimating average abundance over time (of most relevance to ship strike risk) rather than a snapshot abundance estimate.

I treated each transect as a sampling unit giving 29 transects with a total of 243 individual blue whales from 2616km of transect. With the estimated strip half width of 1301m this gives an average density estimate of 0.036 individuals km^{-2} for 2014 and 2015 combined, which matches Priyadarshana et al. (2016).

To estimate variance from the available data to compare with Priyadarshana et al. (2016), each transect was treated as a sampling unit. The variance of *n* can then be calculated from equation 1 (Buckland, 1993).

$$\widehat{var}(n) = L \sum_{i=1}^{k} l_i \left(\frac{n_i}{l_i} - \frac{n}{L}\right)^2 \Big/ (k-1) \qquad (1)$$

Where n is total number of sightings, L is total transect length, k is the number of transects and n_i and l_i are the number of sightings and length of each transect respectively.

In this case n=243, k=29, L=2616 with the n_i and l_i given in Table 1 for each transect.

The variance of D can be estimated by the delta method (Buckland, 1993) by equation 2 if just the variance in encounter rate (by transects) and eshw are included.

$$\widehat{var}(\widehat{D}) = \widehat{D}^2 \left\{ \frac{\widehat{var}(n)}{n^2} + \frac{\widehat{var}[f_0]}{[f_0]^2} \right\}$$

(2)

The CV of eshw from Distance was 0.07 which seems reasonable looking at the fit given in Priyadarshana et al (2016).

This would give an estimate for the CV of *D* of $\sqrt{\frac{\widehat{var}(\widehat{D})}{\widehat{D}^2}}$ of 0.25 using all the data combined. I cannot find the original Distance project to compare, but suspect the CV in Priyadarshana et al. of 0.09 may not be correct, although this does refer to the average density over a two year time period which is slightly different from the point estimate of abundance derived from surveys over a shorter period. The point estimate for all the data combined was the same as given in Priyadarshana et al. (2016).

Abundance estimates

For the purposes of assessment the most useful estimates might be separate estimates for the periods of most intense survey effort from 2014 and 2015. These give the results shown in Tables 2 and 3 with abundance of 306 (155 – 599) in 2014 and 257 (159 – 416) in 2015. The estimates do indicate stable use of the area by blue whales, which is also backed up by whale watching data.

The main consideration is that these estimates only include a very limited but unknown proportion of the range of the population.

References

Priyadarshana, T., Randage, S.M., Alling, A., Calderan, S., Gordon, J., Leaper, R., Porter, L. 2016. Distribution patterns of blue whale (Balaenoptera musculus) and shipping off southern Sri Lanka. Regional Studies in Marine Science 3:181-188, http://dx.doi.org/10.1016/j.rsma.2015.08.002

Table 1.

Date	Number of blue whales sighted	Total survey effort on transect (km)
18 Feb 2014	1	45
19 Feb 2014	17	91
21 Feb 2014	6	93
22 Feb 2014	7	65
28 Feb 2014	1	92
02 Mar 2014	5	91
04 Mar 2014	1	93
05 Mar 2014	2	92
06 Mar 2014	1	93
20 Mar 2014	52	93
21 Mar 2014	16	98
22 Mar 2014	18	93
23 Mar 2014	21	94
24 Mar 2014	2	94
31 Mar 2014	0	93
03 Apr 2014	0	93
16 Jul 2014	25	93
05 Oct 2014	1	93
06 Dec 2014	1	92
19 Dec 2014	0	93
13 Jan 2015	0	93
23 Mar 2015	0	93
24 Mar 2015	10	91
25 Mar 2015	6	93
26 Mar 2015	8	93
30 Mar 2015	15	93
31 Mar 2015	1	92
01 Apr 2015	11	92
02 Apr 2015	15	92

Table 2. 2014 surveys

Survey Period	18/02/2014-03/04/2014
Number of whales	150
Effort (km)	1413
Density (individuals km^{-2})	0.041
Var(n)	2724.3
CV	0.35
Abundance (log-normal 95% CI)	306 (155 – 599)

Table 3. 2015 surveys

Survey Period	23/03/2015 – 02/04/2015
Number of whales	66
Effort (km)	739
Density (individuals km^{-2})	0.034
Var(n)	261.8
CV	0.25
Abundance (log-normal 95% CI)	257 (159 – 416)