Comparison of aerial survey methods
for estimating abundance of common scoters

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During the month of March, four survey methods were applied to the SPA at Carmarthen Bay. WWT staff carried out visual aerial surveys using distance sampling methodology (Camphuysen et al. 2004). Visual shore-based counts were also conducted. Distance measures were not consistently taken by these observers, nor was survey effort equal among the four surveys. Because they are intended to be complete counts without replication within a day, it is not possible to estimate precision of these counts, or assess bias, making comparison with other survey results difficult. Digital still data were collected and processed by APEM Ltd. Digital video imagery were captured and processed by HiDef. This report revision includes 29 March survey data from HiDef not available at the time of the release of our 17 July report.

Estimation of scoter abundance

We analyzed the data received from WWT, APEM, and HiDef to produce SPA-wide estimates of common scoter abundance and estimates of precision to accompany those estimates.

Common scoter abundance estimates from shore-based surveys simply consisted of summing counts from all observer vantage points. Estimates from visual surveys were obtained by fitting detection functions with half-normal and hazard-rate key functions, and separate detection functions for each survey date. Distances from the line from the visual surveys were truncated using sightings from the first 3 distance bins, i.e. w=426m. Data from both sets of digital surveys were treated as strip transects, with abundance estimates computed as

$$\hat{N} = \overline{\hat{D}} \cdot A$$

$$\textit{where}$$

$$\overline{\hat{D}} = \frac{\sum a_i \hat{D}_i}{\sum a_i}$$

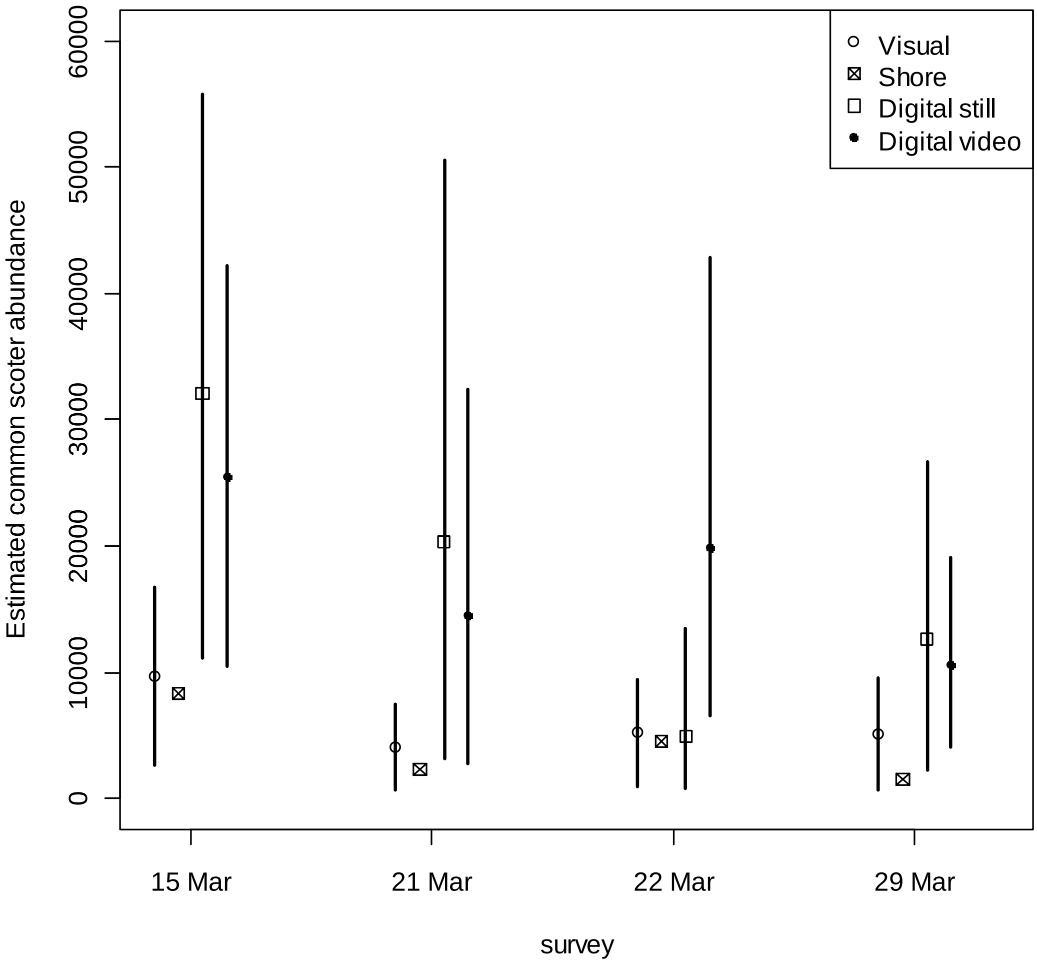
$$\hat{D}_i = \frac{n_i}{a_i}$$

where
$\hat{D}_i$ is the estimated density on the i^{th} transect, n_i is the number of scoters detected on the i^{th} transect, a_i is the area sampled by the i^{th} transect, and A is the size of the SPA ($352.02 km^2$). Confidence intervals for these estimates were obtained using a bootstrap technique in which transects were the sampling unit. Confidence intervals obtained by the bootstrap were reduced by applying a finite population correction

factor (Thompson 1992). A finite population correction factor was also applied to the visual survey coefficient of variation with the correction factor applied to the encounter rate variance component described in Buckland et al. (2001:87).

Results

Point and interval estimates for the surveys are shown in the figure below. Note there is no measure of precision associated with the shore-based surveys, and the data for the digital video survey from 29 March were unavailable. Also note the finite population correction factor is not applied to the confidence intervals presented in the figure (although the fpc is incorporated in the coefficients of variation presented later).



Finite population correction applied to digital methods

To bring out some of the subtleties in the estimates that are difficult to see in the figure, the estimates and coefficients of variation (CV) are shown in the table below. Variance in estimated abundance, and hence confidence interval width, scales with the magnitude of the abundance estimate. This means that large abundance estimates will have proportionally large confidence intervals. To more equitably compare precision in estimates, we can use the coefficient of variation. The table shows CV for visual surveys to be in the range of 0.3-0.4, CV for digital stills to be in the range 0.4-0.8, and the three estimates from digital video to have CVs between 0.35 and 0.6 for this limited number of surveys.

Coverage here is defined as proportion of the SPA sampled by the survey method. This is straightforward to understand with the two digital methods (surface area of Carmarthen Bay painted by the cameras divided by the size of the SPA). For the visual survey method, the coverage is twice the effective strip half-width multiplied by the transect length, this quantity divided by the size of the SPA. Effective strip half-width is defined at the distance from the transect where as many animals are detected beyond this distance as are missed between the transect and this effective strip half-width. For the visual surveys of Carmarthen Bay, the effective strip half-width was 260m.

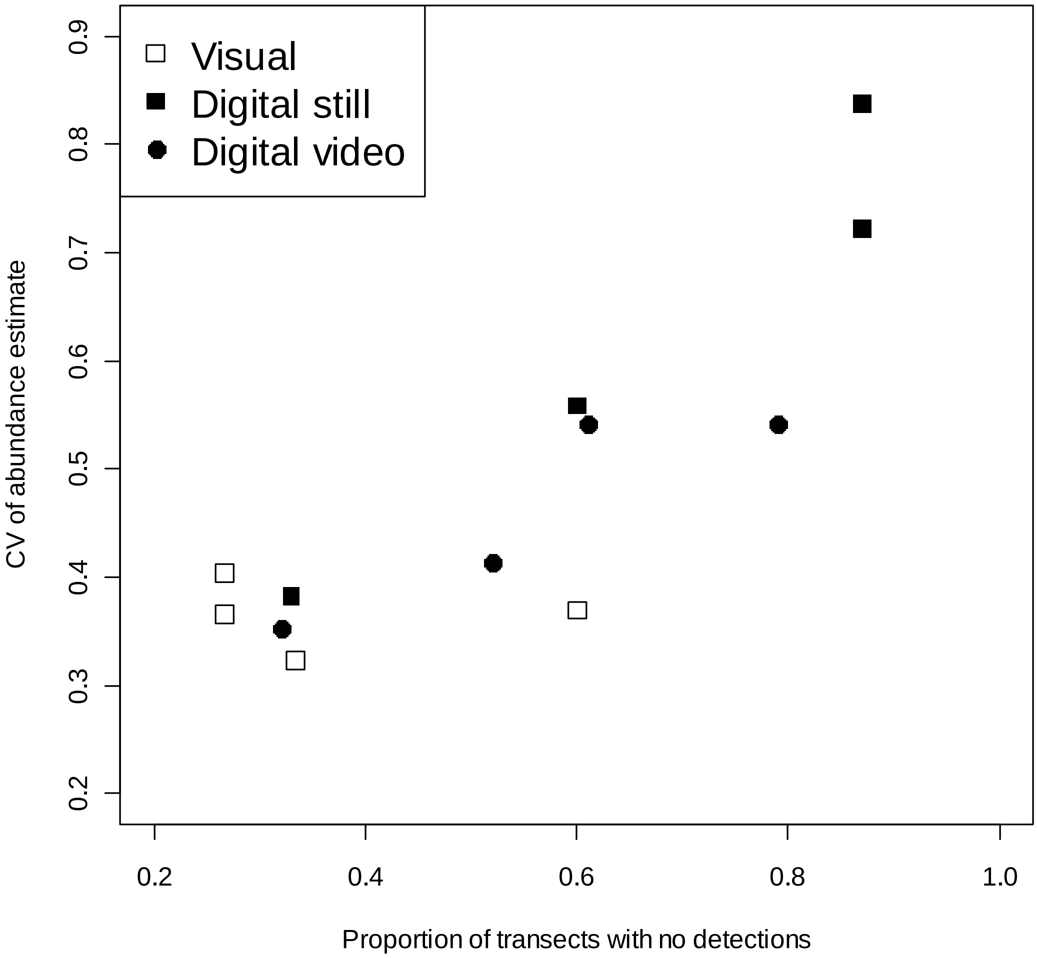
Date	Shore	Visual			Digital Still			Digital Video		
	Estimate	Coverage	Estimate	CV	Coverage	Estimate	CV	Coverage	Estimate	CV
15-Mar	8272	0.257	9694	0.323	0.148	32085	0.382	0.155	25461	0.353
21-Mar	2306	0.258	4049	0.369	0.154	20378	0.723	0.126	14492	0.541
22-Mar	4553	0.249	5217	0.365	0.153	4942	0.838	0.175	19910	0.541
29-Mar	1545	0.261	5110	0.403	0.151	12600	0.558	0.174	10662	0.414

Discussion

Because we do not know the true number of common scoters in Carmarthen Bay on the dates of these surveys, we cannot conclude which survey technique(s) provide the ‘correct’ answer. Our discussion focuses on the precision with which the estimates are calculated.

It comes as no surprise that there is an inverse relationship between proportion of the study region covered by survey effort, and estimated precision. Visual surveys covered the greatest proportion of the study region, (although detection was not assumed to be perfect in the covered region), and produced estimates with the smallest CVs.

The patchy distribution of seaducks is a contributing factor to the large CVs associated with estimates for this species. The digital still surveys had the same number of transects (15) within the study region as the visual surveys, but on the surveys conducted on the 21st and 22nd, scoters were encountered on only 2 of these transects, making the estimate of $\overline{\hat{D}}$, and hence $\hat{N}$, highly variable. In contrast, the smallest number of transects (out of 15) for which scoters were recorded in the visual surveys was 6 on 21 March. Digital video surveys had roughly twice the number of transects, and the number of transects without scoter detections for these surveys were 10 out of 27, 23 out of 30, and 16 out of 29 for the 3 days of survey information available. This relationship between patchiness (as measured by proportion of transects without scoter detections) and uncertainty in abundance estimates is shown in this figure.



Comments and recommendations

Several issues have come to light as a result of this comparison.

- The designs employed for all three aerial surveys were chosen on the basis of what works well for visual surveys, for which a relatively wide strip is surveyed across the full length of the survey region. It is perhaps unsurprising therefore that precision is highest for the visual survey method.
- For digital methods, the greatest survey expense is in the processing, rather than the collection of data. Hence it seems prudent that a greater number of smaller sampling units should be surveyed to improve the precision of estimates associated with seaducks with a patchy distribution. This might be achieved by increasing the number of lines, but decreasing the number of images process per line, so that there are gaps between successive images along a given transect (see Strindberg et al. 2004). If these gaps are about the same as the distance between successive lines, then images will be spread evenly through the region, and precision estimates should be much improved.
- In contrast to visual surveys analysed using distance sampling methods, the only substantial source of uncertainty associated with digital methods is the extrapolation of density from the covered region to the survey region. This uncertainty can be reduced both by distributing the images throughout the region, instead of having contiguous images along lines, and by increasing

the survey effort. When the study region is small, say <500km^2 such as Carmarthen Bay, this uncertainty can be further reduced via the use of a finite population correction. However, in larger regions, where the proportion of the study region covered by survey effort is small, the finite population correction does little to improve precision of estimates.

- In the four surveys compared, the visual survey interval estimates included the shore-based estimate, whereas the shore-based estimates were on the margin of the confidence intervals for the digital survey methods. However, this is not compelling evidence of overestimates by the digital methods, as the shore-based estimates might be biased low. In the case of the 29 March shore-based survey, only three of the four counting stations were visited, so we might expect that estimate at least to be biased low.
- All estimates in this comparison were based on conventional design-based estimation methods. However, the method of fitting density surface models (Hedley and Buckland 2004) can be applied to both line transect and strip transect data (visual and digital methods in context of this report). Under some circumstances, those methods can produce more precise estimates of abundance, and in addition can produce spatial insight about the distribution of animals within the surveyed region. These model-based estimation methods may prove useful for seaduck surveys, given the strong spatial clustering.

Literature cited

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