Summary of simulation trials for Antarctic minke whale abundance surveys using the revised OK method

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ABSTRACT

We investigated the performance of density estimation using the revised OK model with the logistic Q function based on radial distance and sighting angle. The bias was small on average when excluding the duplicate identification error scenarios.

1. INTRODUCTION

Some IA members in the last year SC pointed out that the fitting of the OK method to the sighting angle data was not so good (Okamura and Kitakado 2008a). Through some discussion, the use of the radial distance and sighting angle in the Q function was recommended. We therefore revised the detection function form of the OK method from the perpendicular and forward distance-based Q function to the radial distance and sighting angle-based Q function. Okamura, Kitakado and Skaug (2009) investigated the robustness of different Q functions on density estimation and found that density estimation was insensitive to the form of the Q functions. The logistic function of the two radial distance and sighting angle-based Q functions used in Okamura, Kitakado and Skaug (2009) outperformed another function, the separate-type model in terms of AIC. Thus, we adopted the radial distance and sighting angle-based Q function with the logistic form when applying the model to the real data. In this paper, we investigate the performance of the logistic Q function using the whole IWC simulated data (Palka and Smith 2004, 2005).

2. MATERIALS AND METHODS

The IWC/SC generated the simulated data sets to test the Antarctic minke whale abundance estimation methods (Palka and Smith 2004, 2005). The IWC/SC simulated

data sets consist of 54 scenarios with 100 replications. Each scenario has heterogeneity in factors related to the distribution, density, and behavior of whales to evaluate the robustness of the analysis methods.

We use the following logistic model as the Q function:

$$Q(x, y) = 1/(1 + \exp[\sigma_r R^{\gamma_r} + \sigma_a A^{\gamma_a} + \tau])$$

where $R = \sqrt{x^2 + y^2}$ and $A = \mathrm{atan}(x/y)$.

The covariates used in the model are as follows:

$\log(\sigma_r) \sim \log(\mathrm{School.Size}) + \mathrm{Weather} + \mathrm{Obs}$

$\log(\sigma_a) \sim \mathrm{Const.}$

$\tau \sim \log(\mathrm{School.Size}) + \mathrm{Weather} + \mathrm{Obs}$

In addition, the surfacing related parameter is linked to the true school size:

$$\log(\lambda) \sim \log(\mathrm{School.Size})$$

The school size distribution is dealt with by a negative binomial distribution and the school size misidentification is a Poisson distribution as in Okamura and Kitakado (2009). The density estimation is basically same as Okamura and Kitakado (2009).

3. RESULTS AND DISCUSSION

The resultant estimates for mean school size, school density, and whale density were a little bit higher than previous estimates so that the radial distance and sighting angle-based model provided more upperbias in comparison with the perpendicular and forward distance model (Okamura and Kitakado 2008b). The percent bias for whale density averaged over the whole scenarios was about 5% when excluding the results for the scenarios including the duplicate identification errors (Table 1: Grayed rows indicate the duplicate id. error scenarios). Excluding the duplicate id. error scenarios, the percent bias for almost all the scenarios was within 15% and the confidence intervals included the true values (Figs. 1-3). The averaged bias was small for esw, while the bias was relatively large for mean school size.

The other investigation indicates that the two type of radial distance and sighting angle-based models provide similar results (Okamura, Kitakado, and Skaug 2009). The fitting to the radial distances and sighting angles was greatly improved in comparison with the result for the perpendicular and forward distance model (Fig. 4). In conclusion, the revised OK model still provided satisfactory performance for the simulated data produced by IWC.

4. REFERENCES

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Okamura, H. and Kitakado, T. (2008a) Graphical diagnosis for the IDCR/SOWER abundance estimates using the OK method. SC/60/IA9, 35pp.

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Palka, D.L., and Smith, D.W. (2004) Simulating the IDCR/SOWER surveys – 2004. SC/56/IA6, 16pp.

Palka, D.L., and Smith, D.W. (2005) Description of 2005 simulations of the IWC/SOWER Southern Hemisphere minke whale abundance surveys. SC/57/IA2, 8pp.

Table 1. The estimated meidan values for mean school size, school density, and whale density with the percent bias. Grayed rows were the scenarios including duplicate id. errors and excluded from the average at the bottom.

		E(s)			D_s			D_w	
SC	TRUE	MEDIAN	%bias	TRUE	MEDIAN	%bias	TRUE	MEDIAN	%bias
1	2.450	2.536	3.51	0.029	0.029	-1.87	0.072	0.072	1.31
2	2.450	2.563	4.61	0.029	0.029	0.36	0.071	0.074	4.42
3	1.910	2.086	9.19	0.029	0.029	1.09	0.056	0.062	11.21
4	2.040	2.100	2.92	0.031	0.028	-10.44	0.064	0.059	-6.62
5	2.450	2.483	1.35	0.029	0.030	4.25	0.071	0.075	5.45
6	2.440	2.652	8.70	0.029	0.030	4.00	0.070	0.079	12.13
7	1.910	1.972	3.25	0.029	0.028	-2.93	0.055	0.056	1.70
8	2.040	2.169	6.31	0.031	0.028	-8.91	0.063	0.061	-2.90
9	2.020	2.144	6.13	0.029	0.029	1.64	0.058	0.063	8.05
10	1.960	2.089	6.57	0.029	0.030	2.81	0.057	0.062	9.01
11	2.440	2.424	-0.64	0.030	0.025	-17.07	0.073	0.060	-16.96
12	2.440	2.629	7.73	0.029	0.029	-0.54	0.071	0.076	7.61
13	2.030	2.175	7.14	0.029	0.028	-2.36	0.058	0.062	5.62
14	1.950	2.050	5.14	0.029	0.030	3.07	0.057	0.061	8.18
15	2.450	2.511	2.50	0.032	0.029	-7.06	0.077	0.073	-5.32
16	2.450	2.579	5.26	0.029	0.029	-0.55	0.071	0.075	5.68
17	2.450	2.594	5.88	0.029	0.028	-1.97	0.071	0.074	4.25
18	2.450	2.621	7.00	0.029	0.030	3.06	0.070	0.078	10.34
19	2.450	2.500	2.02	0.030	0.030	-0.93	0.074	0.075	1.01
20	2.450	2.563	4.61	0.032	0.033	5.71	0.077	0.086	11.35
21	2.450	2.503	2.17	0.029	0.032	10.44	0.072	0.080	12.52
22	2.450	2.520	2.84	0.029	0.029	1.89	0.071	0.074	4.84
23	2.450	2.481	1.28	0.029	0.032	9.30	0.071	0.079	10.60
24	2.450	2.495	1.82	0.030	0.031	2.69	0.074	0.078	5.18
25	2.450	2.436	-0.57	0.031	0.035	12.92	0.077	0.087	12.42
26	2.450	2.491	1.68	0.030	0.031	2.71	0.074	0.076	3.14
27	2.450	2.581	5.33	0.029	0.032	11.15	0.071	0.082	15.86
28	2.450	2.460	0.40	0.029	0.030	4.94	0.070	0.075	6.61
29	2.450	2.522	2.96	0.030	0.030	0.80	0.074	0.076	3.15
30	2.440	2.546	4.33	0.029	0.030	3.03	0.071	0.077	8.59
31	2.450	2.532	3.34	0.029	0.028	-1.54	0.071	0.072	2.24
32	2.450	2.646	8.01	0.029	0.030	1.49	0.071	0.079	11.23
33	2.450	2.492	1.73	0.015	0.015	2.96	0.036	0.037	4.71
34	2.030	2.140	5.41	0.015	0.014	-5.54	0.030	0.029	-0.45
35	2.450	2.541	3.71	0.044	0.045	3.53	0.107	0.114	6.70
36	2.030	2.180	7.41	0.045	0.044	-3.89	0.092	0.094	2.25
37	2.470	2.557	3.54	0.015	0.014	-5.20	0.036	0.035	-1.67
38	2.440	2.546	4.33	0.022	0.022	1.37	0.054	0.057	6.75
39	3.500	3.672	4.92	0.029	0.030	3.83	0.102	0.112	9.88
40	3.510	3.838	9.34	0.029	0.045	55.84	0.102	0.173	69.73
41	2.450	2.431	-0.77	0.029	0.034	15.55	0.072	0.082	14.71
42	2.450	2.739	11.82	0.029	0.043	49.00	0.072	0.119	66.54
43	2.620	3.056	16.66	0.029	0.027	-7.98	0.076	0.081	6.52
44	2.630	3.454	31.33	0.029	0.035	21.82	0.077	0.120	57.03
45	2.010	2.186	8.77	0.029	0.024	-17.31	0.059	0.053	-9.46
46	2.020	2.373	17.48	0.029	0.035	19.47	0.059	0.082	40.03
47	2.010	2.349	16.86	0.029	0.034	17.07	0.058	0.080	37.21
48	2.020	2.182	8.00	0.029	0.025	-14.55	0.059	0.055	-6.72
49	2.620	3.465	32.25	0.029	0.035	18.81	0.076	0.121	58.19
50	2.620	3.054	16.58	0.029	0.027	-6.80	0.076	0.084	9.55
51	2.450	2.772	13.13	0.029	0.043	47.99	0.072	0.119	66.01
52	2.450	2.428	-0.88	0.029	0.033	14.60	0.071	0.081	12.77
53	3.510	3.888	10.78	0.029	0.045	53.19	0.102	0.177	73.00
54	3.520	3.769	7.06	0.029	0.030	2.80	0.102	0.115	12.13
Average			4.77			0.32			5.21

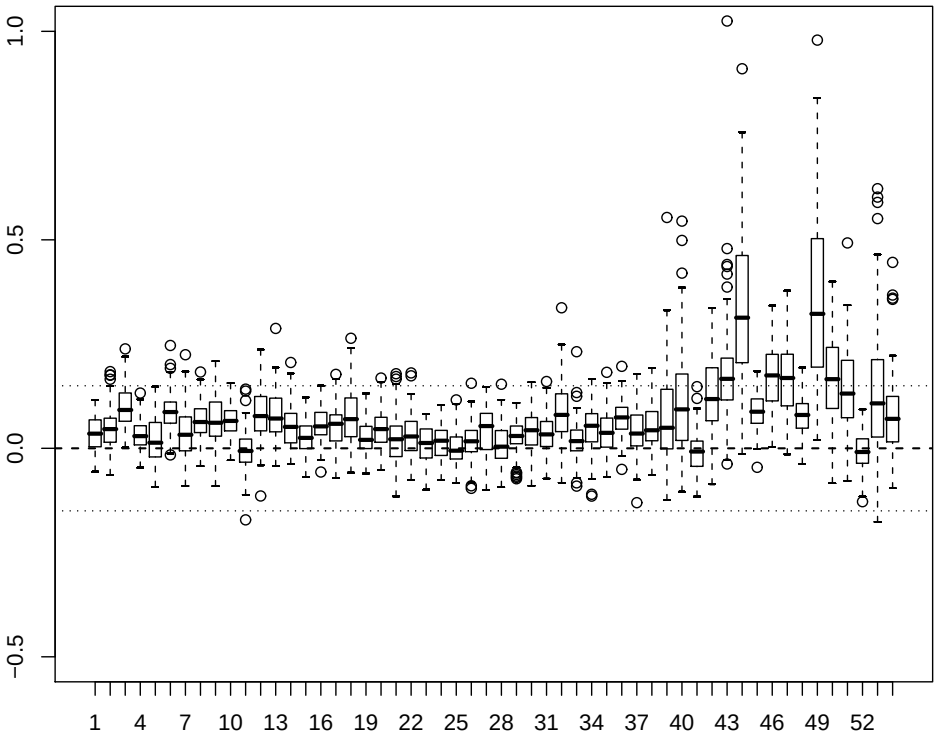

Fig. 1. The percent bias plots of mean school size for the revised OK model.

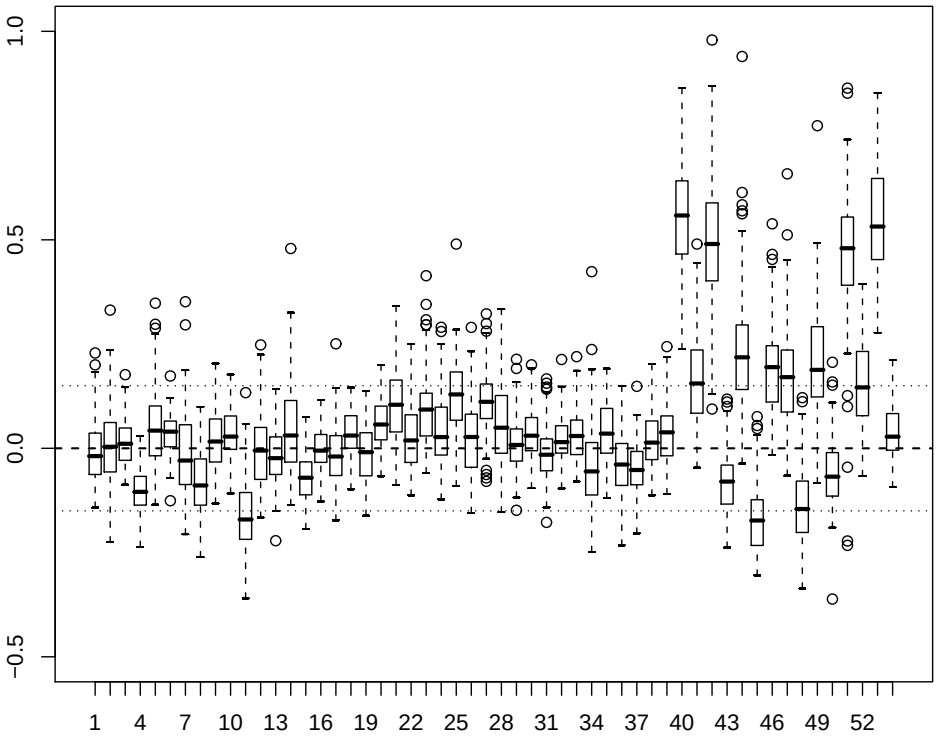

Fig. 2. The percent bias plots of school desnity for the revised OK model.

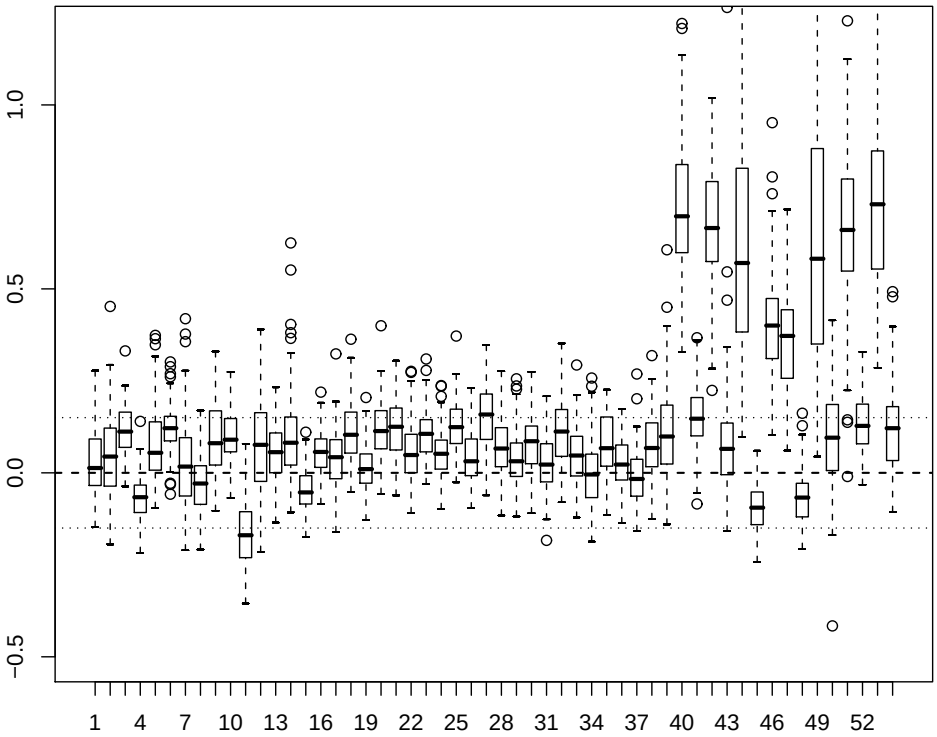

Fig. 3. The percent bias plots of whale desnity for the revised OK model.

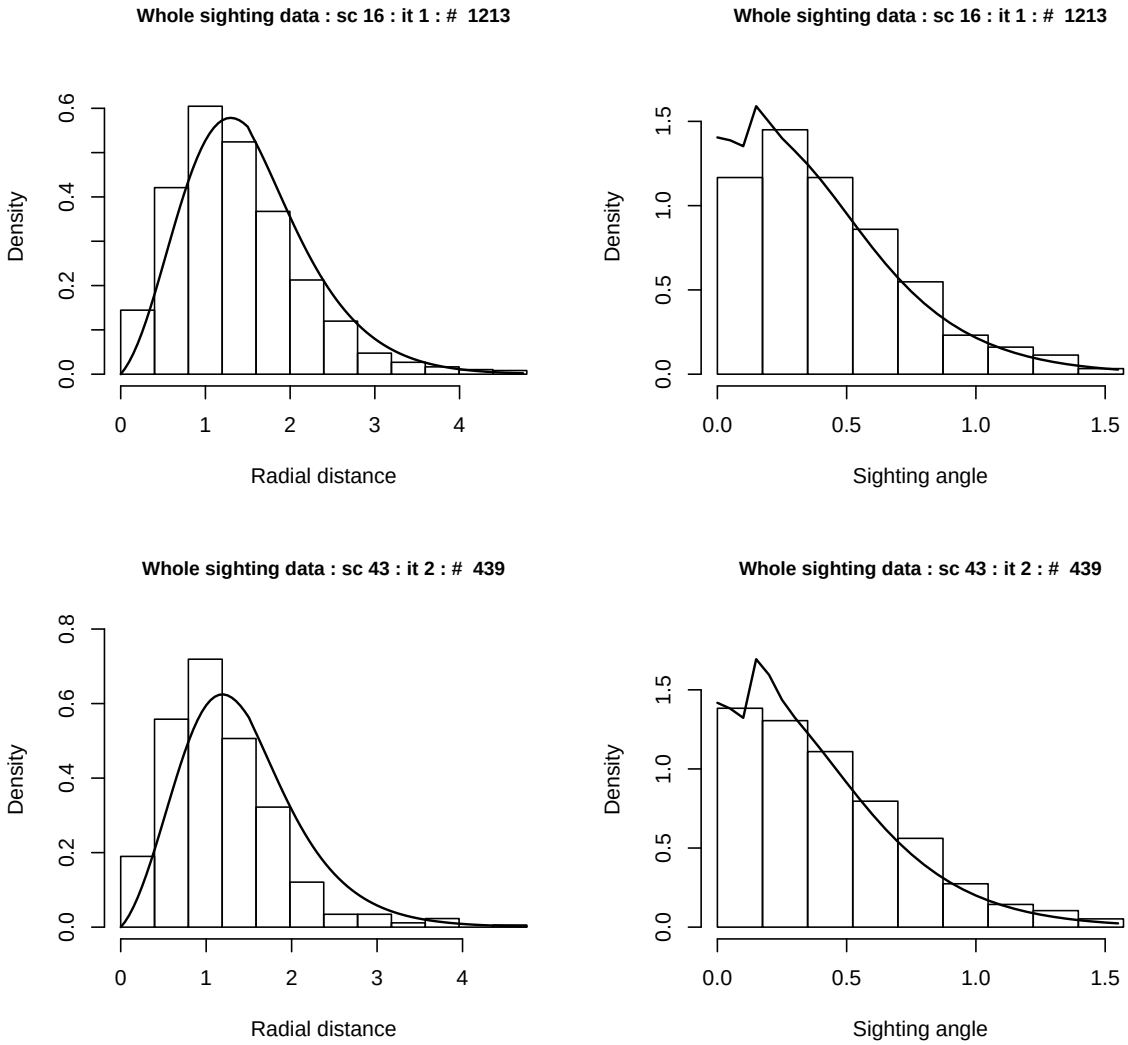

Fig. 4. The diagnotic plots of sighting distance and angle for the revised OK model. Top panels: scenario 16 and iteration 1, and bottom panels: scenario 43 and iteration 2.