Annex F

Catches

[See Scientific Committee Report, Annex D, Appendix 7, this volume p. 125]

Annex G

The Specifications for the *Implementation Simulation Trials* for western North Pacific Bryde's whales

[See Scientific Committee Report, Annex D, Appendix 6, this volume p. 114]

Annex H

An integrated approach for the estimation of abundance through a random-effects model

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Method

Let N_{ay} be the true abundance in the a-th survey block in the year y, and let $\hat{N}_{ay}^{(P)}$ and $\hat{N}_{ay}^{(C)}$ denote estimates of N_{ay} obtained from passing-mode and closing-mode surveys respectively. If abundance estimates in different blocks or years include common parameters such as effective search half-width, then any two of them are correlated, and the method following takes this into account. It is assumed that the abundance estimates are multivariate normally distributed as follows:

$$\begin{cases} \log \hat{N}_{ay}^{(P)} = \log N_{ay} + \varepsilon_{ay}^{(P)}, \\ \log \hat{N}_{ay}^{(C)} = \log R_a N_{ay} + \varepsilon_{ay}^{(C)}, \end{cases}$$

where the vectors of survey error terms, $\varepsilon^{(P)} = (\cdots, \varepsilon_{ay}^{(P)}, \cdots)'$ and $\varepsilon^{(C)} = (\cdots, \varepsilon_{ay}^{(C)}, \cdots)'$ have multivariate normal distributions $N(0,\hat{\Sigma}^{(P)})$ and $N(0,\hat{\Sigma}^{(C)})$, respectively. The variance-covariance matrices $\hat{\Sigma}^{(P)}$ and $\hat{\Sigma}^{(C)}$ are estimated using standard line transect methods. It is assumed that the true abundance level varies randomly as

$$\log N_{ay} = \mu_a + \rho_{ay}$$

where μ_a is a mean block-specific log-abundance for the middle year for the period for which data are available, and ρ_a is a random effect accounting for inter-annual changes in the distribution of the whale population in the surveyed area. The random effect is assumed to be independent and identically distributed according to the normal distribution $N(0, \sigma_A^2)$. Let $\mu = (\mu_1, ..., \mu_A)$ be a vector of the block effects. Then, the unbiased estimator for μ given σ_A^2 is derived from

$$\mu(\sigma_A^2) = (X' \quad V(\sigma_A^2)^{-1} X)^{-1} X' \quad V(\sigma_A^2)^{-1} y$$

where X is a design matrix, y is the vector of the abundance estimates, and $V(\sigma_A^2) = \sigma_A^2 I + \hat{\Sigma}$. The additional variance σ_A^2 is estimated by the REML method (McCulloch and Searle, 2001; Pawitan, 2001; Punt *et al.*, 1997; Skaug *et al.*, 2004), which maximise

$$l_{REML}(\sigma_A^2) = -\frac{1}{2}\log|D| - \frac{1}{2}\log\left|X' \quad V(\sigma_A^2)^{-1} X\right| - \frac{1}{2}(y - X\beta(\sigma_A^2))' \quad V(\sigma_A^2)^{-1}(y - X\beta(\sigma_A^2))$$

The confidence interval for σ_A^2 can be calculated using the profile of the function above. Once σ_A^2 is estimated, then the estimate $\hat{\mu} = \mu(\hat{\sigma}_A^2)$ becomes available. At the same time, the covariance matrix of $\hat{\beta} = \beta(\hat{\sigma}_A^2)$ can be evaluated as

$$Cov(\hat{\beta}) = (X' \quad V(\hat{\sigma}_A^2)^{-1} X)^{-1}$$

The estimation of abundance in areas defined as FGH=F+G+H, IJK=I+J+K and LM=L+M (see Fig. 1) is now considered. For this purpose, option (a) in SC/O05/BWI6, where block K is included, is used. The abundance in each area is estimated by

$$\tilde{N} = \sum \exp(\hat{\mu}_a + Var(\hat{\mu}_a)/2)$$

and its variance by

$$V\hat{a}r(\tilde{N}) = \sum_a \exp(2\hat{\mu}_a)\ \ V\hat{a}r(\hat{\mu}_a) + \sum_{a \neq a'} \exp(\hat{\mu}_a)\exp(\hat{\mu}_{a'})\,c\hat{o}v(\hat{\mu}_a, \hat{\mu}_{a'})$$

The block-effects μ_a are estimated under the assumption that R_a is common across all blocks a.

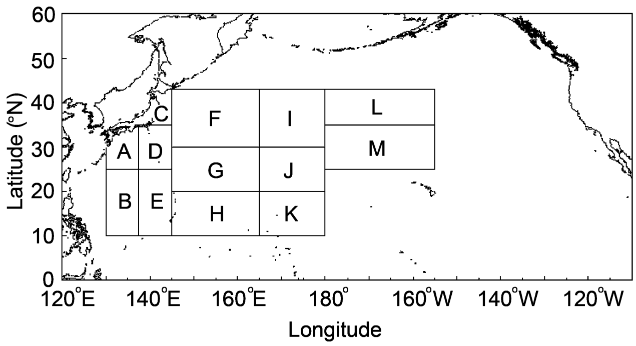

Fig. 1. Survey blocks defined for 1998-2002 surveys.

Results

Table 1

(1) Estimates of block-effects

	F	G	H	I	J	K	L	M
μ	7.89	7.89	7.57	8.46	8.41	6.03	6.97	7.25
SE	0.443	0.459	0.539	0.455	0.480	0.662	0.488	0.566

(2) Estimate of *R* (ratio of closing to passing mode estimates of abundance)

	R
Estimate	0.727
CV (%)	36.4

(3) Estimates of additional standard error and additional variance

	Estimate	95% CI
σ_A^2	0.453	(0.170, 1.041)
σ_A	0.673	(0.412, 1.020)

(4) Abundance estimates and their CVs (assuming passing mode estimates to be unbiased)

	FGH	IJK	LM	F-M
N-tilde	8,152	10,814	2,860	21,826
CV (%)	32.9	34.2	37.2	29.5

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