SC/F16/JR/57

Addendum to JR29

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INTERNATIONAL
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Addendum of SC/F16/JR29

The paper SC/F16/JR29 aimed at assessing predation impact on sandlance population by consumption of common minke whales off Sanriku region. However unfortunately just before the JARPNII review workshop, the authors found a data-handling error in the catch data for sandlance that had been used for input. In relation to this error, through the modification of data-handling, the authors also changed the specification of analysis to some extent. In particular, the start year of data assumed for the analysis was changed from 1960 into 1994 so that separate catch and CPUE data for juvenile and adult sandlance are available (there are records of non-separable catch between 1982 and 1989 by the trawl fishery, though their extents are negligible). In addition, some formulae have been modified.

However, due to time constraints, the authors have not yet been able to finalize all the analyses. Therefore although in this addendum the outline of formulation and one example outcome (without any predation effect) are shown, due to preliminary nature of this analysis, the result should be taken as at best broadly indicative only. The authors plan to submit a full paper with more details on this analysis as well as the analysis with consideration of predation effects in due course.

Data input

1) Catch and CPUE series of juvenile sandlances by lift nets with light fishery (1994-2015)
2) Catch and CPUE series of adult sandlances by dip nets fishery (1994-2015)
3) Time series of age composition data taken from summer sampling survey (2002-2014)
4) Time series of density estimate (in number) during summer sampling survey (2002-2014)
5) Consumption of sandlances by common minke whales in 2005, 2006 and 2012
6) Time series of abundance estimates in Sanriku region for the common minke whales in 2004, 2005, 2006 and 2012

State-space Population Dynamics Models for sandlances (Model I)

We employ a delay-difference model with juvenile and adult stages. The list above summarizes notations used in this paper. The number of juvenile sandlances is assumed to be expressed as a density dependent stock-recruitment model with a process error as follows:

$$N_{J,t} = f\, N_{A,t}\left\{1 + r\left(1 - \left(\frac{N_{A,t}}{K_A}\right)^z\right)\right\} e^{u_{J,t}},\quad u_{J,t} \sim N(0, \sigma_J^2)\,. \tag{1}$$

The number of adult sandlances is expressed as a sum of survived juveniles and adults as follows:

$$N_{A,t} = \left[(1-F_{A,t-1})S_A N_{A,t-1} + (1-F_{J,t-1})S_J^{1/2} S_A^{1/2} N_{J,t-1}\right] e^{u_{A,t}},\quad u_{A,t} \sim N(0, \sigma_A^2) \tag{2}$$

As in other population dynamics models, a simultaneous equation for the equilibrium conditions at the carrying capacity (say K_J and K_A) produces an explicit solution for the fecundity as $f = (1-S_A)S_J^{-1/2}S_A^{-1/2}$. Also, assuming a relationship $w_a = \alpha + \rho w_{a-1}$, then the following recursive formula is obtained:

$$B_{A,t} = (\alpha N_{A,t-1} + \rho B_{A,t-1})(1-F_{A,t})S_A + w_1(1-F_{J,t})S_A^{1/2} S_J^{1/2} N_{J,t-1}\,. \tag{3}$$

State-space Population Dynamics Models for sandlances with whale consumption

In case that the morality by the minke whale predation is taken into account, then the following model is proposed, where *g* is a function for functional response:

$$N_{A,t} = \left[(1-F_{A,t-1})\tilde{S}_{A,t-1} N_{A,t-1} + (1-F_{J,t-1})\tilde{S}_{J,t-1}^{1/2} \tilde{S}_{A,t-1}^{1/2} N_{J,t-1}\right] e^{u_{A,t}}, \tag{4}$$

where, under the assumption of equal predation selectivity between juveniles and adults, the survival rates were modified as

$$\begin{cases} \tilde{S}_{J,t} = S_J - g(B_t)P_t / B_t, \\ \tilde{S}_{A,t} = S_A - g(B_t)P_t / B_t. \end{cases} \quad (5)$$

Where $B_t = B_{J,t} + B_{A,t}$ and the functional response is generally given by

$$g(B_t) = \frac{c_{\max} B_t^m}{B_H^m + B_t^m} \quad (6)$$

though we here assume only a functional response with m=1 (Type II functional response) or a linear functional response.

Observation models

CPUE data (tons/vessel) are available for juvenile and adult sandlances. Also density estimates are used for fitting with population size after fishing season (say N^*). Here, neither of hyperstability nor hyperdepletion is considered for both the fisheries.

$$\begin{cases} \log I_{J,t} \sim N(\log(q_J B_{J,t}), \tau_J^2) \\ \log I_{A,t} \sim N(\log(q_A B_{A,t}), \tau_A^2) \\ \log \hat{D}_t \sim N(\log(b N_t^*), \tau_A^2) \end{cases} \quad (7)$$

The total catch and age-composition data are also available for estimation of parameters as follows:

$$\begin{cases} \log C_{J,t} \sim N(\log(F_{J,t} B_{J,t}), \gamma_J^2) \\ \log C_{A,t} \sim N(\log(F_{A,t} B_{A,t}), \gamma_A^2) \end{cases} \quad (8)$$

and

$$n_t = (n_{t,0}, n_{t,1}, n_{t,2+}) \sim Multinomial(n_{t+}, (p_{t,0}, p_{t,1}, p_{t,2+})), \quad (9)$$

where

$$\begin{cases} p_{0,t} \propto (1 - F_{J,t}) S_J^{1/2} N_{J,t} \\ p_{1,t} \propto (1 - F_{A,t}) S_A (1 - F_{J,t-1}) S_J^{1/2} N_{J,t-1} \\ p_{2+,t} \propto (1 - F_{A,t}) S_A (1 - F_{A,t-1}) S_A^{1/2} N_{A,t-1} \end{cases} \quad (10)$$

and $n_t = (n_{t,0}, n_{t,1}, n_{t,2+})$ is a vector for the age-composition of sampled individuals. We here assume an effective sample size (Neff) as 100 for all the years. The total consumption of sandlance by the common minke whales and the population size of minke whales contributed to the likelihood in Model II.

$$\begin{cases} \log \hat{P}_t \sim N(\log P_t, \hat{C}V_t^2) \\ \log P_t \sim (iid) N(\log \bar{P}, \lambda^2) \end{cases} \quad (11)$$

$$\log Y_t \sim N(\log(g(B_{A,t}) P_t), cv_t^2) \quad (12)$$

Table1. Preliminary results of analysis without consideration of predation effects by common minke whales on the sandlance. Percentages are with respect to median biomass estimates; those numbers would be higher if expressed in terms of adult natural mortality, as estimates of natural mortality are less than 1.

	Median (90% CI)	
Average Biomass last 5 year (tons)	19,934 (14,522 – 31,743)	
Average catch last 5 year except for 2011 and 2012	3,224	16.2%
Average consumption (tons)	1,962	9.8%
Average Biomass last 10 years (tons)	20,147 (15,112 – 32,829)	
Average catch last 10 years except for 2011 and 2012	4,018	19.9%
Average consumption (tons)	1,962	9.7%

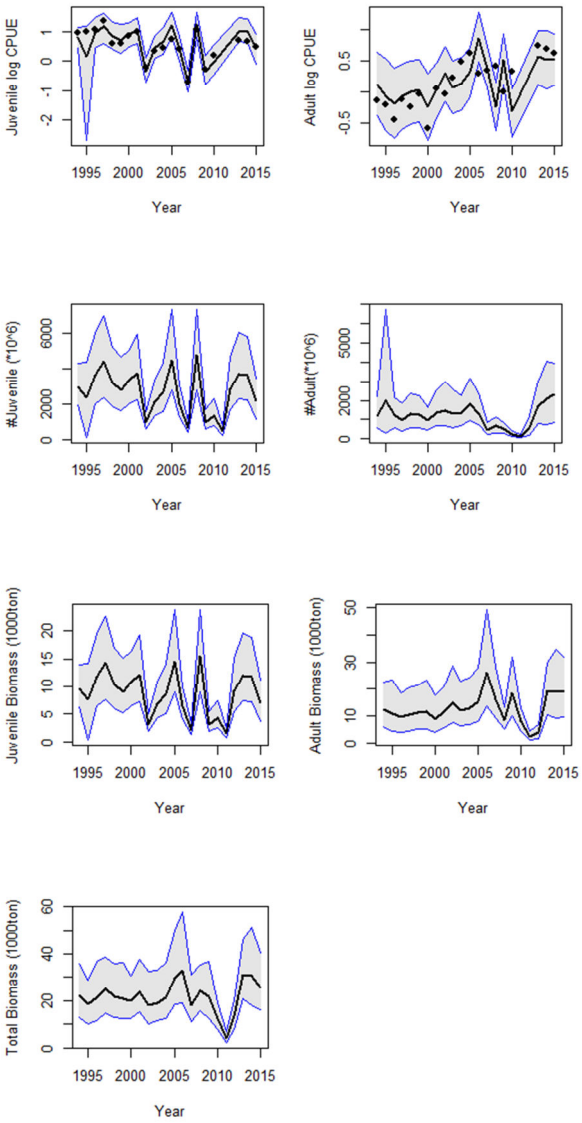

Figure1. Fits to CPUE data and time trajectories of population size and abundance.

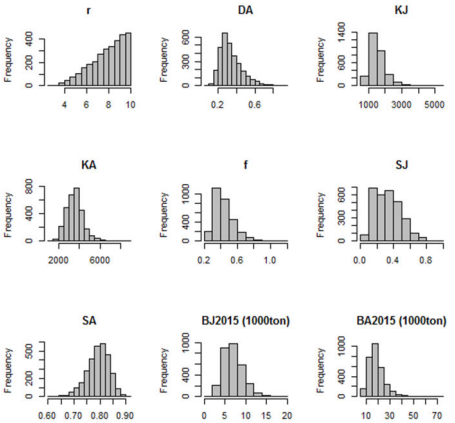

Figure 2. Posterior distributions of primary parameters, which show necessity of more careful prior assumptions.