SC/67A/EM/16

Response to SC/67a/EM01, EM02 and EM03 by De La Mare, McKinley and Welsh

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INTERNATIONAL WHALING COMMISSION

Response to SC/67a/EM1, EM2 and EM3 By de la Mare, McKinley and Welsh

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I thank both Norwegian and Australian groups for paying large efforts to understand minke whale nutritional condition during JARPA period (SC/67a/EM1, EM2, EM3, EM4, EM7, EM8). This paper address some points but covering most of the important issues from de la Mare et al. (2017a; 2017b) and Mackinlay et al. (2017).

Is body weight better than fat weight, blubber or girth measurements? (1) (EM1 and EM3)

- *The analyses here indicate that total body weight (also included in the JARPA data) is a more complete measure of body condition.*
- *The dominant lipid stores are in blubber and muscle, both accounting for similar quantities of stored fat.*

Table 2. Lipid content (%) of fin whales in various tissues by sex given in Lockyer (1987) and for bone in Lockyer (1981a). Standard errors are shown in brackets.

Class	Posterior dorsal blubber (%)	Posterior dorsal muscle (%)	Viscera (%)	Bone (%)
Mature males	74.9 (2.1)	24.1 (3.6)	87.2 (1.2)	56-69
Pregnant females	81.1 (1.3)	33.1 (4.1)	86.6 (1.1)	56-69

from de la Mare et al. (2017a)

Although I agree with the authors of issue to select some good proxies accounted for lipid storage for the analyses, I disagree a decision by de la Mare et al. (2017a) that total body weight is better because of its improper use in citing record of lipid contents from the previous studies. Lipid content (%) at posterior dorsal muscle in fin whales were applied to entire muscle of the Antarctic minke whales to assume the importance of entire lipid contents (see de la Mare 2017a). Nevertheless, posterior dorsal muscle in baleen whales contains obviously higher lipid content % than muscle in other parts of the body (see Watanabe and Suzuki 1950). Their study also indicated fin whales have much larger lipid contents than sei whales do (fin lipid range 1.5-22.9%; sei lipid range 0.5-13.0%). The chemical analysis for the Antarctic minke whale, the ordinal meat which consists of most part of muscle so called "red meat" in the Antarctic minke whale content less than 1 % (see Iida et al. 1998).

In fact, as written by Lockyer's papers, blubber's important function is almost certainly that of an energy store (Lockyer 1984) and most of lipid storage in cetaceans is in blubber (Aguilar and Borrell 1990). Oil yield mainly from blubber showed an increase of nearly 70% (Lockyer 1981a). These all suggest the lipid contents from entire muscle is less important and fat weight is in fact more direct lipid content proxy than body weight. Body weight potentially be affected by contents of stomach and intestine and internal organs which is likely to be independent of lipid contents. So it is no surprise if models with body length have smaller effects of independent variable than in case of blubber thickness or fat weight. Although de la Mare et al. (2017) raised a paradox that the total weight of the minke whales appears to be constant over the JARPA period, this is not paradox (see also statistical confirmation by Cunen (2017a)).

I also mention here that blubber thickness including blubber volume have been commonly used in the previous studies(e.g. Aguilar and Borrell 1990; Moore et al. 2001; Williams et al. 2013; Miller et al. 2011; Christiansen et al. 2013; Solvang et al. 2016), giving biological conclusions. Seasonal changes in nutritional condition increased linearly through the feeding season at the same rate for mature and pregnant minke whale(Christiansen et al. 2013; Solvang et al. 2016). The increase of nutritional condition during feeding area can be confirmed if the model is biologically plausible. I do not see any reason to reject the models with blubber thickness as response variable. Rather I suspect the use of the body condition proxy which do not show seasonal trend (see for example Table 5 in de la Mare et al., 2017).

Analyses of fat weight by de la Mare et al. (EM1 and EM3)

- *Analyses of fat weight with a linear model result in an apparent decline significant with p ~ 0.018, but this probability value overstates the significance by ignoring the effects of model selection, pseudoreplication and random effects. Mixed effects models do not show a significant decline in fat weight.*
- *Better model fits are available and model Fw2 shows that total body weight alone is a substantially better predictor of fat weight than model Fw1.*
  Fw1 YearNum + BLm + DateNumC2 + Diatom + Sex
  Fw2 BWt

First of all, I note that the model selection procedure in de la Mare et al. (2017), which start from one term, is different from one which the Review Panel recommended which suggested to make a biological full model before starting model selection (IWC 2015, see on a later page). The importance of making full model is also mentioned by Cunen (2017b). In the model building in de la Mare et al., (2017a), the reason why BWt is first included followed by DateNum and what kind of purpose this model has were not explained. This is far from the sense of meaning in making biologically plausible model.

As suggested in de la Mare's paper (de la Mare et al., 2017a) and first section of this paper, blubber weight is a part of body weight and blubber is almost certainly that of an energy store (Lockyer 1984). Furthermore body weight and fat weight from the JARPA data are also highly correlated (r=0.89, Fig. 1). These indicate that models by de la Mare et al. gave two close variables into both response and predictor in the model (for example in Fw2), and this absolutely weaken the all effects including year effects and make AIC or BIC smaller. Overall, it is not appropriate in biological models to include BWt into predictor of any models in which energy storage as response variable. And all regression models which includes BWt can not predict biological results. In cases for nutritional condition studies for the Atlantic minke whales, none of models used body weight or proxies of nutritional condition as explanatory variables in regression models (see for example, Christiansen et al. 2013; Williams et al. 2013; Solvang et al. 2016).

I have here conducted a confirmative analysis in the case of FatWeight / BWt as a response variable to avoid the correlation problem between fat weight and body weight (Table 1). This result, which can be compared to the de la Mare et al. (2017, in Table 7), shows precisely the opposite interpretation in the model selection by both AIC and BIC. BWt was not selected in the analysis. More detailed analyses were also conducted by Cunen (2017a).

Table 1. Model selection for the fat proportion (fat weight / body weight) analysis.

Model	Specification	AIC	BIC
Fw1.mod	YearNum + BLm + DateNum + Diatom + Sex	-3857.134	-3825.089
Fw2.mod	BWt	-3597.468	-3583.735
Fw3.mod	YearNum + BWt	-3646.857	-3628.546

Is cutting data set into some small data subsets by McKinlay et al. (EM2) correct?

Ross Sea: *Ross Sea were excluded since minke whales in this region are recognised as having appreciably different feeding ecology compared with other areas sampled under JARPA (Ichii et al., 1998; Smith et al., 2007).*
Diatom: *Higher diatom loads are therefore considered indicative of animals that have been present in Antarctic waters for some time, possibly over winter and perhaps for > 1 season, while low loads are thought to indicate animals that have newly arrived in Antarctica.*

Table 1: Sample sizes at each data processing step.

Step	Description	N	Proportion
1	Read raw catch data	4781	1.00
2	Remove records from Ross Sea	4012	0.84
3	Remove records with latitude > -60S	3973	0.83
4	Remove records before 1 Dec	3962	0.83
5	Remove records missing on length, weight or diatom load	3771	0.79
6	Remove female records missing on fetus length	3743	0.78
7	Remove records missing on stomach weight	2923	0.61

From Mckinlay et al. (2017)

In the data processing, they also cut down data into small sample size, but some are enough be treated as random effects instead of cutting data in recent analyses. I also recognized data cutting of Ross Sea and Diatom have problem. As shown in Figure 1, fetus length and diatom adhesion have clear correlation, suggesting diatom adhesion level increase in later days during a season. This is an evidence that higher diatom adhesion in pregnant females did not spend austral winter season in the Antarctic waters. In mature males have less diatom adhesion than pregnant females, also suggesting no wintering. Overall data separation by diatom can not be justified by the assumption that minke whales with diatom covered had spent over winter.

Nutritional condition is accumulated consequence and not snap shot like evidence. Although different types of krill also available on the continental shelf, such as Ross Sea, they have fed on lower latitude and not isolated. The Antarctic krill, which is a main species, is also available on the Ross Sea. From these, I do not see the necessity of separating Ross Sea data.
Even though there is possible segment of population or different environment, these kinds of analyses have already be done in past SC arguments by including interaction or random effect terms (e.g., see Konishi and Walloe 2015; Cunen et al. 2017). What I should avoid taking risks to separate data and do analyses separately for one population animal because wrong separation of data could be results in less dependable outcome.

Is body weight better than fat weight, blubber or girth measurements? (2) (EM2)
Our rationale was that, for any given length, heavier animals should be considered in better condition than lighter animals.

We are not saying there is no utility in blubber thickness or fat weight in defining condition, as there is clearly some separation on L-W curves.

First I believe that all nutritional condition indices do not necessary correlated with body length nor to be on L-W curve. I have already explained total body weight is not direct measurement of nutritional condition and blubber is the main lipid storage. I do not surprise the body length and weight have high correlation because muscle, bone and other organ weights are less lipid contents and therefore highly depend on their body length (see Fig. 1). Blubber thickness and fat weight are highly variable by lipid accumulation, so these have higher correlation with date than body weight (Fig. 1). I conclude that change of blubber related change should be more prioritized than comparing to L-W curves.

CONCLUSION

We conclude that the results presented in Konishi et al. (2008), Konishi and Walloe (2015) and FIC case by Cunen et al.(2017) about important declines, significant at the 5% level, in fat weight and blubber thickness and girth over the JARPA period remain valid.

The purpose of the collaborative studies by Australian, Norwegian and Japanese teams associated with the recommendation in the review meeting. I would like to remind here what was the original motivation for minke nutritional trend in the Annex K1 of the 2015 SC (IWC, 2016).

De la Mare and McKinlay held the view that the real issue was the heterogeneous manner in which the data were collected, and disagreed with the statement from last year's meeting that the analyses requested by the Working Group and later by the Expert Panel had been satisfactorily completed. In particular, they considered that the following points had not been fully addressed:
(1) develop a conceptual model of the system under consideration;
(2) use the conceptual model to identify a set of covariates to consider in the modelling;
(3) start with a 'full model' and base selection of which factors to include and of which of their interactions to treat as random effects on a reduction process; and
(4) apply both Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) as model selection criteria to simplify models and examine the sensitivity of results to the different models selected.

The authors of the papers (EM1,2,3,4,7,8) and this paper all collaboratively confirmed that it is possible to decide whether there has been a general decline in nutritional condition based on JARPA data, while some analyses seems to lose their way. Nevertheless I presume that the works in this year satisfied a complete final analysis of the JARPA data in relation to nutritional condition based on the above recommendation by Review Panel in 2014 (IWC, 2015).

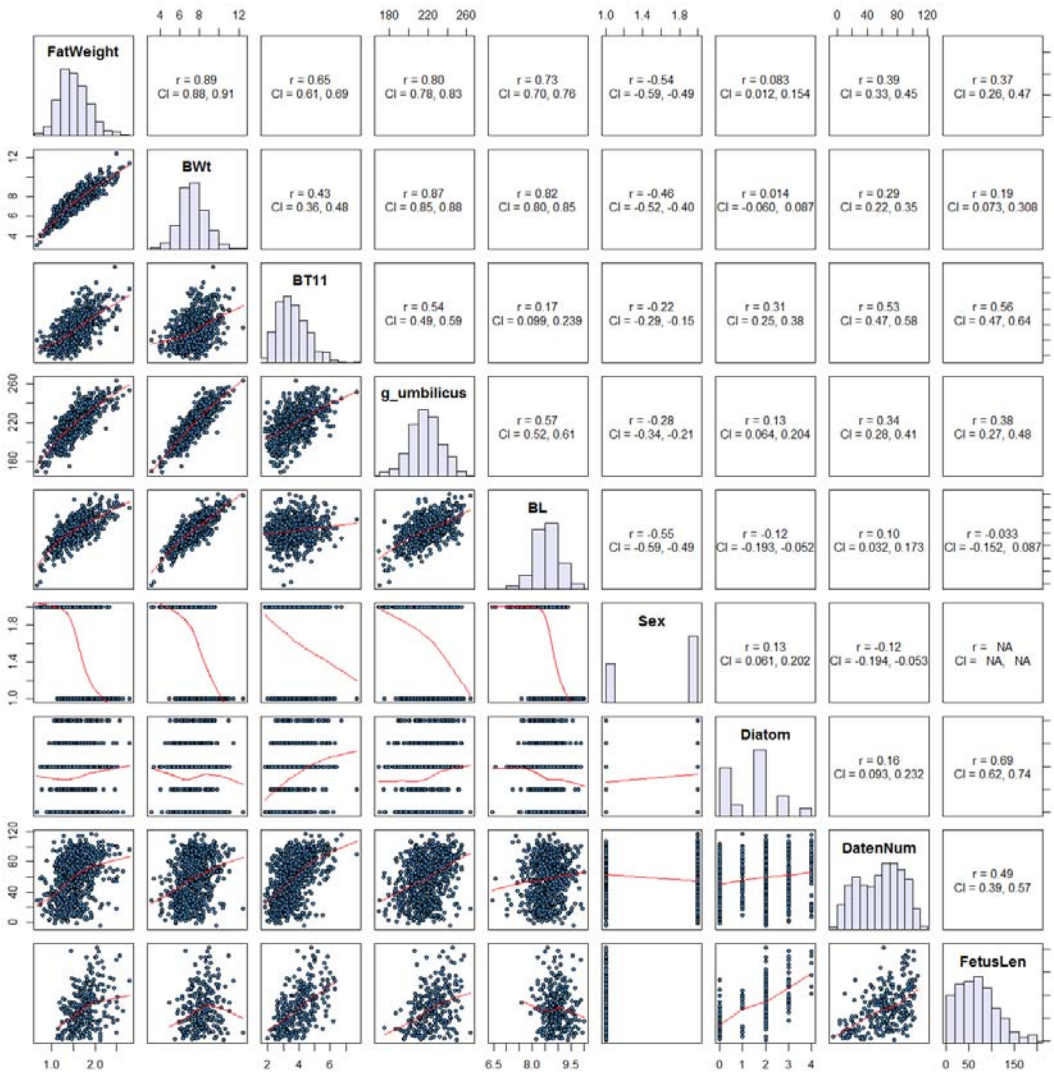

Figure 1 Correlation matrix of variables in the Antarctic minke whale nutritional condition analyses.

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