Further examination of morphological heterogeneity in North Pacific minke whales collected during the JARPN surveys

Takashi Hakamada and Yoshihiro Fujise

The Institute of Cetacean Research
4-18, Toyomi-cho, Chuo-ku, Tokyo, 104-0055, JAPAN

ABSTRACT

In response to a recommendation from the JARPN review workshop, the morphological heterogeneity in North Pacific minke whales was examined further using alternative stratification. We divided sub-area 9 into two sectors by the longitudinal line of 162° E by taking into consideration the results of a mtDNA analysis that showed genetic heterogeneity in the western part of this sub-area in 1995. In this examination, we adopted the regression analysis for 12 parts of external measurements for minke whales collected by JARPN surveys. The result of the regression analysis using the data of the 1995 JARPN sample, showed no significant differences between the western and eastern sectors of sub-area 9. This result is consistent with that obtained if the data of the 1994 and 1997 JARPN surveys in sub-area 9 are added. This result provided no evidence for additional stock structure (e.g. W stock) in sub-area 9.

KEYWORDS: NORTH PACIFIC, MINKE WHALE, MORPHOMETRICS, STOCK STRUCTURE

INTRODUCTION

Morphological and morphometric studies on western North Pacific minke whales related to stock structure, have been conducted previously (Omura and Sakiura, 1956; Ohsumi, 1983; Kato *et al.*, 1992; Fujise and Kato, 1995; 1996).

During the Workshop to review JARPN, Hakamada and Fujise (2000) presented the results of an examination of the morphological heterogeneity in the western North Pacific minke whales using data collected during JARPN survey. They found no significant differences in morphometric among sub-areas 7, 8, and 9 in the Pacific side of Japan. On the other hand, Goto *et al.* (2000) found certain degree of mtDNA heterogeneity in the western sector of sub-area 9 in the 1995 JARPN survey, though samples in other years did not show such heterogeneity. The Workshop recommended that the morphological data should be re-analysed by considering the result of Goto *et al.* (2000) and the results of the re-analysis should be presented to the 52 IWC/SC meeting (Anonymous, 2000).

We adopted the regression analysis for 12 external measurements of minke whales collected by the JARPN surveys using the same stratification used by Goto *et al.* (2000) for sub-area 9. They divided sub-area 9 into two sectors by the longitudinal line of 162° E.

MATERIALS AND METHODS

External measurements data for male minke whales collected in sub-area 9 during the 1995 JARPN survey were examined by the regression analyses. The sample size used was 63 for the western sector and 18 for the eastern sector in the 1995 survey in sub-area 9 (Table 1). Female samples were not examined because the sample size was too small (6 in the western sector and 3 in the eastern sector). The 13 external measurements used in this study are shown in Fig. 1.
The following regression model was used:

$$\log_e Ln = \alpha^* \log_e L1 + \beta^* WE + const. \quad (1),$$

where Ln (n = 2, 3, ..., 13) is the length of external character; Vn, α and β are regression coefficients, $L1$ is the body length, WE is a dummy variable, which indicates if the location of detection is in the western or eastern sectors. These variables are selected by a stepwise selection method. Significant level to include variable was set at 5% and the one to exclude variable was set at 10%. In order to take into consideration the effect of the growth, $L1$ was included in the formula (1).

In order to taking into consideration the sample size, a similar analysis was conducted but using the data for male minke whales of all JARPN survey in sub-area 9 (Table 1). In this analysis, the following regression model was considered:

$$\log_e Ln = \alpha^* \log_e L1 + \beta^* WE + \gamma^* D1 + \delta^* D2 + const. \quad (2),$$

where Ln, $L1$ and WE are the same as in formula (1), α, β, γ and δ are regression coefficients, $D1$ and $D2$ is dummy variables that represents the researchers. Similar to the above analysis, variables were selected by a stepwise selection method. The reason why $D1$ and $D2$ are included in the model is that significant differences may exist between different researchers who made measurements (Fujise and Kato, 1996). Year was not included in the model as a variable because it might be correlated to the researchers. If $D1$ or $D2$ was selected as a variable into the model, this means that there are significant differences between researchers.

RESULTS AND DISCUSSIONS

Table 2 shows the regression models of each external measurement from the data of 1995 for sub-area 9. For all external measurements, the regression model selected by the stepwise selection method in each measurement shows the model including the body length as a variable and did not include the WE as a variable. Therefore, the regression analysis for the data in 1995 season shows no significant differences of external measurements between western and eastern sectors in sub-area 9.

Table 3 shows the selected best regression model for each external measurement using the data from sub-area 9 in the three JARPN surveys (1994, 1995 and 1997). Similar to the result of the analysis using data of 1995 alone, for all external measurements, the selected regression model by the stepwise selection method, shows the model including the body length as a variable and did not include the WE as a variable. This means that morphological differences between the western and eastern sectors were not observed even if the all available data in that sub-area are used

Furthermore, for some external measurements $D1$ and/or $D2$ were selected as a variable (cases of V2, V3, V4, V6, V8, V9). If $D1$ or $D2$ are selected as a variable into the model, this means that there are significant differences between researchers, and the implication of this should be considered more carefully in the analysis of morphmertic data.

Our results of the morphometric analysis provide no evidence for the existence of additional stock structure in sub-area 9 either when only the 1995 data are used or the total JARPN data for this sub-area are used.

ACKNOWLEDGEMENTS

We thank all the researchers and crewmembers involved in the JARPN surveys from 1994 to 1999. We also thank D. Butterworth (University of Cape Town) and L. Walloe (University of Oslo) for valuable suggestions on data analysis. We also thank H. Hatanaka for valuable comments on this paper.

REFERENCES

Anonymous. 2000. Report of the Workshop to Review the Japanese Whale Research Programme under Special Permit for North Pacific Minke Whales (JARPN), Tokyo, 7-10 February 2000. Paper SC/52/Rep2 presented to the IWC Scientific Committee, June 2000 (unpublished). 29pp.

Fujise, Y. and Kato, H. 1995. Preliminary report of morphological differences of minke whales between coastal Japan (sub-area 7) and off-shore area (sub-area 9) in the western North Pacific. Paper SC/47/NP5 presented to the IWC Scientific Committee, May 1995 (unpublished). 9pp.

Fujise, Y. and Kato, H. 1996. Some morphological aspects of the western North Pacific minke whales; preliminary analyses of materials from the JARPN surveys in 1994-95. Paper SC/48/NP11 presented to the IWC Scientific Committee, June 1996 (unpublished). 10pp.

Goto, M., Abe, H. and Pastene, L.A. Additional analyses of mtDNA control region sequences in the western North Pacific minke whales using JARPN samples. Paper SC/F2K/J32 presented to the workshop to Review the Japanese Whale Research Programme under Special Permit for North Pacific Minke Whales (JARPN), February 2000 (unpublished), 5pp.

Kato, H., Kishiro, T., Fujise, Y. and Wada, S. 1992. Morphology of minke whales in the Okhotsk sea, Sea of Japan and off the East Coast of Japan, with respect to stock identification. *Rep. Int. Whal. Commn* 42: 437-442.

Ohsumi, S. 1983. Minke Whales in the coastal waters of Japan. *Rep. Int. Whal. Commn* 33: 365-371.

Omura, H. and Sakiura, H. 1956. Studies on the little picked whale from the coast of Japan. *Sci. Rep. Whales Res. Inst., Tokyo* 11: 1-37.

Table1. Numbers of male samples used in this study, by JARPN survey and longtitudinal sector in sub-area 9.

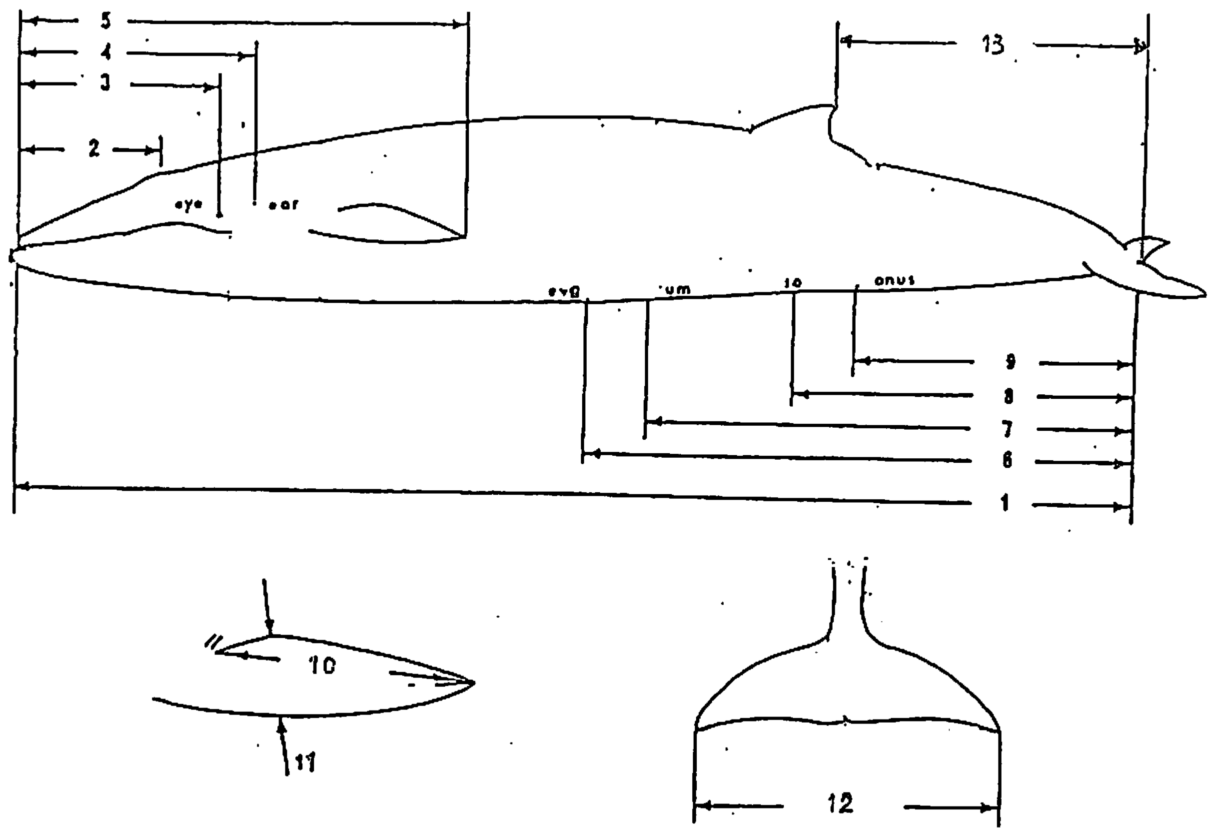
year	western sector	eastern sector	total
1994	5	12	17
1995	63	18	81
1997	13	40	53
total	81	70	151

Table 2. Regression formula of external measurements of samples from sub-area 9 in 1995.

measurement	regression model	R^2 value
V2	log L2 = 0.967*log L1-1.863	R^2 = 0.740
V3	log L3 = 0.915*log L1-1.335	R^2 = 0.786
V4	log L4 = 0.861*log L1-0.686	R^2 = 0.823
V5	log L5 = 0.901*log L1-0.235	R^2 = 0.932
V6	log L6 = 1.028*log L1-0.782	R^2 = 0.938
V7	log L7 = 1.091*log L1-1.348	R^2 = 0.956
V8	log L8 = 1.007*log L1-1.166	R^2 = 0.899
V9	log L9 = 1.020*log L1-1.471	R^2 = 0.860
V10	log L10 = 1.044*log L1-2.576	R^2 = 0.806
V11	log L11 = 0.959*log L1-3.014	R^2 = 0.775
V12	log L12 = 1.038*log L1-1.489	R^2 = 0.696
V13	log L13 = 1.018*log L1-1.381	R^2 = 0.870

Table 3 Regression formula of external measurements of samples from sub-area 9 in 1994, 1995 and 1997.

measurement	regression model	R^2 value
V2	log L2 = 0.911*log L1-0.072*D1-0.016*D2-1.475	R^2 = 0.758
V3	log L3 = 0.859*log L1-0.042*D1-0.962	R^2 = 0.791
V4	log L4 = 0.844*log L1-0.027*D1-0.577	R^2 = 0.843
V5	log L5 = 0.952*log L1-0.576	R^2 = 0.925
V6	log L6 = 1.042*log L1-0.018*D1-0.012*D2-0.863	R^2 = 0.938
V7	log L7 = 1.051*log L1-1.077	R^2 = 0.949
V8	log L8 = 0.982*log L1-0.009*D2-0.993	R^2 = 0.902
V9	log L9 = 0.990*log L1-0.13*D2-1.265	R^2 = 0.863
V10	log L10 = 1.188*log L1-3.535	R^2 = 0.844
V11	log L11 = 1.103*log L1-3.969	R^2 = 0.834
V12	log L12 = 1.043*log L1-1.521	R^2 = 0.766
V13	log L13 = 0.981*log L1-1.129	R^2 = 0.851



V1. Total length

V2. Tip of snout to blowhole

V3. Tip of snout to eye

V4. Tip of snout to ear

V5. Tip of snout to tip of flipper

V6. Notch of flukes to end of ventral groove

V7. Notch of flukes to umbilicus

V8. Notch of flukes to reproductive aperture

V9. Notch of flukes to anus

V10. Flipper, tip to posterior insertion

V11. Flipper, maximal width

V12. Flukes, tip to tip

V13. Notch to flukes to tip of dorsal fin

Fig. 1. The external characters of minke whale in this study.