Report of an experiment on alternative sampling methodology performed during the 1999/2000 JARPA survey.

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ABSTRACT

At the meeting of the Intersessional Working Group to Review Data and Results from JARPA, Schweder commented on the sampling scheme used in JARPA surveys (IWC, 1998). He proposed a modified sampling methodology at the meeting of 49th Scientific Committee (Annex U of the report of 49th Scientific Committee). In response to his proposal, a limited scale feasibility study on whether the modified methodology is workable or not was conducted during the 1999/2000 JARPA survey. This paper explains the alternative sampling methodology based on Schweder's proposal and reports the results of the experiment using the modified sampling methodology.

KEYWORDS: MINKE WHALE, SAMPLING STRATEGY

INTRODUCTION

The present sampling scheme adopted for the JARPA surveys is two-stage random sampling (Kishino *et al.*, 1991; Fujise *et al*, 1997),because of the sampling fraction is depended on their school size. In the present scheme, one whale was sampled at random from every school. At the Meeting of the Intersessional Working Group to Review Data and Results from JARPA in 1997, Schweder pointed out that the sampling method resulted in over-sampling from small schools. On the other hand, large schools are easier to detect. He also commented that another source of sampling bias results from under-surveying in areas of high minke whale density (IWC, 1998). At the meeting of 49th Scientific Committee, he proposed a modified sampling and sighting protocol following. i) Sample, on average, $C_a s/p_s$ whales from an encountered school of size s in survey area a (Notations are explained in the section "MATERIAL AND METHOD"). ii) Further, area-specific constant C_a, should be chosen to make the probability of sampling an individual whale the same in all survey areas. iii) Finally, the vessel continues the next day at the position at which it stopped the last evening (without moving to the next target point) (Schweder, 1998).

In response to his proposal, it was intended to conduct a limited scale feasibility study during 1998/99 JARPA survey (Government of Japan, 1998). This feasibility study was aimed to collect the

information on whether the modified method was workable or not, and the improvement of the current sampling and sighting scheme. The experiment was called off due to fire on the research ship, *Nisshin-Maru* (Government of Japan, 1999a), but it was attempted during the 1999/2000 JARPA survey (Government of Japan, 1999b). Some examinations using a simulation model were made regarding the feasibility study.

MATERIAL AND METHODS
In accordance with i), the number of samples per one school of size s is set to

$$\frac{Cs}{p_s},$$

where C is a constant independent of s , and p_s is the probability of sighting a school of size s within a strip of width 4 n.miles (Schweder, 1998). Constant C is set to

$$C = \frac{T}{\sum_s sN_s e},$$

where N_s is the number of schools within 2 n.miles from the trackline, T is the target sample size (the number intended to be sampled), and e is the sampling efficiency. Then, the expected sample size $E(n)$ is represented as following;

$$E(n) = \sum_s N_s p_s \left(\frac{Cs}{p_s}\right) e = T.$$

In other words, C is set to a value such that $E(n)$ equals T. p_s is calculated from the effective search half-width from sighting data excluding the detection within a strip of width 4 n.miles

Regarding ii), it was planned that this feasibility study be conducted in one stratum, therefore it was not necessary to take ii) into account. Accordance to iii), All SSVs stayed at the position where the survey of the day was finished until next day (Ishikawa *et al.*, 2000).

The experiment on modified sampling methodology was planned for the East-south stratum for two weeks. From sighting data of previous JARPA surveys in East-south stratum from the 1991/92 to the 1995/96 seasons, we estimated probability of detection, total number of individuals within a strip of width 4 n.miles including missing whales and average sampling efficiency to calculate $\dfrac{Cs}{p_s}$'s for any school of size s not more than 10 were calculated. Table 1 shows the results of this calculation and average number of detections of schools and individual whales stratified by school size and so on, which were expected to be similar to school size composition of the population.

Table 2 shows the number of samples per one school of size s planned for this feasibility study. Option B in Table 2 corresponds to the results shown in Table 1. At first, Option B was adopted. After five

days' survey, the option to be adopted was reviewed. Option A was to be adopted in the case that fewer whales are detected than expected and Option C was to be adopted in the case that more whales are detected. Option D, which represents the usual sampling methodology, was to be adopted in the case much fewer whales are detected. 1/2 means sampling one whale from every two schools and 2 means sampling two whales from every school.

Table 3 shows the results of the simulations. The simulations were conducted to examined how many samples could be collected during two weeks' of survey and how long the vessel proceed along the trackline. The simulations for each Option were repeated 100 times, respectively. For the sake of simplicity, only one trackline is considered, though three vessels in fact operate as sighting and sampling vessels for the JARPA surveys. In the simulations, it was assumed from the previous survey record that survey can not conducted for four days due to rough sea condition, and the density index (DI) and mean school size (MSS) is 6 and 3.15, respectively. But in simulating Option C, density index was assumed to be 10, which almost corresponds to the highest density index obtain in previous JARPA surveys in this stratum.

RESULTS

The feasibility study on the modified sampling scheme was conducted in the East–South stratum in Area IV from 28 January to 10 February (Ishikawa et al., 2000). The feasibility study was planned to be conducted in the entire East–South stratum. However, the density of whales was higher than expected, actual distance proceeded along the trackline during the feasibility study was 391.0 n.miles per one vessel, which corresponded to approximately 30% of the entire length of the trackline. In the rest of the East-South stratum, at most, 4 whales were to be taken per day. After 4 whales were sampled, only the sighting survey was conducted until the end of the survey of that day.

Table 4 shows the numbers of sightings of schools and individuals stratified by size s during the feasibility study. The time spent in interrupting the survey caused by the modified sampling scheme to avoid the lack of surveying on the trackline was 47 hours and 52 minutes (15 hours and 57 minutes per one vessel). Although it had been expected that such interruptions might occur we had no expectation of how much time would be spent in such interruption.

DISCUSSIONS

Comparison of data from the previous surveys (Tables 1 and 3) with data from this feasibility study (Table 4), shows that more schools were detected and more whales were sampled than we had expected. Comparison of data in Table 3 with the distance covered along the trackline, shows that much less distance was covered along the trackline than was expected. Such comparisons may provide information concerning problems of the modified sampling scheme.

In this year, it was very difficult to execute the feasibility study on the modified sampling

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scheme along the planned schedule. The experiments should be continued in several years to evaluate this new method and/or to improve the current sampling method. This would provide opportunities to improve the method taking account of various circumstance or conditions.

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Table 1.Expected sighting data from the JARPA surveys from 1991/92 to 1995/96 and the number of samples per school adopted in feasibility study on modified sampling scheme in 1999/2000 JARPA survey.

School size	Mean of No. of detection 1)			Detection probability 2)	Estimated No. of individuals	No. of samples per school (calculated)	No. of samples per school (conducted)	Expected sample size
	School	Percentage	Individual					
1	20	37.9%	20	0.2	102	0.486	1/2	8
2	13	23.5%	25	0.2	126	0.971	1	10
3	5	9.2%	15	0.5	29	0.583	1/2	2
4	6	11.3%	24	0.6	40	0.648	1/2	2
5	2	3.4%	9	0.7	13	0.694	1/2	1
6	1	2.8%	9	1	9	0.583	1/2	1
7	2	3.2%	12	1	12	0.680	1/2	1
8	1	2.2%	10	1	10	0.777	1	1
9	0	0.0%	0	1	0	0.874	1	0
10+	4	6.6%	45	1	45	1.594	2	6
Combined	54	100.0%	169		386			30

1) the weighted mean of number of detection from the 1991/92 to the 1995/96 survey converted to correspondence to 14 days.

2) estimated from the effective strip half-width using detections within a strip of width 4n.mile.

Table 2. 4 Options used for the feasibility study.

School size	Option A	Option B	Option C	Option D
1	1/2	1/2	1/3	1
2	1	1	1/2	1
3	1	1/2	1/3	1
4	1	1/2	1/3	1
5	1	1/2	1/3	1
6	1	1/2	1/3	1
7	1	1/2	1/3	1
8	1	1	1/2	1
9	1	1	1/2	1
10+	2	2	1	1

Table 3. Results of simulation of each of the Options (average and SD in 100 trials).

		schools detected	whales detected	whales sampled	searching distance
Option A	mean	47.9	145.2	32.0	795.0
	SD	4.8	22.0	4.4	60.9
Option B	mean	51.9	156.7	27.4	858.0
	SD	4.5	22.5	3.6	56.4
Option C *	mean	84.1	258.2	26.6	839.4
	SD	8.0	34.8	3.4	56.5

*: Under the condition that Dl=10

Table 4. The number of sighted schools and individuals sampled stratified by school size.

School size	Number of sighted schools				Number of individuals sampled			
	K01	YS1	T25	combined	K01	YS1	T25	combined
1	10	12	3	25	5	6	2	13
2	15	16	14	45	15	16	13	44
3	2	3	3	8	1	2	1	4
4	1	0	3	4	1	0	2	3
5	0	1	0	1	0	1	0	1
6	1	0	1	2	1	0	1	2
7	0	0	0	0	0	0	0	0
8	1	1	1	3	1	1	1	3
9	0	0	0	0	0	0	0	0
10+	8	8	5	21	14	16	10	40
Total	38	41	30	109	38	42	30	110