Performance of biopsy skin sampling for minke whales during the JARPN and JARPA surveys using ICR air gun

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ABSTRACT

Trials of biopsy skin sampling for minke whales using ICR air gun (ICRgun) were attempted as a feasibility study during the JARPN and JARPA surveys. In the JARPN surveys, trials were made in the pelagic and the coastal waters. In the JARPA surveys, these were implemented using the choice and random sampling procedures in the high-density area of minke whales. Following results were obtained from these trials. The pelagic waters were more difficult to approach and shoot to the target than the case of the coastal waters. It was indicated that the random sampling was more difficult to approach and shoot to the target than the case of the choice sampling procedure. The most samples taken were from 11 m to 20 m in the shooting range. The solitary or below three animals in the school size was very difficult to take a sample and to approach within the effective shooting range. A sample was widely collected from 0 to 3 in the sea-state. In the cases which animal could not be approach within the effective shooting range, sea-state was in the range from 2 to 4. The sea-state seemed to be not important for sampling efficiency. However, when the level of the sea-state became high, the trial was decreased and cases which could not be approach within the effective shooting range was increased. Gauthier and Sears (1999) attempted to take a biopsy sampling of the minke whale on the inflatable boat using the cross bow with the recovering system in the estuary and Gulf of St. Lawrence. Twenty-seven trials were implemented for the minke whale and it succeeded to take 25 samples. An inflatable-boat can approach slowly along with the swimming of the target animal and can take position within 6 m to 20 m of the shooting range. Therefore, the biopsy sampling trial is easier, because of behaviors such as the escape swimming and the long diving is not occurred. The effective shooting range from these sampling results was the same degree to our trials succeeded. Therefore, it seems that the behavior of the minke whale is more influential than the efficiency of the equipment. The sampling rate of the whale harpoon was remarkably higher than the ICR gun. The effective shooting range is from 30 m to 45 m in the whale harpoon compared with 6 m to 20 m in the ICR gun. These results show that the wide effective shooting range overcomes the avoidance behavior in the case of whale harpoon. Existing biopsy sampling techniques for minke whales have some problems. In the recovering system, the dart tip is small and light in the weight. It looses-ability by the opposite wind. The retrieving system pulls a rope, and easily looses the power when the shooting range become larger, but it is very difficult to attain the efficiency of the wahle harpoon

INTRODUCTION

Biopsy skin sampling using a crossbow with the recovering system has been successfully carried out on slow swimming cetacean species in coastal waters (e.g. Winn *et al.*, 1973; Lambertsen, 1987; Mathews *et al.*, 1988; Brown *et al.*, Palsboll *et al.*, 1991; Weinrich *et al.*, 1991).

In 1988/89, a biopsy skin sampling system for fast swimming whales in pelagic waters was made by Japan. This system, which used a powerful compound crossbow and fishing reel with monofilament nylon line as the retrieving system, was used on the Southern minke whales in the Antarctic. The experiments of this system were not successful and several problems were identified (Kasamatsu *et al.*, 1989). The largest problem (related to the use of a crossbow with the retrieving system) was that its power was reduced by entanglement with line broke. It was concluded that a crossbow with the retrieving system was an unsuitable delivery system for obtaining biopsy samples from fast swimming whales in pelagic waters.

Species such as minke whale must usually be chased at high speed and it is difficult for a firing system with weak power to hit the whale with sufficient strength to sustain wind pressure and the ship's speed. The

Institute of Cetacean Research (ICR) has developed, with the cooperation of the Miroku Machinery Company Limited, a system specifically designed to collect biopsy skin samples from fast swimming whales (Kasamatsu *et al.*, 1991). Systematic field experiments of ICR gun with retrieving system were conducted for most Balaenopteridae species in 1989/90 IWC/IDCR Southern Hemisphere Minke Whale Assessment Cruise (Nishiwaki *et al.*1990). This experiment showed that it is feasible to obtain a limited number of tissue samples from most of target species using ICR gun with the retrieving system. Minke whales proved to be the most difficult one of all the species pursued, as the animals usually stayed just beyond the 30m firing range of this air gun.

Trials of biopsy skin sampling for minke whales using ICR gun were attempted as a feasibility study during the JARPA and JARPN surveys. This paper considered on the potential and performance of biopsy skin sampling for minke whale during JARPA and JARPAN surveys using ICR gun

MATERIALS AND METHOD

The ICR air gun (The ICR gun)

Fig.1 outlines the ICR gun. This gun was a modified version of *Miroku Line-Shooter M-63* originally developed by Miroku Machinery Co. LTD. The length of the gun is 85mm and that of the barrel is 45mm. Its weight is 4kg. Air pressure is set at 90-150kgf/cm^2. The initial shooting velocity of the dart with a 5mm in diameter nylon line is 70m-86m/sec at the filling pressure is set at 100-150kgf/cm^2. The maximum range is 80-100m (against an effective sample collecting distance of within 30m) with a shooting angle of 15 degree from the horizon.

The biopsy dart system was composed of three parts: a biopsy dart tip, a mounting shaft and a retrieval line (Fig.2). The dart tip had a core opening of 11mm and penetration was limited to 60mm by 14mm diameter stopper on the dart. The dart tip had a total length of 80mm and a mass of 100g.

The dart tip was mounted on an alumait shaft with nylon sleeves. The sleeves provided a tight seal for the dart within the gun barrel. The mounting shaft has a length of 192mm and a weight of 220g, and the nylon sleeves has a diameter of 40mm. The total length of the dart and arrow is 260mm. The retrieval line is a 60m length of braided nylon line attached to the mounting shaft loosely and coiled in a plastic tub for free play out. The 3mm in diameter nylon multi-filament rope is folded and accommodated in the storage so as not to hamper flight. The dart and nylon rope can be detached immediately.

Details of the development and initial testing of this biopsy system were presented by Kasamatsu *et al* (1990). The biopsy system was designed to use at the forecastle deck of research ships. The trial of this gun was conducted from a research vessel at chasing speeds of 10-15 n.miles. Firings were conducted from forecastle deck that was 6.5m from the sea surface.

RESULTS

The biopsy skin sampling trials were conducted as a moderate-priority activity of the research cruise. Trials were attempted whenever minke whale was sighted, when they would not affect on the sighting and sampling surveys. The time for the trial was limited within 60 minutes in principle.

Test shooting of the ICR gun by the retrieving system was considered satisfactory. The maximum effective range was about 30m and the flight of the dart system was straight and accurate. At ranges greater than 30m the dart system appeared to stall, resulting in a sharply curved trajectory. This effect was most pronounced when the ship was underway, particularly when moving forward the wind. Trial was curtailed when poor water transparency prevented the tracking of the whales.

Trials

In the JARPN surveys, trials were made in the pelagic and the coastal waters. These results were summarized in Table 1. These were conducted on 54 individuals of 47schools with a total chasing time of 1,779 minutes. The average chasing time per trial was 37.9 minutes. Twenty-one animals of 20 schools

were approached to within the effective shooting range of biopsy system. Thirty-four shots were made and got 8 samples.

In the case of pelagic waters, trials were attempted on 29 animals of 25 schools with a total chasing time of 1024 minutes and a mean chasing time of 41.0 minutes. Nine individuals were approached within the effective shooting range. Fifteen shots were made and got 3 samples. Other 20 individuals could not be approached as they were not driven within the effective shooting range or they dodged the shooting timing.

In the case of coastal waters, trials were attempted on 25 individuals of 22 schools with a total chasing time of 755 minutes and a mean chasing time of 35.2 minutes. Twelve individuals were approached within the effective shooting range. Nineteen shots were made and got 4 samples. Other 13 individuals could not be approached as they were not driven within the effective shooting range or they dodged the shooting timing.

Compared with each result in the pelagic and the coastal waters, the approached rate (successfully approached animals) was 0.31 and 0.44. The shooting rate (hits to shootings), it was 0.2 and 0.26. Also, in the hit rate (hits to the target animals) was 0.1in the pelagic waters and 0.2 in the coastal waters. It was indicated by these results that the pelagic waters were more difficult to approach and hit to the target than the case of the coastal waters.

In the JARPA surveys, trials were implemented under the choice and random sampling procedures in the high-density area of minke whales. It is summarizing the outline of the experiment in table 2. These were conducted on 102 individuals of 26 schools with a total chasing time of 817 minutes. The average chasing time per trial was 31.4 minu tes. Fifty-six animals of 21 schools were approached to within the effective shooting range of biopsy system. Thirty-seven shots were made and got 16 samples. The other 14 animals of 5 school could not approach within the effective shooting range.

In the case of choice sampling procedure trials, 45 animals were approached to within the effective shooting range. Fifteen shots were made and got 8 samples. The other 6 animals of one school could not approach within the effective shooting range.

In the case of random sampling procedure trials, 11 animals were approached to within the effective shooting range. Twenty-two shots were made and got 8 samples. The other 8 animals of one school could not approach within the effective shooting range. When seeing yearly basis, these results are different substantially. In the 1997/98 surveys, 4 animals were approached to within the effective shooting range. Eight shots were made and got one sample. The other 8 animals of 4 schools could not approach within the effective shooting range. In the 1999/2000 surveys, 7 animals were approached to within the effective shooting range. Fourteen shots were made and got 7samples. It was indicated by these results that the reaction of the minke whale is more influential than the efficiency of the ICR gun.

Compared with the choice and the random sampling procedures, the approached rate (successfully approached schools) was 0.91 and 0.73. The shooting rate (hits to shootings) was 0.53 and 0.36. Also in the hit rate (hits to the target schools) was 0.73 in the choice sampling and 0.53 in the random sampling procedures. It was indicated by these results that the random sampling to the minke whales were more difficult to approach and hit to the target than the case of the choice sampling procedure.

The sampling efficiency by the shooting range

Table 3 showed the sampling efficiency by the shooting range of trials during the JARPN and JARPA surveys. The most samples taken were from 11 m to 20 m in the shooting range. It was suggested that approaching within the most effective shooting distance, i.e. chasing, is important to success.

Thirty-two schools could not be approached through all trials. These account for 43.8 % of all trials. Of those, 27 schools could not be approached into the effective shooting range of the ICR gun. Five schools could approach within effective shooting range but they dodged the shooting timing. These results show the difficulty of the approach within an effective shooting range of the ICR gun by the chasing.

The sampling efficiency by the school size

According to the table4, the sampling efficiency is low for solitary or below three animals in the school size but it becomes high at equal to or more than four animals in the school size. Also, of32 examples which could not be approached within the effective shooting range, 22 examples were solitary animal and 9 examples were below three animals, and only one example approached was equal to or more than four animal. Taking sample and approaching target within the effective shooting range were very difficult at the solitary or below three animals in the school size.

The sampling efficiency by the sea-state

A sampling efficiency by the sea-state was shown in table 5. The sea-state is expressed by the Beaufort-level. The research activity is carried out in 0 to 4 of the sea-state during the research periods.

Samples were widely collected from 0 to 3 in the sea-state through the JARPN and JARPA surveys. Cases which could not be approach within the effective shooting range were on the range from 2 to 4.

The sea-state seemed to be not important for sampling efficiency. However, when the level of the sea-state became high, the trial was decreased and cases which could not be approach within the effective shooting range was increased.

DISCUSSION

Feasibility study of biopsy skin sampling to minke whales in the North Pacific Ocean using the ICR air gun on board of large-type and small-type whale-catcherboats were examined by Shimada and Kato (1994). These trials were conducted in pelagic waters by the large-type whale-catcherboat and in the coastal waters by small-type whale-catcherboat. These large-type whale-catcherboats are the same typed vessels as the JARPN and JARPA surveys.

Regarding large-type catcher boat in the pelagic water, trials were attempted at 13 animals of 9 schools. Four individuals were approached within the effective shooting range of this biopsy system and 9 shots were made, but no sample was collected. In the case of the small-type whale-catcherboat in the coastal waters, trials were attempted at 23 individuals of 18 schools with the mean chasing time of 37 minutes (15 to 105 minutes). Ten individuals were approached within the effective shooting range and 19 shots were made. They were 5 hits, 6 ricochets and 8 misses. A total of five samples were obtained.

In the study of Shimada and Kato (1994) the rate of successful approach and the rate of sampling were 0.44 and zero in the pelagic waters, and 0.55 and 0.26 in the coastal water. In the JARPN surveys, they were 0.31 and 0.10 in the pelagic waters and 0.48 and 0.20 in the coastal waters. These results suggest that sampling in pelagic waters are more difficult (both to approach and shoot the target) compared with the coastal waters.

Gauthier and Sears (1999) attempted to take a biopsy sampling of the minke whale on the inflatable boat using the cross bow with the recovering system in the estuary and Gulf of St. Lawrence, Quebec, in the summer season from 1990 to 1995. Twenty-seven trials were implemented for the minke whale and it succeeded to take 25 samples. The sampling efficiency of the cross bow was higher than the ICR gun.

An inflatable-boat can approach slowly along with the swimming of the target animal and can take position within 6 m to 20 m of the shooting range. Therefore, the biopsy sampling trial is easier, because behaviors such as the escape swimming and the long diving are not occurred. It seems that there is no substantial difference in the efficiency of equipment of both systems.

The sampling efficiency of the ICR gun and the whale harpoon was shown in table 6. e sampling rate of the whale harpoon was remarkably higher than the ICR gun. The effective shooting range is from 30 m to 45 m in the whale harpoon compared with 6 m to 20 m in the ICR gun. These results show that the wide effective shooting range overcomes the avoidance behavior in the case of whale harpoon.

Existing biopsy sampling techniques for minke whales have some problems. In the recovering system, the dart tip is small and light in the weight. It looses-ability by the opposite wind. The retrieving system pulls a rope, and easily looses the power when the shooting range become larger, but it is very difficult to attain the efficiency of the wahle harpoon

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Table 1. Summary of biopsy sampling trials to the minke whales during the JARPN surveys

Research area	Year	Trial-target		Chasing time		Effective approach				Unsuccessfully	
		School	Animal	Total	Mean	School	Target	Shots	Hits	School	Animal
Pelagic	1994	1	1	70	70.0	1	1	2	0	0	0
	1995	8	8	356	44.5	6	6	9	3	2	2
	1997	5	5	172	34.4	2	2	4	0	3	3
	1999	11	15	426	38.7	0	0	0	0	11	15
	Combine	25	29	1024	41.0	9	9	15	3	16	20
Coastal	1996	9	9	230	25.6	5	5	9	2	4	4
	1999	13	16	525	40.4	6	7	10	3	7	9
	Combine	22	25	775	35.2	11	12	19	5	11	13
Total		47	54	1779	37.9	20	21	34	8	27	33

Table 2. Summary of biopsy sampling trial to the minke whales during the JARPA surveys

Procedure	Year	Trial-target		Chasing time		Eeffective approach				Unsuccessfully	
		School	Animal	Total	Mean	School	Target	Shots	Hits	School	Animal
Choice	1994/95	11	61	241	21.9	10	55	15	8	1	6
Random	1997/98	8	20	497	62.1	4	4	8	1	4	9
	99/2000	7	31	79	11.3	7	7	14	7	0	0
	Combine	15	51	576	38.4	11	11	22	8	4	8
Total		26	112	817	31.4	21	56	37	16	5	14

Table 3. The sampling efficiency by shooting range

Research		Sampling activety								Sampling effeciency				Unsuccessfully approached			
		Take(samples)				Miss(shots)				(Samples/all shots)				(Schools)			
		<10m	<20m	<30m	31m>	<10m	<20m	<30m	31m>	<10m	<20m	<30m	31m>	<10m	<20m	<30m	31m>
JARPN	Pelagic	0	3	0	0	0	5	4	3	0.00	0.38	0.00	0.00	0	3	0	13
	Coastal	1	3	1	0	1	8	5	0	0.50	0.27	0.17	0.00	0	0	0	11
	Combine	1	6	1	0	1	13	9	3	0.50	0.32	0.10	0.00	0	3	0	24
JARPA	Choice	0	8	0	0	1	5	0	1	0.00	0.62	0.00	0.00	0	0	0	1
	Random	3	4	0	1	1	7	7	0	0.75	0.36	0.00	0.00	0	0	0	4
	Combine	3	12	0	1	2	12	7	1	0.60	0.50	0.00	1.00	0	0	0	5
Total		4	18	1	1	3	25	16	4	0.57	0.42	0.06	0.20	0	3	0	29

Table 4. The sampling efficiency by school size

Research	School	Sampling activety								Samping effeciency				Unsuccessfully approached			
	Size	Take				Miss(shots)				(Samples/all shots)				(Schools)			
	Individual	1	<3	<6	7>	1	<3	<6	7>	1	<3	<6	7>	1	<3	<6	7>
JARPN	Pelagic	3	0	0	0	12	0	0	0	0.20	0.00	0.00	0.00	13	3	0	0
	Coastal	4	1	0	0	14	0	0	0	0.22	1.00	0.00	0.00	9	2	0	0
	Combine	7	1	0	0	26	0	0	0	0.21	1.00	0.00	0.00	22	5	0	0
JARPA	Choice	1	0	5	2	1	0	3	3	0.50	0.00	0.38	0.40	0	0	1	0
	Random	0	4	3	1	0	11	3	0	0.00	0.27	0.50	1.00	0	4	0	0
	Combine	1	4	8	3	1	11	6	3	0.50	0.27	0.57	0.50	0	4	1	0
Total		8	5	8	3	27	11	6	3	0.23	0.31	0.73	0.50	22	9	1	0

Table 5. The sampling efficiency by sea state (Beaufort level)

Research	Sea	Sampling activety										Sampling effeciecy					Unsuccessfully approached				
	State	Take					Miss(shots)					(Samples/all shots)					(Schools)				
	Beaufort	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
JARPN	Pelagic	0	1	2	0	0	0	3	4	5	0	0.00	0.25	0.33	0.00	0	0	2	7	5	1
	Coastal	1	2	1	1	0	6	0	6	2	0	0.14	0.00	0.14	0.33	0	0	1	7	3	0
	Combine	1	3	3	1	0	6	3	10	7	0	0.14	0.50	0.23	0.13	0	0	3	14	8	1
JARPA	Choice	0	0	2	6	0	0	1	1	5	0	0.00	0.00	0.33	0.55	0	0	0	0	1	0
	Random	0	2	6	0	0	0	4	9	1	0	0.00	0.33	0.40	0.00	0	0	0	0	1	4
	Combine	0	2	8	6	0	0	5	10	6	0	0.00	0.29	0.44	0.50	0	0	0	0	2	4
Total		1	5	11	7	0	6	8	20	13	0	0.14	0.45	0.35	0.35	0	0	3	14	10	5

Table 6. The sampling efficiency by ICR gun and whale harpoon

Research area			ICR gun			Whale harpoon		
		Year	School	Hits	Rate	School	Hits	Rate
JARPN	Pelagic	1994	1	0	0.00	42	21	0.50
		1995	8	3	0.38	131	100	0.76
		1997	5	0	0.00	144	100	0.69
		1999	11	0	0.00	66	50	0.76
		Combine	25	3	0.12	383	274	0.72
	Coastal	1996	9	2	0.22	103	60	0.58
		1999	13	3	0.19	77	50	0.65
		Combine	22	5	0.23	180	110	0.61
Total			47	8	0.17	543	384	0.71
JARPA	Choice	1994/95	11	8	0.73	134	108	0.81
	Random	1997/98	8	1	0.13	21	16	0.76
		99/2000	7	7	1.00	113	110	0.97
		Combine	15	8	0.53	134	126	0.94
Total			26	16	0.62	268	234	0.87

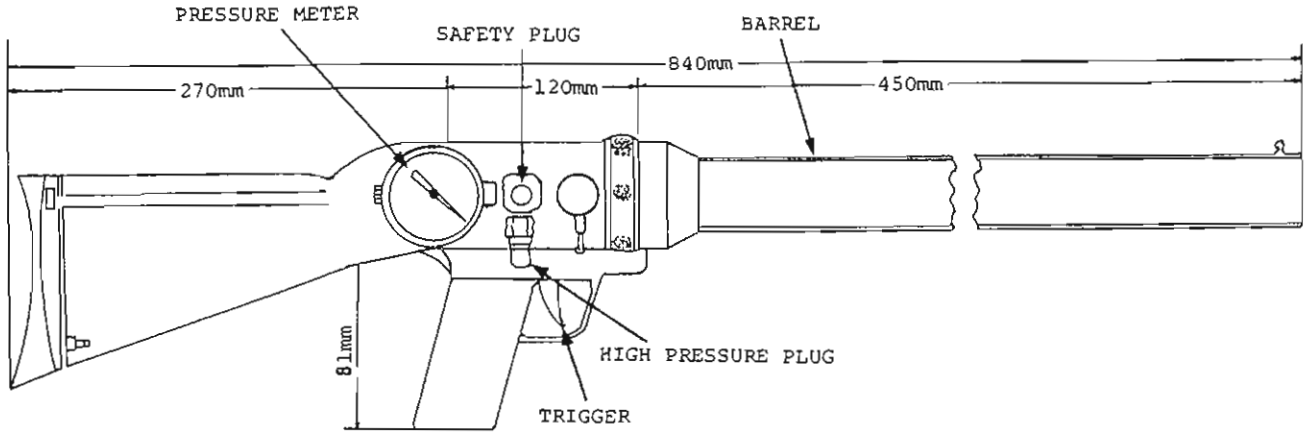

Fig.1. Outline of ICR air gun

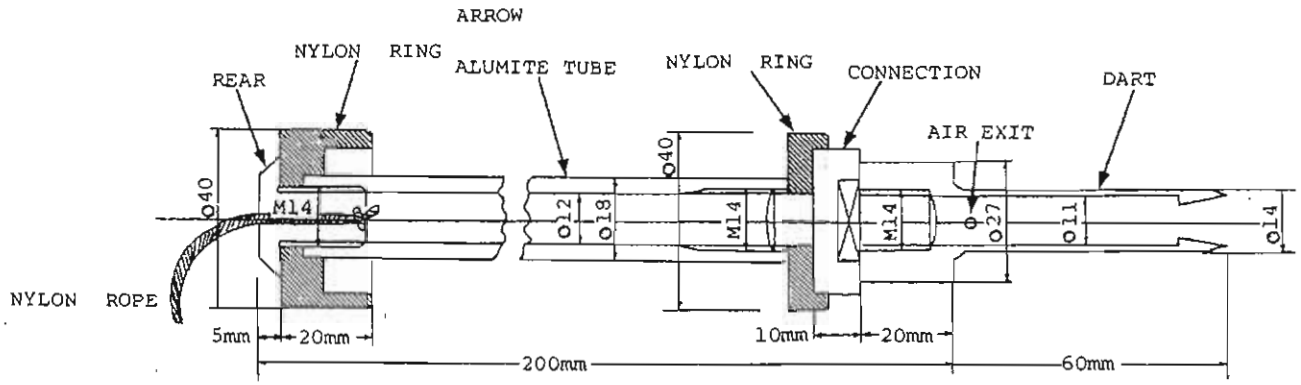

Fig.2. Outline of biopsy dart to be installed on the gun