Progress Report on the Killing Method of Whales in the Second Phase of Japanese Whale Research Program in the Antarctic Sea (JARPAII) and Northwestern Pacific Ocean (JARPNII)

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Japanese Whale Research Programs have been conducted since the 1987/88 season in the Antarctic Sea (JARPA and JARPAII) and since the 1994 season in the Northwestern Pacific Ocean (JARPN and JARPNII). Since these programs adopt lethal methods, whale killing methods have been examined and improved with a special interest in reducing the time-to-death (TTD) and increasing the instantaneous death rate (IDR) of whales. This document reports major efforts and results on the whale killing method mainly from 2005 to 2009 season in the Japanese whale research (JARPAII and JARPN II).

DATA COLLECTION, ANALYSIS and TRAINING of GUNNERS

Improvement of the whale killing method has been conducted based on the IWC Action plan developed at the workshop on whale killing method in 1992 (revised in 1995 and 1999). This action plan especially encouraged improving whaling equipment and methods to reduce TTD.

Data collection

Japan has been collecting catch records including the TTD for all whales taken by sampling vessels (catcher boats). The catch records include all firing time of a whaling cannon, detail of grenade used and the IWC criteria used for death confirmation of the whale. All firing time of a rifle and type of bullets are also recorded, if the secondary killing (back up) method is used. Necropsies (gross anatomical observation) of whale carcasses have been conducted by a veterinarian or an experienced biological researcher on the research base ship. The necropsy record* includes the hit point and internal track of the whaling harpoon, explosive point of the grenade, examination of the harpoon wounds and the effect of bullets used for the secondary killing method.

*From 2009/10 season, the necropsy record of Antarctic minke whales was simplified to record the hit point and internal track of the explosive harpoon.

Data-feedback system and data analysis

In mother-ship type operation of the whale research, it is difficult for a gunner to examine a whale carcass shot by him. Therefore, during the research cruise, the necropsy records obtained by a researcher on the research base ship are sent to the gunners on the sampling vessels as soon as possible so that they can review in detail the results of their shots while their memories are still fresh. When the whale did not die instantaneously, the gunners learn the reason of prolonged TTD and make good use of data to correct their shooting in next time.

Firing accuracy has been improved as gunners gain knowledge about the most preferable firing angles and shooting areas in the whale body by combining their experience with the anatomical and medical data from a researcher on the research base ship. This rapid-analysis and data-feedback system has been considered as the main reason for the successful improvement of the TTD and IDR in the Japanese whale research (Ishikawa, 1999).All data was accumulated and analyzed so as to improve killing method of whales. Gunners and crews of sampling vessels are briefed at a pre-cruise meeting on the analysis of the past research for the killing methods and are encouraged to achieve the shorter TTD and higher IDR.

Recruitment of new gunners

Cadets for gunners were recruited in 2004. Three excellent crew of the sampling vessel were selected as gunner trainees and were getting experience year by year. The gunner cadets are on board with regular gunners and are allocated a number of firing opportunity. The regular gunners are responsible for the training of the cadets and report progress of training to their company in every cruise.

IMPROVEMENT OF WHALING DEVICES

Improvement of whaling devices also contributed to reduce the TTD. Large caliber rifle with solid bullets as the secondary killing (back up) method was introduced since 1996. As handling of rifles was easier than that of electric lances previously used, introduction of the rifle shortened TTD significantly. Since 2002, Japan introduced an improved grenade with refined fuse. It explodes shorter distance after a harpoon hits the whale body with little misfiring than Japanese old grenade. Comparative experiments with Norwegian new grenade, Whalegrenade-99, showed both Japanese improved and Norwegian grenades reduced TTD and increase IDR significantly compared to the Japanese old grenade (Ishikawa and Shigemune, 2008).

Replacement of sampling vessels

Kyodo-Senpaku Co.Ltd, owner of research vessels, newly built and replaced three sampling vessels from 1999 to 2007. Building of pelagic whaling boat was the first time in 26 years in Japan. New vessels, Yushin-Maru series (No 1-3) are equipped 5280 ps main engine and variable pitch propeller. They also have a 75 mm whaling cannon with two whaling winches, and developed whaling sonar as whaling devices. Introduction of new whaling vessels made easy to chase whales and increased shooting chances for gunners, resulting high shooting accuracy and improved TTD.

Design of Harpoon head

In purpose of reducing struck and lost, the design of the harpoon head was modified. The struck and lost was occurred by reason of losing out of a harpoon or breaking line of the harpoon. During the course of the investigation on reason of the struck and lost, it was suggested that in some cases a harpoon line was cut by large shrapnel of the grenade inside the body of a whale. As an ordinal steel head of the explosive harpoon remained large shrapnel after explosion, design of the steel head was modified so as to remain relatively uniform sized and light shrapnel after explosion (Fig.1).

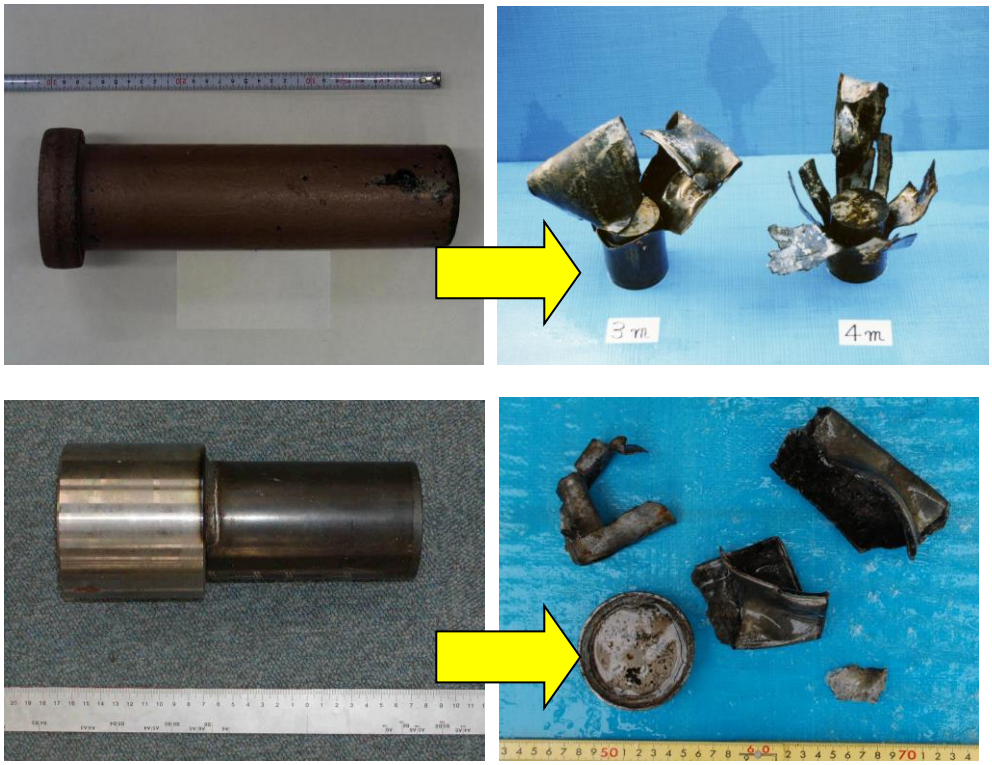

Fig. 1. (Upper) The traditional style harpoon head and shrapnel after explosion. A large shrapnel with a heavy weight was left in the whale body frequently. It sometimes cut harpoon line and caused “struck and lost”. (Lower) Improved harpoon head produces fewer and smaller shrapnel than the traditional one, which is expected to reduce possible struck and lost.

Whaling devices for larger whale species

With the second phase of JARPA and JARPN, larger whales than minke whale were targeted for lethal research. Whaling devices for fin, sei, Bryde's and sperm whales were considered and increased penthrite explosive, delayed fuse and larger caliber rifle (.458) were introduced.

Table 1 summarizes primary and secondary killing devices for each target species in the latest season. Penthrite charge of the grenade varied from 30g to 60g according to species and estimated body size of the target. 60g of penthrite charge proved to be effective to kill 20 m length fin whales instantaneously when the grenade exploded inside of thorax. Three types of fuse for the grenade (0sec, 0.05sec delayed and 0.1 sec delayed) were selected after several examinations of five types of fuse. Two types of fuse, 0.025 and 1 sec delayed fuse were not adopted because 0.025 sec. delayed fuse exploded the grenade too fast for sei whale and 1 sec. delayed fuse exploded after penetration of the whale body of sei and fin whales.

Rifle shot as the secondary killing method for large whales were also considered. Large caliber rifle (.458) proved to penetrate the skull of Bryde's whales (up to 14 m in body length). However, primary use of the second explosive harpoon was recommended for the sei whales because the rifle was not as effective for large sei whales (up to 16 m in body length) as for Bryde's whales. Experimental shooting to a fin whale carcass (20 m in body length) was conducted to examine efficiency of the large caliber rifle (.458), but necropsy revealed that no bullet reached at central nervous system. Use of the large caliber rifle to sperm whales was not adopted because it was considered that their unique anatomical character of the skull would prevent penetration of the bullets.

Table 1. Summary of primary and secondary killing devices for target whale species.

	Primary killing method (grenade)	Primary killing method (fuse)	Secondary killing method	Remarks
Fin whale	75mm harpoon with 60g penthrite explosive	0.1sec./0.05sec. delayed	Second harpoon with 60g penthrite explosive	Rifle is not effective as the secondary killing method.
Sei whale	75mm harpoon with 60g/50g penthrite explosive	Ditto.	Second explosive harpoon and large caliber rifle (.458)	Penthrite amount and fuse was selected by estimated body length.
Sperm Whale	Ditto.	Ditto.	Second explosive harpoon with 60g/50g penthrite explosive	Rifle is not effective as the secondary killing method.
Bryde's whale	75mm harpoon with 50g/30g penthrite explosive	0.05sec. delayed or 0sec.	Second explosive harpoon and large caliber rifle (.458/.375)	Penthrite amount and fuse was selected by estimated body length.
(Antarctic) minke Whale	75mm harpoon with 30g penthrite explosive	0sec. fuse	Second cold harpoon or large caliber rifle (.375)	50mm explosive harpoon is used for coastal operation.

Results of the JARPAII from 2005/06 season

The JARPAII was conducted in the eastern part of Area III, Area IV and western part of Area V in the 2005/06 and 2007/08 season, whereas in the Area V and western part of Area VI in the 2006/07 and 2008/09 season. Although 850 Antarctic minke whales and 10 (50 after 2007/08) fin whales were planned to be taken in each season, it was not achieved. Ten and three fin whales were taken in the 2005/06 and 2006/07 season respectively, whereas no fin whale was taken in the 2007/08 season. Only one fin whale was taken in the 2008/09.

Table 2 shows the TTD and the IDR information for Antarctic minke whales from the 2005/06 to 2008/09 seasons. Regression analysis revealed significant decrease of the TTD ($p<0.0001$) and increase of the IDR ($p<0.0001$) during research years (from 1993/94 to 2008/09 season).

Table 2. TTD and IDR from the 2005/06 to 2008/09 JARPAII. The data for fin whales was excluded because of insufficient number of data for analysis.

Season	*Species*	*Total number*	*Time to death* (TTD)			*Instant death rate* (IDR)
			MED	MEAN	S.D.	
2005/06	Antarctic Minke whale	853	0:00	2:06	3:37	50.3 %
2006/07		505	2:00	2:26	3:57	40.6 %
2007/08		551	0:00	1:57	2:33	51.0 %
2008/09		679	0:00	2:12	3:17	54.2 %

Results of the JARPNII (offshore operation) from the 2005 season

The JARPNII offshore operations from 2005 to 2009 season were conducted in sub-areas 8 and 9 in the western North Pacific. For the offshore operation, sample size of 100 minke whales, 50 Bryde's whales and 100 sei whales were allocated in each season. A total of 17 sperm whales were taken from 2005 to 2009 season.

Table 3 shows the TTD and IDR information in each season. Regression analysis revealed significant decrease of the TTD ($p<0.0001$) and increase of the IDR ($p<0.0001$) for common minke whales during research years (from 1994 to 2009 season). It was also revealed significant decrease of the TTD ($p=0.0005$) and increase of the IDR ($p<0.0001$) for Bryde's whales during research years (from 2000 to 2009 season). The IDR for sei whales also increased significantly ($p=0.021$), however, the TTD for sei whale did not show significant decrease ($p=0.352$).

Table 3. TTD and IDR for minke, Bryde's and sei whales from the 2005 to 2009 JARPNII. The data for sperm whales was excluded because of insufficient number of data for analysis.

Season	*Species*	*Total number*	*Time to death* (TTD)			*Instant death rate* (IDR)
			MED	MEAN	S.D.	
2005	Minke whale (offshore)	100	2:30	2:32	3:02	40.0 %
2006		100	1:30	2:01	2:36	44.0 %
2007		100	0:55	3:02	6:11	50.0 %
2008		59	0:00	2:37	4:06	52.5 %
2009		43	0:00	1:49	2:09	53.5 %
2005	Bryde's whale	50	2:15	2:25	2:56	42.0 %
2006		50	2:25	2:14	2:13	40.0 %
2007		50	0:00	2:23	3:11	54.0 %
2008		50	0:00	4:49	13:17	60.0 %
2009		50	0:00	1:59	3:35	68.0 %
2005	Sei whale	100	3:20	3:59	4:21	38.0 %
2006		100	2:40	3:43	4:52	42.0 %
2007		100	3:55	4:54	5:24	34.0 %
2008		100	3:30	4:31	7:45	43.0 %
2009		100	3:25	4:29	7:46	47.0 %

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