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Movement of Bryde's whales in the western North Pacific as revealed by satellite tracking experiments conducted under JARPN II

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ABSTRACT

Using an air gun system (ICR air gun) a satellite tag was successfully attached on one Bryde's whales in the western North Pacific during the research conducted by JARPN II in each 2006 and 2008. The movement of these two whales were tracked for a period of 15 and 21 days, respectively. In general, movement in both cases was from temperate to subtropical waters. In 2006, an Argos transmitter was attached at position 37º 36.54'N; 156º10.44'E on 13 July. The whale had an estimated body length of 12.5m and was accompanied by a calf (estimated body length of 8.7m).The distance of movement during the transmission was approximately 1,024.53km and the daily average movement distance was 77.13km. The whale showed a movement from north to south. In 2008, an Argos transmitter was attached in position 37º56.64'N; 147º51.72'E on 24 July. The whale had an estimated body length of 12.6m. The distance of movement during the transmission was approximately 2,629.70km and the daily average movement distance was 127.14km. This whale moved first in easterly direction for the first nine days reaching 160ºE after which it moved in a southerly direction, for the last 12 days of transmission. These results demonstrated that the ICR system for delivering satellite tags is useful for fast swimming whales in pelagic waters. Information on movement and residence time in the feeding grounds will be useful to assist the stock structure studies of Bryde's whales in this ocean basin, which is an important piece of information for the RMP's *Implementation Simulation Trials* (*ISTs*).

KEYWORDS: BRYDE'S WHALE, NORTH PACIFIC; SCIENTIFIC PERMIT; SATELLITE TAG

INTRODUCTION

Satellite tagging using a crossbow system has been successfully carried out on several cetacean species in coastal waters (Mate *et al*. 2007). In pelagic waters, only large vessels can be used and the target species are usually fast swimming whales. Such whale species are usually chased at high speed and it is not possible for a weak powered-crossbow system to fire and attach the tag under condition of high ship speed and strong wind. Since the late 1980's the Institute of Cetacean Research (ICR), with the cooperation of the Miroku Machinery Co.Ltd., developed an air gun with the original objective of biopsy skin sampling. This is called the "ICR gun" (Nishiwaki *et al*., 1990; Kasamatsu *et.al* 1991). The ICR gun has been used to collect a substantial number of biopsy samples from large whales in both the Antarctic (under JARPA/JARPA II) and western North Pacific (under JARPN.JARPN II).

More recently the ICR gun has been improved to attach satellite tags on fast swimming whales in pelagic waters. At this stage experiments on satellite tagging under JARPA/JARPA II and JARPN/JARPN II are conducted as a medium-priority activity (the time for the trial is limited to 60 minutes or less in principle). Satellite tagging experiments could provide important information on distribution and movement of whales. Particularly it could provide information of movement of whales within the feeding grounds as well movement between feeding and breeding grounds. Such information could assist the studies on stock structure of large whales based on genetics and other non-genetics approaches.

This study provides technical information of the tagging system used by the ICR and reports results of two successfully deployed tags on western North Pacific Bryde's whales, under the JARPN II.

MATERIALS AND METHODS

ICR gun

Figure 1 show the ICR gun, which is used for satellite tagging. This gun is a modified version of the original Miroku Line-shooter M-63 designed for life saving in case of fire and ship wrecks (developed by Miroku Machinery Co.Ltd). The calibre was modified from 63mm to 40mm and the barrel is made of stainless steel instead of the original iron. The length of the gun is 100cm and that of the barrel is 60cm. The weight is 5kg. The initial shooting speed of the satellite tag with a 3mm nylon rope is 70m-86m/sec at the filling pressure of 100-150kgf/cm^2. The maximum shooting range is 80-100m with angle of 15 degree from the horizon. Firings are made from the forecastle deck which is 6.5m above the sea surface. The effective firing distance is less than 30m at vessel speeds of 12-15knots.

Satellite tagging darts

The satellite tagging dart system was designed for installation on the ICR gun (Figure 2). The 3mm nylon rope is folded and accommodated in the storage compartment to avoid interference with the trajectory of the dart. The dart system was composed of three parts: the dart, an Argos transmitter and a retrieve cylinder. When the whale is hit, the dart becomes embedded in the blubber and muscle. And the Argos transmitter is fixed at the surface of the body. The retrieve cylinder with the nylon rope is dislodged by the swimming of the whale.

RESULTS AND DISCUSSION

Summary of the JARPN II satellite tagging on Bryde's whales

Table 1 shows a summary of the satellite tagging experiments on Bryde's whales under JARPN II for the period 2004 - 2008. A total of nineteen schools (21 individual whales) were approached for satellite tagging. The total experiment time was 632 minutes. Fifteen of these schools were approached within the optimum firing range of the equipment (30m or less). 18 shots were made within this range. There were 7 hits and 2 ricochets and 9 misses. Through these trials in 6 of the 7hits Argos transmitters were fixed to the body of the whale. Others failed because the shooting impact caused the rope to break and the transmitter to fault.

Vertical fixation of the antenna related to the surface of the sea is important to get a valid transmission performance. If the tag is attached on the back of the body Argos transmissions are effective (there are two example cases in the experiments under JARPN II where the antenna was fixed on the front back of the body near the dorsal fin; Figure 3). The angle of the fixed antenna in relation to the surface determines the effectiveness of the transmissions.

Movement of tagged Bryde's whales

In the case of two Bryde's whales the antenna was fixed and transmission obtained for period of 15and 21 days respectively (Table 1). In both cases movement from the temperate area toward the subtropical area in the north-west Pacific Ocean in the summer season was observed.

In 2006, an Argos transmitter was attached (15-days transmission) (Table 2) at position 37º 36.54'N; 156º10.44'E on 13 July. The chasing time before firing was eight minutes. The firing distance was 10 meters. The whale had an estimated body length of 12.5m and was accompanied by a calf (estimated body length of 8.7m).The distance of movement during the transmission was approximately 1,024.53km and the daily average movement was 77.13km. The whale moved from north to south (Figure 4).

In 2008, an Argos transmitter was attached (21-days transmission) (Table 3) at position 37º56.64'N; 147º51.72'E on 24 July. The chasing time before firing was four minutes. The firing distance was 20 meters. The whale had an estimated body length of 12.6m. The distance of movement during the transmission was approximately 2,629.70km and the daily average movement was 127.14km. This whale moved first in easterly direction for the first nine days reaching 160ºE after which it moved in a southerly direction for the last 12 days of transmission (Figure 4).

These results demonstrated that the ICR system for delivering satellite tags is useful for fast swimming whales in pelagic waters. Information on seasonal movements, and residence time in the feeding grounds will be further accumulated if the effort on these experiments is increased. This information will be useful to assist the stock structure studies of Bryde's whales in this ocean basin, which is an important piece of information for the RMP's *Implementation Simulation Trials* (*ISTs*). Experiments will be attempted on other baleen whale species in the future.

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Table 1 Summary of the satellite tagging experiments for Bryde's whales during JARPN II surveys.

Vessel	Date	Sight No.	Scl. size	Est.body length of target ind.(m)	Trial duration (h:m)	Chase duration (h:m)	Firing dist. (m)	Verdicts	Position struck	Transmitter attached	Electric wave received
YS1	20040913	1	1	13.5	00:40	00:09	27	Miss			
						00:14	27	Hit	LE1	Fix	No
YS2	20040913	3	1	10.8	00:09	00:09	10	Hit	LB1P	Fix	No
YS2	20040913	4	1	11.2	00:09	00:09	15	Ricochet	LB1P	Lost	
YS1	20060713	11	1	11.0	00:46	00:23	20	Miss			
						00:23	18	Miss		Lost	
YS2	20060713	5	1	9.5	00:31	00:31	10	Miss		Lost	
YS2	20060713	7	2	12.5	00:08	00:08	10	Hit	RC1	Fix	Yes
YS2	20080715	5	1	13.3	00:51						
YS2	20080715	6	1	12.8	00:32						
YS2	20080723	4	1	12.5	00:24	00:24	25	Miss		Lost	
YS2	20080723	6	1	11.7	00:31						
YS2	20080724	4	1	12.6	00:10	00:04	20	Hit	RC1	Fix	Yes
YS2	20080726	4	1	12.6	00:34	00:09	30	Miss			
						00:09	25	Hit	RC1	Fix	No
YS1	20080722	3	1	13.5	00:55						
YS1	20080722	5	1	12.2	00:55	00:55	13	Miss			
YS1	20080723	6	1	12.2	00:44	00:44	10	Ricochet	LC2		
YS1	20080723	7	1	13.2	00:31	00:31	9	Miss			
YS1	20080723	8	1	11.8	00:31	00:31	10	Miss			
YS1	20080724	7	1	12.4	00:25	00:25	8	Hit	RC2	Lost	
YS1	20080726	10	2	12.4	01:05	01:04	9	Hit	LB2	Fix	No

Table 2 Summary of the satellite tracking of a Bryde's whale in the western North Pacific (15-days transmission) (2006 JARPN II)

Date			Time	Location level	Position				Trackking dist.(Km)	
					Latitude		Longtuide		Daily	Cumulative
2006	7	13	Attached		37.609	N	156.174	E		
			7:09:07	0	37.541	N	156.038	E	14.16	
			23:23:10	0	37.176	N	155.561	E	58.43	72.60
	7	14	2:10:45	1	37.182	N	155.537	E	2.23	74.82
			5:06:26	1	37.038	N	155.531	E	15.96	90.79
			6:45:11	0	36.961	N	155.528	E	8.53	99.32
			10:42:16	2	36.780	N	155.422	E	22.16	121.48
			19:05:45	3	36.591	N	155.311	E	23.16	144.64
	7	15	0:42:27	1	36.458	N	155.243	E	15.94	160.58
			4:54:12	1	36.551	N	155.147	E	13.41	173.99
			10:18:12	1	36.617	N	154.994	E	15.50	189.49
			14:26:28	2	36.617	N	154.998	E	0.36	189.84
			17:21:42	0	36.599	N	154.986	E	2.26	192.11
			18:41:38	1	36.603	N	155.003	E	1.58	193.69
	7	16	1:48:47	0	36.586	N	154.828	E	15.74	209.43
			3:04:18	1	36.599	N	154.821	E	1.57	211.00
			3:29:28	2	36.580	N	154.802	E	2.70	213.71
			5:58:45	1	36.596	N	154.829	E	2.99	216.70
			11:34:30	0	36.456	N	154.893	E	16.53	233.23
			17:07:55	2	36.366	N	154.705	E	19.56	252.79
	7	17	1:39:06	1	36.180	N	154.589	E	23.08	275.87
			3:18:52	2	36.186	N	154.543	E	4.18	280.06
			5:22:15	2	36.177	N	154.453	E	8.14	288.20
			7:12:18	1	36.201	N	154.395	E	5.85	294.05
			16:58:02	1	36.446	N	154.247	E	30.21	324.25
			19:33:01	0	36.516	N	154.118	E	13.88	338.14
	7	18	19:10:17	1	36.149	N	153.940	E	43.64	381.77
	7	19	4:36:48	A	35.727	N	154.060	E	47.97	429.74
			6:23:33	A	35.611	N	153.826	E	24.74	454.49
			18:32:09	A	35.132	N	153.737	E	53.66	508.15
	7	20	2:49:59	0	34.734	N	153.429	E	52.26	560.41
			15:15:48	0	34.331	N	153.156	E	51.16	611.57
	7	21	3:43:23	0	34.044	N	153.200	E	32.04	643.61
			5:20:02	B	34.010	N	153.260	E	6.69	650.30
			15:07:28	1	33.872	N	153.237	E	15.43	665.73
	7	22	14:56:20	1	33.450	N	153.370	E	48.32	714.04
	7	23	3:23:17	0	33.338	N	153.444	E	14.18	728.22
	7	24	3:10:49	0	33.127	N	153.766	E	37.99	766.21
	7	25	17:05:14	1	32.055	N	153.873	E	119.09	885.30
	7	26	1:47:05	2	31.714	N	153.758	E	39.27	924.57
	7	27	6:33:02	0	30.863	N	153.406	E	99.96	1024.53

Table 3 Summary of the satellite tracking of a Bryde's whale in the western North Pacific (21-days transmission) (2008 JARPN II)

Date	Time	Location level	Position Latitude	Position Longtuide	Trackking dist.(Km) Daily	Trackking dist.(Km) Cumulative
2008 7 24	Attached		37.944 N	147.862 E		
	5:39:38	0	38.014 N	147.867 E	7.77	
25	1:34:31	1	38.341 N	148.874 E	95.24	103.00
	11:54:30	1	38.150 N	149.430 E	52.99	156.00
	18:28:06	1	38.117 N	149.758 E	28.94	184.94
	22:28:32	1	38.039 N	150.012 E	23.87	208.80
	23:01:42	1	38.020 N	150.041 E	3.30	212.10
26	23:48:00	1	37.763 N	151.494 E	130.71	342.82
27	1:12:44	1	37.781 N	151.628 E	11.95	354.76
	5:41:28	3	37.739 N	151.915 E	25.67	380.43
	6:08:19	2	37.738 N	151.957 E	3.70	384.13
	10:00:18	2	37.711 N	152.223 E	23.60	407.73
28	15:05:04	1	37.470 N	154.044 E	162.74	570.48
29	5:17:53	2	37.397 N	154.794 E	66.75	637.23
	5:19:17	2	37.392 N	154.791 E	0.61	637.84
	23:20:07	1	37.218 N	155.767 E	88.50	726.34
30	5:05:33	1	36.925 N	156.275 E	55.56	781.90
	22:55:57	2	36.290 N	157.268 E	113.19	895.09
31	4:53:47	1	36.141 N	157.913 E	60.20	955.29
	18:30:09	1	36.201 N	158.668 E	69.20	1024.49
	22:36:06	1	36.115 N	158.996 E	29.94	1054.43
1	5:47:33	2	35.987 N	159.582 E	54.58	1109.01
	9:09:11	2	35.906 N	159.800 E	21.59	1130.60
	18:07:24	2	35.739 N	160.035 E	28.13	1158.73
	22:14:33	2	35.554 N	160.214 E	26.11	1184.84
2	1:47:29	2	35.411 N	160.349 E	20.01	1204.85
	6:09:47	2	35.205 N	160.520 E	27.59	1232.44
3	18:26:51	2	34.684 N	160.682 E	59.56	1292.00
	22:23:55	2	34.519 N	160.660 E	18.38	1310.38
4	8:55:16	2	34.215 N	160.851 E	37.96	1348.34
	9:40:50	2	34.244 N	160.896 E	5.24	1353.58
	10:30:54	2	34.203 N	160.857 E	5.79	1359.36
	13:54:13	2	34.200 N	160.921 E	5.90	1365.26
5	5:34:11	1	33.959 N	161.358 E	48.30	1413.56
	18:10:27	1	33.802 N	161.782 E	42.84	1456.40
6	2:45:04	1	33.505 N	162.196 E	50.50	1506.91
	8:52:32	1	33.324 N	162.598 E	42.36	1549.27
	17:48:10	2	33.180 N	162.860 E	29.12	1578.39
	22:14:23	3	32.965 N	163.032 E	28.70	1607.09
7	9:28:18	3	32.393 N	163.039 E	63.32	1670.41
	17:35:44	2	32.242 N	163.124 E	18.53	1688.94
8	9:08:24	1	31.481 N	163.398 E	88.12	1777.06
	17:25:59	2	31.224 N	163.561 E	32.38	1809.44
	21:32:08	1	30.948 N	163.664 E	32.08	1841.53
9	10:26:43	1	30.141 N	163.974 E	94.11	1935.64
10	2:03:38	1	29.348 N	164.294 E	93.03	2028.66
11	1:52:46	1	27.970 N	164.701 E	157.54	2186.20
	10:13:31	1	27.366 N	164.703 E	66.81	2253.01
	17:30:47	2	26.967 N	164.757 E	44.45	2297.47
	22:12:28	2	26.629 N	164.840 E	38.28	2335.75
12	1:40:04	0	26.392 N	164.870 E	26.29	2362.04
	18:24:07	0	25.441 N	164.702 E	106.59	2468.63
	22:19:22	0	25.195 N	164.688 E	27.24	2495.87
13	5:55:50	2	24.762 N	164.548 E	49.91	2545.79
	10:42:10	3	24.522 N	164.585 E	26.80	2572.59
	14:04:45	2	24.356 N	164.652 E	19.57	2592.15
	21:31:11	2	24.035 N	164.773 E	37.55	2629.70

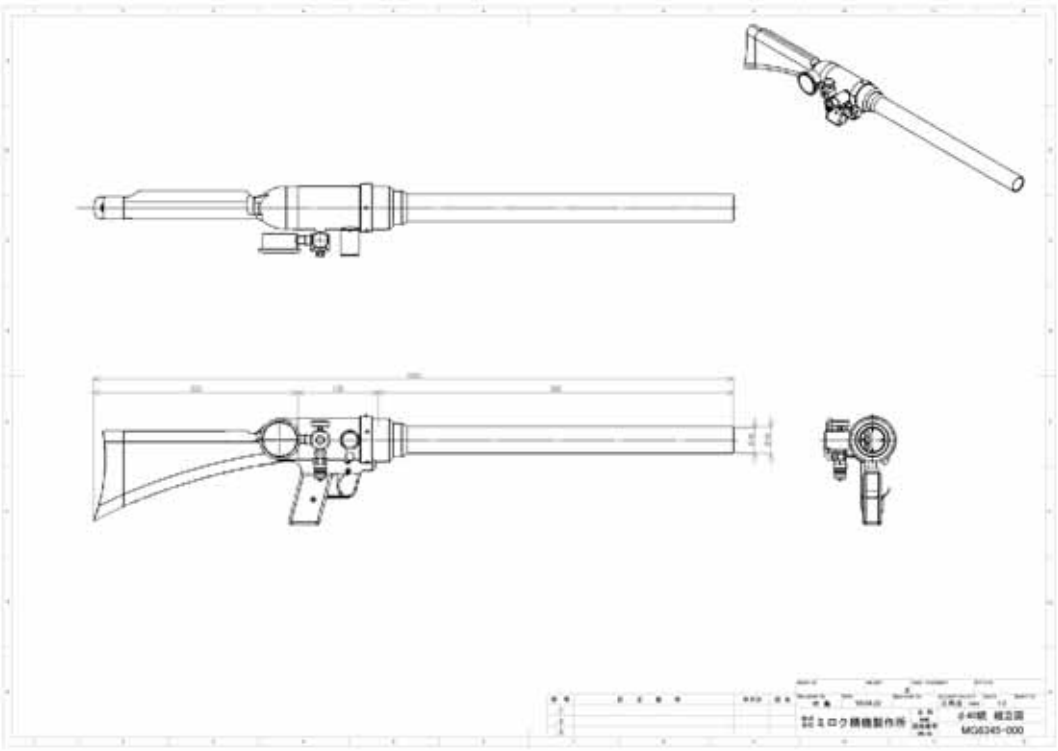

Figure 1 ICR air gun used for satellite tag experiments

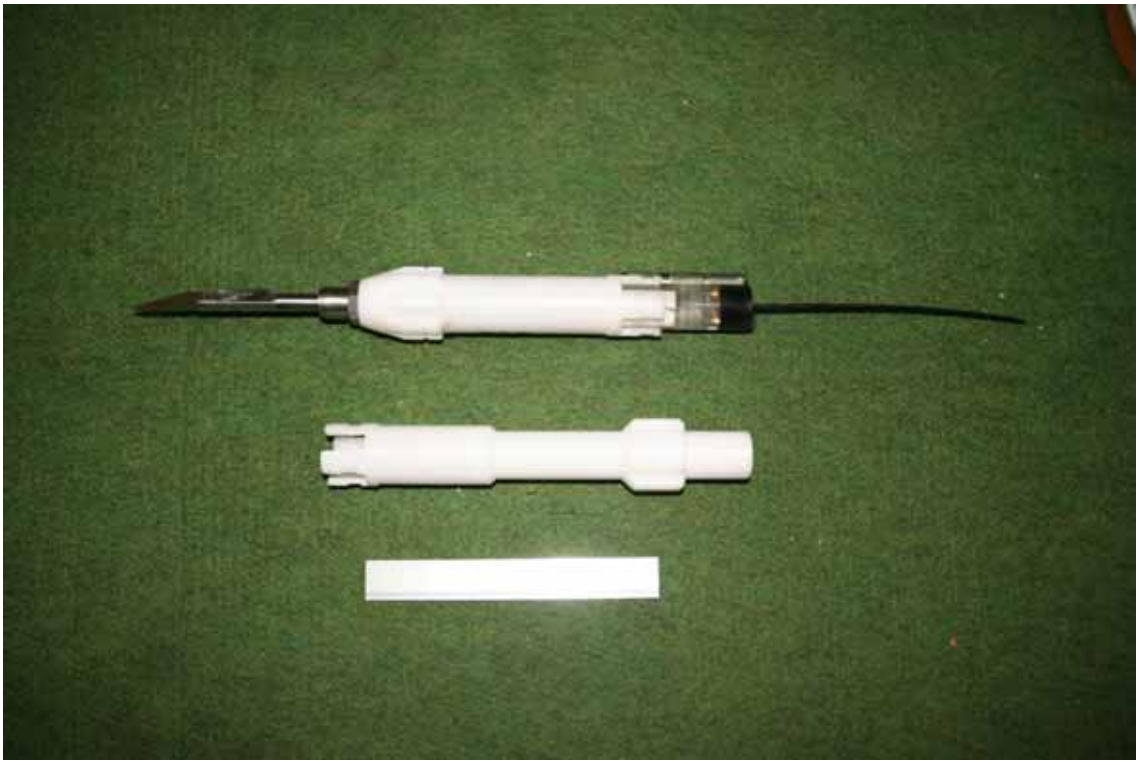

Figure 2 Satellite tag dart, which is installed in the ICR air gun

Figure 3 The Bryde's whale with the satellite tag attached (Red circle).
(Left: 2006 JARPN II, Right: 2008 JARPN II))

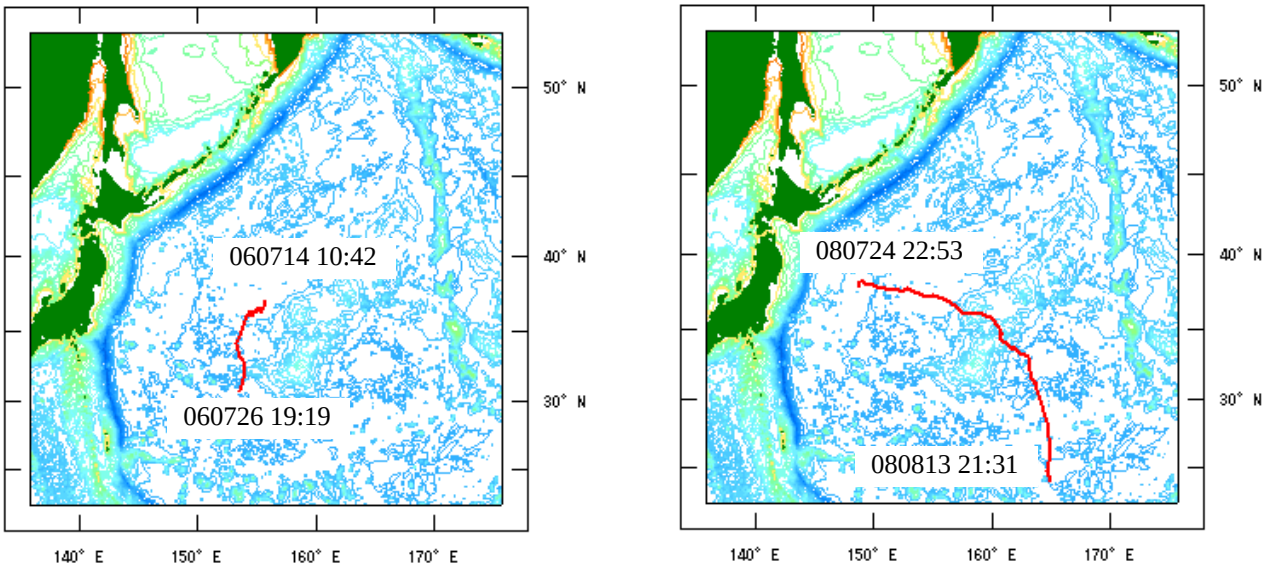

Figure 4 Satellite tracks of two Bryde's whales in the western North Pacific (2006 and 2008 JARPN II surveys)
(Left: 2006 JARPN II, Right: 2008 JARPN II)