Status of I131, Cs134 and Cs137 in baleen and sperm whales from the western North Pacific during 2011-2015

GENTA YASUNAGA AND YOSHIHIRO FUJISE

Institute of Cetacean Research, 4-5 Toyomi-cho, Chuo-ku, Tokyo 104-0055, Japan

Contact e-mail:yasunaga@cetacean.jp

ABSTRACT

From 11 March 2011 onward, radioisotopes (RIs) were released to the marine environment from the Nuclear Power Plant in Fukushima following an earthquake and tsunami. To assess the presence of these RIs in the large whales from the western North Pacific, the I131, Cs134 and Cs137 levels in muscle samples of 53 common minke, 16 Bryde's, 32 sei and 3 sperm whales from JARPNII surveys were measured in the period of JARPNII (2011-2015). I131 was not detected in muscle samples of all large whales, except for two minke whales from off Kushiro in 2012. Ranges of Cs134 + Cs137 concentrations in minke, sei, Bryde's and sperm whales were ND-31, ND-9.8, ND-7.1 and ND-0.59 Bq/kg wet wt., respectively. The radioisotope levels in all whales examined have been decreasing since 2011, and were also extremely lower than the radiation safety threshold for humans. Therefore, risk of acute toxicity levels for I131, Cs134 and Cs137 would be extremely low in the large whales from the western North Pacific.

KEYWORDS: SPERM WHALE; BALEEN WHALES; CESIUM; IODINE; RADIOISOTOPES; FUKUSHIMA

INTRODUCTION

On 11 March 2011, the Great East Japan Earthquake and following tsunami destroyed the Nuclear Power Plant in Fukushima. This accident led to release of large amounts of radioactive materials. The main radioactive isotopes emitted were I131, Cs134, Cs137, Nb95, Ce144, Ru103, Ru106, Sr90, Pu239 and Pu240 etc., and the total amount was in the order of 14×10^{18} Becquerels (Yamashita and Suzuki, 2013). Radiation exposure from I131 fallout causes cancer of thymus, and Cs134 and Cs137 cause solid cancer and leukemia in humans.

Highly migratory, top predator species, such as common minke (*Balaenoptera acutorostrata*), sei (*B. borealis*), Bryde's (*B. edeni*) and sperm whales (*Physeter macrocephalus*) have been exposed to these radioactive materials in the western North Pacific, and especially young minke whales pass through coastal waters of east Japan. Also, the 2011 IWC/SC annual meeting suggested that concentrations of radionuclides, especially caesium-137, should be included under second objective, "monitor environmental pollutants in cetaceans and the marine ecosystem" in the JARPNII programme (IWC, 2012).

In the present study, we monitored I131, Cs134 and Cs137 concentrations in muscle to assess health of four large whale species from the western North Pacific, and we compared these data to safety threshold for humans.

MATERIALS AND METHODS

Muscle tissue samples of 53 minke, 32 sei, 16 Bryde's and 3 sperm whales taken form the western North Pacific were analyzed for I131, Cs134 and Cs137 concentrations (Bq/kg wet wt.) (Table 1). All samples were stored in polyethylene bags at -20°C until analysis.

The samples were sent to the National Research Institute of Fisheries Science (Kanagawa, Japan) before 2013 and the Marine Ecology Research Institute (Chiba, Japan) after 2013 for analyses of the I131, Cs134 and Cs137 radioisotopes. Analyses were performed in each institute according to the analytical manual for radioactive materials in foods in emergency (Ministry of Health, Labour and Welfare, 2002).

The correlations between Cs134 + Cs137 concentrations in muscle of whales and the research years were assessed by Spearman rank test (Zar, 1999) in minke whales in sub-areas 7, 8 and 9, off Kushiro and off Sanriku, sei whales in sub-areas 8 and 9 and Bryde's whales in sub-areas 7, 8 and 9. A *p* value of less than 0.05 was considered to indicate statistical significance in all tests. These statistical analyses were executed using SPSS ver.11 for Windows (SPSS Co. Ltd.).

RESULTS AND DISCUSSION

Table 2 shows the I131, Cs134 and Cs137 concentrations in muscle of minke, sei, Bryde's and sperm whales. I131 concentrations in only two minke whales from off Sanriku among all whales were detected. Ranges of Cs134 + Cs137 concentrations in minke, sei, Bryde's and sperm whales were ND-31, ND-9.8, ND-7.1 and ND-0.59 Bq/kg wet wt., respectively. Significant correlation of concentrations of Cs134 + Cs137 in whales and research years were observed in minke whales from off Sanriku, sei and Bryde's whale in sub-areas 7, 8 and 9 ($p<0.05$), whereas no significant correlations were observed in minke whales from sub-areas 7, 8 and 9, and off Kushiro. However, maximum levels in Cs134 + Cs 137 apparently decreased with research years in minke whales from off Kushiro and the sub-areas 7, 8 and 9 samples.

Internal exposure to radioactive iodine causes thyroid cancer over 50-200mSv in human children (Brenner *et al.*, 2011; Yamashita and Suzuki, 2013). Concentrations of I131 in muscle of only two minke whales from off Sanriku were about 0.5 Bq/kg, whereas this RI was not detected in almost all whales tested. This detected level can be converted to about 0.44μSv (0.5Bq/kg × 40kgBW ×0.022 = 0.26μSv in human children), suggesting that thyroid cancer risk for the whales may be extremely low. And also, internal exposure to radioactive cesium does not cause solid cancer under 100mSv in humans (Yamashita and Suzuki, 2013). The maximum radioactive Cs value detected in all whales was 31 Bq/kg. This level can be converted to about 24 μSv (31Bq/kg × 60kgBW ×0.013 = 24.18μSv in human), suggesting that solid cancer risk for the whales may also be extremely low. Therefore, risk of acute toxicity for I131, Cs134 and Cs137 would be extremely low in the large whales from the western North Pacific.

REFERENCES

Brenner, A.V., Tronko, M.D., Hatch, M., Bogdanova, T.I., Oliynik, V.A., Lubin, J.H., Zablotska, L.B., Tereschenko, V.P., McConnell, R.J., Zamotaeva, G.A., O'Kane, P., Bouville, A.C., Chaykovskaya, L.V., Greenebaum, E., Paster, I.P. Shpak, V.M. and Ron, E. 2011. I-131doseresponse for incident thyroid cancers in Ukraine related to the Chernobyl accident. *Environ. Health Perspect.* 119:933–939.

International Whaling Commission. 2012. Report of the Scientific Committee. *J. Cetacean Res. Manage.* (Suppl.) 13: 1-73.

Ministry of Health, Labour and Welfare. 2002. The analytical manual for radioactive materials in foods in the emergency. http://www.mhlw.go.jp/stf/houdou/2r9852000001558e-img/2r98520000015cfn.pdf

Yamashita, S. and Suzuki, S. 2013. Risk of thyroid cancer after the Fukushima unclear power plant accident. *Respir. Investig.* 51:128-133.

Zar, J.H. 1999 *Biostatistical analysis*, 4th ed., Prentice Hall, New Jersey, USA, 663pp.

Table 1. Sample list of common minke, sei, Bryde's and sperm whales taken from JARPNII surveys and used in the present study

Area	Species	Year	*n*	Body length (m)					
				Average		Range			
Off shore	common minke whale	2011	3(2M1F)	7.1	(	6.2	-	8.11	)
		2012	6(5M1F)	6.9	(	4.8	-	7.87	)
		2013	1(1M)	7.5					
	sei whale	2011	3(2M1F)	14.0	(	13.6	-	14.7	)
		2012	10(4M6F)	13.7	(	12.4	-	15.2	)
		2013	5(2M3F)	14.0	(	13.5	-	14.3	)
		2014	7(4M3F)	14.0	(	12.7	-	15.1	)
		2015	7(2M5F)	13.5	(	11.7	-	15.2	)
	Bryde's whale	2011	3(3F)	13.2	(	13.0	-	13.4	)
		2012	3(2M1F)	12.0	(	10.7	-	13	)
		2013	4(3M1F)	12.7	(	11.2	-	13.8	)
		2014	3(1M2F)	12.8	(	12.5	-	13.2	)
		2015	3(2M1F)	12.3	(	11.1	-	13.2	)
	sperm whale	2012	2(1M1F)	10.1	(	8.7	-	11.5	)
		2013	1(1F)	7.4					
Off Sanriku	common minke whale	2012	6(2M4F)	4.9	(	4.0	-	5.92	)
		2013	3(1M2F)	4.6	(	3.7	-	5.28	)
		2014	4(3M1F)	6.1	(	4.7	-	7.47	)
		2015	5(3M2F)	6.2	(	4.7	-	8.05	)
Off Kushiro	common minke whale	2011spring	6(3M3F)	7.2	(	5.9	-	8.11	)
		2011autumn	6(3M3F)	5.8	(	4.3	-	7.28	)
		2012	5(3M2F)	5.8	(	5.1	-	7.38	)
		2013	5(1M4F)	7.1	(	5.1	-	8.68	)
		2014	3(2M1F)	6.8	(	5.5	-	8.21	)

Table 2. Concentration values of I131, Cs134 and Cs137 (Bq/kg-wet) in muscle of common minke, sei, Bryde's and sperm whales taken from JARPNII surveys

Area	Species	Year		I131	Cs134	Cs137	Cs134+137
Off shore	common minke whale	2011	11NP-M001	ND	ND	ND	ND
			11NP-M002	ND	9.1	12	21
			11NP-M049	ND	ND	ND	ND
		2012	12NP-M001	<0.54	3.1	4.5	7.6
			12NP-M008	<0.69	2.4	3.9	6.3
			12NP-M011	<0.53	1.4	1.7	3.1
			12NP-M038	<0.48	<0.53	<0.94	ND
			12NP-M045	<0.69	1.2	2.1	3.3
			12NP-M072	<0.58	4.5	7.1	11.6
		2013	13NP-M002	<0.465	0.556	1.57	2.1
	sei whale	2011	11NP-SE014	ND	ND	ND	ND
			11NP-SE043	ND	ND	ND	ND
			11NP-SE071	ND	ND	ND	ND
		2012	12NP-SE001	<0.50	1.6	2.3	3.9
			12NP-SE003	<0.61	3.3	6.5	9.8
			12NP-SE009	<0.54	<0.55	<1.1	ND
			12NP-SE012	<0.74	1.3	2.6	3.9
			12NP-SE024	<0.51	2.8	3.4	6.2
			12NP-SE043	<0.62	1.3	2.1	3.4
			12NP-SE047	<0.50	0.93	2	2.93
			12NP-SE051	<0.59	<0.62	<0.86	ND
			12NP-SE064	<0.65	<0.69	<1.0	ND
			12NP-SE068	<0.53	<0.63	1.1	1.1
		2013	13NP-SE001	<0.303	0.425	1.05	1.5
			13NP-SE005	<0.437	<0.462	0.794	0.79
			13NP-SE022	<0.304	<0.304	1.03	1
			13NP-SE055	<0.468	<0.468	1.17	1.2
			13NP-SE091	<0.328	0.702	1.49	2.2
		2014	14NP-SE001	<0.359	<0.432	0.764	0.76
			14NP-SE007	<0.425	<0.585	0.589	0.59
			14NP-SE026	<0.400	<0.599	0.842	0.84
			14NP-SE044	<0.417	<0.594	0.595	0.6
			14NP-SE057	<0.481	<0.480	<0.609	<1.1
			14NP-SE070	<0.424	<0.465	0.714	0.71
			14NP-SE082	<0.389	<0.402	0.812	0.81
		2015	15NP-SE001	<0.415	<0.492	<0.536	<1.0
			15NP-SE011	<0.441	<0.448	0.95	0.95
			15NP-SE022	<0.370	<0.418	<0.458	<0.88
			15NP-SE035	<0.361	<0.499	0.75	0.75
			15NP-SE049	<0.403	<0.605	<0.480	<1.1
			15NP-SE060	<0.418	<0.460	<0.557	'<1.0
			15NP-SE080	<0.347	<0.360	<0.373	<0.73
	Bryde's whale	2011	11NP-B007	ND	2.9	3.6	6.5
			11NP-B039	ND	2.9	4.2	7.1
			11NP-B047	ND	ND	ND	ND
		2012	12NP-B001	<0.57	1.6	2.6	4.2
			12NP-B008	<0.53	<0.62	1.7	1.7
			12NP-B011	<0.43	1.3	1.6	2.9
		2013	13NP-B001	<0.407	<0.395	0.691	0.69
			13NP-B002	<0.365	<0.376	0.931	0.93
			13NP-B021	<0.373	<0.422	0.95	0.95
			13NP-B024	<0.347	<0.350	1.11	1.1

Table 2. Continued

Area	Species	Year		I131	Cs134	Cs137	Cs134+137
		2014	14NP-B001	<0.474	<0.508	<0.516	<1.0
			14NP-B007	<0.387	<0.445	<0.492	<0.94
			14NP-B019	<0.491	<0.511	0.589	0.59
		2015	15NP-B001	<0.332	<0.395	<0.404	<0.80
			15NP-B015	<0.390	<0.326	<0.441	<0.77
			15NP-B025	<0.381	<0.380	<0.439	<0.82
	sperm whale	2012	12NP-S001	<0.55	<0.46	<0.82	ND
			12NP-S003	<0.51	<0.54	<0.79	ND
		2013	13NP-S001	<0.411	<0.376	<0.363	<0.74
Off Sanriku	common minke whale	2012	12NPCS-M001M	<0.32	<0.33	0.7	0.7
			12NPCS-M005M	<2.80	<0.51	<0.90	ND
			12NPCS-M008M	<0.68	6.2	10	16
			12NPCS-M012M	<0.66	5.2	7.9	13
			12NPCS-M031M	<0.48	<0.52	<0.91	ND
			12NPCS-M055M	<0.68	6.1	9.3	15
		2013	13NPCS-M001M	<0.412	<0.448	0.6	0.6
			13NPCS-M005M	0.495	1.1	1.79	2.9
			13NPCS-M016M	0.483	1.17	2.34	3.5
		2014	14NPCS-M001M	<0.448	<0.448	0.725	0.73
			14NPCS-M013M	<0.395	<0.396	0.614	0.61
			14NPCS-M020M	<0.468	<0.479	0.648	0.65
			14NPCS-M029M	<0.496	0.362	0.584	0.95
		2015	15NPCS-M001M	-	<0.329	<0.496	<0.83
			15NPCS-M002M	-	<0.455	<0.520	<0.98
			15NPCS-M013M	-	<0.384	<0.445	<0.83
			15NPCS-M018M	-	<0.427	<0.457	<0.88
			15NPCS-M019M	-	<0.394	<0.517	<0.91
Off Kushiro	common minke whale	2011spring	11NPCS-M001M	ND	ND	ND	ND
			11NPCS-M004M	ND	ND	ND	ND
			11NPCS-M007M	ND	14	17	31
			11NPCS-M011M	ND	ND	ND	ND
			11NPCS-M016M	ND	9.3	15	24
			11NPCS-M017M	ND	ND	ND	ND
		2011autumn	11NPCK-M001M	ND	ND	ND	ND
			11NPCK-M019M	ND	-	-	17.6
			11NPCK-M032M	ND	-	-	12.5
			11NPCK-M039M	ND	-	-	5.4
			11NPCK-M043M	ND	-	-	ND
			11NPCK-M050M	ND	-	-	21.6
		2012	12NPCK-M001M	<0.44	1.2	2.8	4
			12NPCK-M006M	<0.55	<0.52	1.8	1.8
			12NPCK-M027M	<0.57	<0.53	<0.89	ND
			12NPCK-M040M	<0.59	<0.58	0.9	0.9
			12NPCK-M041M	<0.539	<0.588	<0.901	ND
		2013	13NPCK-M001M	<0.437	<0.388	<0.451	ND
			13NPCK-M028M	<0.465	<0.436	1.21	1.2
			13NPCK-M041M	<0.442	<0.481	<0.476	ND
			13NPCK-M052M	<0.457	<0.426	0.48	0.48
			13NPCK-M053M	<0.416	<0.467	0.47	0.47
		2014	14NPCK-M001M	<0.318	<0.274	<0.302	0.48
			14NPCK-M014M	<0.357	<0.446	<0.528	ND
			14NPCK-M035M	<0.483	<0.470	<0.438	0.85

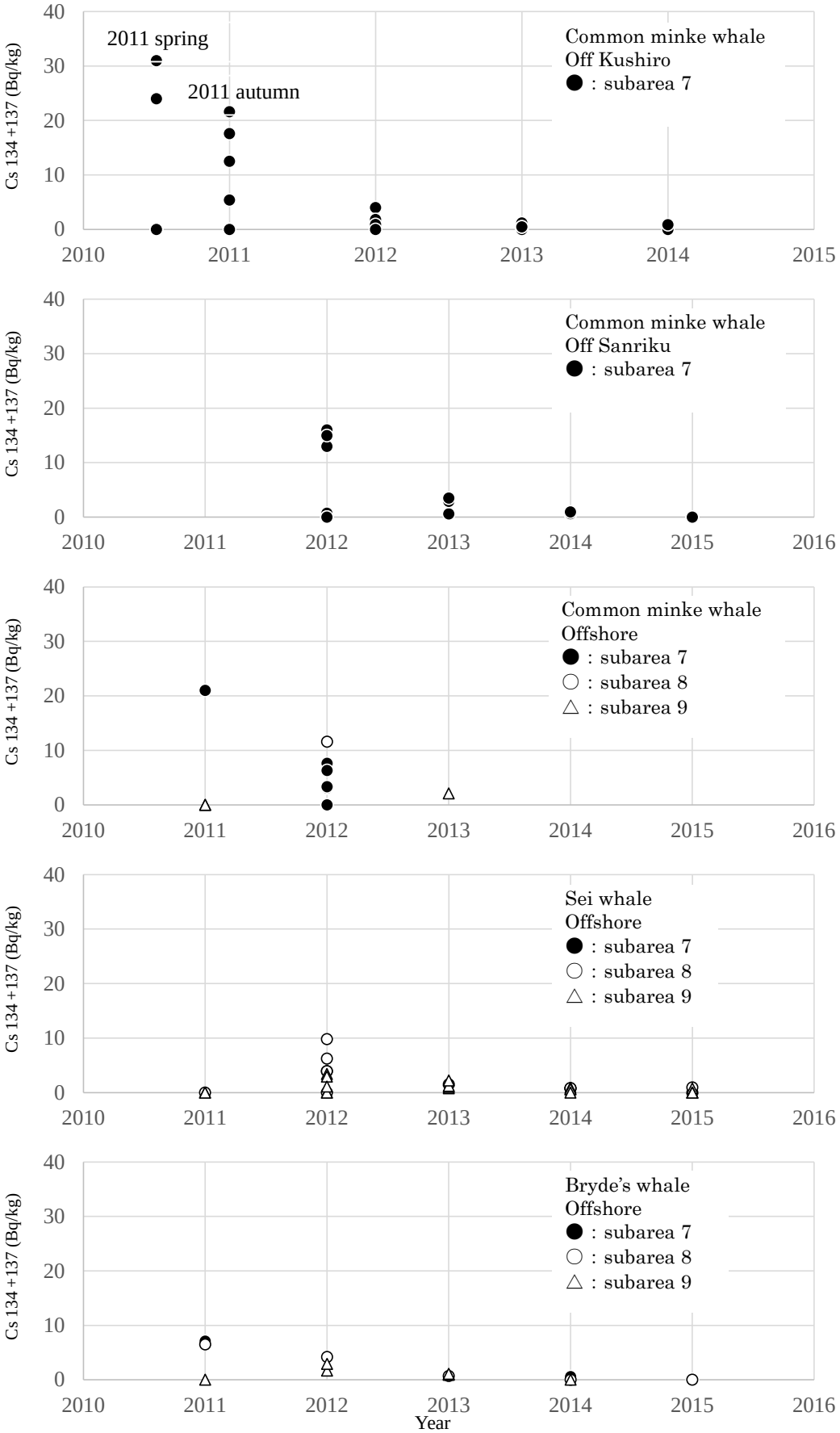

Figure 1. Concentrations of Cs 134+137 in muscle of common minke, sei and Bryde's whales taken from the western North Pacific from 2011 to 2015