SC/F14/J22

Observation of marine debris in the Antarctic based on JARPA and JARPAII data

Tatsuya Isoda, Tsutomu Tamura, Shigetoshi Nishiwaki and Luis A. Pastene

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

ABSTRACT

Records of marine debris in the Antarctic waters and ingestions/entanglements by whales are very limited. In this study, we summarized the information on marine debris collected during the surveys of the Japanese Whale Research under Special Permit in the Antarctic (JARPA) and its Phase II (JARPAII), for the period of 1987/88 to 2010/11. We considered three kinds of observations: marine debris on the sea surface, marine debris in the stomachs of whales caught under JARPA and JARPAII (Antarctic minke, dwarf minke and fin whales), and entanglements. Marine debris on the sea surface was recorded through the sighting surveys of the JARPA and JARPAII. In the Antarctic research area (south of 60°S), marine debris included metals (drum, can) and petrochemical products (buoy, ball, bottle, container, fender, net, rope, styrofoma). Buoys were the most abundant type of debris (69% of all marine debris recorded). The highest density index (DI: number of marine debris observed per 100 nautical miles) was recorded in Area V (DI: 0.15), followed by Area IV (DI: 0.12). DI of buoys in Area IV and V suddenly increased after the 2005/06 austral summer season. The increase of buoy debris coincides with an increase of longline fishery operations in this area. The stomachs of a total of 10,041 Antarctic minke whales, 16 dwarf minke whales and 16 fin whales were examined for debris. A total of 70 pieces of marine debris and objects other than prey were found in the stomachs of three species, including feather, stone, wood, plastic and others. The number of occurrences of marine debris and objects other than prey in the fore and main stomachs per 100 Antarctic minke whales examined was estimated at 0.35. The size of solid objects in the stomachs was small, less than 100×100mm. We found four cases of entanglement in a total of 10,041 Antarctic minke whales examined. Those involved fishing hooks, monofilament fishing lines, ropes and packing bands. Given the low indices, the effect of marine debris on whales in the Antarctic is expected to be limited at the present time. This study provided the first comprehensive observations of marine debris found on the sea surface, inside the stomachs of whales, and in entanglements of whales in the Antarctic.

KEYWORDS: DEBRIS; ANTARCTIC; SURVEY-VESSELS; ANTARCTIC MINKE WHALE; MINKE WHALE; FIN WHALE

INTRODUCTION

Gregory (2009) recognized several problems associated with marine debris, for example the aesthetic values, entanglement, ingestion, smothering, ghost fishing and hanging-on/hitch-hiking alien invasions. The Antarctic is one of the most isolated places and the effects of human activities in this regard are limited. However, marine debris has been recorded in sub-Antarctic and Antarctic islands, although there is very little information about marine debris in the sea (Barnes *et al*. 2010, Ivar do Sul *et al*. 2011).

Marine debris causes negative effects on whales through ingestion and entanglement. There is no information on the relationship between marine debris and whales in the Antarctic. However, there are a few reports of entanglement by fisheries to whales (Kock *et al*. 2006, SC-CAMLR 2004, 2012).

JARPA and JARPAII have been conducting systematic monitoring of the Antarctic ecosystem including observation of marine debris in whales and their environment. The present study summarizes the observations on marine debris collected by JARPA and JARPAII in a research area covering half of the Antarctic waters and during a research period of more than 20 years.

MATERIALS AND METHODS

The present study was based on data collected by the JARPA (1987/88 - 2004/05 seasons) and JARPAII, (2005/06 - 2010/11 seasons) (regarding general methodology and survey procedure, see Nishiwaki *et al*. 2006 and Nishiwaki *et al*. 2014).

Marine debris on the sea surface

Marine debris on the sea surface was collected by dedicated sighting vessels in the International Whaling Commission (IWC) Antarctic management Areas III (East) (35°E-70°E), IV (70°E-130°E), V (130E°-170°W) and VI (West) (170°W-145°W), south of 60°S during 1995/96-2010/11 seasons. Data collected included sighting dates, sighting positions and types of marine debris. Marine debris data was roughly sorted into three types of debris: metal, petrochemical products and other, and in consideration of the search effort e.g. data obtained on and off during the search effort. The density index (DI: number of marine debris per 100 nautical miles) was also calculated in the period of the 1995/96–2009/10 seasons. No independent sighting surveys were conducted in the 2010/11 season due to external interferences.

Ingestion of marine debris and objects other than prey

Ingestion of marine debris and objects other than prey were examined in 10,041 Antarctic minke whales (*Balaenoptera bonaerensis*) (research seasons: JARPA from 1987/88 to 2004/05, JARPAII from 2005/2006 to 2010/11), 16 dwarf minke whales (*Balaenoptera acutorostrata* subsp.) (research seasons: JARPA from 1987/88 to 1992/93) and 16 fin whales (*Balaenoptera physalus*) (research seasons: JARPAII from 2005/06 to 2010/11).

The examination of whale stomachs was conducted onboard the research base vessel. The three stomach chambers and the duodenal ampulla were examined during the JARPA, and the fore and main stomachs were examined during the JARPAII. Some marine debris and objects were recorded being found in body parts other than the stomach. Marine debris and objects other than prey were tabulated by five categories: feather, stone, wood, plastic and other. The sizes of solid objects (stone, wood and plastic) were estimated from photographic records. The relationship between body length and body weight of Antarctic minke whales was compared between whales with and without debris in their stomachs (n=8,086). This was made to examine the body condition of the whales with debris in their stomachs.

Entanglement

Observations of the external part of the bodies of the whales were made onboard the research base vessel. All cases of entanglements (attached objects) in Antarctic minke whales sampled by the JARPA and JARPAII (n= 10,041) were recorded. Furthermore scars and marks in the body of whales possibly produced by entanglements was examined for whales sampled under the JARPAII (n=3,264). The latter analysis was based on JARPAII samples only because more detailed body observations, supported by the use of digital cameras, started from JARPAII.

The relationship between body length and body weight of Antarctic minke whales was compared between whales with and without entanglements (n=8,086). This was made to examine the body condition of the whales with entanglements.

RESULTS

Marine debris on the sea surface

A total of 131 records of marine debris were made (nine metals, 121 petrochemical products and one other) (Table 1). Buoys (type of petrochemical) accounted for 69% of all marine debris. Marine debris was found throughout all research areas; however, the DI was higher in Areas IV and V particularly during the JARPAII period (Figures 1a and 1b, Table 2). The most southerly debris was a buoy found in area V (Ross Sea) at 74°S, 176°W.

The highest DI was recorded in Area V (DI: 0.15), followed by Area IV (DI: 0.12). The average DI in the four Areas was 0.12 (Table 2). DI for buoys ranged from zero to 0.33 (Figure 2) and these increased suddenly in Areas IV and V after the 2005/06 season.

Ingestion of debris
A total of 59 out of the 10,041 Antarctic minke whales examined had ingested marine debris and objects other than prey (Table 3). Feathers accounted for 43 cases, stones in six cases, pieces of wood in eight cases and plastics in nine cases. In 35 cases, debris was found in the fore and main stomach.

The occurrence of marine debris in the fore and main stomachs per 100 Antarctic minke whales examined was calculated at 0.35 (Table 3). The size of solid objects (stone, wood, plastic) was less than 100×100mm. There were two occurrences (one plastic and one wood) in which the size of the objects was more than 100×100mm (Figure 3).

There were no differences in the relationship between body length and body weight of Antarctic minke whales and whales with or without debris in their stomachs (Figure 4).

No debris was found in the stomachs of the 16 dwarf minke whales examined. In the case of the fin whales, only one animal had ingested two feathers.

Entanglement
Four cases of entanglements were found in a total of 10,041 Antarctic minke whales examined (Table 4, Figures 5). Those involved fishing hooks, monofilament fishing lines, ropes and packing bands. There were no differences in the relationship between body length and body weight of Antarctic minke whales and whales with or without entanglements (Figure 4).

At least four out of 3,264 Antarctic minke whales examined in JARPAII had scars presumably derived from entanglements (Figure 6).

DISCUSSION

Evidence from remote oceanic islands suggests a southward-decreasing, strong latitudinal gradient in litter densities from subtropical and temperate waters through the subtropical convergence to polar front and beyond (i.e. there is a clear trend in marine debris accumulation with latitude) (Barnes 2005, Gregory and Ryan 1997).

Matsumura and Nasu (1997) reported the results of sighting surveys which showed the distribution of floating marine debris in the North Pacific Ocean and its adjacent waters during 1987-1991. These surveys covered approximately 926,000 n. miles and counted 136,338 pieces of marine debris (including natural objects). About 60% of marine debris accounted for petrochemical debris (e.g. fishing gear, styrofoma, other plastic products). Total debris densities in coastal waters were 20-40 objects per square n. mile, while the density in the north equatorial current area (5°to15°N, across the central Pacific) was about 0.2 objects per square n. mile, and 1-3 objects per square n. mile in the subarctic boundary area (35° to 45°N) (Matsumura and Nasu 1997). DI in our study (Table 2) was compared with those results by Matsumura and Nasu (1997). DI in the Antarctic is lower by two orders of magnitude in comparison with the North Pacific Ocean and its adjacent waters. Thus our observations prove that the Antarctic waters have a very low density of marine debris on the sea surface.

Sources of marine debris include fishing, and research/tourism vessels traveling in the Southern Ocean, but also global oceanic debris rafting across the Polar Front. Fishing operations are important sources of marine debris to Antarctica, contributing not only with direct fishing-related debris but also miscellaneous items (Ivar do Sul *et al*. 2011). According to our results, fishing buoys accounted for about 69% of all sighted marine debris on the sea surface. Barnes *et al*. (2010) recorded three pieces of marine debris in the Durmont D'Urville and Davis Seas (i.e. Areas IV and V): a plastic cup and two fishing buoys. Oceanic fronts, such as the subtropical Convergence and Polar Front, were obstructions along which marine debris tended to collect and become concentrated, and which would be difficult to cross (Gregory and Ryan 1997). They are somewhat leaky barriers (Gregory 2009). The assumption that all buoys observed in the Antarctic were transported from lower latitudes is unreasonable in consideration of the barrier effects of

the Polar Frontal Zone, even if it is weak. Webber and Parker (2012) showed fishing gear loss of bottom longline fisheries targeting Antarctic toothfish (*Dissostichus mawsoni*). Since 2004/05, licensed longline vessels have conducted exploratory fishery for *Dissostichus* spp. (target species is Antarctic toothfish) in CCAMLR division subarea 58.4.1, and there are high levels of IUU (illegal, unreported and unregulated) fishing conducted outside CCAMLR regulations (SC-CAMLR 2011). CCAMLR division subarea 58.4.1 overlaps with IWC Antarctic management Areas IV and V. Therefore, the number of sighted buoys suddenly increased in these Areas after the 2005/06 season, which coincides with the increase of longline fisheries operations (include IUU fishing).

In Iceland, six of 82 examined fin whales (commercial whaling) and in the New York area of the USA, three of 19 examined mysticetes (stranding) contained synthetics in the gut (Sadove and Morreale 1990). The occurrence rates of marine litter ingestion obtained from stranded animals examined in the UK were 2.2% in the harbour porpoise (*Phocoena phocoena*) and 2.3% in the short-beaked common dolphin (*Delphinus delphis*) (Deaville and Jepson 2010). We found 59 minke whales with 68 pieces of marine debris and objects other than prey out of 10,041 Antarctic minke whales sampled in the Antarctic (0.59%). Among them, there were only nine cases of plastics, which is an extremely low frequency (0.09%) in comparison with other oceanic basins. Given this low frequency the effect of marine debris on whales is expected to be low.

Entanglement of Antarctic fur seals (*Arctocephalus gazella*) was caused mostly by loop shaped debris such as packing bands (Croxall *et al*. 1990, Arnould and Croxall 1995). CCAMLR has prohibited and restricted the use of packing bands on fishing vessels in Conservation Measure 26-01. In this study, some entangled whales strapped with packing bands around their upper rostrums were found (Figures 5-d). Similar cases were reported in common minke whales (*Balaenoptera acutorostrata*) in the Atlantic (Gill *et al*. 2000). It has been indicated that loop shaped debris causes the entanglement of whales as well pinnipeds.

Fishing gear is the most significant source of entanglements for whales and those entanglements were reported in various waters (Laist 1997, Simmonds 2012). Documented interaction between whales and fisheries in the Southern Ocean included killer (*Orcinus orca*) and sperm whales (Kock *et al*. 2006), however entanglement mortalities recorded in the case of sperm whales and possibly minke whales (SC-CAMLR 2004, 2012) were low. In this study, only three cases of entanglements (probably by fishing gear) were found among the 10,041 Antarctic minke whales examined.

At least four out of 3,264 Antarctic minke whales examined in JARPAII had scars presumably derived from entanglements (see Figure 6). Those scars suggested that the entanglements occurred in previous cases, but that they escaped from the obstructive objects and survived. Entanglements along the eastern seaboard of the United States and Canada during a five year period were reported, and 27 cases of minke whales and 77 of humpback whales were accounted (Glass *et al*. 2008). In Iceland, five of 95 fin whales examined showed signs of previous entanglement (Sadove and Morreale 1990). The entanglements of Antarctic minke whales are less frequent. Therefore the level of impact of entanglements on Antarctic minke whales would be low in comparison with other oceanic basins.

This study provided the first comprehensive quantitative approach of marine debris on the sea surface, ingestion of marine debris and entanglement of whales in the Antarctic. Given the low frequencies and indices, the impact of marine debris on whales in the Antarctic is expected to be limited. Our study provides some evidence that some degree of interaction between whales and fishery exist in the Antarctic. Webber and Parker (2012) recommended that fishing vessels and/or the CCAMLR observer should record the detailed gear loss, for estimating unaccounted fishing mortality and to reduce the loss of fishing gear. That information is also essential to understand the interaction between whales and fishery and marine debris. JARPAII provides a unique opportunity for monitoring the Antarctic environment including marine debris in whales and their environment.

ACKNOWLEDGEMENTS

We would sincerely like to thank H. Hatanaka, S. Ohsumi, K. Matsuoka and N. Kanda of the Institute of Cetacean Research (ICR) and H. Kato of Tokyo University of Marine Science and Technology for their

useful comments and suggestion in preparing this paper. We also would like to thank all of the captains, crewmembers, cruise leaders and researchers onboard the research vessels of JARPA and JARPA II for their contributions in collecting the data used in this study.

REFERENCES

Arnould, J.P.Y. and Croxall, J.P. 1995. Trends in entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at South Georgia. *Marine Pollution Bulletin* 30(11): 707-712.

Barnes, D.K.A. 2005. Remote islands reveal rapid rise of southern hemisphere sea debris. *Sci. World J*. 5: 915-921.

Barnes, D.K.A., Walters, A. and Gonçalves, L. 2010. Macroplastics at sea around Antarctica. *Marine Environmental Research* 70: 250-252.

Croxall, J.P., Rodwell, S. and Boyd, I.L. 1990. Entanglement in man-made debris of Antarctic fur seals at Bird Island, South Georgia. *Marine Mammal Science* 6: 221-233.

Deaville, R. and Jepson, P.D. 2010. Final Report for the period 1st January 2005 - 31st. December 2010. UK Cetacean Strandings Investigation Programme. 98pp.

Gill, A., Fairbairns, B. and Fairbairns, R. 2000. Photo-identification of the Minke Whale (*Balaenoptera acutorostrata*) around the Isle of Mull, Scotland. *Report to the Hebridean Whale and Dolphin Trust.* 88pp.

Glass, A.H., Cole, T.V.N., Garron, M., Merrick, R.L. and Pace III, R.M. 2008. Mortality and serious injury determinations for baleen whale stocks along the United States eastern seaboard and adjacent Canadian Maritimes, 2002-2006. U.S. Dep. Commer., *Northeast Fish. Sci. Cent.Ref. Doc*. 08-04. 18 pp.

Gregory, M.R. and Ryan, P.G. 1997. Pelagic plastics and other seaborne persistent synthetic debris: a review of southern hemisphere perspectives. In Coe J.M. and Rogers D.B. (eds) *Marine Debris, sources, impacts, and solutions.* Pp. 49–66. New York. Springer-Verlag.

Gregory, M.R. 2009. Environmental implications of plastic debris in marine settings-entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions. *Phil. Trans. R. Soc. B* 364: 2013-2025.

Ivar do Sul, J.A., Barnes, D.K., Costa, M.F., Convey, P., Costa, E.S. and Campos, L. 2011. Plastics in the Antarctic environment: Are we looking only at the tip of the iceberg? *Oecologia Australis*, 15(1): 150-170.

Kock, K.H., Purves, M.G., and Duhamel, G. 2006. Interactions between cetacean and fisheries in the Southern Ocean. *Polar Biol.* 29: 379-388.

Laist, D.W. 1997. Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In Coe J.M. and Rogers D.B. (eds) *Marine Debris, sources, Impacts, and solutions.* Pp. 99-139. New York. Springer-Verlag.

Matsumura, S. and Nasu, K. 1997. Distribution of floating debris in the North Pacific Ocean: sighting surveys 1986-1991. In Coe J.M. and Rogers D.B. (eds) *Marine Debris, sources, Impacts, and solutions.* Pp. 15-24. New York. Springer-Verlag.

Nishiwaki, S., Ishikawa, H. and Fujise, Y. 2006. Review of general methodology and survey procedure under the JARPA. *JARPA review meeting document SC/D06/J2.*

Nishiwaki, S., Ishikawa, H., Goto, M., Matsuoka, K. and Tamura, T. 2014. Review of general

methodology and survey procedure under the JARPAII. *JARPAII review meeting document SC/F14/J2.*

Sadove, S.S., and Morreale, S.J. 1990. Marine mammal and sea turtle encounters with marine debris in the New York Bight and the northeast Atlantic. In: Shomura, R.S. and Godfrey, M.L. (eds) *Proceedings of the Second International Conference on Marine Debris, 2–7 April 1989, Honolulu, Hawaii*. NOAA Tech. Memo. NMFS-SWFSC-154., Pp. 562–570.

SC-CAMLR. 2004. Report of the Working Group on Fish Stock Assessment. In: *Report of the twenty-third Meeting of the Scientific Committee (SC-CAMLR-XXIII)*, Annex 5. CCAMLR, Hobart, Australia: 338-657.

SC-CAMLR. 2011. Report of the Working Group on Fish Stock Assessment (APPENDIX N: Fishery Report: Exploratory fishery for *Dissostichus* spp.in Division 58.4.1). In: *Report of the thirtieth Meeting of the Scientific Committee (SC-CAMLR-XXX)*, Annex 7. CCAMLR, Hobart, Australia. 14pp.

SC-CAMLR. 2012. Report of the Working Group on Fish Stock Assessment. In: *Report of the Thirty-first Meeting of the Scientific Committee (SC-CAMLR-XXXI)*, Annex 7. CCAMLR, Hobart, Australia: 265-377.

Schlitzer, R. 2013. *Ocean Data View.* http://odv.awi.de.

Simmonds, M.P. 2012. Cetaceans and Marine Debris: The Great Unknown. *Journal of Marine Biology*. Vol. 2012 Article ID 684279, doi:10.1155/2012/684279. 8 p.

Webber, D.N. and Parker, S.J. 2012. Estimating unaccounted fishing mortality in the Ross sea region and Amundsen sea (CCAMLR subareas 88.1 and 88.2) bottom longline fisheries targeting Antarctic toothfish. *CCAMLR Science* 19: 17-30.

Table 1. Summary of the sightings of marine debris on the sea surface in Areas III (East), IV, V and VI (West) during the JARPA and JARPAII (1995/96-2010/11).

Category	Metal (Total number=9)				Petrochemical products (Total number=121)																		Other (Total number=1)				
	Can		Drum(≦200L)		Buoy*		Ball		Bottle		Container		Fender		Net		Rope		Other plastic products		Styrofoma products		Other products*		Sub total		Total
AREA / Type of searching effort	on	off	on	off	on	off	on	off	on	off	on	off	on	off	on	off	on	off	on	off	on	off	on	off	on	off	
AREA III (East)			1		3				1	1											1				6	1	7
AREA IV			1	1	26	3					1				1		1			1	7	1	1		38	6	44
AREA V	2		1	2	35	13	1		3		2		5	1	2						1				52	16	68
AREA VI (West)			1		7	4																			8	4	12
Total	2	0	4	3	71	20	1	0	4	1	3	0	5	1	3	0	1	0	0	1	9	1	1	0	104	27	131

Buoy/fenders were floating as single object, however, at least in six observation cases several buoy/fenders were observed; those cases were counted as one in this study.
*Material of buoys was considered to be plastic, in addition styrofoma and rubber.
*Other products were unknown material square boxes.

Table 2. The Density indices (DI, number of marine debris per 100 n.miles) during JARPA and JARPAII (1995/96-2009/10).

Area	Searching distance (n.miles)	Number of marine debris (on searching effort)	Density indices (number of marine debris per 100n.miles)
Area III (East)	14,570	6	0.04
Area IV	30,768	38	0.12
Area V	33,615	52	0.15
Area VI (West)	10,096	8	0.08
Total	89,049	104	0.12

Table 3. Marine debris and objects other than prey ingested in Antarctic minke whales examined by JARPA and JARPAII (1987/88-2010/11).

Antarctic minke whale		Category												Index of occurrence of marine debris and objects other than prey in the forestomach and main stomach (per 100 antarctic minke whales)
Research season	Total number of examined Antarctic minke whales	Feather		Stone		Wood		Plastic		Others		Total		
1987/88	272	-	-	-	-	-	-	1	(0)	-	-	1	(0)	0.00
1988/89	236	-	-	-	-	-	-	-	-	-	-	-	-	0.00
1989/90	326	-	-	-	-	-	-	-	-	-	-	-	-	0.00
1990/91	323	-	-	-	-	-	-	-	-	-	-	-	-	0.00
1991/92	288	-	-	-	-	1	(0)	1	(0)	-	-	2	(0)	0.00
1992/93	327	2	(2)	-	-	1	(0)	1	(0)	-	-	4	(2)	0.61
1993/94	330	-	-	-	-	1	(0)	1	(0)	-	-	2	(0)	0.00
1994/95	330	-	-	-	-	-	-	-	-	-	-	-	-	0.00
1995/96	439	-	-	-	-	-	-	-	-	-	-	-	-	0.00
1996/97	440	8	(7)	1	(0)	-	-	-	-	-	-	9	(7)	1.59
1997/98	438	4	(0)	-	-	-	-	-	-	-	-	4	(0)	0.00
1998/99	389	1	(0)	1	(1)	1	(0)	1	(0)	-	-	4	(1)	0.26
1999/00	439	-	-	-	-	1	(0)	2	(0)	-	-	3	(0)	0.00
2000/01	440	-	-	-	-	2	(2)	1	(0)	-	-	3	(2)	0.45
2001/02	440	1	(0)	1	(0)	-	-	-	-	-	-	2	(0)	0.00
2002/03	440	2	(1)	-	-	-	-	1	(1)	1	(0)	4	(2)	0.45
2003/04	440	4	(3)	1	(0)	-	-	-	-	1	(1)	6	(4)	0.91
2004/05	440	8	(3)	1	(0)	1	(0)	-	-	-	-	10	(3)	0.68
2005/06	853	11	(11)	-	-	-	-	-	-	-	-	11	(11)	1.29
2006/07	505	-	-	-	-	-	-	-	-	-	-	-	-	0.00
2007/08	551	-	-	-	-	-	-	-	-	-	-	-	-	0.00
2008/09	679	-	-	1	(1)	-	-	-	-	-	-	1	(1)	0.15
2009/10	506	2	(2)	-	-	-	-	-	-	-	-	2	(2)	0.40
2010/11	170	-	-	-	-	-	-	-	-	-	-	-	-	0.00
Total	10,041	43	(29)	6	(2)	8	(2)	9	(1)	2	(1)	68	(35)	0.35

All items were found in the stomach and duodenal ampulla except for three feathers, one small stone and one plastic piece found in the oral cavity, small intestine and anus respectively. The category “Others” includes one small rubber piece and one small mineral matter such as coal.
(Number in parentheses): number of marine debris and objects other than prey found in the fore stomach and main stomach.

Table 4. List of entangled whales found by JARPA and JARPAII (1987/88-2010/11).

Research season	Specimen No.	Date	Latitude	Longitude	Body length(m)	Body weight(t)	Sex	Stomach contents	Entanglement objects	Figure 5
1995/96	065	22/12/1995	62°48'S	68°55'E	7.5	4.7	M	Empty	Fishing hook	a
2003/04	046	10/12/2003	63°10'S	54°56'E	5.7	2.1	M	Krill	Monofilament fishing line	b
2005/06	190	6/1/2006	64°26'S	72°40'E	7.8	NA	F	Krill	Rope	c
2005/06	765	5/3/2006	63°56'S	103°46'E	5.7	NA	M	Krill	Packing band	d

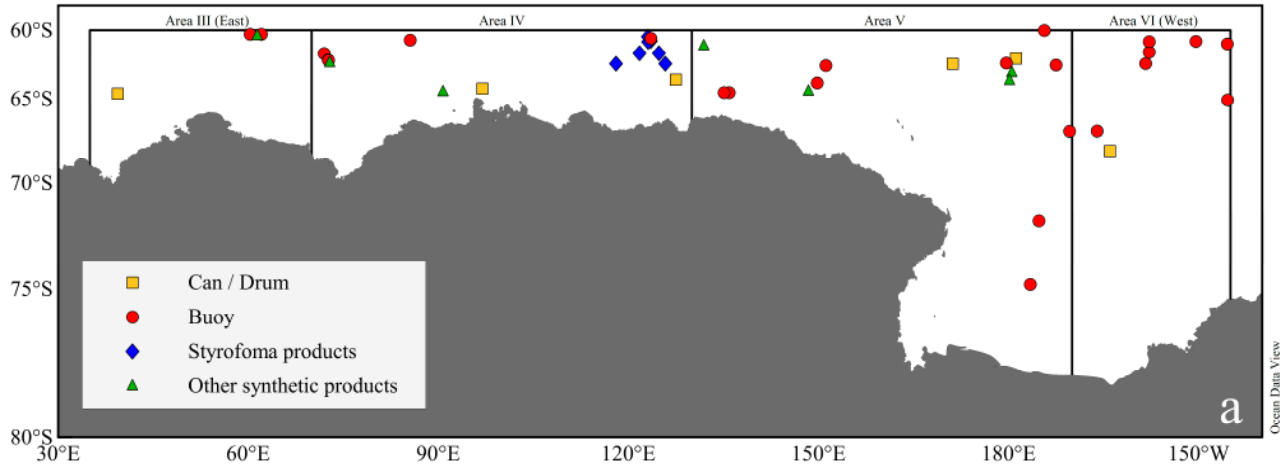

Figure 1a. Distribution of marine debris sighted during the JARPA (1987/89-2004/05). Figure made by Ocean Data View (Schlitzer, 2013)

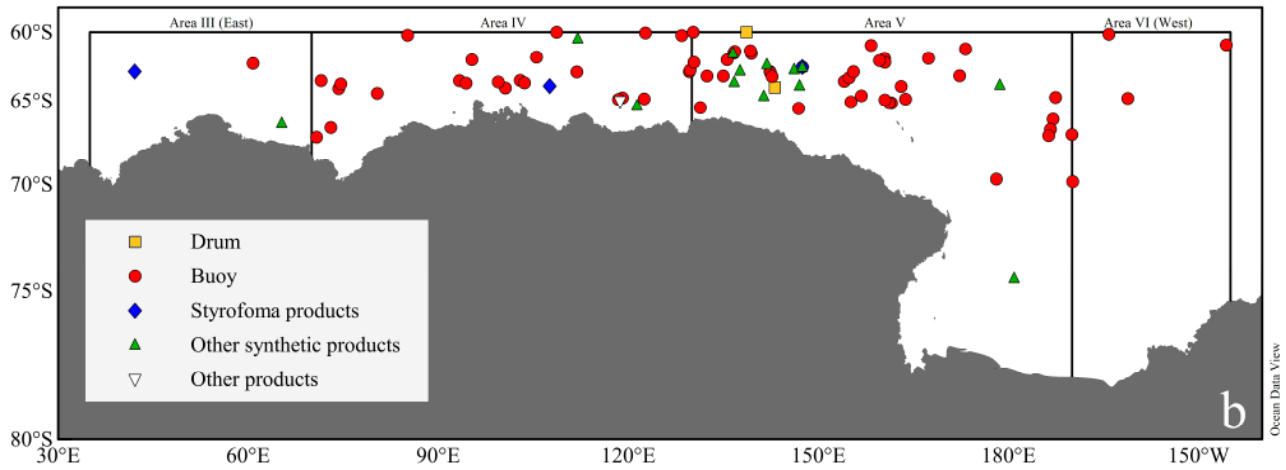

Figure 1b. Distribution of marine debris sighted during the JARPAII (2005/06-2010/11). Figure made by Ocean Data View (Schlitzer, 2013)

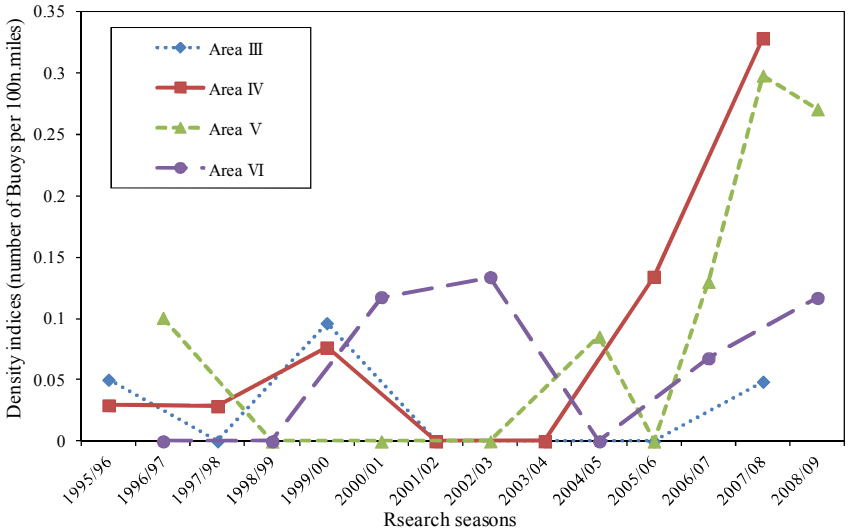

Figure 2. Density indices in each research season/area of sighted buoys during the search effort (n=71) of the JARPA and JARPAII (1995/96-2008/09). Since the 2009/10 season was excluded from this graph, there was a large unsurveyed area due to external interferences (see Nishiwaki *et al*. 2014).

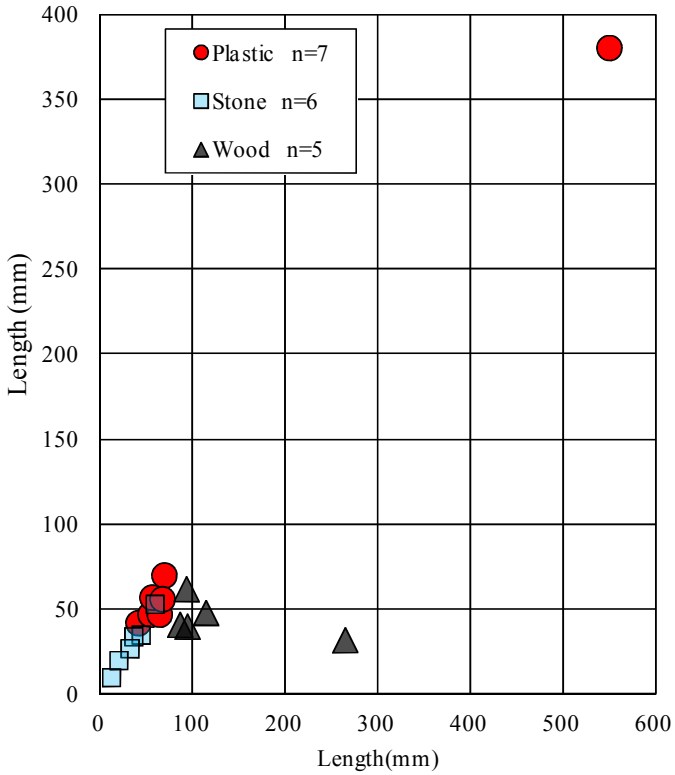

Figure 3. Size of marine debris ingested by Antarctic minke whales examined by JARPA and JARPAII. One piece each of plastic and wood was more than 100×100mm in size and in the shape of a bag and scantling, respectively.

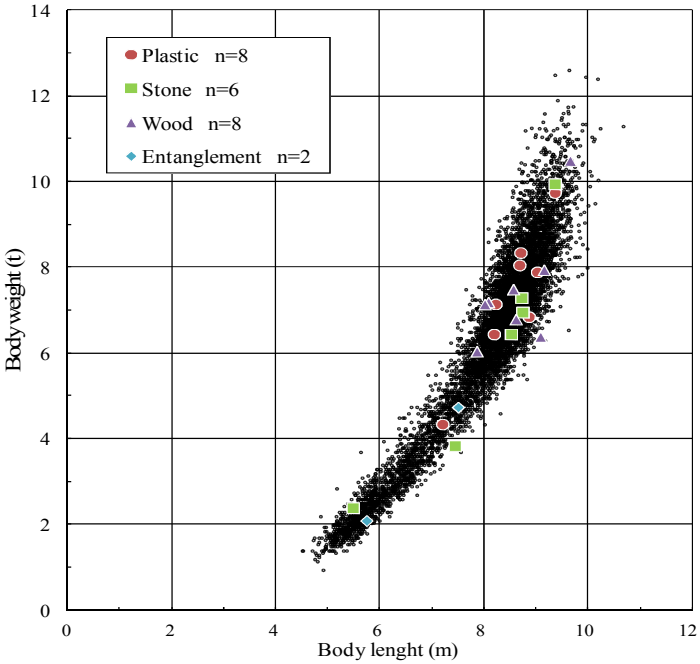

Figure 4. Relation of body length and body weight in Antarctic minke whales (n=8,086) plotted against ingested debris and entangled whale data.
There is no data regarding the body weight of one whale that ingested plastic and two whales that were entangled.

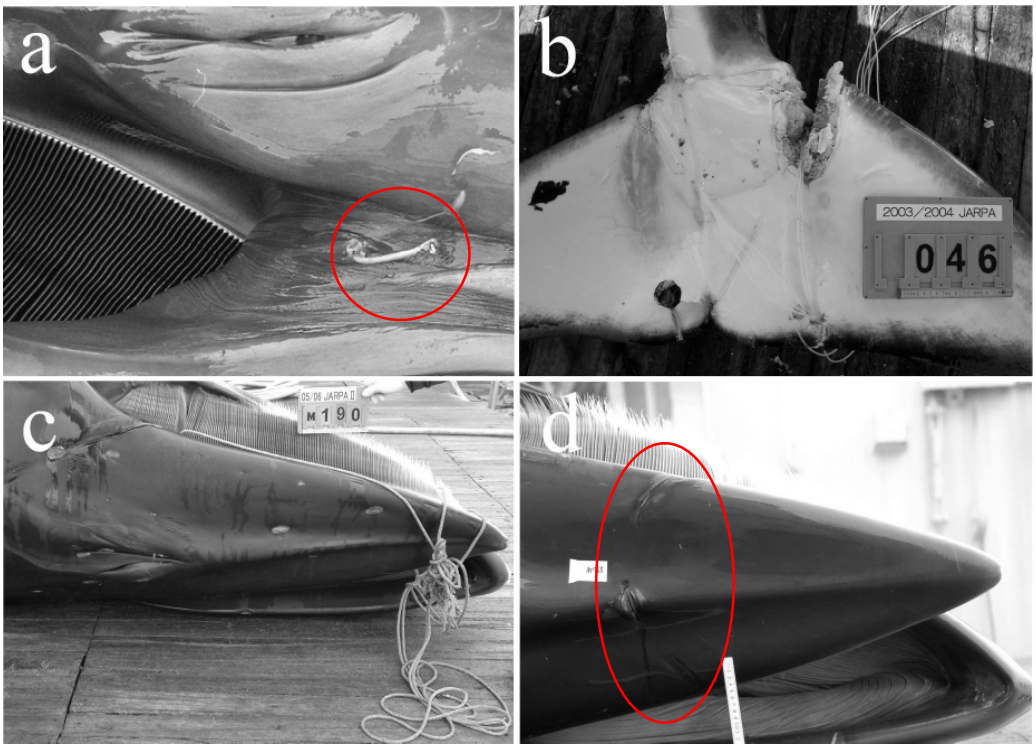

Figure 5. Four entangled Antarctic minke whales in JARPA and JARPAII (1987/88-2010/11).
(a) Fishing hook, (b) Monofilament fishing line, (c) Rope, (d) Packing band. (d) Loose packing band when a whale was being transported on the way to research base vessel.

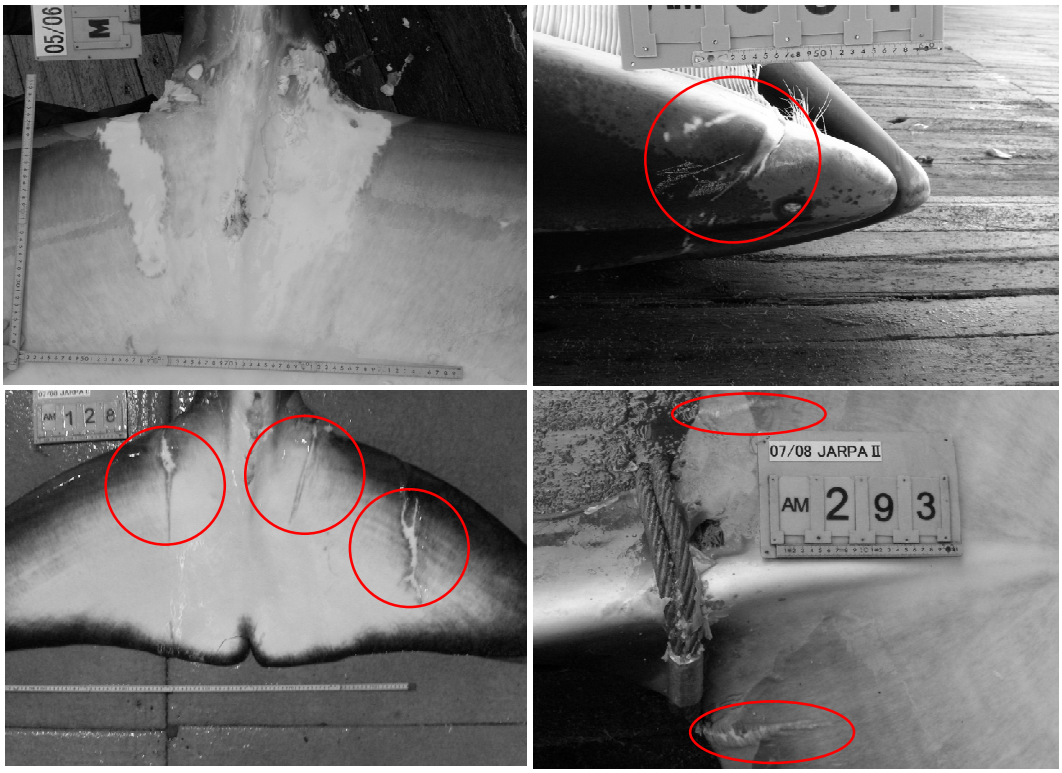

Figure 6. Four cases of Antarctic minke whales that were scarred probably entanglement in JARPAII (2005/06-2010/11).
In the lower right-hand picture the wire rope used in the processing is also shown.