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Plankton Sampling in 2009–2013 —Continuous Plankton Recorder survey—

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Introduction

The Japanese Antarctic Research Expedition (JARE) has been conducting routine zooplankton observations with a NORPAC standard net in the Indian Ocean sector of the Southern Ocean every austral summer since 1972 (JARE-14), initially on the icebreaker *Fuji* and later the *Shirase* (Fukuchi and Tanimura, 1981; Watanabe *et al*., 1984; Takahashi *et al*., 1997; Sawabe *et al*., 2005; Takahashi *et al*., 2008). The NORPAC net has been invaluable in understanding long-term interannual and interdecadal cyclic patterns (Takahashi *et al*., 1998). However, because of the small size of the net coupled with net avoidance problems, and the large distances between sampling sites, the NORPAC net is not ideal for long-term mapping and monitoring of changes in distribution or abundance in relation to the various oceanographic boundaries in the Southern Ocean. To improve the interpretation of data collected by the NORPAC net, JARE initiated an annual Continuous Plankton Recorder (CPR) survey since 1999 (JARE-41) as part its monitoring program in the Antarctic (Takahashi *et al*., 2006, 2009). This report presents sampling information and the distance traveled by CPR tows aboard the icebreaker *Shirase* (JARE-51~54). Additionally, information on CPR tows aboard the RT/V *Umitaka-Maru* of the Tokyo University of Marine Science and Technology, which collaborated with JARE-52, -53 and -54.

Background to the Continuous Plankton Recorder

The CPR was designed by Sir Alister Hardy in the mid 1920s, and first used in the Antarctic during the 1925/27 Discovery expedition. The CPR can collect surface plankton continuously for 450 nautical miles (830 km) during a single tow (Figure 1). CPRs have been used successfully in the monitoring of plankton communities in the North Sea and North Atlantic Ocean over the past 70 years, operated by the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) (Reid *et al*., 2003). The Australian Antarctic Program started a long-term CPR survey in 1991 to monitor zooplankton abundances and distribution in the Southern Ocean (Hosie *et al*., 2003). The Australian CPR survey covers a wide area through much of the year, which reflects broad logistical and research objectives in each season. The *Shirase* travels along much the same cruise track at roughly the same time each year. The collection of CPR data on the *Shirase* will provide an important time reference with which to interpret the data collected by the Australian Antarctic Program over the rest of the area. Sharing of data and results will greatly benefit both the Australian and Japanese programs.

Sampling protocol

CPR tows on the *Shirase* were conducted mainly on three tows south along 110°E from 45°S to the ice edge in December and three or four tows north along 150°E in February to March during each voyage (Figures 2, 3, 5 and 7). The *Umitaka-Maru* transects were mainly along 110°E from 45°S to 60°S in December to January and along 140°E in January to March (Figures 4, 6 and 8). We used a Type II (Mark V) CPR (Figure 1), based on the design of the SAHFOS CPRs with minor modifications to the external design, simplification of the internal cassettes, and built using marine grade 316 steel rather than phosphor bronze (Hosie *et al*., 2003). The CPR was towed horizontally at a ship speed of about 15 knots, from the stern with a wire cable paid out to 100 m. The depth of the CPR tow was about 10 m. The CPR has a mouth opening of 1.6 cm^2 and was fitted with 270 μm silk gauze. The towing of the CPR through the surface water turns an external propeller that drives the mesh rolls across the tunnel at a rate of approximately 1 cm per 1 nautical mile of tow. The 6-m-long mesh is sufficient to sample 450 nautical miles (830 km) as a normal towing distance. All

zooplankton samples were preserved in a 5–10% buffered formaldehyde and seawater solution, and were returned to the laboratory for analysis. The CPR mesh rolls were cut into segments, each representing a 5-nautical-mile sample (approximately 9.2 km) along the length of the transect. Complete details of the processing techniques have been described in Hosie *et al*. (2003). Information on sampling undertaken from the *Shirase* is listed in Tables 1, 2, 4 and 6, and from the *Umitaka-Maru* is listed in Tables 3, 5 and 7.

Scientists on board

The sampling during each cruise was carried out by the JARE members listed in Table 8, and these participants are acknowledged for their assistance.

Data policy

Written permission is required to publish or present the data of this report. Please address inquiries to:

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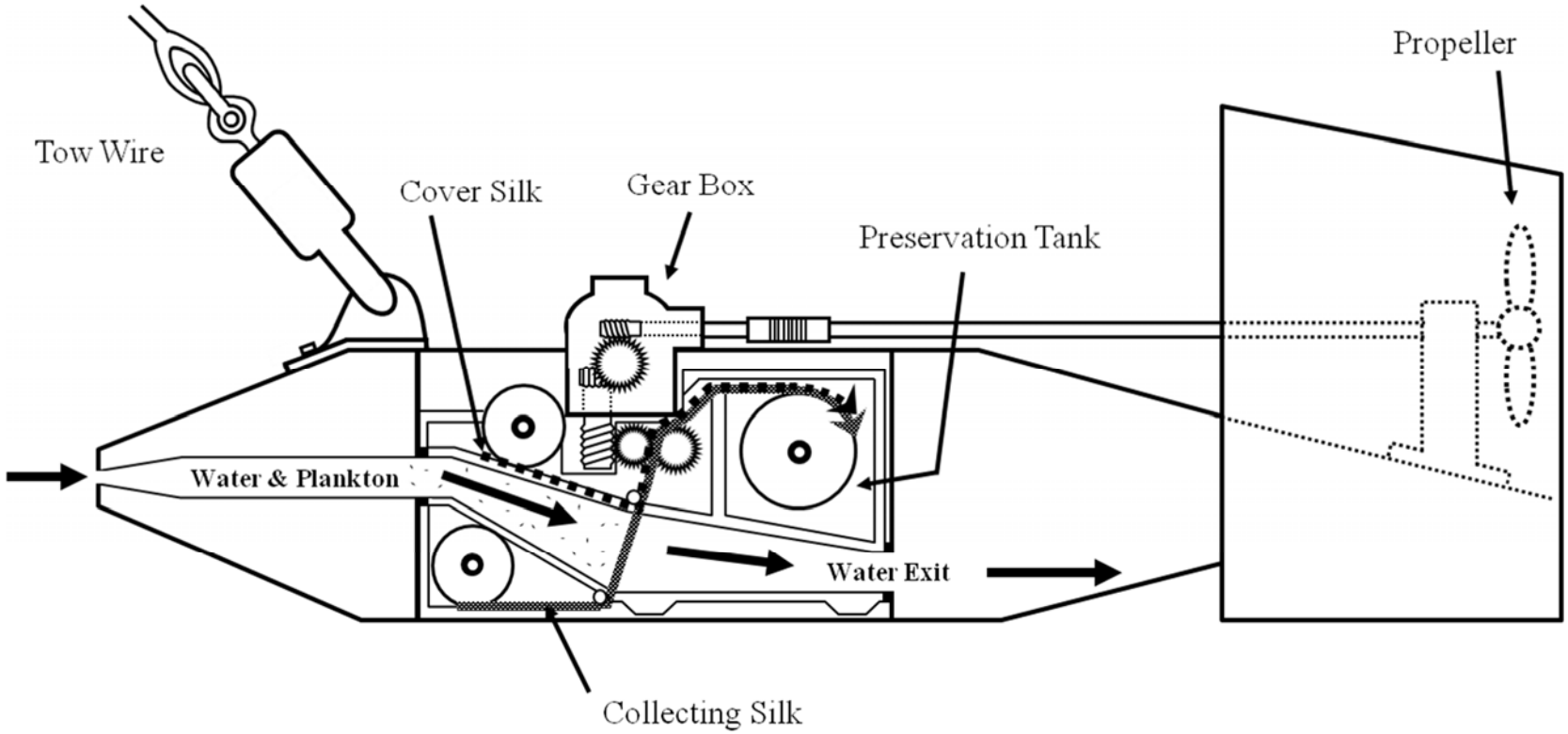

Fig. 1. Cutaway view of the internal mechanism of the CPR, Type II (Mark V) designed by the Australian Antarctic Division (Hosie *et al*., 2003). Plankton are filtered by the collecting silk (▒) stretched across the tunnel. The plankton are then met by the cover silk (▮▮▮) before rolling into the preservation tank.

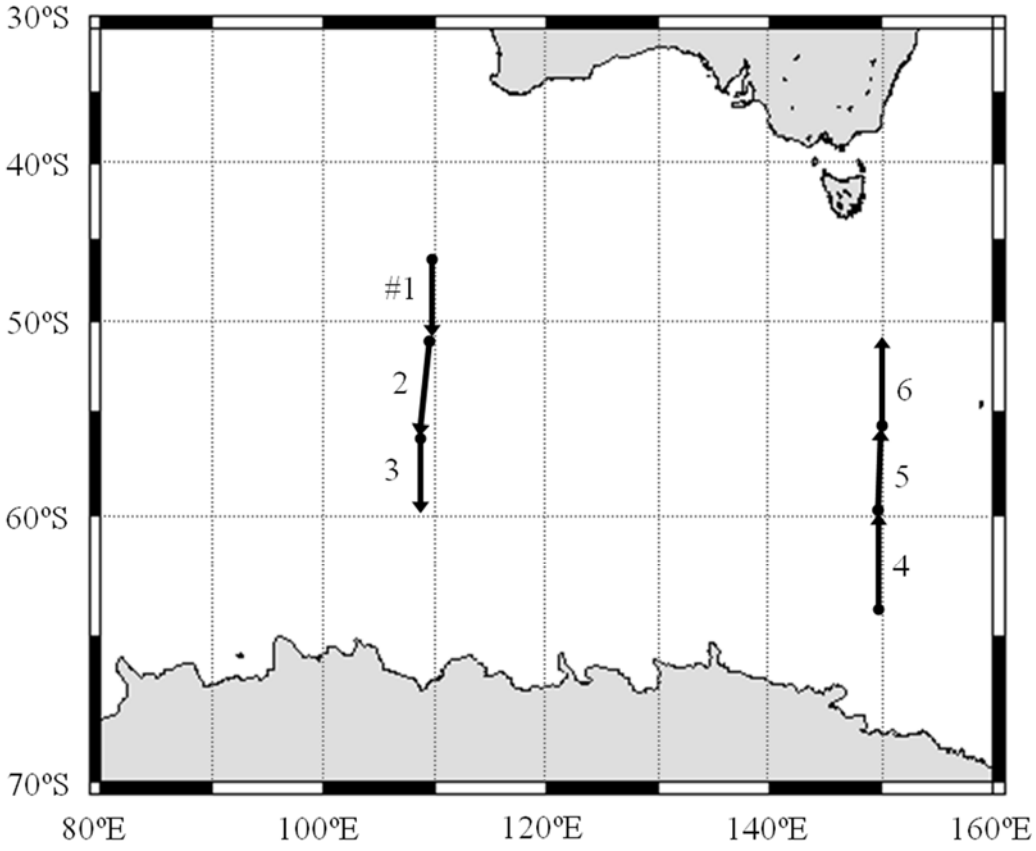

Fig. 2. Transect of the CPR survey during JARE-51 in 2009/2010. Numbers indicate the serial number (#) of the CPR run. ●: Start position, ▼: End position.

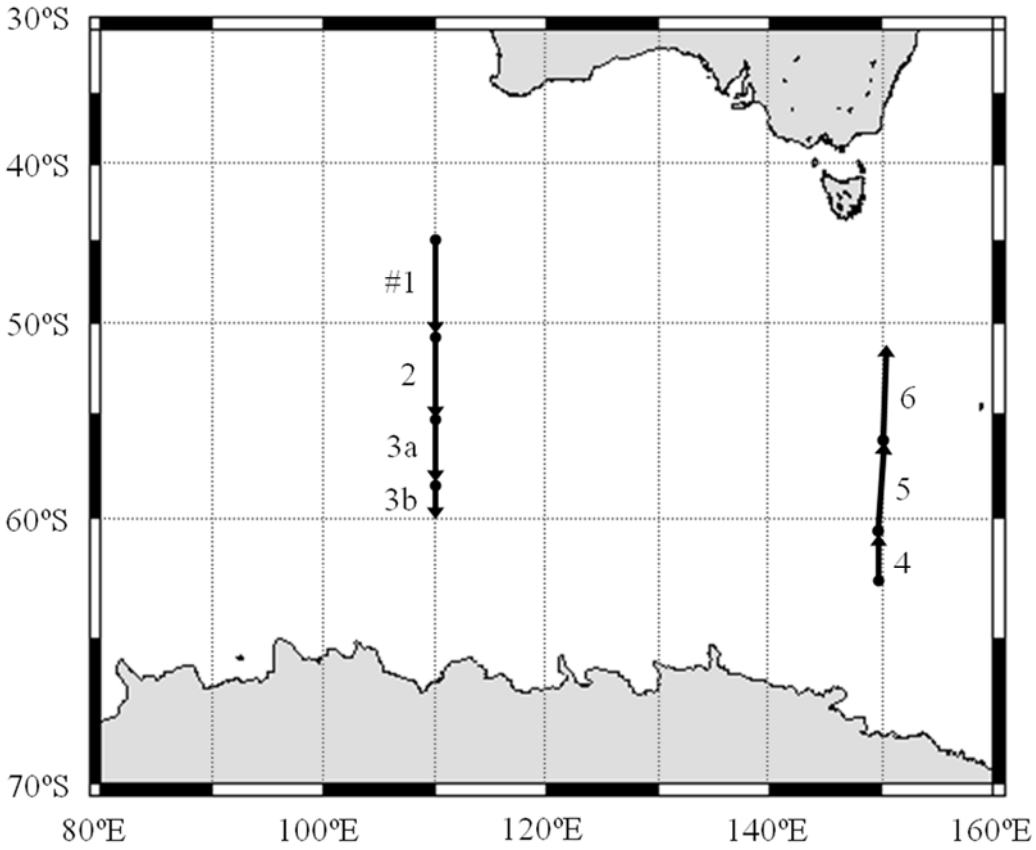

Fig. 3. Transect of the CPR survey during JARE-52 in 2010/2011. Numbers indicate the serial number (#) of the CPR run. ●: Start position, ▼: End position.

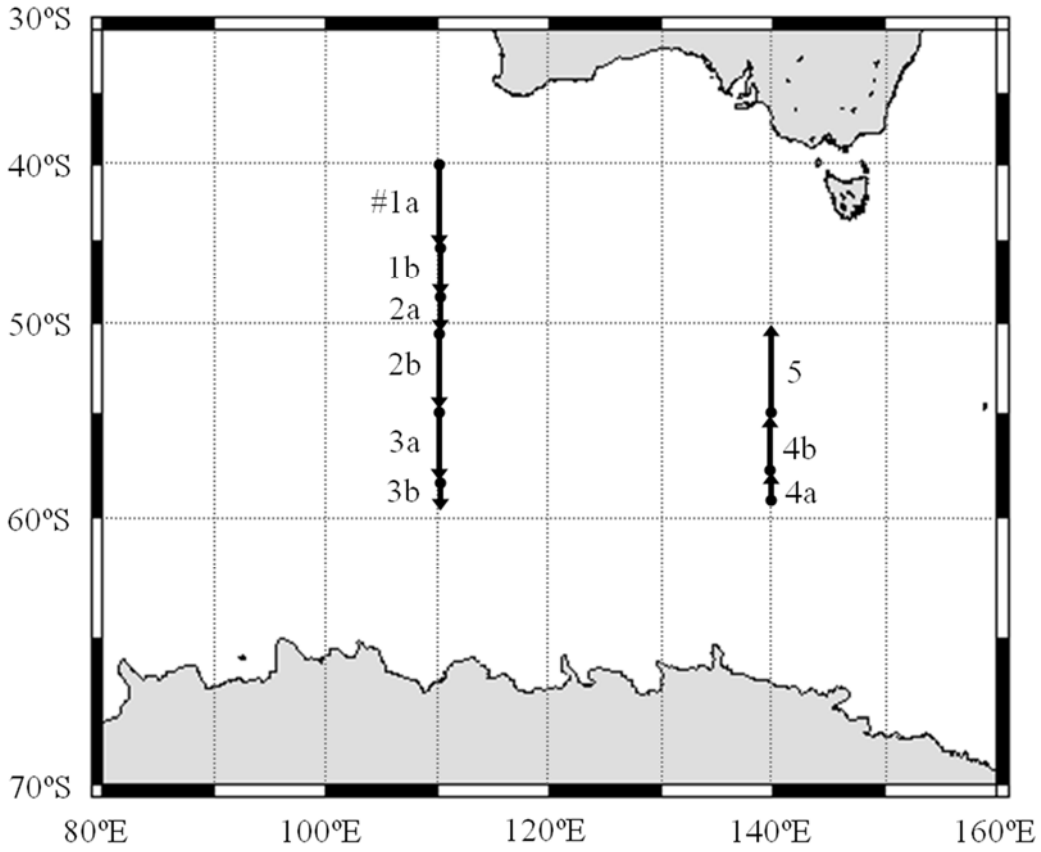

Fig. 4. Transect of the CPR survey during *Umitaka-Maru* cruise in 2010/2011. Numbers indicate the serial number (#) of the CPR run. ●: Start position, ▼: End position.

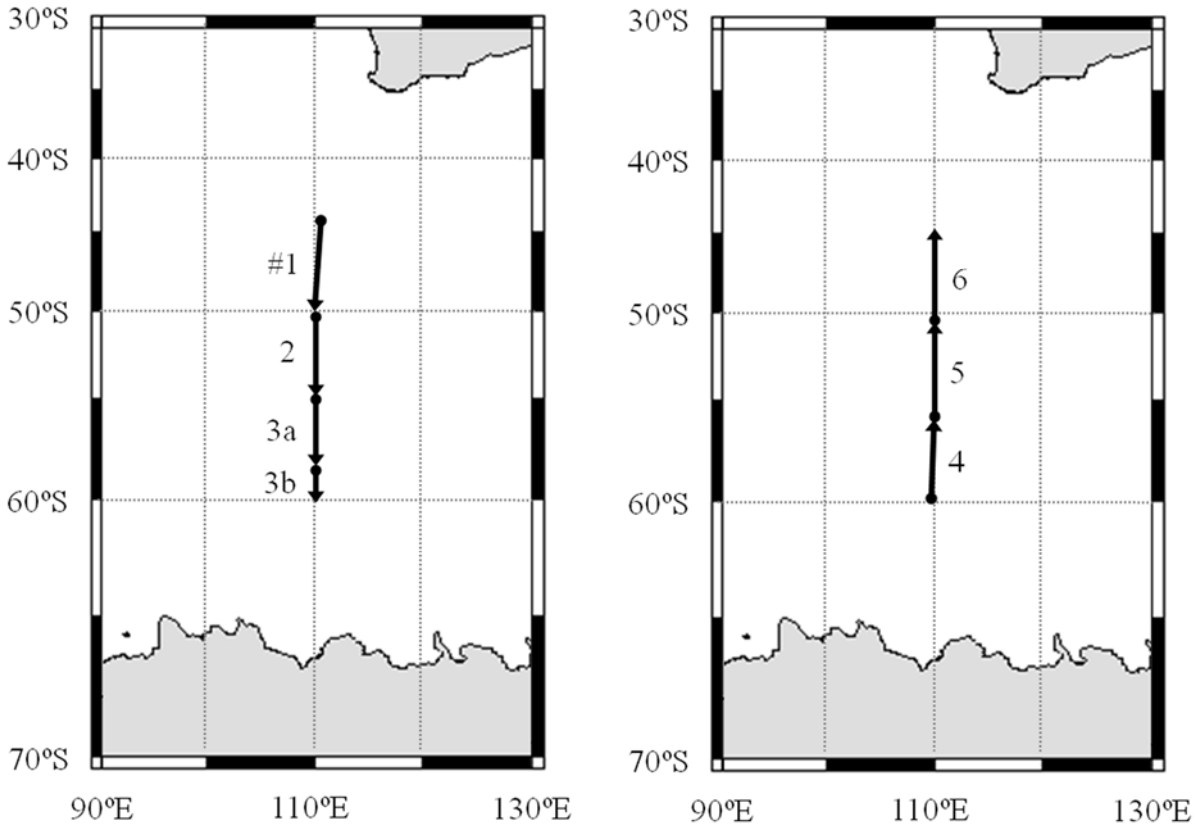

Fig. 5. Transect of the CPR survey during JARE-53 in 2011/2012. Numbers indicate the serial number (#) of the CPR run. ●: Start position, ▼: End position.

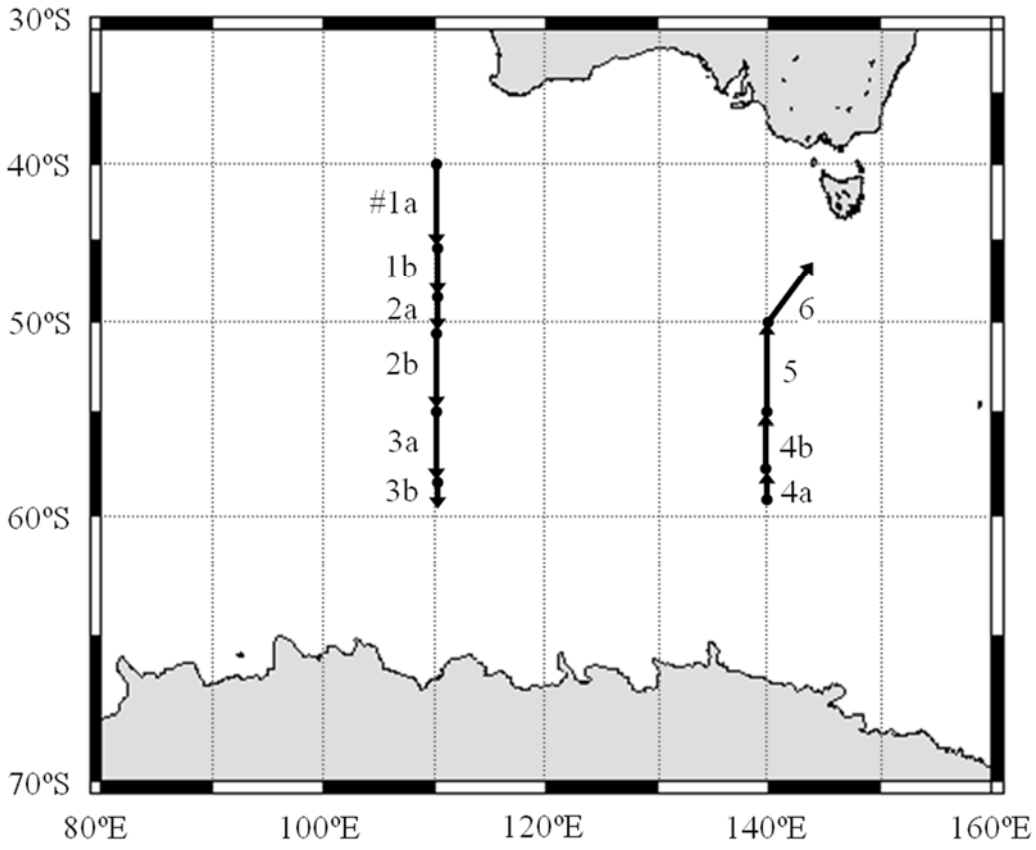

Fig. 6. Transect of the CPR survey during *Umitaka-Maru* cruise in 2011/2012. Numbers indicate the serial number (#) of the CPR run. ●: Start position, ▼: End position.

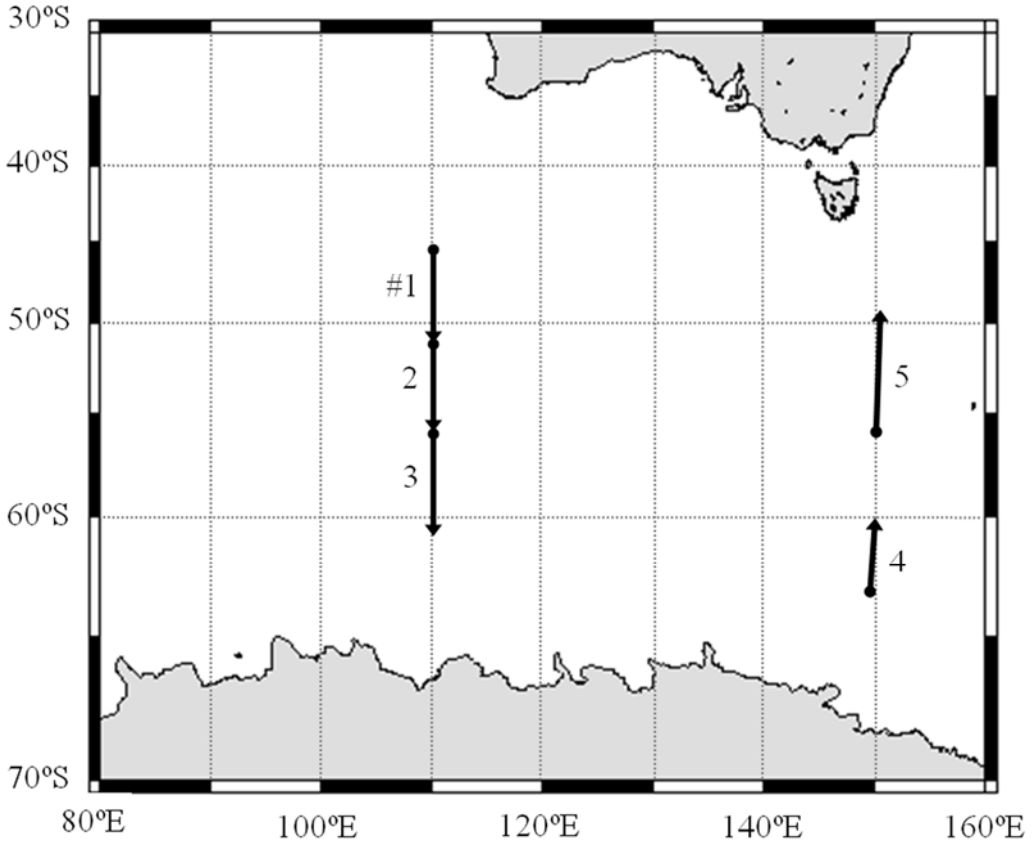

Fig. 7. Transect of the CPR survey during JARE-54 in 2012/2013. Numbers indicate the serial number (#) of the CPR run. ●: Start position, ▼: End position.

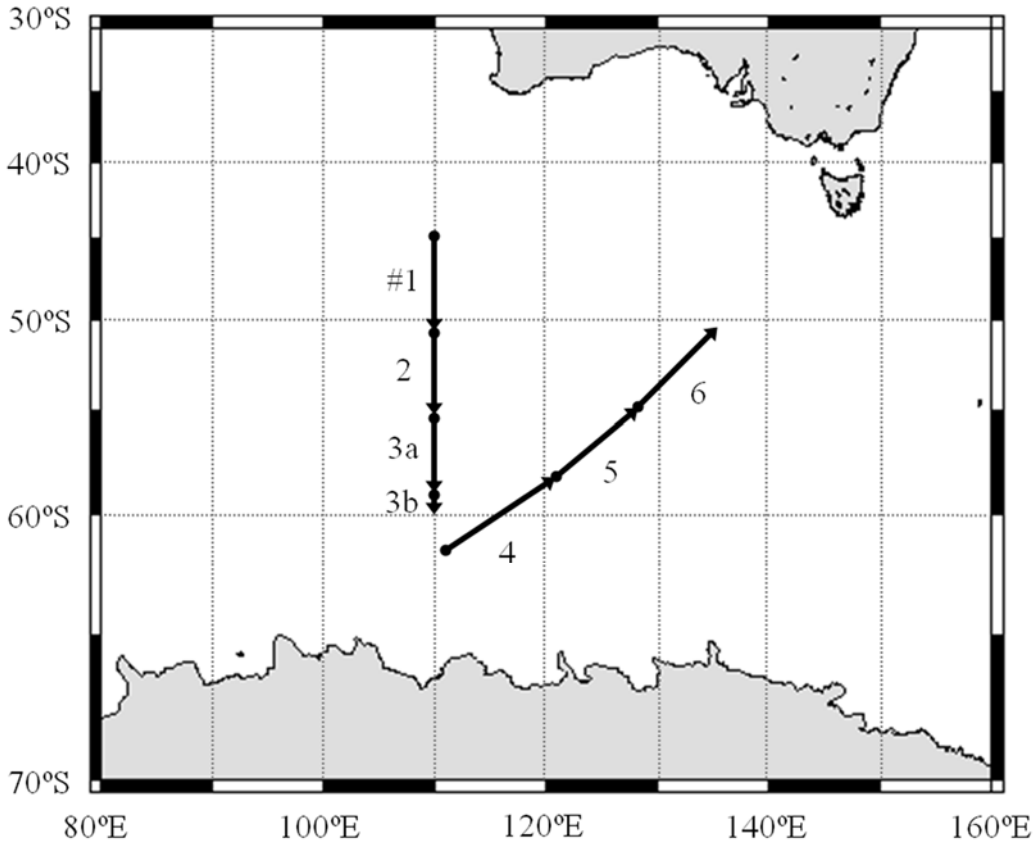

Fig. 8. Transect of the CPR survey during *Umitaka-Maru* cruise in 2013. Numbers indicate the serial number (#) of the CPR run. ●: Start position, ▼: End position.

Table 1. Data on plankton collected by Continuous Plankton Recorder (CPR) during the JARE-51 cruise of the *Shirase* to the Indian sector of the Southern Ocean, December 2009 to March 2010. Samplings was performed by H. Shinagawa.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1	Dec. 2, 2009; 01:54	45° 52.3´S 110° 01.4´E	Dec. 3, 2009; 00:40	50° 55.3´S 110° 05.9´E	61	560	
2	Dec. 3, 2009; 01:57	50° 55.0´S 110° 07.9´E	Dec. 4, 2009; 00:39	55° 30.9´S 108° 38.5´E	58	533	
3	Dec. 4, 2009; 02:20	55° 34.1´S 108° 40.1´E	Dec. 5, 2009; 00:39	59° 19.7´S 108° 39.5´E	46	422	
4	Mar. 7, 2010; 00:23	64° 07.4´S 149° 45.2´E	Mar. 8, 2010; 22:49	60° 12.8´S 149° 48.2´E	58	535	
5	Mar. 9, 2010; 00:10	60° 11.4´S 149° 54.0´E	Mar. 11, 2010; 06:34	55° 32.3´S 150° 02.9´E	70	642	
6	Mar. 11, 2010; 06:43	55° 31.8´S 150° 02.8´E	Mar. 12, 2010; 06:06	50° 49.1´S 150° 02.9´E	58	532	

*Each segment of cut silk corresponds to 5 nautical miles of towing distance.

Table 2. Data on plankton collected by Continuous Plankton Recorder (CPR) during the JARE-52 cruise of the *Shirase* to the Indian sector of the Southern Ocean, December 2010 to March 2011. Samplings was performed by T. Odate.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1	Dec. 3, 2010; 01:52	45° 11.2´S 110° 00.2´E	Dec. 4, 2010; 00:52	50° 35.4´S 110° 00.8´E	65	600	
2	Dec. 4, 2010; 02:14	50° 36.7´S 110° 02.0´E	Dec. 5, 2010; 00:51	54° 53.3´S 109° 59.9´E	52	475	
3a	Dec. 5, 2010; 02:02	54° 53.6´S 110° 00.7´E	Dec. 5, 2010; 23:52	58° 24.4´S 110° 00.0´E	43	390	
3b	Dec. 6, 2010; 00:55	58° 25.3´S 110° 01.0´E	Dec. 6, 2010; 06:52	59° 58.9´S 110° 00.0´E	19	173	
4	Mar. 10, 2011; 21:41	63° 05.4´S 149° 48.6´E	Mar. 11, 2011; 06:04	60° 53.2´S 149° 48.6´E	27	245	
5	Mar. 11, 2011; 07:13	60° 54.2´S 149° 50.9´E	Mar. 12, 2011; 06:57	55° 58.4´S 150° 01.1´E	60	550	
6	Mar. 12, 2011; 08:32	56° 02.2´S 150° 03.2´E	Mar. 13, 2011; 04:57	50° 57.7´S 150° 10.3´E	62	565	

*Each segment of cut silk corresponds to 5 nautical miles of towing distance.

Table 3. Data on plankton collected by Continuous Plankton Recorder (CPR) during the JARE-52 cruise of the *Umitaka-Maru* to the Indian sector of the Southern Ocean, December 2010 to January 2011. Samplings was performed by K. Uchiyama.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1a	Dec. 26, 2010; 02:22	40° 00.3´S 109° 59.8´E	Dec. 26, 2010; 20:35	44° 55.3´S 110° 00.0´E	60	547	Failed
1b	Dec. 27, 2010; 01:55	44° 59.8´S 110° 00.9´E	Dec. 27, 2010; 13:42	47° 30.2´S 110° 00.9´E	31	279	
2a	Dec. 27, 2010; 13:51	47° 30.6´S 110° 00.5´E	Dec. 28, 2010; 04:31	49° 59.7´S 110° 00.3´E	30	276	
2b	Dec. 28, 2010; 09:47	50° 00.9´S 110° 00.4´E	Dec. 29, 2010; 06:26	54° 59.8´S 110° 00.0´E	60	555	
3a	Dec. 29, 2010; 13:28	55° 04.5´S 110° 01.0´E	Dec. 30, 2010; 05:53	58° 24.5´S 109° 59.6´E	41	371	
3b	Dec. 30, 2010; 11:25	58° 24.7´S 110° 07.0´E	Dec. 30, 2010; 23:18	59° 34.1´S 113° 32.9´E	26	235	
4a	Jan. 16, 2011; 00:12	58° 59.6´S 140° 00.2´E	Jan. 16, 2011; 04:36	58° 10.4´S 139° 59.8´E	10	91	

*Each segment of cut silk corresponds to 5 nautical miles of towing distance.

Table 3. Continued.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
4b	Jan. 16, 2011; 06:07	58° 09.9´S 139° 59.5´E	Jan. 16, 2011; 23:57	55° 00.5´S 139° 59.3´E	39	357	
5	Jan. 17, 2011; 02:55	54° 59.6´S 139° 59.8´E	Jan. 18, 2011; 07:53	50° 01.8´S 143° 38.5´E	65	598	Failed

*Each segment of cut silk corresponds to 5 nautical miles of towing distance.

Table 4. Data on plankton collected by Continuous Plankton Recorder (CPR) during the JARE-53 cruise of the *Shirase* to the Indian sector of the Southern Ocean, December 2011 to March 2012. Samplings was performed by K. T. Takahashi.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1	Dec. 3, 2011; 07:48	44° 21.6´S 110° 30.3´E	Dec. 4, 2011; 06:23	49° 50.4´S 110° 04.9´E	66	611	
2	Dec. 4, 2011; 07:35	49° 50.5´S 110° 02.0´E	Dec. 5, 2011; 06:23	54° 56.9´S 110° 00.8´E	63	574	
3a	Dec. 5, 2011; 07:49	54° 58.9´S 110° 05.3´E	Dec. 5, 2011; 23:50	58° 20.5´S 109° 59.8´E	41	374	
3b	Dec. 6, 2011; 00:51	58° 22.3´S 110° 01.3´E	Dec. 6, 2011; 05:51	59° 34.2´S 109° 59.7´E	15	120	
4	Mar. 10, 2012; 06:55	59° 53.6´S 109° 48.6´E	Mar. 11, 2012; 00:32	55° 43.4´S 109° 58.8´E	51	466	
5	Mar. 11, 2012; 01:42	55° 42.8´S 109° 58.6´E	Mar. 12, 2012; 00:35	50° 11.3´S 109° 59.3´E	67	617	
6	Mar. 12, 2012; 01:46	50° 10.8´S 110° 05.6´E	Mar. 13, 2012; 00:34	44° 35.3´S 109° 59.3´E	68	625	

*Each segment of cut silk corresponds to 5 nautical miles of towing distance.

Table 5. Data on plankton collected by Continuous Plankton Recorder (CPR) during the JARE-53 cruise of the *Umitaka-Maru* to the Indian sector of the Southern Ocean, December 2011 to January 2012. Samplings was performed by T. Iida.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1a	Dec. 29, 2011; 00:32	40° 00.0´S 109° 59.9´E	Dec. 29, 2011; 22:49	45° 01.7´S 110° 00.7´E	61	559	
1b	Dec. 30, 2011 05:51	45° 00.2´S 110° 00.4´E	Dec. 30, 2011; 12:41	46° 36.9´S 110° 01.3´E	20	179	Failed
2a	Dec. 30, 2011; 12:50	46° 37.3´S 110° 01.6´E	Dec. 31, 2011; 02:53	49° 59.8´S 110° 00.0´E	41	375	Failed
2b	Dec. 31, 2011; 07:08	50° 00.3´S 110° 00.9´E	Jan. 1, 2012; 05:53	54° 59.1´S 110° 00.9´E	61	557	
3a	Jan. 1, 2012; 07:15	55° 04.5´S 110° 02.4´E	Jan. 2, 2012; 03:49	58° 20.9´S 110° 00.1´E	43	389	
3b	Jan. 2, 2012; 09:45	58° 22.4´S 110° 02.9´E	Jan. 2, 2012; 19:38	59° 59.6´S 109° 58.7´E	20	180	
4a	Jan. 27, 2012; 02:57	59° 55.3´S 139° 59.4´E	Jan. 27, 2012; 07:47	59° 00.1´S 140° 00.6´E	11	100	

*Each segment of cut silk corresponds to 5 nautical miles of towing distance.

Table 5. Continued.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
4b	Jan. 27, 2012; 15:26	58° 59.4´S 139° 59.8´E	Jan. 28, 2012; 08:11	55° 02.4´S 139° 59.8´E	48	439	
5	Jan. 28, 2012; 12:04	54° 59.7´S 140° 00.2´E	Jan. 29, 2012; 08:46	49° 59.8´S 140° 00.0´E	60	555	
6	Jan. 29, 2012; 12:09	49° 59.3´S 140° 00.6´E	Jan. 30, 2012; 05:39	46° 49.2´S 144° 03.8´E	49	452	

*Each segment of cut silk corresponds to 5 nautical miles of towing distance.

Table 6. Data on plankton collected by Continuous Plankton Recorder (CPR) during the JARE-54 cruise of the *Shirase* to the Indian sector of the Southern Ocean, December 2012 to March 2013. Samplings was performed by T. Takamura.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1	Dec. 3, 2012; 02:13	45° 34.5´S 110° 03.4´E	Dec. 4, 2012; 01:09	50° 31.6´S 109° 58.9´E	60	553	
2	Dec. 4, 2012; 03:45	50° 36.4´S 110° 03.8´E	Dec. 5, 2012; 01:07	55° 26.9´S 109° 58.5´E	59	544	
3	Dec. 5, 2012; 02:13	55° 27.8´S 109° 57.7´E	Dec. 6, 2012; 01:07	60° 49.9´S 110° 02.9´E	65	601	
4	Mar. 9, 2013; 23:43	63° 11.8´S 149° 14.7´E	Mar. 10, 2013; 20:42	60° 10.0´S 149° 58.8´E	38	344	
5	Mar. 12, 2013; 06:30	55° 57.6´S 150° 02.8´E	Mar. 13, 2013; 21:58	49° 12.3´S 150° 23.7´E	82	756	

*Each segment of cut silk corresponds to 5 nautical miles of towing distance.

Table 7. Data on plankton collected by Continuous Plankton Recorder (CPR) during the JARE-54 cruise of the *Umitaka-Maru* to the Indian sector of the Southern Ocean, January 2013. Samplings was performed by T. Iida.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1	Jan. 3, 2013; 01:44	45° 04.0´S 110° 00.9´E	Jan. 4, 2013; 05:01	50° 28.6´S 110° 00.2´E	67	614	
2	Jan. 4, 2013; 09:41	50° 28.6´S 110° 02.1´E	Jan. 5, 2013; 05:38	55° 00.7´S 110° 00.0´E	55	504	
3a	Jan. 5, 2013; 10:54	55° 01.5´S 109° 59.9´E	Jan. 6, 2013; 04:30	59° 00.3´S 110° 00.0´E	48	442	
3b	Jan. 6, 2013; 09:18	59° 01.2´S 110° 00.9´E	Jan. 6, 2013; 13:53	59° 58.1´S 110° 08.8´E	12	110	
4	Jan. 18, 2013; 07:09	61° 55.9´S 110° 34.8´E	Jan. 19, 2013; 09:30	57° 52.0´S 120° 15.6´E	77	704	
5	Jan. 19, 2013; 09:47	57° 51.2´S 120° 17.6´E	Jan. 20, 2013; 09:00	54° 27.9´S 127° 48.6´E	65	600	
6	Jan. 20, 2013; 09:12	54° 27.3´S 127° 50.4´E	Jan. 21, 2013; 08:38	50° 55.6´S 134° 45.7´E	66	611	

*Each segment of cut silk corresponds to 5 nautical miles of towing distance.

Table 8. List of scientists participating in each cruise.

JARE (Year)	Name of members	Affiliations *
JARE-51 (2009/10)		
Shirase	H. Shinagawa	University of Tsukuba
JARE-52 (2010/11)		
Shirase	T. Odate	National Institute of Polar Research
Umitaka-Maru	K. Uchiyama	Tokyo University of Marine Science and Technology
JARE-53 (2011/12)		
Shirase	K.T. Takahashi	National Institute of Polar Research
Umitaka-Maru	T. Iida	National Institute of Polar Research
JARE-54 (2012/13)		
Shirase	T. Takamura	National Institute of Polar Research
Umitaka-Maru	T. Iida	National Institute of Polar Research

*Affiliations are for the year each scientist was on board.