

## Plankton Sampling on Board *Shirase* in 1999–2004 — Continuous Plankton Recorder survey —

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### Introduction

In the Indian Ocean sector of the Antarctic Ocean, the Japanese Antarctic Research Expedition (JARE) has been conducting routine zooplankton observations with a NORPAC standard net every austral summer since 1972 (JARE-14), initially on icebreaker *Fuji* and later *Shirase* (Fukuchi and Tanimura, 1981; Watanabe *et al.*, 1984; Takahashi *et al.*, 1997; Sawabe *et al.*, 2005). The NORPAC net has been invaluable in demonstrating 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, it was noted that the NORPAC net was 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. As a part of the monitoring program in Antarctica, the JARE has initiated a Continuous Plankton Recorder (CPR) survey since 1999 (JARE-41), in order to help to interpret the data collected by NORPAC net. This report presented the sampling information and distance traveled of the CPR tows aboard the icebreaker *Shirase* during 1999–2004 (JARE-41–45). Additionally, information of the CPR tows aboard the RV *Tangaroa*, chartered by the JARE-43 in 2002, are also presented.

### Background about CPR

The CPR was designed by Sir Alister Hardy in the mid 1920s, and firstly used

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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. Therefore, CPRs have been used successfully in the monitoring of zooplankton communities in the North Sea and North Atlantic Ocean over the past seventy years, operated by the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) (Reid *et al.*, 2003). The Australian Antarctic program has initiated a long-term CPR survey in 1991 to monitor zooplankton abundances and distribution patterns in the Southern Ocean (Hosie *et al.*, 2003). The Australian CPR survey covers a wide area through much of the year depending on logistics and research objectives. By comparison, *Shirase* travels along much the same cruise track each season and at roughly the same time of year. The collection of CPR data on *Shirase* will be a very important time reference to help interpret the data collected by Australia 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 *Shirase* were conducted on three transects such as south along 110°E from 45°S to the ice edge in December, west between 80 and 150°E along 63°S in February to March, and north along 150°E. From 2002 (JARE-44), six tows are scheduled on each voyage, three tows south along 110°E from 45°S to ice edge and three tows north along 150°E. We used a Type II (Mark V) CPR (Fig. 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. Depth of CPR tow was about 10 m. The instrument has a mouth opening of 1.6 cm<sup>2</sup> and was fitted with 270 µm silk mesh. The movement of the CPR through the water turns an external propeller, which drives the mesh rolls across the tunnel at a rate of approximately 1 cm per 1 nautical miles 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 returned to the laboratory for analysis. The CPR mesh rolls were cut into segments, each representing 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).

Sampling stations during the period in 1999–2004 (JARE-41~45) are shown in Figs. 2–7, and the data are listed in Tables 1–6.

### Scientists on board

The samplings during each cruise were carried out by the following members who participated in JARE and acknowledgments are given to these persons listed below;

JARE (Year)	Name of members	Affiliations *
JARE-41 (1999/2000)	H. Umeda	The Graduate University for Advanced Studies
	C. Hamada	Nichiyu Giken Kogyo Co., LTD.
JARE-42 (2000/01)	T. Hirawake	National Institute of Polar Research
	S. Ban	Hokkaido University
	W. Sato-Okoshi	Tohoku University
JARE-43 (2001/02)		
<i>Shirase</i>	T. Hirawake	National Institute of Polar Research
	H. Kinoshita	Japan Coast Guard
	T. Nosaka	Japan Coast Guard
<i>Tangaroa</i>	K. T. Takahashi	The Graduate University for Advanced Studies
JARE-44 (2002/03)	T. Masuzawa	Shizuoka University
JARE-45 (2003/04)	M. Iida	Hokkaido University

\*Affiliations are as of the year they were on board.

### Data policy

Before using the data for publication or presentation, please request permission in writing. Inquiries about details of the data record should be addressed to:

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Phone: +81-3-3962-6031, Facsimile: +81-3-3962-4914  
E-mail: fukuchi@nipr.ac.jp

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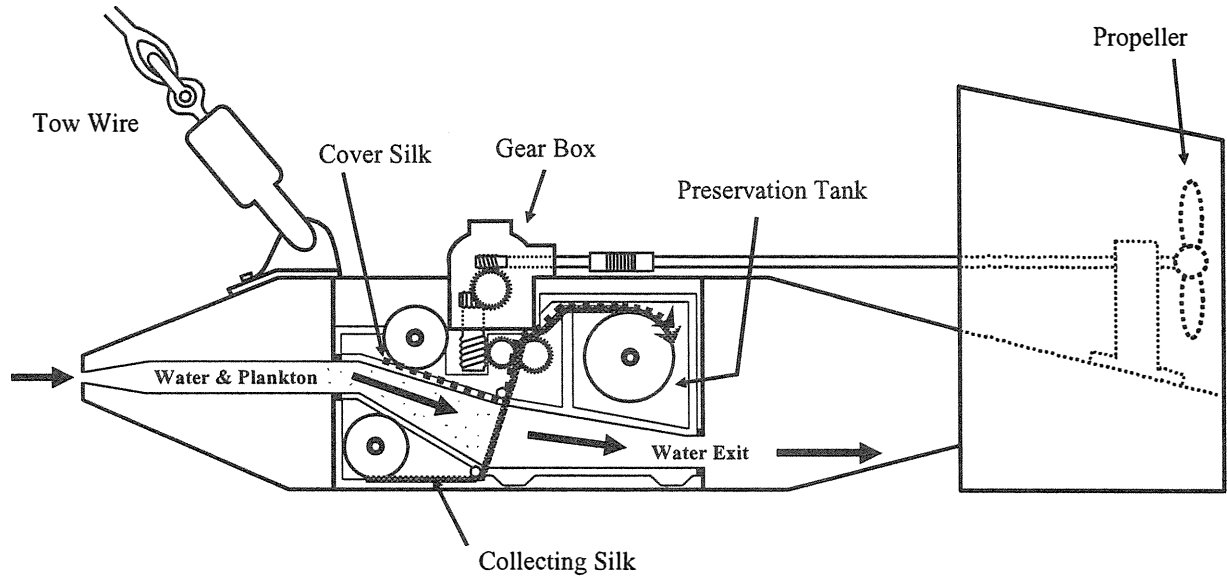




Fig. 1. Cutaway view of the internal mechanisms of the Australian Antarctic Division designed CPR, Type II (Mark V) (Hosie *et al.*, 2003). Plankton are filtered by the collecting silk (  ) stretched across the tunnel. This is then met by the cover silk (  ) before rolling into the preservation tank.

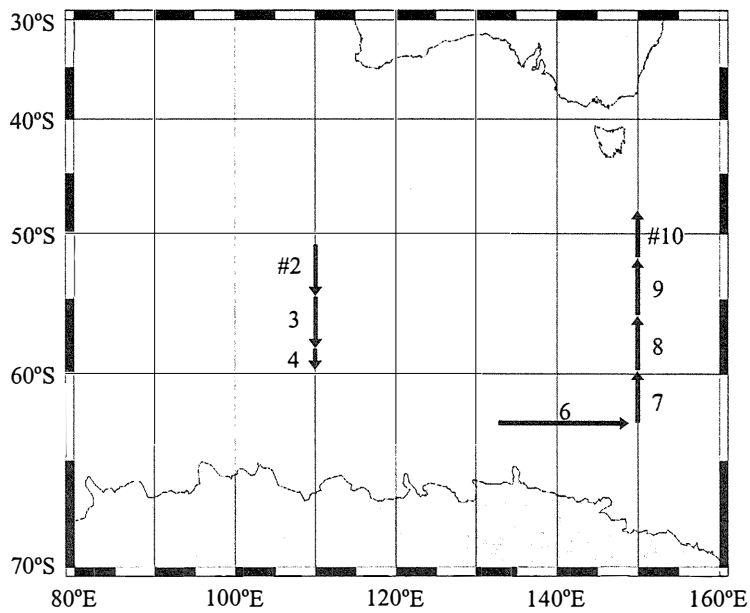


Fig. 2. Map showing the locations of the CPR survey during JARE-41 in 1999/2000. The arrows indicate the direction and distance covered during each tow. Numerals indicate CPR run number in reference to the Table 1.

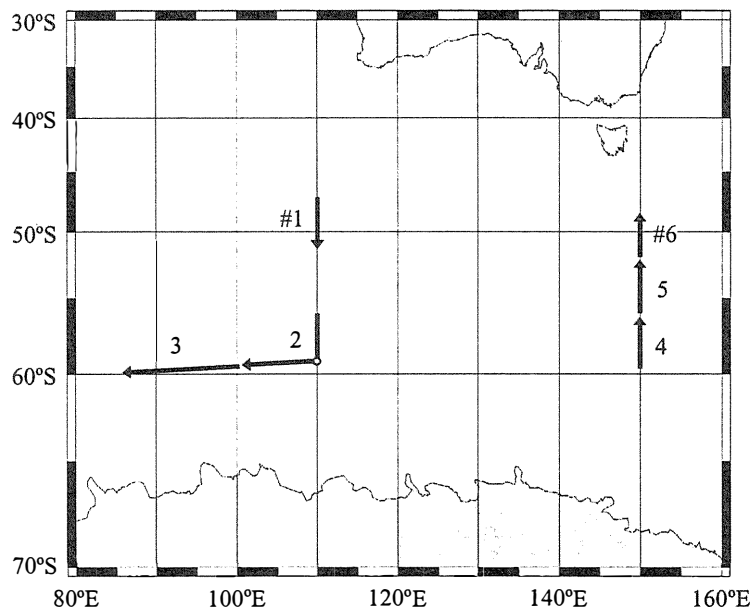


Fig. 3. Map showing the locations of the CPR survey during JARE-42 in 2000/2001. The arrows indicate the direction and distance covered during each tow. Numerals indicate CPR run number in reference to the Table 2. ○: CTD position.

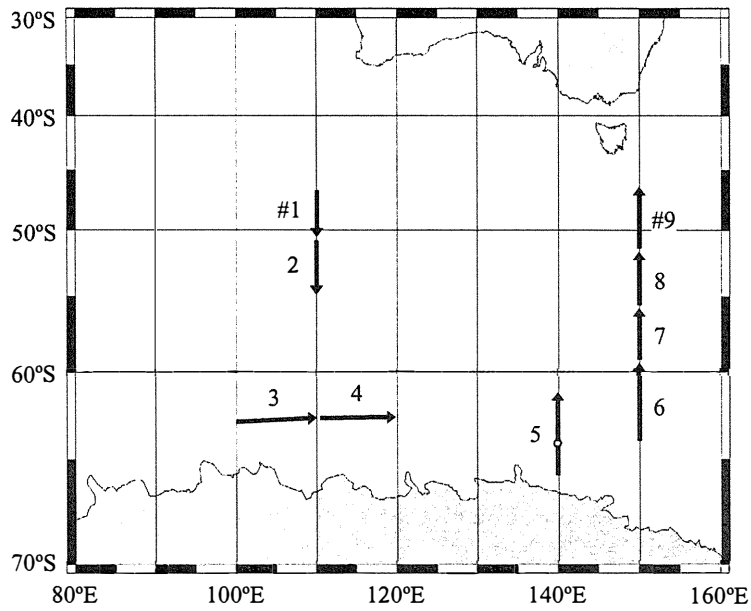


Fig. 4. Map showing the locations of the CPR survey during JARE-43 in 2001/2002. The arrows indicate the direction and distance covered during each tow. Numerals indicate CPR run number in reference to the Table 3. ○: CTD position.

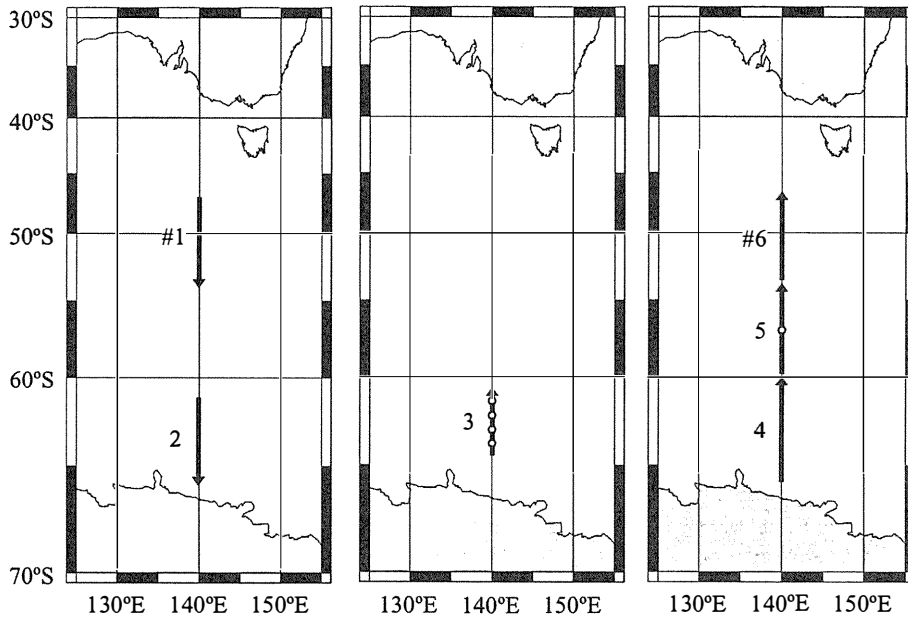


Fig. 5. Map showing the locations of the CPR survey during JARE-43 *Tangaroa* cruise in 2002. The arrows indicate the direction and distance covered during each tow. Numerals indicate CPR run number in reference to the Table 4. ○: CTD position.

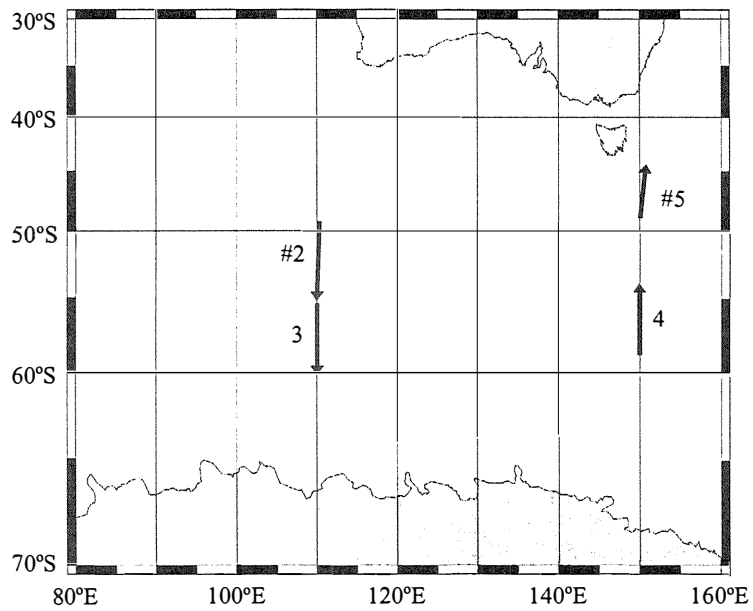


Fig. 6. Map showing the locations of the CPR survey during JARE-44 in 2002/2003. The arrows indicate the direction and distance covered during each tow. Numerals indicate CPR run number in reference to the Table 5.

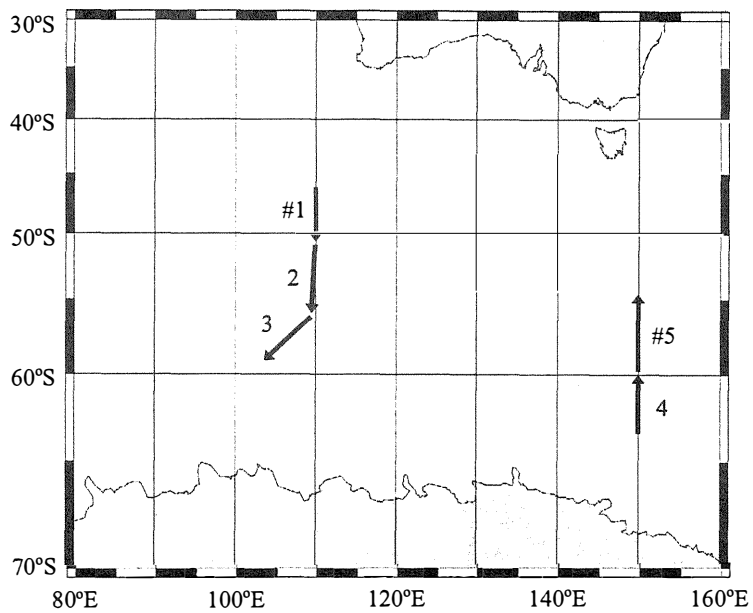


Fig. 7. Map showing the locations of the CPR survey during JARE-45 in 2003/2004. The arrows indicate the direction and distance covered during each tow. Numerals indicate CPR run number in reference to the Table 6.



Table 1. Data on plankton collected by Continuous Plankton Recorder (CPR) in the JARE-41 cruise of the *Shirase* to the Indian sector of the Southern Ocean, December 1999–March 2000. Samplings were carried out by H. Umeda and C. Hamada.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1	Dec. 6, 1999; 09:42	46° 17.3'S 110° 13.3'E	Dec. 7, 1999; 06:00	50° 26.3'S 110° 00.0'E	—	—	Failed
2	Dec. 7, 1999; 08:55	50° 26.5'S 110° 02.0'E	Dec. 8, 1999; 06:00	55° 03.7'S 109° 59.6'E	56	514	
3	Dec. 8, 1999; 09:54	55° 13.7'S 110° 12.3'E	Dec. 9, 1999; 02:55	59° 02.7'S 109° 45.6'E	47	424	
4	Dec. 9, 1999; 03:05	59° 04.5'S 109° 45.4'E	Dec. 9, 1999; 06:00	59° 44.2'S 109° 52.3'E	8	74	
5	Mar. 4, 2000; 01:50	63° 01.1'S 90° 00.0'E	Mar. 6, 2000; 01:48	62° 59.8'S 106° 30.0'E	—	—	Failed
6	Mar. 9, 2000; 07:54	62° 59.9'S 133° 00.5'E	Mar. 11, 2000; 07:15	62° 59.5'S 149° 22.3'E	90	824	
7	Mar. 12, 2000; 04:24	62° 59.4'S 150° 02.0'E	Mar. 13, 2000; 02:48	59° 39.0'S 149° 57.0'E	41	371	
8	Mar. 13, 2000; 04:22	59° 39.9'S 150° 03.6'E	Mar. 14, 2000; 02:50	56° 35.0'S 149° 59.5'E	38	343	
9	Mar. 14, 2000; 04:39	56° 36.4'S 150° 02.8'E	Mar. 15, 2000; 02:50	52° 17.8'S 149° 59.0'E	52	479	
10	Mar. 15, 2000; 04:47	52° 17.8'S 150° 07.2'E	Mar. 16, 2000; 04:28	47° 40.2'S 150° 05.2'E	57	515	

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

Table 2. Data on plankton collected by Continuous Plankton Recorder (CPR) in the JARE-42 cruise of the *Shirase* to the Indian sector of the Southern Ocean, December 2000–March 2001. Samplings were carried out by T. Hirawake, S. Ban and W. Sato-Okoshi.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1	Dec. 6, 2000; 08:05	46° 40.1'S 110° 08.3'E	Dec. 7, 2000; 05:46	51° 31.9'S 110° 01.0'E	61	541	
2a	Dec. 8, 2000; 07:14	55° 53.3'S 110° 02.6'E	Dec. 9, 2000; 00:47	59° 16.6'S 109° 59.7'E	41	377	
2b	Dec. 9, 2000; 03:26	59° 16.4'S 110° 01.8'E	Dec. 10, 2000; 00:51	59° 37.4'S 100° 38.0'E	58	532	
3	Dec. 10, 2000; 00:59	59° 37.6'S 100° 37.1'E	Dec. 11, 2000; 09:53	59° 51.5'S 85° 55.5'E	90	822	
4	Mar. 14, 2001; 06:30	59° 53.0'S 149° 56.9'E	Mar. 15, 2001; 02:43	56° 32.4'S 149° 56.5'E	41	372	
5	Mar. 15, 2001; 04:55	56° 33.1'S 150° 09.4'E	Mar. 16, 2001; 02:43	51° 52.9'S 150° 01.6'E	57	519	
6	Mar. 16, 2001; 03:29	51° 52.9'S 150° 08.9'E	Mar. 16, 2001; 21:20	48° 25.8'S 149° 59.6'E	43	384	

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

Table 3. Data on plankton collected by Continuous Plankton Recorder (CPR) in the JARE-43 cruise of the *Shirase* to the Indian sector of the Southern Ocean, December 2001–March 2002. Samplings were carried out by T. Hirawake, H. Kinoshita and T Nosaka.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1	Dec. 6, 2001; 08:40	46° 54.1'S 109° 54.5'E	Dec. 7, 2001; 01:30	50° 39.7'S 109° 58.6'E	42	420	
2	Dec. 7, 2001; 04:15	50° 38.0'S 110° 07.1'E	Dec. 8, 2001; 06:02	55° 08.8'S 108° 45.3'E	56	510	
3	Mar. 5, 2002; 07:43	63° 34.9'S 100° 01.0'E	Mar. 6, 2002; 05:48	63° 14.6'S 110° 25.2'E	58	519	
4	Mar. 6, 2002; 08:50	63° 18.5'S 110° 23.3'E	Mar. 7, 2002; 05:51	63° 20.3'S 119° 55.7'E	53	475	
5a	Mar. 10, 2002; 06:54	65° 30.5'S 140° 00.9'E	Mar. 10, 2002; 22:46	63° 58.4'S 140° 00.3'E	24	171	
5b	Mar. 11, 2002; 01:17	64° 00.1'S 140° 03.2'E	Mar. 11, 2002; 22:46	61° 00.9'S 139° 58.3'E	36	332	
6	Mar. 13, 2002; 05:21	64° 02.7'S 150° 03.4'E	Mar. 14, 2002; 02:47	59° 12.2'S 150° 00.4'E	58	541	
7	Mar. 14, 2002; 05:10	59° 11.1'S 150° 07.1'E	Mar. 15, 2002; 02:46	56° 17.6'S 149° 58.4'E	35	324	
8	Mar. 15, 2002; 05:27	56° 16.1'S 150° 04.4'E	Mar. 16, 2002; 02:57	51° 59.5'S 150° 18.1'E	56	504	
9	Mar. 16, 2002; 03:05	51° 59.3'S 150° 17.1'E	Mar. 17, 2002; 02:51	46° 45.1'S 149° 57.8'E	69	637	

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

Table 4. Data on plankton collected by Continuous Plankton Recorder (CPR) in the JARE-43 cruise of the *Tangaroa* to the Indian sector of the Southern Ocean, February–March 2002. Samplings were carried out by K. T. Takahashi.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1	Feb. 7, 2002; 19:32	46° 59.9'S 139° 59.9'E	Feb. 9, 2002; 13:16	54° 00.0'S 140° 00.0'E	84	777	
2	Feb. 11, 2002; 04:55	61° 02.9'S 140° 00.0'E	Feb. 12, 2002; 08:00	66° 14.9'S 139° 58.2'E	63	577	
3a	Feb. 19, 2002; 06:09	64° 44.9'S 139° 51.6'E	Feb. 19, 2002; 10:42	64° 02.3'S 139° 58.0'E	9	79	
3b	Feb. 19, 2002; 20:52	63° 56.5'S 139° 53.1'E	Feb. 20, 2002; 01:21	63° 15.6'S 140° 00.0'E	7	76	
3c	Feb. 20, 2002; 11:45	63° 13.8'S 140° 00.1'E	Feb. 20, 2002; 17:55	62° 28.9'S 140° 00.8'E	8	83	
3d	Feb. 21, 2002; 09:13	62° 32.2'S 140° 02.1'E	Feb. 21, 2002; 15:45	61° 45.1'S 140° 00.0'E	9	88	

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

Table 4. Continued.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
3e	Feb. 22, 2002; 08:03	61° 44.4'S 140° 00.9'E	Feb. 22, 2002; 13:25	61° 00.2'S 140° 00.0'E	8	82	
4	Feb. 25, 2002; 04:30	66° 26.0'S 140° 00.0'E	Feb. 26, 2002; 20:26	59° 59.3'S 140° 01.4'E	80	717	
5a	Feb. 27, 2002; 04:46	60° 00.0'S 139° 59.9'E	Feb. 27, 2002; 20:36	57° 02.6'S 140° 00.1'E	36	330	
5b	Feb. 28, 2002; 20:57	56° 55.6'S 139° 54.4'E	Mar. 1, 2002; 19:03	54° 00.1'S 139° 59.5'E	36	325	
6	Mar. 2, 2002; 02:10	54° 00.9'S 139° 59.9'E	Mar. 3, 2002; 16:00	47° 01.2'S 140° 00.0'E	89	778	

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

Table 5. Data on plankton collected by Continuous Plankton Recorder (CPR) in the JARE-44 cruise of the *Shirase* to the Indian sector of the Southern Ocean, December 2002–March 2003. Samplings were carried out by T. Masuzawa.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1	Dec. 6, 2002; 10:00	44° 27.5'S 110° 03.4'E	Dec. 7, 2002; 05:30	49° 16.8'S 109° 51.9'E	—	—	Failed
2	Dec. 7, 2002; 09:00	49° 15.6'S 109° 54.9'E	Dec. 8, 2002; 05:30	54° 47.2'S 109° 53.9'E	67	622	
3	Dec. 8, 2002; 07:00	54° 51.6'S 109° 54.0'E	Dec. 9, 2002; 05:30	60° 00.6'S 109° 47.0'E	63	585	
4	Mar. 14, 2003; 23:30	58° 59.9'S 150° 02.9'E	Mar. 15, 2003; 22:04	54° 00.9'S 150° 14.4'E	63	579	
5	Mar. 17, 2003; 00:30	49° 05.2'S 150° 06.7'E	Mar. 17, 2003; 22:20	44° 30.6'S 151° 03.5'E	59	546	

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

Table 6. Data on plankton collected by Continuous Plankton Recorder (CPR) in the JARE-45 cruise of the *Shirase* to the Indian sector of the Southern Ocean, December 2003–March 2004. Samplings were carried out by M. Iida.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time GMT	Position	Date & Time GMT	Position			
1	Dec. 6, 2003; 10:05	46° 05.1'S 110° 08.5'E	Dec. 7, 2003; 05:54	50° 34.6'S 110° 02.0'E	56	511	Samples perished
2	Dec. 7, 2003; 07:41	50° 41.5'S 110° 03.1'E	Dec. 8, 2003; 05:48	55° 27.9'S 109° 18.4'E	60	550	Samples perished
3	Dec. 8, 2003; 07:44	55° 25.6'S 109° 23.5'E	Dec. 9, 2003; 05:55	59° 09.1'S 103° 32.0'E	60	547	Samples perished
4	Mar. 11, 2004; 02:04	63° 17.5'S 150° 29.4'E	Mar. 11, 2004; 11:50	60° 02.3'S 149° 49.4'E	44	402	Samples perished
5	Mar. 12, 2004; 01:37	60° 01.7'S 150° 05.1'E	Mar. 14, 2004; 02:53	55° 15.1'S 149° 56.6'E	—	—	Samples perished

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