Zooplankton sampling during the 55th Japanese Antarctic Research Expedition in austral summer 2013–2014

Kunio T. TAKAHASHI[1, 2]*, Takahiro IIDA[1, 2], Motoha OJIMA[2] and Tsuneo ODATE[1, 2]

[1] National Institute of Polar Research, Research Organization of Information and Systems, 10–3 Midori-cho, Tachikawa, Tokyo, 190-8518.
[2] Department of Polar Science, School of Multidisciplinary Sciences, SOKENDAI (The Graduate University for Advanced Studies), 10–3, Midori-cho, Tachikawa, Tokyo, 190-8518.
*Corresponding author. E-mail: takahashi.kunio@nipr.ac.jp

1. Introduction

The Japanese Antarctic Research Expedition (JARE) has been conducting routine zooplankton monitoring in the Indian Ocean sector of the Southern Ocean every austral summer (December–March) since 1972 (JARE-14). The monitoring is conducted from an icebreaker, which travels along much the same cruise track at roughly the same time each year. This routine schedule is ideal as a long-term temporal reference for monitoring work. Zooplankton samplings were also carried out from RT/V *Umitaka-Maru*, Tokyo University of Marine Science and Technology, during the 2013/2014 season (JARE-55) as a part of the JARE monitoring program.

Three tools are used for zooplankton sampling; a NORPAC (NORth PACific) standard net, a closing net, and a Continuous Plankton Recorder (CPR). This report presents the data obtained from these three sampling tools during JARE-55 (December 2013 to March 2014).

2. Background and sampling protocol

2.1. NORPAC standard net

The NORPAC standard net was established as a standard for collecting zooplankton in international cooperative surveys at an international meeting held in Honolulu in February 1956 (Motoda, 1957). Although several kinds of plankton nets have been employed from the icebreakers,

vertical hauls using a NORPAC standard net have been routinely and frequently carried out to estimate the mean biomass of surface zooplankton and its spatiotemporal variability in the upper layer of the Indian Ocean sector of the Southern Ocean. Samplings were conducted from the icebreaker *Fuji* during JARE-14 to JARE-24 (1972–1983), the icebreaker *Shirase* during JARE-25 to JARE-49 (1983–2008), RSV *Aurora Australis* chartered by JARE-50 (2009), and the new icebreaker *Shirase* during JARE-51 to JARE-54 (2009–2013) (Fukuchi and Tanimura, 1981; Watanabe *et al*., 1984; Takahashi *et al*., 1997; Sawabe *et al*., 2005; Takahashi *et al*., 2008; Takahashi *et al*., 2014a).

From JARE-14 to JARE-28 (1986/1987), NORPAC standard net sampling sites were mainly conducted in the western part of the Indian Ocean sector; thereafter, sampling stations were shifted to the east because the cruise tracks of the *Shirase* remained along the same cruise track each season and at the same time of year beginning with JARE-29 (1987/1988). Regular sampling was conducted from *Shirase* along longitude 110°E from 40°S to 60°S in December and along 150°E from 64°S to 45°S in March on each voyage. The *Umitaka-Maru* transect was along 110°E from 40°S to 65°S in January.

A twin NORPAC standard net made of nylon bolting cloth (NGG 54, mesh size 330 μm; NXX 13, mesh size 100 μm), was used at all sampling stations. The net was hauled vertically at a speed of about 1 m/s from a depth of approximately 150 m. The maximum depth reached was estimated from the wire angle and length of wire paid out. All samples obtained were immediately preserved on board in seawater with 5–10% buffered formalin. The volume of water filtered by each net was estimated using a flow-meter mounted at the center of the mouth ring of the net. The locations of sampling stations during two ship's surveys are shown in Figures 1 and 2, and zooplankton sampling information and wet weights are presented in Tables 1 and 2. For a detailed description of zooplankton processing for wet-weight measurements see Ukai *et al*. (2014).

2.2. Closing net

The ship-based marine-biological monitoring program for the sea-ice region of Lützow-Holm Bay, off Syowa Station, Antarctica, began during JARE-52 (Takahashi *et al*., 2014a). The aim of this

program is to investigate biological production and mechanisms in relation to sea-ice. Zooplankton samples are collected using a closing net (mouth diameter 0.60 m, mesh size 100 μm) in various sea ice environments: fast-ice, pack-ice, and ice-free open ocean. To prevent sea-ice from entering the net, an "ice-fence" is employed and the net is closed as it reaches the surface (Takahashi *et al*., 2012, 2014b). The net is equipped with a flow-meter to estimate the volume of water filtered, and is hauled vertically from a depth of 150 m to the surface at stations where the bottom is deeper than 150 m, or from 5 m above the bottom to the surface at stations where the bottom is shallower than 150 m. All samples are fixed immediately in seawater with 5% buffered formalin. The locations of sampling stations are shown in Figure 1, and the sampling information and wet weight of zooplankton are listed in Table 3.

2.3. Continuous Plankton Recorder

The CPR was designed by Sir Alister Hardy in the mid 1920s, and first used in the Antarctic during the 1925–1927 Discovery Expedition. The CPR can collect surface plankton continuously for 450 nautical miles (830 km) during a single tow. 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 distributions in the Southern Ocean (Hosie *et al*., 2003). The Australian CPR survey covers a wide area through much of the year, reflecting broad logistic and research objectives in each season.

The icebreaker *Shirase* travels along much the same cruise track at roughly the same time each year. The CPR data collected from *Shirase* provides 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. JARE initiated an annual CPR survey beginning in 1999 (JARE-41) as part its monitoring program in the Antarctic (Takahashi *et al*., 2006, 2009; Takahashi and Hosie, 2014).

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 and March during each voyage (Figure 3). The *Umitaka-Maru* transects were mainly along 110°E from 45°S to 60°S in January and around 110°E to south of Tasmania, Australia, in January and February (Figure 4). We used a Type II (Mark V) CPR, 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 stainless-steel rather than phosphor bronze (Hosie *et al*., 2003). The CPR was towed horizontally at a ship speed of about 15 knots, deployed from the stern with 100 m of wire cable paid out. The depth of CPR tows was about 10 m.

The CPR has a mouth opening of 1.6 cm^2 and is 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/nautical mile (1852 m) of tow. The 6-m-long mesh is sufficient to sample 450 nautical miles (833 km) as a normal towing distance. All zooplankton samples were preserved in seawater with 5–10% buffered formalin and were brought to the laboratory for analysis. The CPR mesh rolls were cut into segments, each representing a 5-nautical-mile sample (approximately 9.3 km) along the transect. Complete details of the processing techniques have been described by Hosie *et al*. (2003). CPR data are available at the Australian Antarctic Data Centre through the home page of the Southern Ocean Continuous Plankton Recorder (SO-CPR) Survey (http://data.aad.gov.au/aadc/cpr/). Information on sampling from the *Shirase* is presented in Table 4 and from the *Umitaka-Maru* in Table 5.

3. Scientists on board

The sampling during each cruise was carried out by K. T. Takahashi (National Institute of Polar Research) on the *Shirase* and by T. Iida (National Institute of Polar Research) on the *Umitaka-Maru*.

4. Data archive

Permission to use these data for publication of presentation should be obtained in writing. Inquiries about details of the data record should be addressed to:

Kunio T. Takahashi, Assistant Professor

National Institute of Polar Research

10-3 Midori-cho, Tachikawa-shi, Tokyo 190-8518, Japan

Phone: +81-42-512-0743, Facsimile: +81-342-528-3492

E-mail: takahashi.kunio@nipr.ac.jp

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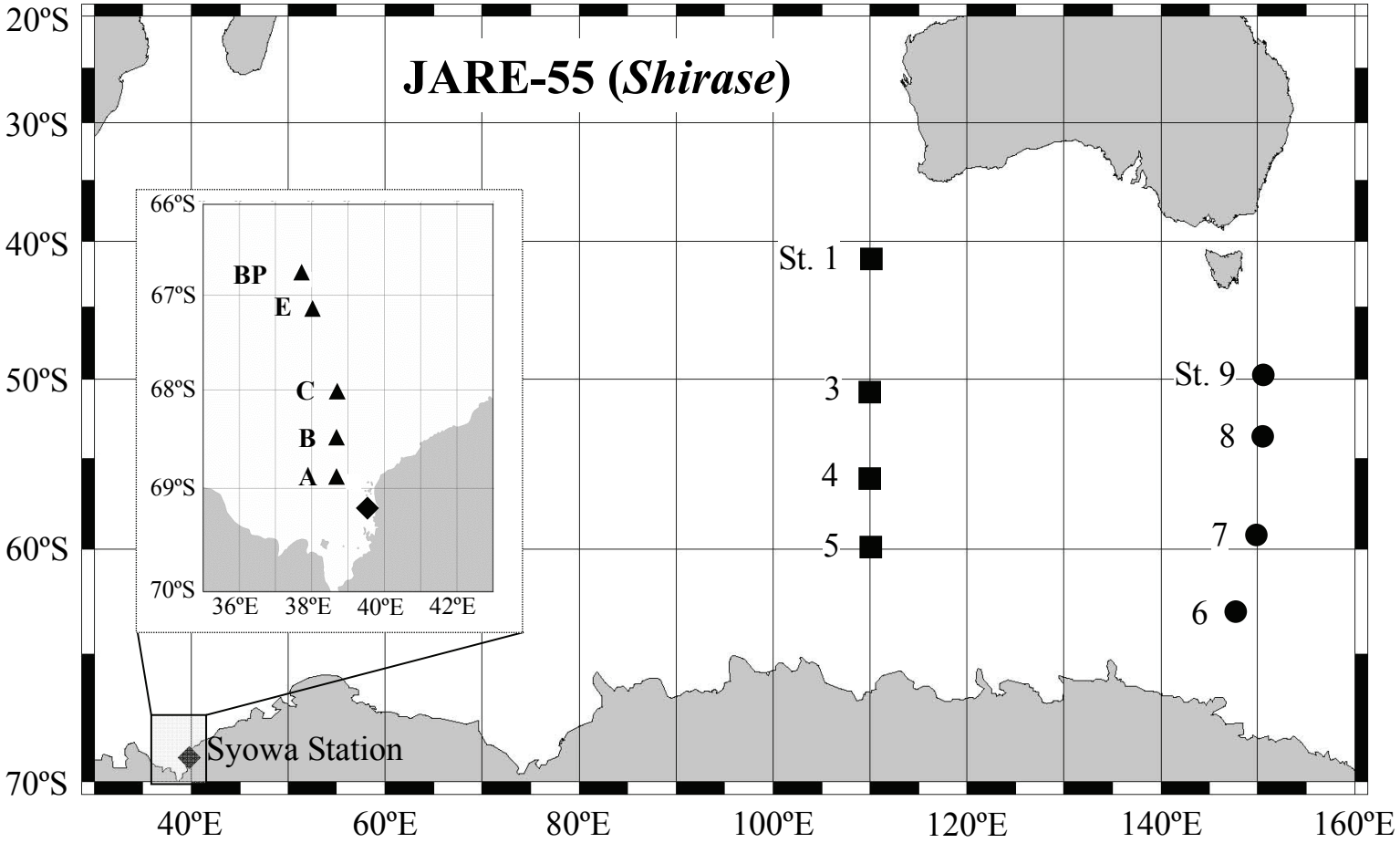

Fig. 1. Icebreaker *Shirase* sampling stations during JARE-55 in 2013/2014. ■: November & December, ▲: February, ●: March.

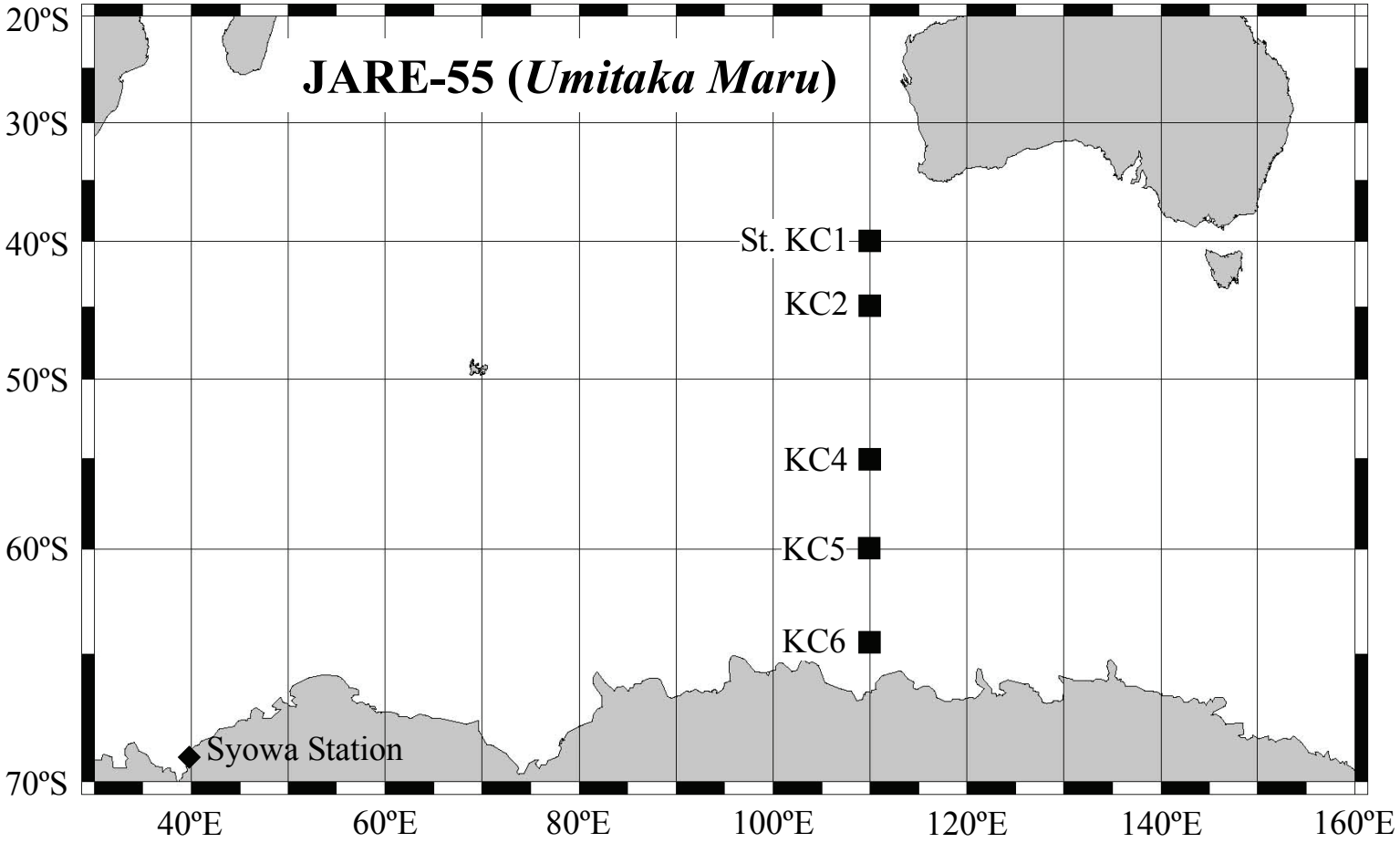

Fig. 2. RT/V *Umitaka-Maru* sampling stations during JARE-55 in January 2014.

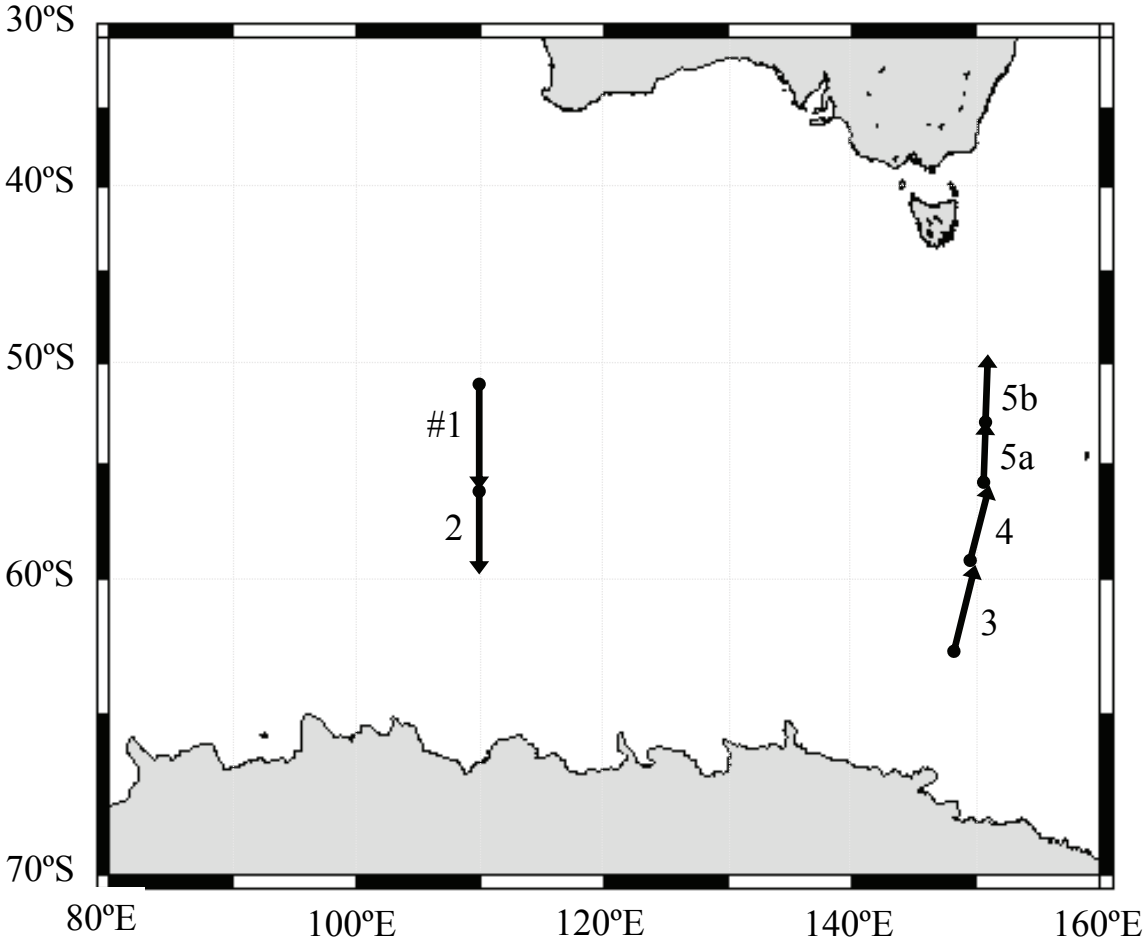

Fig. 3. Transects for CPR surveys by the icebreaker *Shirase* during JARE-55 in 2013/2014. Numbers indicate the sequential number of the CPR run. ●: Starting position, ▼: ending position.

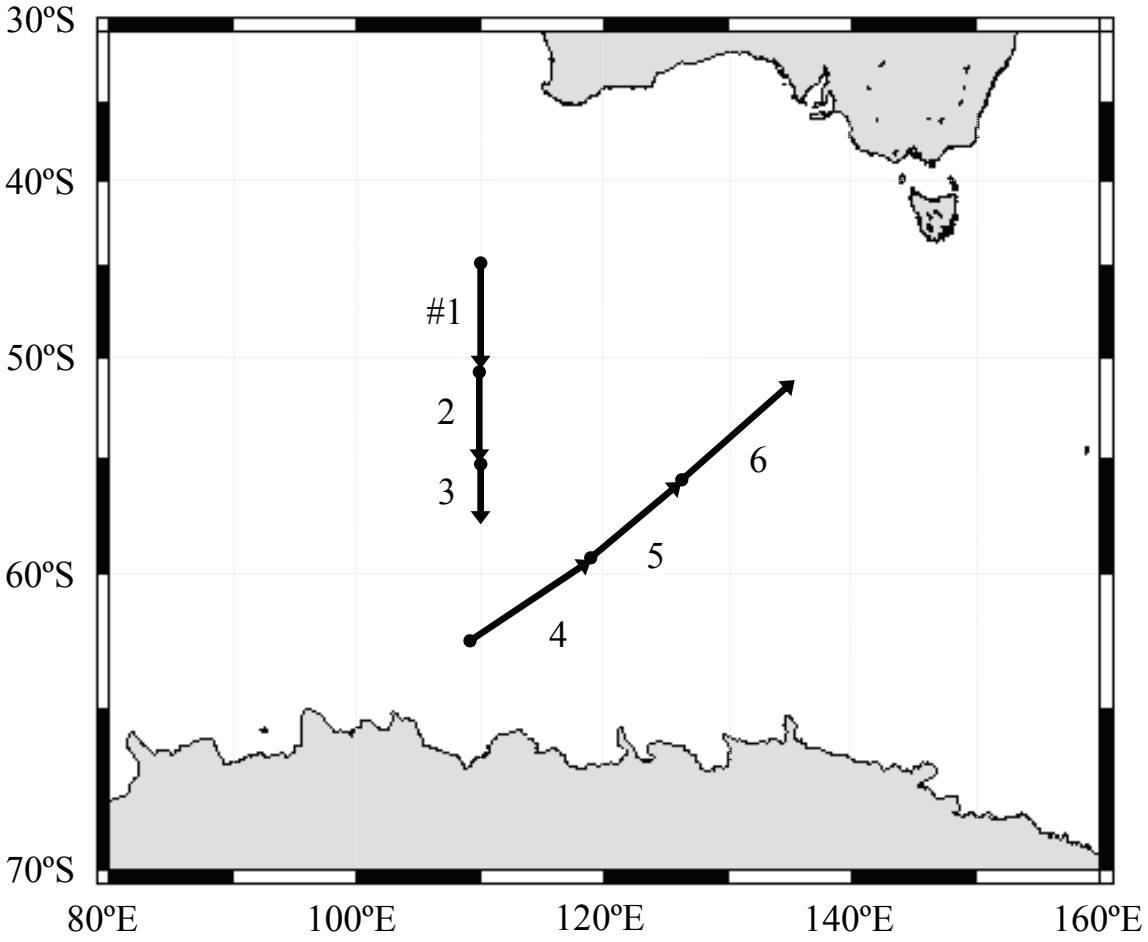

Fig. 4. Transect for CPR surveys by RT/V *Umitaka-Maru* during JARE-55 in 2014. Numbers indicate the sequential number of the CPR run.
●: Starting position, ▼: ending position.

Table 1. Data for plankton samples collected by vertical hauls with twin NORPAC standard nets during the JARE-55 cruise of the icebreaker *Shirase* to the Indian Ocean sector of the Southern Ocean, November 2013–March 2014. Sampling was conducted by K.T. Takahashi.

Station No.	Position	Ship's time (LMT)		Length of wire (m)	Angle of wire (°)	Estimated depth of haul (m)	Flow-meter		Estimated volume of water filtered (m^3)	Wet weight of sample in a haul (mg)	Wet weight of sample per m^3 (mg)	Mesh size (μm)	Sample No.
		Date	Time				No.	Revolutions					
L01	40°51′S	Nov. 29	0842	162	22	150	2469	2382	33.19	14125	425.6	330	L01.GG
	109°59′E						2473	1988	26.49	12410	468.5	100	L01.XX
L03	50°54′S	Dec. 1	0847	156	16	150	2469	2260	31.49	24950	792.4	330	L03.GG
	110°00′E						2473	2036	27.13	8747	322.4	100	L03.XX
L04	55°53′S	Dec. 2	0838	155	14	150	2469	1668	23.24	2284	98.3	330	L04.GG
	109°58′E						2473	1720	22.92	2247	98.0	100	L04.XX
L05	59°50′S	Dec. 3	0441	167	26	150	2469	1708	23.80	1414	59.4	330	L05.GG
	109°59′E						2473	1792	23.88	1405	58.8	100	L05.XX
L06	63°39′S	Mar. 6	1502	151	8	150	2469	1840	25.63	348	13.6	330	L06.GG
	148°35′E						2473	1770	23.58	315	13.4	100	L06.XX
L07	59°13′S	Mar. 8	0834	170	28	150	2469	2152	29.98	735	24.5	330	L07.GG
	150°08′E						2473	1802	24.01	1029	42.9	100	L07.XX
L08	53°48′S	Mar. 9	0839	177	32	150	2469	2130	29.67	1179	39.7	330	L08.GG
	151°02′E						2473	1568	20.89	1411	67.5	100	L08.XX
L09	49°49′S	Mar. 11	0753	158	18	150	2469	1849	25.76	1041	40.4	330	L09.GG
	151°00′E						2473	2381	31.73	1895	59.7	100	L09.XX

Table 2. Data for plankton samples collected by vertical hauls with twin NORPAC standard nets during the JARE-55 cruise of RT/V *Umitaka Maru* to the Indian Ocean sector of the Southern Ocean, January 2014. Sampling was conducted by T. Iida.

Station No.	Position	Ship's time (LMT)		Length of wire (m)	Angle of wire (°)	Estimated depth of haul (m)	Flow-meter		Estimated volume of water filtered (m^3)	Wet weight of sample in a haul (mg)	Wet weight of sample per m^3 (mg)	Mesh size (μm)	Sample No.
		Date	Time				No.	Revolutions					
KC1	40°00′S	Jan. 13	1104	202	42	150	2471	3518	49.01	451	9.2	330	KC1 GG
	110°00′E						3729	3110	41.44	548	13.2	100	KC1 XX
KC2	45°00′S	Jan. 14	1822	155	14	150	2471	2480	34.55	1231	35.6	330	KC2 GG
	110°00′E						3729	2445	32.58	381	11.7	100	KC2 XX
KC4	55°00′S	Jan. 17	0528	150	4	150	2471	2272	31.65	3044	96.2	330	KC4 GG
	110°00′E						3729	2405	32.05	6527	203.7	100	KC4 XX
KC5	60°00′S	Jan. 19	2055	152	2	150	2471	2250	31.35	976	31.1	330	KC5 GG
	110°00′E						3729	2319	30.90	4614	149.3	100	KC5 XX
KC6	65°00′S	Jan. 24	2352	150	4	150	2471	1523	21.22	2060	97.1	330	KC6 GG
	110°00′E						3729	1250	16.66	1212	72.8	100	KC6 XX

Table 3. Data for plankton samples collected by vertical hauls with a closing net during the JARE-55 cruise of the icebreaker *Shirase* in Lützow-Holm Bay off Syowa Station, Antarctica, February 2014. Sampling was conducted by K.T. Takahashi.

Station No.	Position	Ship's time (LMT)		Length of wire (m)	Angle of wire (°)	Estimated depth of haul (m)	Flow-meter		Estimated volume of water filtered (m^3)	Wet weight of sample in a haul (mg)	Wet weight of sample per m^3 (mg)	Mesh size (μm)	Sample No.
		Date	Time				No.	Revolutions					
A	68°52′S 38°42′E	Feb. 9	0916	150	0	150	2469	1221	17.01	2586	152.0	100	A.XX
B	68°29′S 38°40′E	Feb. 9	1505	150	0	150	2469	1222	17.02	2425	142.4	100	B.XX
C	68°05′S 38°40′E	Feb. 12	0759	196	40	150	2469	2489	34.68	3844	110.9	100	C.XX
E	67°11′S 38°07′E	Feb. 12	1337	190	38	150	2469	2621	36.52	1952	53.5	100	E.XX
BP	66°49′S 37°48′E	Feb. 12	1814	173	30	150	2469	1818	25.33	1512	59.7	100	BP.XX

Table 4. Data for plankton samples collected by Continuous Plankton Recorder (CPR) during the JARE-55 cruise of the icebreaker *Shirase* to the Indian Ocean sector of the Southern Ocean, December 2013–March 2014. Sampling was conducted 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. 1, 2013; 0236	50°56.1′S 110°00.2′E	Dec. 2, 2013; 0101	55°53.6′S 109°57.9′E	60	555	
2	Dec. 2, 2013; 0208	55°52.9′S 109°59.3′E	Dec. 2, 2013; 2100	59°50.6′S 109°59.7′E	48	441	
3	Mar. 6, 2014; 0902	63°33.0′S 148°39.6′E	Mar. 7, 2014; 2159	59°13.3′S 150°07.0′E	54	498	
4	Mar. 7, 2014; 2304	59°14.3′S 150°08.6′E	Mar. 9, 2014; 0453	55°49.3′S 150°47.1′E	43	394	
5a	Mar. 9, 2014; 0534	55°48.3′S 150°49.1′E	Mar. 9, 2014; 2158	53°47.8′S 150°59.8′E	26	231	
5b	Mar. 9, 2014; 2304	53°49.2′S 151°01.4′E	Mar. 10, 2014; 2158	49°48.1′S 150°59.5′E	49	450	

Table 5. Data for plankton samples collected by Continuous Plankton Recorder (CPR) during the JARE-55 cruise of RT/V *Umitaka Maru* to the Indian Ocean sector of the Southern Ocean, January–February 2014. Sampling was carried out by T. Iida.

CPR Run #	Start		End		*No. of Segments	Distance towed (km)	Remarks
	Date & Time (GMT)	Position	Date & Time (GMT)	Position			
1	Jan. 14, 2014; 1405	45°00.0′S 109°59.8′E	Jan. 15, 2014; 2149	50°58.8′S 109°59.8′E	72	665	
2	Jan. 15, 2014; 2320	51°00.0′S 110°00.5′E	Jan. 16, 2014; 1953	55°00.0′S 110°00.6′E	49	445	
3	Jan. 17, 2014; 0205	55°00.3′S 109°58.8′E	Jan. 17, 2014; 1420	57°30.4′S 110°00.0′E	31	279	
4	Jan. 29, 2014; 0915	63°01.4′S 109°15.9′E	Jan. 30, 2014; 1030	59°28.8′S 119°11.5′E	72	661	
5	Jan. 30, 2014; 1044	59°28.6′S 119°12.6′E	Jan. 31, 2014; 1100	56°16.5′S 127°53.2′E	68	624	
6	Jan. 31, 2014; 1114	56°16.0′S 127°55.1′E	Feb. 1, 2014; 2301	52°10.2′S 135°39.8′E	74	679	