

**Zooplankton sampling during the 57th Japanese Antarctic Research Expedition  
in austral summer 2015–2016**

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## **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 TV *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-57 (December 2015 to March 2016).

## **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-56 (2009–2015) (Fukuchi and Tanimura, 1981; Watanabe *et al.*, 1984; Takahashi *et al.*, 1997; Sawabe *et al.*, 2005; Takahashi *et al.*, 2008, 2014a, 2015, 2016).

From JARE-14 to JARE-28 (1986/1987), NORPAC standard net sampling sites were mainly 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 315  $\mu\text{m}$ ; NXX 13, mesh size 100  $\mu\text{m}$ ) 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 ships' 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 the *Shirase* provides an important time reference with which to interpret the data collected by the Australian Antarctic Program over the rest of the Indian Ocean sector of the Southern Ocean. 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, 2015, 2016; Takahashi and Hosie, 2014).

CPR tows on the *Shirase* were conducted mainly on three transects 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. 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. 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<sup>2</sup> and is fitted with 270- $\mu$ m 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/>). The locations of CPR towing transects during two ship's surveys are shown in [Figures 3](#) and [4](#), and 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 T. R. Takamura (National Institute of Polar Research) on the *Shirase* and by R. Makabe (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:

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#### References

- Fukuchi, M. and Tanimura, A. (1981): Plankton samplings on board *Fuji* in 1972–1980. JARE data reports, **60** (Marine biology **1**), 27 p.
- Hosie, G.W., Fukuchi, M. and Kawaguchi, S. (2003): Development of the Southern Ocean Continuous Plankton Recorder survey. *Prog. Oceanogr.*, **58**, 263–283, doi: 10.1016/j.pocean.2003.08.007.
- Motoda, S. (1957): North Pacific standard plankton net. *Inform. bull. planktol. Japan*, **4**, 13–15 (in Japanese).
- Reid, P.C., Colebrook, J.M., Matthews, J.B.L., Aiken, J. and Continuous Plankton Recorder Team (2003): The Continuous Plankton Recorder: concepts and history, from Plankton Indicator to undulating recorders. *Prog. Oceanogr.*, **58**, 117–173, doi: 10.1016/j.pocean.2003.08.002.
- Sawabe, E., Takahashi, K.T., Umeda, H. and Fukuchi, M. (2005): Plankton sampling on board *Shirase* in 1997–2001 —NORPAC standard net samples—. JARE data reports, **284** (Marine

biology **32**), 16 p.

Takahashi, K.T. and Hosie G.W. (2014): Plankton sampling in 2009–2013 —Continuous Plankton Recorder survey —. JARE data reports, **328** (Marine biology **45**), 22 p.

Takahashi, K., Tanimura, A. and Fukuchi, M. (1997): Plankton sampling on board *Shirase* in 1983–1996 —NORPAC standard net samples—. JARE data reports, **224** (Marine biology **28**), 35 p.

Takahashi, K.T., Hosie G.W., Umeda, H., Hirawake, T. and Fukuchi, M. (2006): Plankton sampling on board *Shirase* in 1999–2004 —Continuous Plankton Recorder survey—. JARE data reports, **286** (Marine biology **33**), 15 p.

Takahashi, K.T., Sawabe, E., Tsujimoto, M. and Fukuchi, M. (2008): Plankton sampling on board *Shirase* in 2002–2008 —NORPAC standard net samples—. JARE data reports, **306** (Marine biology **38**), 26 p.

Takahashi, K.T., Hosie G.W. and Fukuchi, M. (2009): Plankton sampling in 2004–2009 —Continuous Plankton Recorder survey—. JARE data reports, **311** (Marine biology **39**), 31 p.

Takahashi, K.T., Iida, T., Hashida, G. and Odate, T. (2012): Field test of “ice-fence” for oceanographic observation in the sea-ice zone. *Nankyoku Shiryô* (Antarctic Record), **56**, 447–455 (in Japanese with English abstract).

Takahashi, K.T., Ojima, M., Ukai, Y. and Tanimura, A. (2014a): Plankton sampling from the *Aurora Australis* and the *Shirase* in 2009–2013 —NORPAC standard net & closing net samples—. JARE data reports, **329** (Marine biology **46**), 19 p.

Takahashi, K.T., Takamura, R.T. and Odate, T. (2014b): Report on a modified ice-fence for oceanographic observations under heavy sea-ice conditions during JARE-54 and JARE-55. *Nankyoku Shiryô* (Antarctic Record), **58**, 393–403 (in Japanese with English abstract).

Takahashi, K.T., Iida, T., Ojima, M. and Odate, T. (2015): Zooplankton sampling during the 55th Japanese Antarctic Research Expedition in austral summer 2013–2014. JARE data reports, **336** (Marine biology **49**), 15 p.

Takahashi, K.T., Takamura T.R., Iida, T. and Odate, T. (2016): Zooplankton sampling during the 56th Japanese Antarctic Research Expedition in austral summer 2014–2015. JARE data reports,

**351** (Marine Biology **59**), 15 p.

- Ukai Y., Takahashi, K.T., Fukuchi, M. and Tanimura, A. (2014): Revaluation of zooplankton wet weight data of the NORPAC net samples collected in the Indian sector of the Southern Ocean. Nankyoku Shiryo (Antarctic Record), **58**, 19–41 (in Japanese with English abstract).
- Watanabe, K., Nakajima, Y., Ino, Y., Sasaki, H. and Fukuchi, M. (1984): Plankton samplings on board the *Fuji* in 1980–1983. JARE data reports, **90** (Marine biology **5**), 11 p.

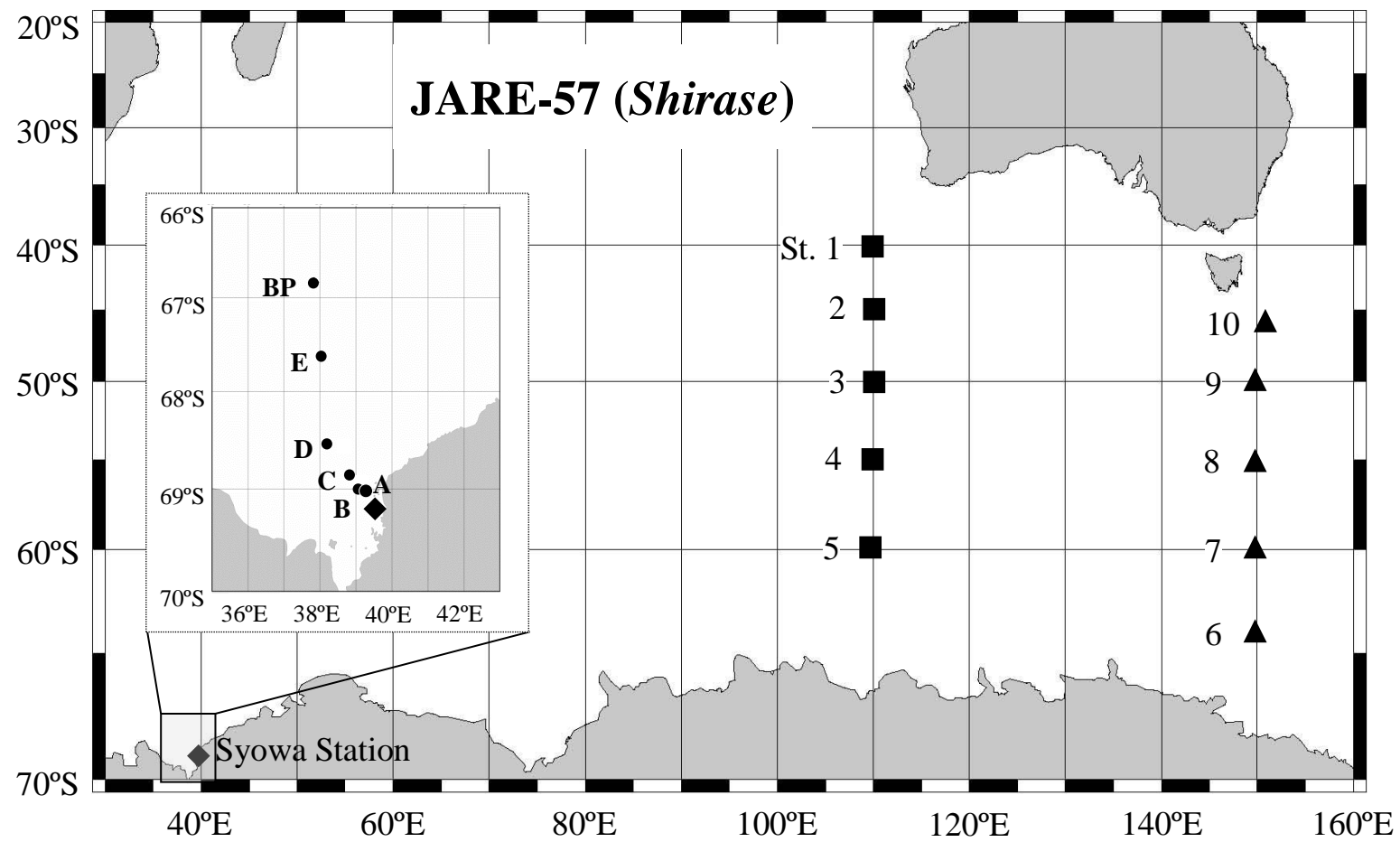


Fig. 1. Icebreaker *Shirase* sampling stations during JARE-57 in 2015/2016. ■: December, ●: February, ▲: March.



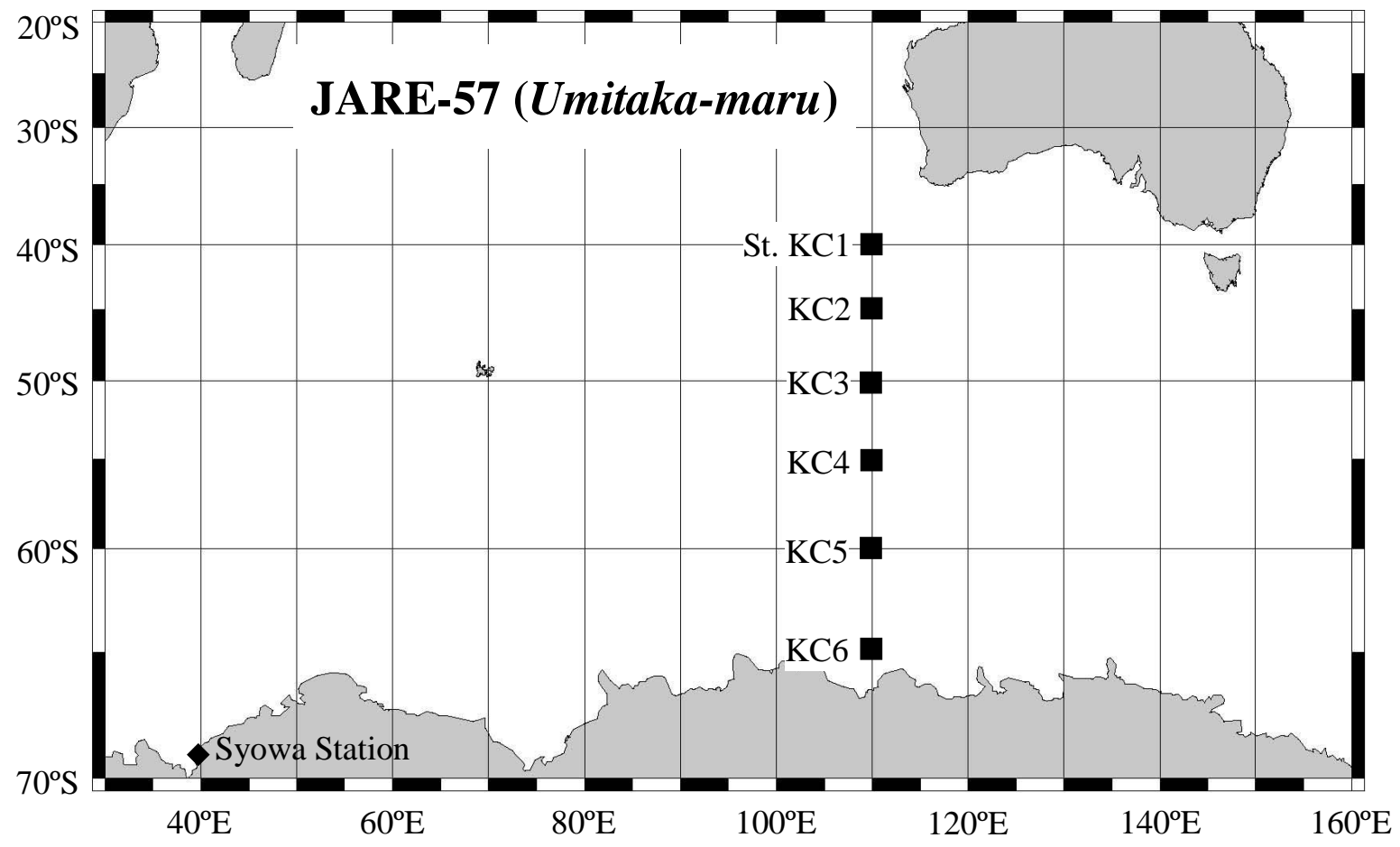


Fig. 2. TV *Umitaka-maru* sampling stations during JARE-57 in January 2016.

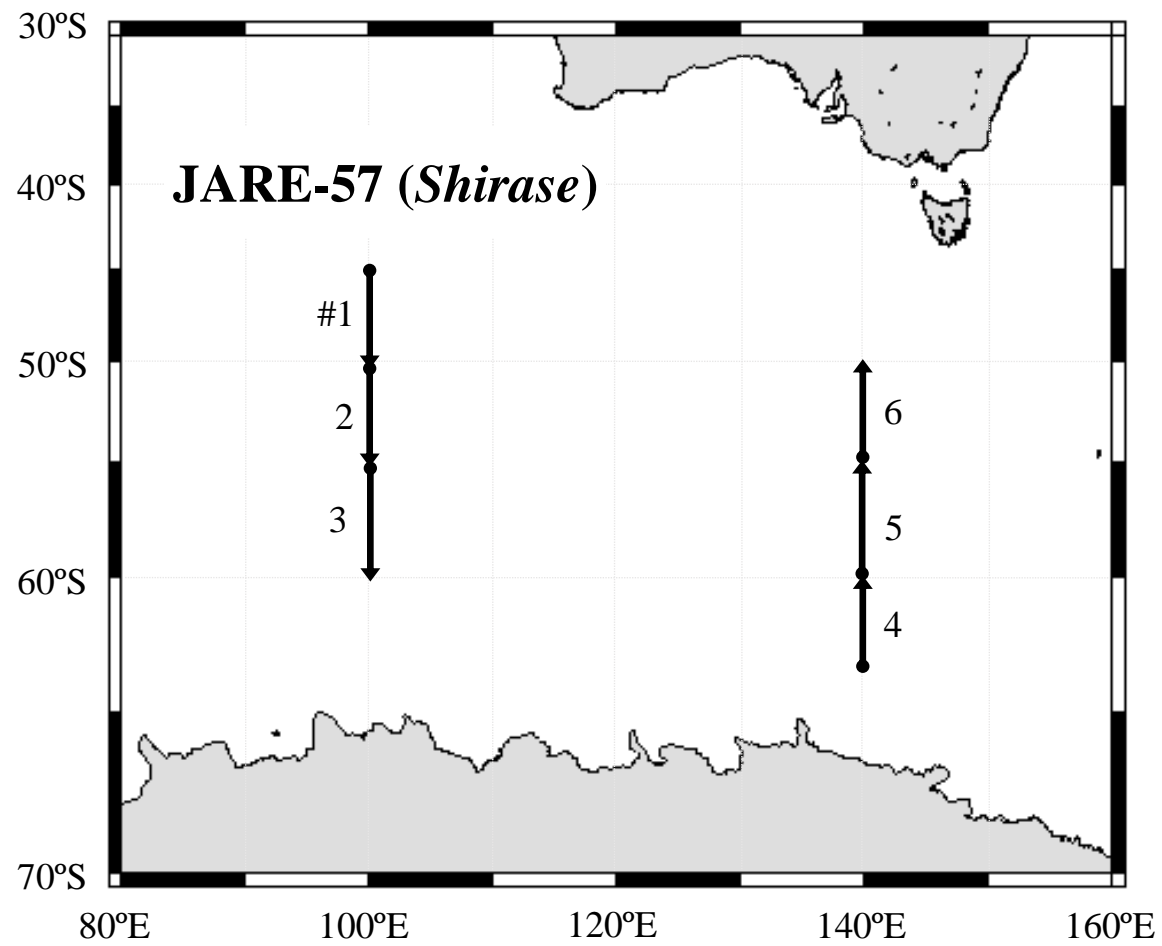


Fig. 3. Transects for CPR surveys by the icebreaker *Shirase* during JARE-57 in 2015/2016. Numbers indicate the sequential number of the CPR run. ●: Starting position, ▼: ending position.

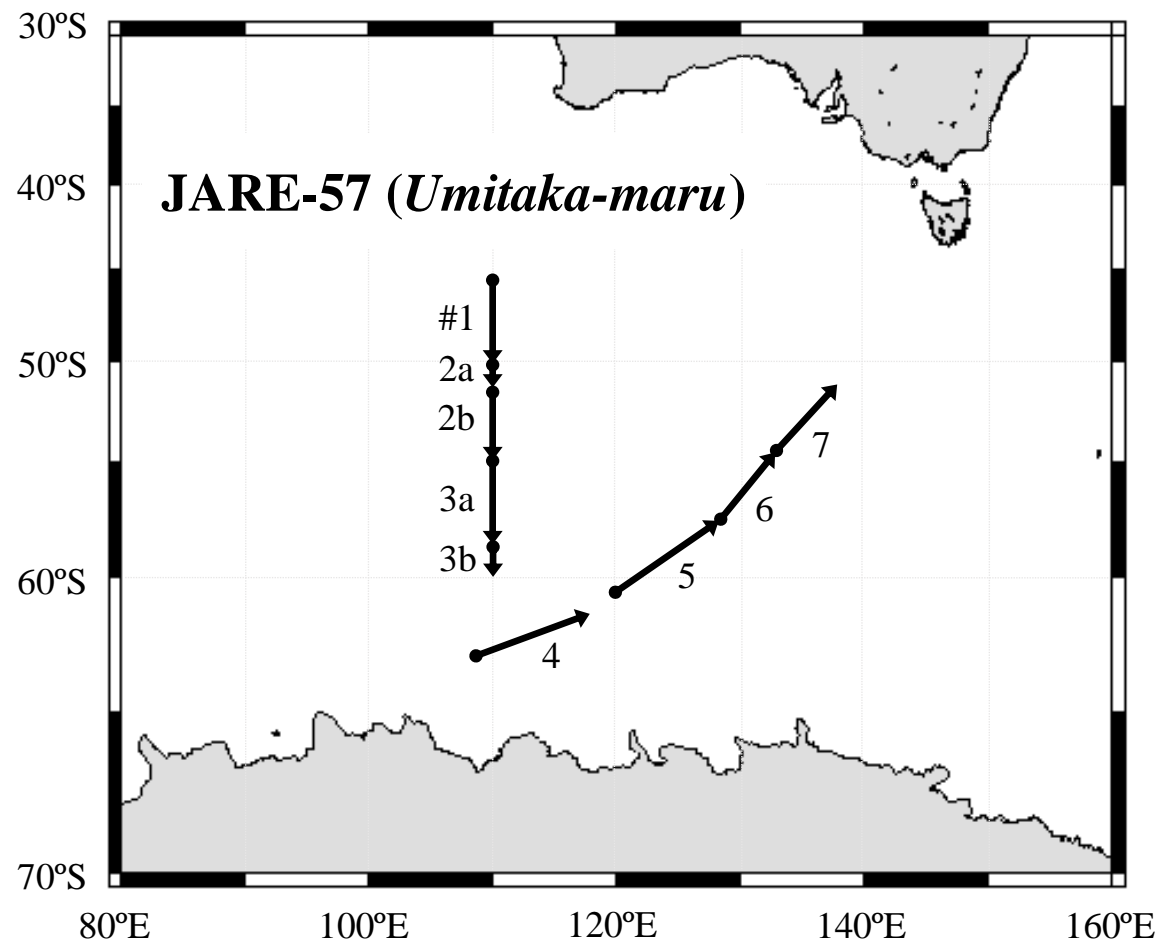


Fig. 4. Transect for CPR surveys by TV *Umitaka-maru* during JARE-57 in 2016. Numbers indicate the sequential number of the CPR run. ●: Starting position, ▼: ending position.

Table 1. Data for plankton samples collected by vertical hauls with twin NORPAC standard nets during the JARE-57 cruise of the icebreaker *Shirase* to the Indian Ocean sector of the Southern Ocean, December 2015-March 2016. Sampling was conducted by T. Takamura.

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 <sup>3</sup> )	Wet weight of sample in a haul (mg)	Wet weight of sample per m <sup>3</sup> (mg)	Mesh size (µm)	Sample No.
		Date	Time				No.	Revolutions					
L01	39°58'S	Dec. 8	1333	167	25	150	2469	3101	43.20	1146	26.5	330	L01.GG
	110°01'E						2473	2898	38.61	1723	44.6	100	L01.XX
L02	44°58'S	Dec. 9	1639	185	36	150	2469	5280	73.56	2597	35.3	330	L02.GG
	110°03'E						2473	5008	66.73	2698	40.4	100	L02.XX
L03	50°01'S	Dec. 11	0844	216	55	150	2469	3880	54.06	3379	62.5	330	L03.GG
	110°01'E						2473	3758	50.07	2939	58.7	100	L03.XX
L04	54°50'S	Dec. 12	1047	164	23	150	2469	2995	41.73	1603	38.4	330	L04.GG
	110°01'E						2473	3863	51.47	3002	58.3	100	L04.XX
L05	59°51'S	Dec. 13	1408	167	26	150	2469	3130	43.61	4768	109.3	330	L05.GG
	109°58'E						2473	2620	34.91	4114	117.8	100	L05.XX
L06	64°00'S	Mar. 16	0824	170	28	150	2469	2482	34.58	1152	33.3	330	L06.GG
	150°00'E						2473	2581	34.39	3963	115.2	100	L06.XX
L07	59°58'S	Mar. 17	0816	202	52	150	2469	3203	44.62	1900	42.6	330	L07.GG
	150°01'E						2473	3290	43.84	2120	48.4	100	L07.XX
L08	55°01'S	Mar. 18	1016	224	74	150	2469	4715	65.69	1611	24.5	330	L08.GG
	150°04'E						2473	4405	58.69	2353	40.1	100	L08.XX
L09	49°59'S	Mar. 19	1250	173	30	150	2469	2618	36.47	703	19.3	330	L09.GG
	150°01'E						2473	2480	33.05	3741	113.2	100	L09.XX
L10	46°00'S	Mar. 20	0915	164	23	150	2469	3072	42.80	547	12.8	330	L10.GG
	152°00'E						2473	2912	38.80	3078	79.3	100	L10.XX

Table 2. Data for plankton samples collected by vertical hauls with twin NORPAC standard nets during the JARE-56 cruise of TV *Umitaka-maru* to the Indian Ocean sector of the Southern Ocean, January 2015. Sampling was conducted by R Makabe.

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 <sup>3</sup> )	Wet weight of sample in a haul (mg)	Wet weight of sample per m <sup>3</sup> (mg)	Mesh size (µm)	Sample No.
		Date	Time				No.	Revolutions					
KC1	40°00'S	Jan. 17	0308	151	3	150	3923	2213	29.66	178	6.0	315	KC1 GG
	110°00'E						3807	1989	26.37	93	3.5	100	KC1 XX
KC2	45°00'S	Jan. 19	0834	156	16	150	3923	2170	29.09	411	14.1	315	KC2 GG
	110°00'E						3807	2030	26.91	343	12.7	100	KC2 XX
KC3	45°00'S	Jan. 20	1258	155	15	150	3923	2660	35.65	4313	121.0	315	KC3 GG
	110°00'E						3807	2541	33.68	6905	205.0	100	KC3 XX
KC4	55°00'S	Jan. 22	0053	151	5	150	3923	2088	27.99	1904	68.0	315	KC4 GG
	110°00'E						3807	1938	25.69	4776	185.9	100	KC4 XX
KC5	60°00'S	Jan. 23	1017	150	2	150	3923	3168	42.46	1072	25.2	315	KC5 GG
	110°00'E						3807	3798	50.35	5884	116.9	100	KC5 XX
KC6	65°00'S	Jan. 27	0534	152	10	150	3923	2530	33.91	280	8.3	315	KC6 GG
	110°00'E						3807	2262	29.98	66	2.2	100	KC6 XX

Table 3. Data for plankton samples collected by vertical hauls with a closing net during the JARE-57 cruise of the icebreaker *Shirase* in Lützow-Holm Bay off Syowa Station, Antarctica, February 2016. Sampling was conducted by T. Takamura.

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 <sup>3</sup> )	Wet weight of sample in a haul (mg)	Wet weight of sample per m <sup>3</sup> (mg)	Mesh size (µm)	Sample No.
		Date	Time				No.	Revolutions					
A	69°04'S 39°19'E	Feb. 2	0925	150	0	150	2469	676	9.42	1336	141.9	100	A.XX
B	69°02'S 39°10'E	Feb. 6	1630	150	0	150	2469	323	4.50	6880	1528.9	100	B.XX
C	68°50'S 38°51'E	Feb. 12	1013	150	0	150	2469	324	4.51	1670	370.0	100	C.XX
D	68°36'S 38°20'E	Feb. 12	1644	150	4	150	2469	908	12.65	2178	172.2	100	D.XX
E	67°39'S 38°08'E	Feb. 15	1549	170	28	150	2469	-	-	-	-	100	<i>Failed</i>
E	67°39'S 38°07'E	Feb. 15	1609	164	24	150	2469	442	6.16	1203	195.4	100	E.XX
BP	66°50'S 37°46'E	Feb. 16	0738	173	30	150	2469	570	7.94	1102	138.8	100	BP.XX

Table 4. Data for plankton samples collected by Continuous Plankton Recorder (CPR) during the JARE-57 cruise of the icebreaker *Shirase* to the Indian Ocean sector of the Southern Ocean, December 2015–March 2016. Sampling was conducted by T. Takamura.

CPR Run #	Start		End		No. of Segments	Distance towed (km)	Remarks
	Date & Time (GMT)	Position	Date & Time (GMT)	Position			
1	Dec. 9, 2015; 10:11	44° 58.8'S 110° 05.2'E	Dec. 11, 2015; 00:46	49° 58.9'S 110° 00.3'E	61	556	
2	Dec. 11, 2015; 02:14	50° 02.4'S 110° 02.8'E	Dec. 12, 2015; 02:50	54° 49.0'S 110° 00.0'E	58	531	
3	Dec. 12, 2015; 04:13	54° 51.4'S 110° 01.8'E	Dec. 13, 2015; 06:16	59° 51.1'S 109° 59.5'E	60	555	
4	Mar. 16, 2016; 21:48	64° 00.7'S 150° 00.5'E	Mar. 17, 2016; 20:20	59° 57.0'S 150° 00.0'E	49	453	
5	Mar. 17, 2016; 21:41	59° 59.1'S 150° 01.2'E	Mar. 18, 2016; 22:19	54° 59.8'S 149° 59.2'E	61	557	
6	Mar. 18, 2016; 23:41	55° 02.1'S 150° 07.0'E	Mar. 20, 2016; 01:04	49° 59.5'S 149° 59.4'E	61	561	

Table 5. Data for plankton samples collected by Continuous Plankton Recorder (CPR) during the JARE-57 cruise of TV *Umitaka-maru* to the Indian Ocean sector of the Southern Ocean, January–February 2016. Sampling was carried out by R. Makabe.

CPR Run #	Start		End		No. of Segments	Distance towed (km)	Remarks
	Date & Time (GMT)	Position	Date & Time (GMT)	Position			
1	Jan. 19, 2016; 11:09	45° 30.7'S 110° 00.1'E	Jan. 20, 2016; 11:55	49° 59.4'S 109° 59.8'E	54	798	
2a	Jan. 20, 2016; 15:10	50° 00.3'S 110° 00.0'E	Jan. 20, 2016; 22:02	51° 09.1'S 110° 00.3'E	14	127	
2b	Jan. 21, 2016; 03:30	51° 11.9'S 110° 04.8'E	Jan. 21, 2016; 22:31	54° 58.6'S 110° 00.2'E	46	422	
3a	Jan. 22, 2016; 04:20	54° 59.9'S 109° 59.9'E	Jan. 22, 2016; 22:29	58° 58.2'S 110° 00.2'E	48	441	
3b	Jan. 23, 2016; 04:25	59° 00.0'S 109° 58.8'E	Jan. 23, 2016; 09:20	59° 58.0'S 109° 59.9'E	12	108	
4	Jan. 30, 2016; 04:12	63° 28.8'S 107° 30.7'E	Jan. 31, 2016; 00:38	61° 58.2'S 117° 14.6'E	58	529	
5	Jan. 31, 2016; 10:50	60° 55.9'S 120° 00.0'E	Feb. 1, 2016; 08:57	57° 36.8'S 128° 03.7'E	64	587	
6	Feb. 1, 2016; 10:08	57° 34.8'S 128° 07.3'E	Feb. 2, 2016; 03:30	54° 32.3'S 133°28.0'E	52	475	
7	Feb. 2, 2016; 08:39	54° 30.0'S 133° 35.4'E	Feb. 3, 2016; 05:20	50° 51.3'S 138° 41.9'E	58	532	