

**Plankton sampling by the training vessel *Umitaka-maru* in the Indian sector of
the Southern Ocean in the austral summer of 2014**

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1. Introduction

The training vessel (T/V) *Umitaka-maru* II of the Tokyo University of Fisheries [currently Tokyo University of Marine Science and Technology (TUMSAT)] participated in the first Japanese Antarctic Research Expedition (JARE-1) as the ship associated with the icebreaker *Soya*. Research voyages for marine science in the Southern Ocean have been intermittently taken over by T/V *Umitaka-maru* III and IV (the present ship). After many years of a collaborative relationship, the National Institute of Polar Research (NIPR) and TUMSAT signed a comprehensive cooperation agreement on 9 February 2009.

With the second half of the six-year plan for JARE phase VIII (2010–2015) by NIPR, the new three-year (2013–2015) TUMSAT-NIPR joint program on “Studies on plankton community structure and environment parameters in the Southern Ocean.” was established. This program focused on the

spatio-temporal variation in plankton distribution in the Southern Ocean ecosystem as one of the JARE projects (Project no. AP-46; Associate Professor Masato Moteki, TUMSAT, principal investigator).

The present report describes the data from the first year research cruise conducted by T/V *Umitaka-maru* IV under the mission of the AP-46 project. This report contains information about the samples collected using four kinds of plankton nets—an Intelligent Operative Net Sampling System (IONESS), a Rectangular Midwater Trawl (RMT), an Ocean Research Institute (ORI) net, and a closing net ('Gamaguchi net')—along longitude 110°E off Wilkes Land, Antarctica, during the cruise period between 11 January 2014 and 5 February 2014.

2. Cruise number

Data covered in this report were obtained from the 17th *Kaiyodai* (abbreviated Japanese name for TUMSAT) Antarctic Research Expedition (*KARE-17*) cruise by T/V *Umitaka-maru*, which was conducted as a part of the 55th Japanese Antarctic Research Expedition (JARE-55) program. This cruise also served as a leg of the long-distance voyage of the Advanced Course of Marine Science and Technology of TUMSAT (voyage number UM-13-09).

3. Sampling protocol

(1) IONESS

The IONESS is a multiple-net opening and closing zooplankton sampler (Kitamura *et al.*, 2001). IONESS was equipped with nine nets with 335- μ m mesh for catching meso- to macro-zooplankton.

IONESS was deployed from the stern of the vessel and towed obliquely over predetermined depth intervals. Each of the nets was opened and closed sequentially by commands from a deck transmitter through an armored cable to an underwater receiver. A deployment consisted of an oblique down-cast from the surface to the maximum depth; the opening and closing sequences through specific depth strata occurred during the up-cast.

Although there was a flow-meter (Tsurumi-Seiki Kosakusho Co., Ltd., Yokohama, Japan) mounted outside the opening of the net mouth to estimate towing distance, it was not used during this cruise because of a problem with the reliability of the flow-meter rotation due to the rough sea

conditions. In the present report, therefore, the volume of water filtered (V , m³) by each net was estimated with the following equation, assuming filtration efficiencies of 100%:

$$V = D \times A, \quad (1)$$

where D and A are towing distance (m) and mean working filtration area (m²), respectively. D was calculated as:

$$D = \sqrt{D_h^2 + D_v^2}, \quad (2)$$

where D_h (m) and D_v (m) were the horizontal distance [towing time (s) multiplied by the ship speed (1.0 m s⁻¹)] and vertical distance, respectively. A was calculated as:

$$A = a \times \sin(\pi \times R/180), \quad (3)$$

where a was the mouth area of the net [1.44 m² (1.44 m high × 1.0 m wide)] and R was the mean frame angle during each net tow, calculated using the frame angle recorded every 2 s.

Depth, temperature and salinity were also measured with a conductivity-temperature-depth (CTD) probe (SBE 37-SIP microCAT, Sea-Bird Electronics, Inc., Bellevue, WA, USA) mounted on the net frame. CTD data were recorded in real-time by an onboard computer.

Two stations were occupied along 110°E for IONESS samplings ([Fig. 1](#)). Detailed sampling information for the two successful IONESS tows is given in [Table 1](#).

(2) RMT 1+8

The RMT 1+8 is a multiple-net opening and closing zooplankton sampler (Baker *et al.*, 1973). An RMT 1+8 consists of two rectangular net systems that open and close simultaneously: an RMT-8 (mouth area, 8 m²; mesh size, 4.5 mm) and an RMT-1 (mouth area, 1 m²; mesh size, 335 μm) for

catching meso- to macro-zooplankton. Three nets are mounted in each system.

The RMT 1+8 was operated in a manner similar to the IONESS; it was deployed from the stern of the vessel and towed obliquely with the nets sampling over predetermined depth intervals. The nets were opened and closed sequentially by commands from a deck transmitter through a single conducting cable to an underwater receiver.

The RMT 1+8 was equipped with a calibrated flow-meter (Tsurumi-Seiki Kosakusho Co., Ltd.). The volume of water filtered was calculated according to the formula in the RMT 1+8 instruction manual as a function of the mouth area of the net perpendicular to the axis of flow and the towing distance indicated by the flow-meter. The average trawling speed was approximately 1.0 m s^{-1} . Depth, temperature and salinity were also measured with a conductivity-temperature-depth (CTD) probe (SBE MicroCAT, Sea-Bird Electronics, Inc., Bellevue, WA, USA), which was mounted on the release gear immediately above the net. CTD data were recorded in real-time by an onboard computer.

During the KARE-17 cruise, RMT sampling was conducted at two stations along 110°E ([Fig. 2](#)). At each station, the samples were collected from three specific depth strata, 0–50 m, 50–100 m and 100–200 m depth. Detailed sampling information is given in [Table 2](#).

(3) ORI net

An ORI net, made of nylon bolting cloth with a $335\text{-}\mu\text{m}$ mesh and a mouth ring diameter of 1.6 m, was used for catching meso- to macro-zooplankton (Omori, 1965). During the KARE-17 cruise, plankton sampling using the ORI net was carried out by following two methods, i.e., surface horizontal sampling and oblique sampling in the upper 200 m.

(3-1) Surface horizontal sampling

The ORI net was deployed off the starboard side of the vessel and towed along the sea surface horizontally at a rate of about 1 m s^{-1} . The sampling depth was estimated to have been 0–2 m. The towing time was set to 5–12 minutes depending on the degree of mesh clogging by phytoplankton. The volume of water filtered was estimated using a digital mechanical flowmeter (#2030R; General Oceanics Inc. Miami, Florida, USA), mounted in the mouth of the net.

Eight stations were occupied along the 110°E transect for surface horizontal sampling with the ORI net ([Fig. 3](#)). Detailed sampling information is given in [Table 3](#).

(3-2) Oblique sampling of the upper 200 m

The ORI net was launched from the stern of the ship. The wire was paid out until the net reached depth of nearly 200 m. The depth reached was estimated from the wire angle and length of wire paid out. After reaching a depth of nearly 200m, the net was retrieved at approximately 0.5 m s^{-1} , while the ship moved at 1 m s^{-1} . The volume of water filtered was estimated using a digital mechanical flowmeter (#2030R; General Oceanics Inc.), mounted in the mouth of the net.

Eight stations were occupied along the 110°E transect for oblique sampling with the ORI net ([Fig.4](#)). Detailed sampling information is given in [Table 4](#).

(4) Closing net ('Gamaguchi net')

A vertical closing net with a mouth ring diameter of 0.6m and a 100- μm mesh aperture (modified from Kawamura, 1989) was used to sample micro-and meso-zooplankton. The net was towed vertically from the bottom to the top of a designated depth stratum at a speed of 1.0 m s^{-1} . After closing the mouth of the net with a messenger, the net was brought to the surface at 2.0 m s^{-1} . A designated depth stratum was 0–200 m. The sampling layer was estimated from the wire angle and length of wire paid out. The volume of water filtered was estimated using a calibrated flow-meter (RIGO Co., Ltd., Tokyo, Japan) mounted at the center of the mouth ring of the net.

Ten stations were occupied along the 110°E transect for sampling with the closing net ([Fig.5](#)). Detailed sampling information is given in [Table 5](#).

(5) Zooplankton sample processing

All zooplankton samples were immediately preserved in 5% borate-buffered formalin seawater on board and stored in a cool, dark place in the ship.

4. Data policy

The purpose of this data report is to provide information about the collection of zooplankton samples for scientists and students researching Antarctic ecosystems and zooplankton. This report should also make interested researchers aware of the opportunity to use these samples to quantitatively describe the zooplankton distribution and biomass in the Southern Ocean. All underlying physical data collected with the CTD and the samples are available for scientific use. We expect the information in this report, in combination with the available samples and environmental data set, to be utilized in various future studies.

Permission to use the data and the preserved samples for publication or presentation should be obtained in writing. Inquiries about details of the data record should be addressed to one of the following:

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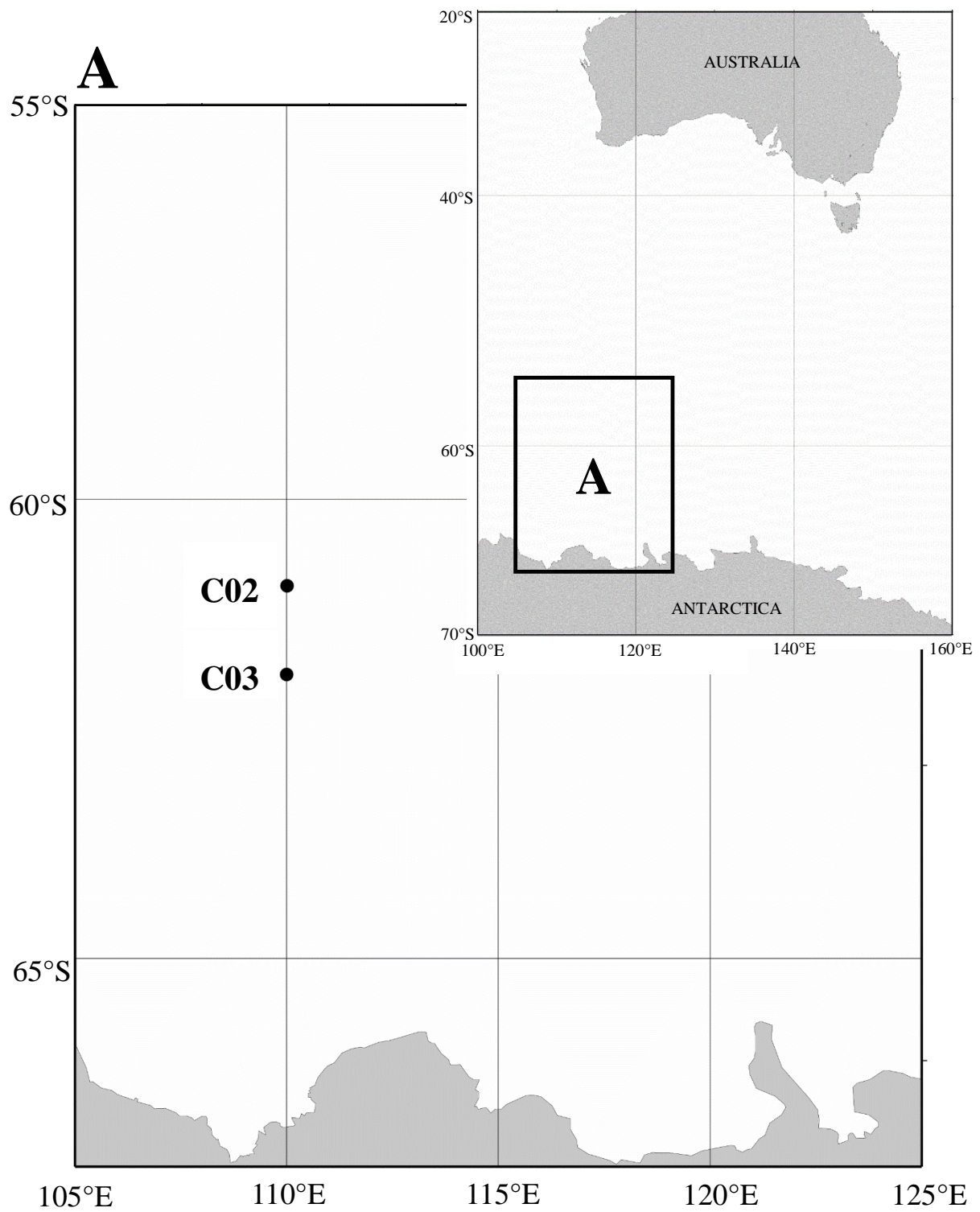


Fig. 1. Stations sampled with IONESS opening/closing multiple-net systems on board the training vessel

Umitaka-maru in the Indian sector of the Southern Ocean, January 2014.

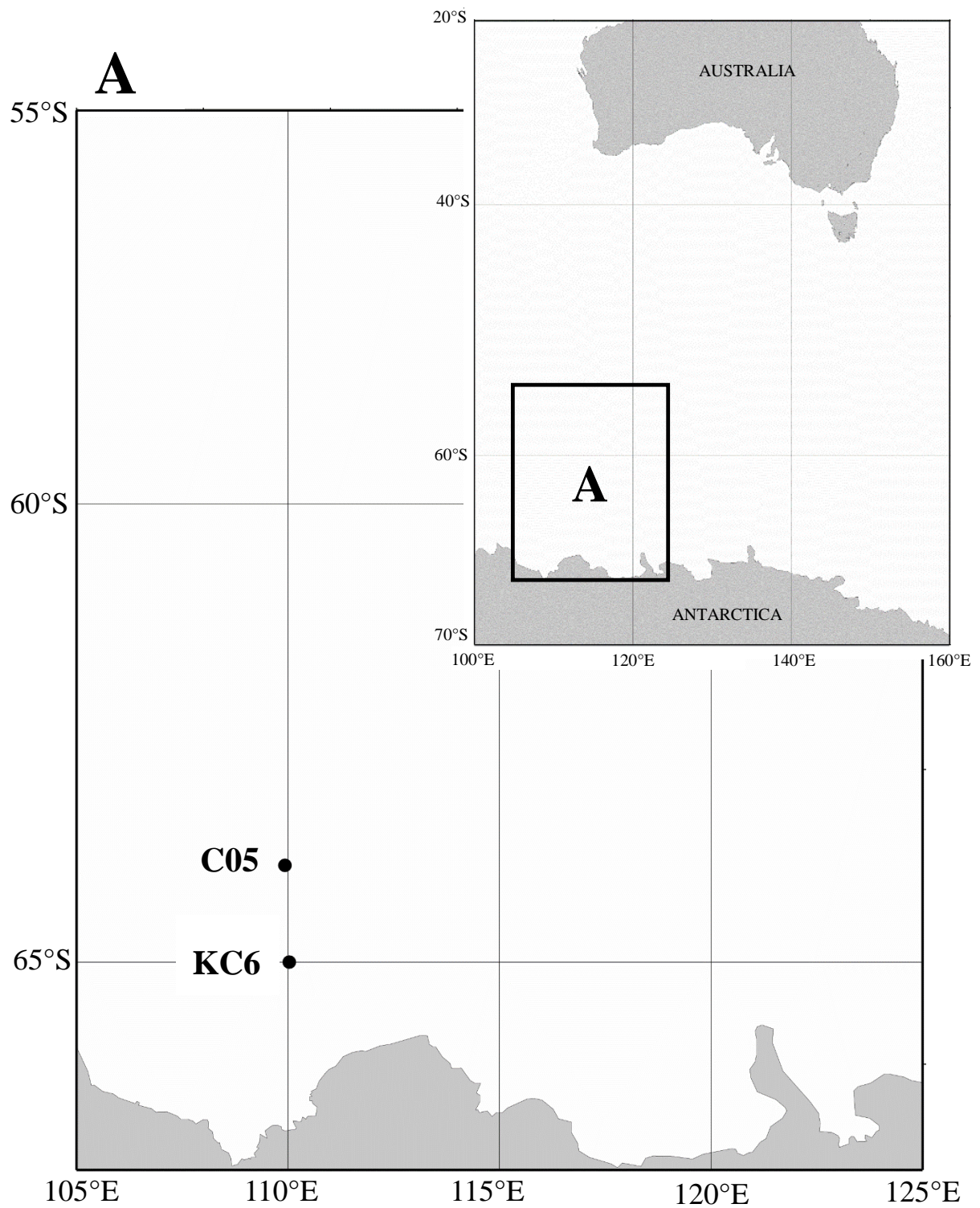


Fig. 2. Stations sampled with RMT 1+8 opening/closing multiple-net systems on board the training vessel *Umitakamaru* in the Indian sector of the Southern Ocean, January 2014.

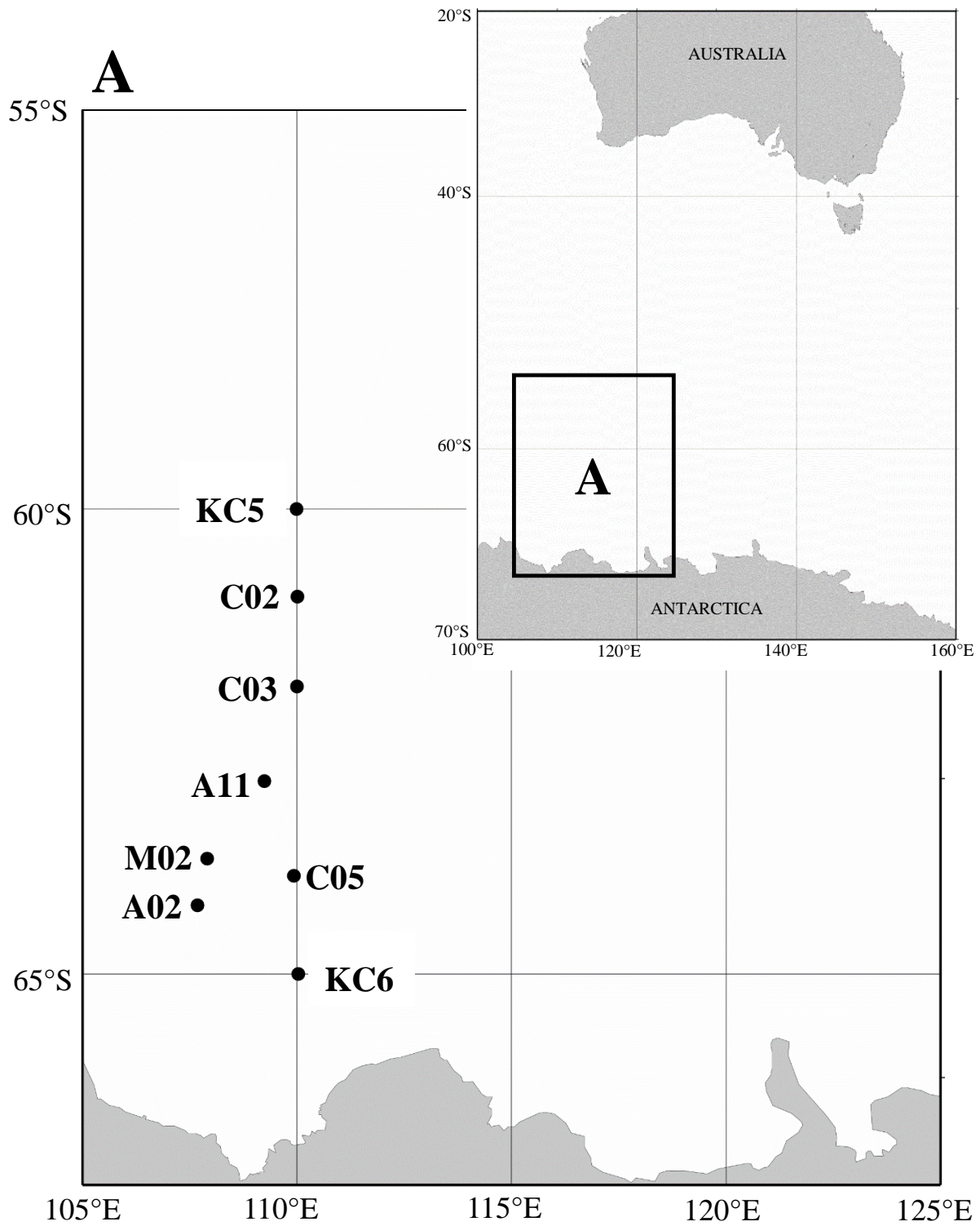


Fig. 3. Stations sampled with an ORI net by surface horizontal tows on board the training vessel *Umitaka-maru* in the Indian sector of the Southern Ocean, January 2014.

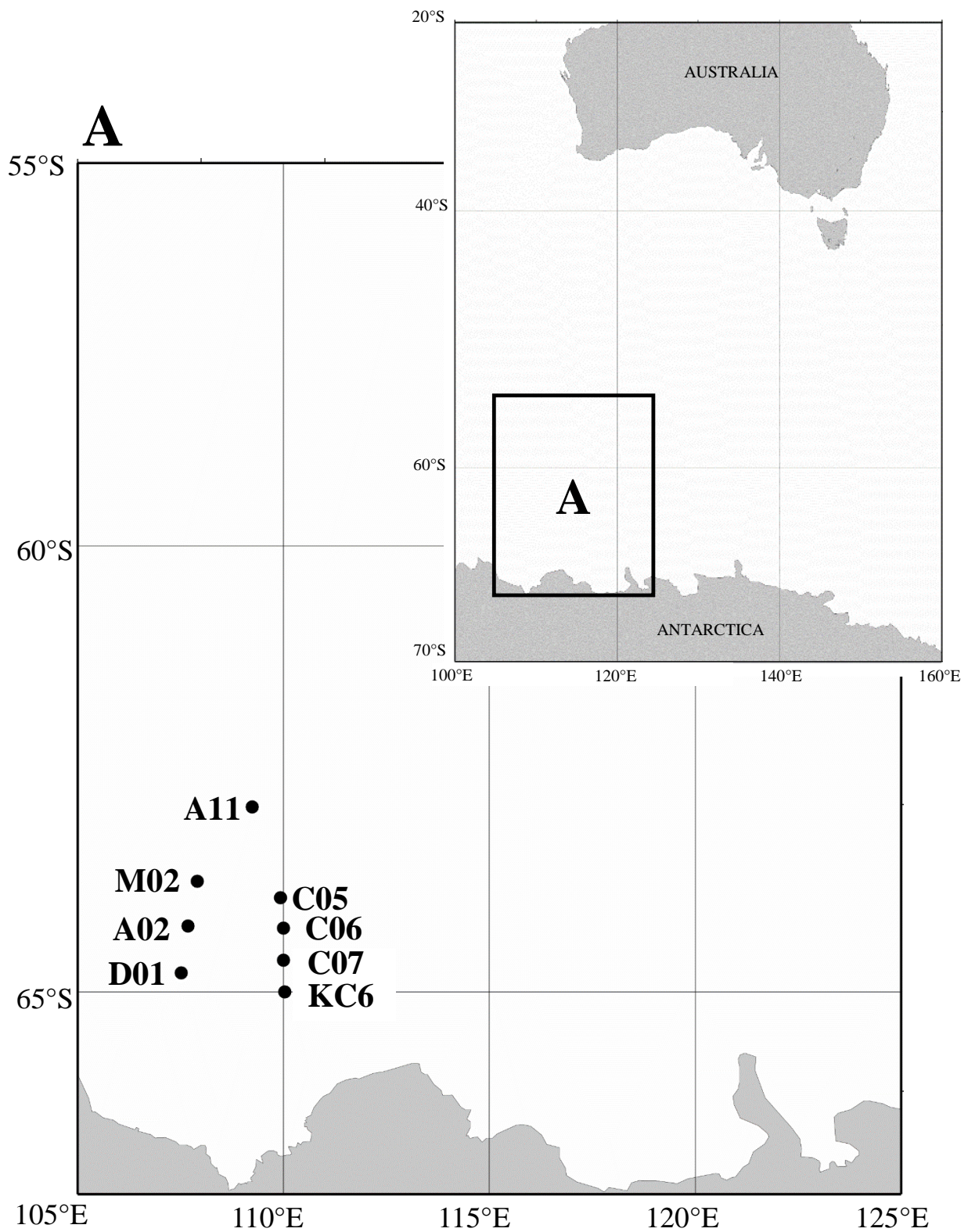


Fig. 4. Stations sampled with an ORI net by oblique tows on board the training vessel *Umitaka-maru* in the Indian sector of the Southern Ocean, January 2014.

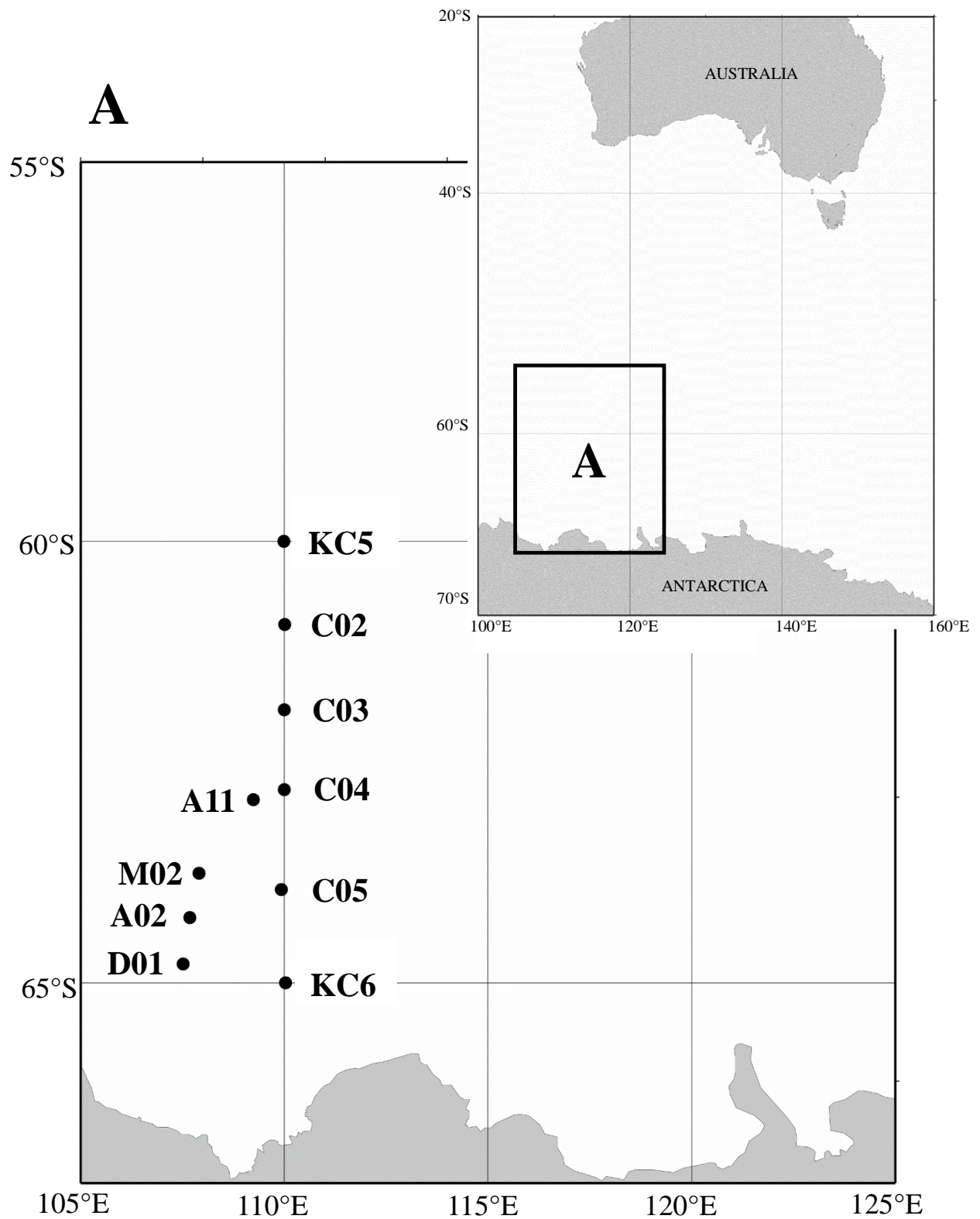


Fig. 5. Stations sampled with a closing net (“Gamaguchi net”) on board the training vessel *Umitaka-maru* in the Indian sector of the Southern Ocean, January 2014.

Table 1. Sampling data of an IONESS along the 110°E transect in the Southern Ocean in January 2014.

Stn.	Tow	Position				Date (yyyy/mm/dd) & Time (UTC) ^a		Bottom depth (m)	Net No. ^b	Sampling depth interval (m)	Volume filtered (m ³)
		Start		Finish		Start	Finish				
C02	2	61 °	0.20 ' S	61 °	3.87 ' S	2014/01/20 07:33	2014/01/20 09:17	4285	1	5-40	341
		110 °	0.11 ' E	110 °	3.72 ' E				2	40-80	642
						3	80-120		749		
						4	120-160		777		
						5	160-200		522		
						6	200-250		496		
						7	250-300		521		
						8	300-400		1101		
						D	0-400				
C03	3	62 °	0.18 ' S	62 °	5.83 ' S	2014/01/22 15:50	2014/01/22 18:03	4026	1	5-40	1247
		110 °	0.00 ' E	109 °	57.87 ' E				2	40-80	628
						3	80-120		508		
						4	120-160		1622		
						5	160-200		546		
						6	200-250		286		
						7	250-300		366		
						8	300-400		774		
						D	0-400				

^aShip mean time = UTC + 8h

^bMesh size, 335 µm; D, down-tow

Table 2. Sampling data of an RMT 1+8 along the 110°E transect in the Southern Ocean in January 2014.

Stn.	Position				Date (yyyy/mm/dd) & Time (UTC) ^a		Bottom depth (m)	Net No. ^b	Sampling depth interval (m)	Volume filtered (m ³)
	Start		Finish		Start	Finish				
C05	64 °	0.69 ' S	64 °	3.10 ' S	2014/01/23 23:31	2014/01/24 00:52	3378	1-1	0-50	966
	109 °	50.88 ' E	109 °	53.60 ' E				8-1	0-50	12118
								1-2	50-100	966
								8-2	50-100	12118
								1-3	100-200	644
								8-3	100-200	8079
KC6	65 °	0.14 ' S	64 °	59.42 ' S	2014/01/24 22:24	2014/01/24 23:45	2630	1-3	0-50	966
	109 °	58.91 ' E	110 °	6.49 ' E				8-3	0-50	12118
								1-2	50-100	966
								8-2	50-100	12118
								1-1	100-200	837
								8-1	100-200	10502

^aShip mean time = UTC + 8 h

^bMesh size for 1-m² net, 335 µm; mesh size for 8-m² net, 4.5 mm

Table 3. Sampling data of an ORI net by surface horizontal tows along the 110°E transect in the Southern Ocean in January 2014.

Stn.	No.	Position		Date (yyyy/mm/dd) & Time (UTC) ^a		G.O. ^b Flowmeter revolutions	Volume filtered (m ³) ^c	Remarks
		Start	Finish	Start	Finish			
KC5	1	60 ° 0.07 ´ S	60 ° 1.14 ´ S	2014/01/19 17:46	2014/01/19 17:52	21209	1145	
		109 ° 58.80 ´ E	109 ° 57.90 ´ E					
C02	2	61 ° 1.56 ´ S	61 ° 2.04 ´ S	2014/01/20 08:07	2014/01/20 08:18	23607	1275	
		110 ° 1.50 ´ E	110 ° 1.98 ´ E					
C03	3	62 ° 1.62 ´ S	62 ° 2.16 ´ S	2014/01/22 16:21	2014/01/22 16:31	26452	1429	
		110 ° 0.00 ´ E	110 ° 0.00 ´ E					
C05	4	64 ° 1.56 ´ S	64 ° 1.68 ´ S	2014/01/23 23:55	2014/01/24 00:05	21608	1167	
		109 ° 56.46 ´ E	109 ° 56.22 ´ E					
KC6	5	65 ° 0.06 ´ S	65 ° 0.00 ´ S	2014/01/24 22:38	2014/01/24 22:43	16479	890	
		110 ° 0.84 ´ E	110 ° 1.38 ´ E					
A02	6	64 ° 16.98 ´ S	64 ° 16.50 ´ S	2014/01/27 08:37	2014/01/27 08:48	29409	1588	
		107 ° 41.52 ´ E	107 ° 41.76 ´ E					
M02	7	63 ° 50.28 ´ S	63 ° 50.28 ´ S	2014/01/27 19:52	2014/01/27 20:02	22509	1216	
		107 ° 51.12 ´ E	107 ° 50.16 ´ E					
A11	8	63 ° 2.40 ´ S	63 ° 2.94 ´ S	2014/01/29 04:52	2014/01/29 05:02	29808	1610	
		109 ° 13.56 ´ E	109 ° 13.26 ´ E					

^aShip mean time = UTC + 8 h

^bGeneral Oceanics Inc.

^cMesh size, 335 µm

Table 4. Sampling data for oblique tows of an ORI net along the 110°E transect in the Southern Ocean in January 2014.

Stn.	No.	Position		Date (yyyy/mm/dd) & Time (UTC) ^a		Wire length (m)	Wire angle (°)	Estimated depth of haul (m)	G.O. ^b Flowmeter revolutions	Volume filtered (m ³) ^c	Remarks
		Start	Finish	Start	Finish						
C05	1	64 ° 3.80 ' S		2014/01/24 03:37	2014/01/24 04:08	363	58	192	59994	3240	
		109 ° 51.60 ' E									
C06	2	64 ° 20.22 ' S	64 ° 21.48 ' S	2014/01/24 06:03	2014/01/24 06:38	280	43	205	51961	2806	
		110 ° 0.00 ' E	110 ° 0.00 ' E								
C07	3	64 ° 40.20 ' S	64 ° 42.06 ' S	2014/01/24 10:47	2014/01/24 11:30	320	N.D.		44027	2378	
		110 ° 0.00 ' E	110 ° 0.12 ' E								
KC6	4	64 ° 59.28 ' S	64 ° 59.64 ' S	2014/01/25 00:52	2014/01/25 01:50	400	58	212	113986	6156	
		110 ° 7.26 ' E	110 ° 12.66 ' E								
D01	5	64 ° 46.38 ' S	64 ° 44.10 ' S	2014/01/26 22:47	2014/01/26 23:40	380	57	207	117726	6358	
		107 ° 31.26 ' E	107 ° 31.92 ' E								
A02	6	64 ° 19.62 ' S	64 ° 17.88 ' S	2014/01/27 07:39	2014/01/27 08:27	370	57	202	95843	5176	
		107 ° 40.20 ' E	107 ° 41.10 ' E								
M02	7	63 ° 50.22 ' S	63 ° 50.28 ' S	2014/01/27 19:01	2014/01/27 19:36	386	59	199	59490	3213	
		107 ° 55.68 ' E	107 ° 51.96 ' E								
A11	8	63 ° 2.40 ' S	63 ° 1.98 ' S	2014/01/29 03:57	2014/01/29 04:35	330	51	208	83047	4485	
		109 ° 14.82 ' E	109 ° 13.74 ' E								

^aShip mean time = UTC + 8 h

^bGeneral Oceanics Inc.

^cMesh size, 335 µm

Table 5. Sampling data of a closing net ("Gamaguchi net") along the 110°E transect in the Southern Ocean in January 2014.

Stn.	No.	Position		Date (yyyy/mm/dd) & Time (UTC) ^a		Wire length (m)	Wire angle (°)	Estimated depth of haul (m)	Flow meter		Volume filtered (m ³) ^b	Remarks
		Start	Finish	Start	Finish				ID. no.	Revolutions		
KC5	1	59 ° 59.99 ' S	60 ° 00.01 ' S	2014/01/19 13:21	2014/01/19 13:32	201	6	200	3727	2112	50.35	
		109 ° 59.96 ' E	109 ° 59.99 ' E									
C02	2	60 ° 59.99 ' S	61 ° 00.01 ' S	2014/01/20 03:58	2014/01/20 04:08	202	9	200	3727	2365	56.38	
		109 ° 59.96 ' E	109 ° 59.98 ' E									
C03	3	62 ° 00.00 ' S	61 ° 59.99 ' S	2014/01/22 19:45	2014/01/22 19:57	200	0	200	3727	2886	68.80	
		110 ° 00.00 ' E	109 ° 59.99 ' E									
C04	4	62 ° 55.00 ' S	62 ° 54.99 ' S	2014/01/23 07:10	2014/01/23 07:20	200	0	200	3727	2465	58.77	
		109 ° 59.99 ' E	109 ° 59.99 ' E									
C05	5	63 ° 59.98 ' S	63 ° 59.98 ' S	2014/01/23 19:24	2014/01/23 19:33	200	3	200	3727	N.D	-	
		109 ° 59.98 ' E	109 ° 59.96 ' E									
KC6	6	65 ° 00.02 ' S	65 ° 00.02 ' S	2014/01/24 16:10	2014/01/24 16:20	204	12	200	3727	1480	35.28	
		109 ° 59.88 ' E	109 ° 59.89 ' E									
D01	7	64 ° 49.97 ' S	64 ° 49.97 ' S	2014/01/26 17:51	2014/01/26 18:02	200	0	200	3727	1910	45.53	
		107 ° 30.04 ' E	107 ° 30.03 ' E									
A02	8	64 ° 19.96 ' S	64 ° 19.98 ' S	2014/01/27 03:10	2014/01/27 03:21	200	1	200	3727	2110	50.30	
		107 ° 39.99 ' E	107 ° 39.98 ' E									
M02	9	63 ° 50.21 ' S	63 ° 50.21 ' S	2014/01/27 14:29	2014/01/27 14:38	201	6	200	3727	1690	40.29	
		107 ° 56.74 ' E	107 ° 56.74 ' E									
A11	10	62 ° 59.96 ' S	62 ° 59.96 ' S	2014/01/29 01:47	2014/01/29 01:56	200	4	200	3727	1690	40.29	
		109 ° 14.99 ' E	109 ° 14.99 ' E									

^aShip mean time = UTC + 8 h

^bMesh size, 100 µm