



## Marine ecosystem monitoring in the sea-ice region of Lützow-Holm Bay, off Syowa Station, during the icebreaker *Shirase* cruise of the 61st Japanese Antarctic Research Expedition

Kunio T. TAKAHASHI <sup>1,2\*</sup>, Ryosuke MAKABE <sup>1,2,3</sup>,  
Keigo D. TAKAHASHI <sup>2\*\*</sup> and Tsuneo ODATE <sup>1,2†</sup>

<sup>1</sup> National Institute of Polar Research, Research Organization of Information and Systems,  
10-3, Midori-cho, Tachikawa, Tokyo 190-8518.

<sup>2</sup> Polar Science Program, Graduate Institute for Advanced Studies, SOKENDAI, 10-3, Midori-cho,  
Tachikawa, Tokyo 190-8518.

<sup>3</sup> Tokyo University of Marine Science and Technology, 4-5-7, Konan, Minato, Tokyo 108-8477.

\*Corresponding author. E-mail: [takahashi.kunio@nipr.ac.jp](mailto:takahashi.kunio@nipr.ac.jp)

\*\*Current affiliation. Faculty of Fisheries Sciences, Hokkaido University, 3-1-1, Minato-cho,  
Hakodate, Hokkaido 041-8611.

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**Abstract:** As part of the monitoring program of the Japanese Antarctic Research Expedition (JARE), marine ecosystem survey in the sea-ice region of Lützow-Holm Bay, off Syowa Station, has been routinely carried out since JARE-52 (2010/11 season) to understand biological production and mechanisms in relation to sea-ice. Water temperature, salinity, chlorophyll-*a* concentration, macronutrients (nitrate, nitrite, phosphate, and silicate), and zooplankton data were collected at six stations in various sea-ice environments: fast-ice, pack-ice, and ice-free open ocean. The use of an “ice-fence” protected observation equipment (e.g., plankton nets and CTDs) from damage due to sea-ice. This report provides the data obtained during the icebreaker *Shirase* cruise of the 61st Japanese Antarctic Research Expedition in the 2019/20 season, and is the fourth report for the marine ecosystem monitoring in the sea-ice region from the first report of the 2016/17 season in this journal.

† Deceased

## 1. Background and Summary

The Southern Ocean marine ecosystems have been changing dramatically due to the effects of global climate change<sup>1</sup>. Among the most obvious physical changes are the regionally contrasting variations in the extent and seasonality of sea-ice<sup>1</sup>. The Antarctic sea-ice zone is an ecologically important region of the Southern Ocean. The seasonal fluctuation of sea-ice formation and melting events has a significant effect on the life cycle of many organisms living in this region. However, since it is difficult to access by existence of sea-ice in these areas, the accumulation of biological knowledge is extremely poor compared to the open ocean region until now.

The powerful ice-breaking capability of the current Japanese icebreaker *Shirase* (Japan Maritime Self-Defense Force) raises the possibility of marine observations in the fast-ice and/or permanent ice zone. The ship-based marine ecosystem monitoring program for the sea-ice region of Lützow-Holm Bay, off Syowa Station, East Antarctica, began with the 52nd Japanese Antarctic Research Expedition (JARE-52) during 2010/11 season<sup>2</sup>. The aim of this program is to investigate biological production and mechanisms in relation to sea-ice.

This report presents the water temperature, salinity, macro-nutrients, phytoplankton chlorophyll-*a* concentrations, and zooplankton monitoring data obtained during a cruise by the icebreaker *Shirase* as part of the JARE-61 (January to February 2020). Similar datasets collected previously by JARE have been published in JARE Data Reports<sup>2, 3, 4, 5, 6, 7, 8, 9, 10, 11</sup>, and this journal<sup>12, 13, 14</sup>. This report is the fourth report for the marine ecosystem monitoring in the sea-ice region in this journal.

## 2. Sampling Location

Seawater and plankton samples were collected at six monitoring stations (A, B, C, D, E, and BP) in Lützow-Holm Bay in various sea-ice environments: fast-ice, pack-ice, and ice-free open ocean (Fig. 1 and Table 1). At the time of sampling, Station A and B were in the multi-year fast-ice zone, Station C and D were in the pack-ice zone, and Stations E and BP were in the open-ocean zone.

## 3. Methods

### 3.1. Protection of the observation equipment

Oceanographic observations in sea-ice areas have the problem that the existence of sea-ice makes it difficult to use conventional equipment such as plankton net. We devised the “ice-fence” which guards observation equipment from sea-ice (Fig. 2)<sup>15, 16</sup>.

### 3.2. Temperature and salinity

Vertical profiles of temperature and salinity were determined at six stations using a conductivity-

temperature-depth (CTD) memory probe (SBE19 plus, Sea-Bird Scientific) attached to a water sampler with six 4-L bottles (SBE 55 ECO, Sea-Bird Scientific). The data were downloaded from the CTD to a laptop computer immediately after each cast. The CTD sensor was calibrated by Sea-Bird Scientific prior to the observation. The salinity data in this report were not corrected by the bottle salinity data by the salinometer.

### 3.3. Chlorophyll *a*

Vertical water samples were collected over the upper 100 m of the water column using six Niskin bottles attached to the water sampler, and surface water was collected using a plastic bucket. Samples for chlorophyll-*a* measurement were collected in two dark bottles (ca. 300 mL) for bulk measurements using a glass-fiber filter (Whatman, GF/F, diameter 25 mm) and size-fractionated measurements to determine the phytoplankton size composition using a Whatman nuclepore membrane filter (pore size: 10 and 2  $\mu\text{m}$ , diameter 47 mm) and a Whatman GF/F (Diameter 47 mm). The filters were immediately soaked in N, N-dimethylformamide<sup>17</sup>, and the pigments were extracted for more than 24 hours. The samples were stored ( $-18^{\circ}\text{C}$ ) until onboard analysis. Concentrations of chlorophyll-*a* were determined fluorometrically<sup>18</sup> with an onboard fluorometer (10-AU; Turner Design, Sunnyvale, CA, USA). The fluorometer was calibrated against a chlorophyll-*a* standard (Fujifilm Wako Pure Chemical Corp., Osaka, Japan) at a laboratory on-land before the cruise, using a spectrophotometer and the specific absorption coefficient of chlorophyll-*a*<sup>19</sup>. For a fluorometer calibration result, see Makabe and Takahashi (2022)<sup>20</sup>.

### 3.4. Macro-nutrients

Seawater to determine macro-nutrient contents was collected at the time when seawater was sampled for chlorophyll-*a*. The sampled water was stored ( $-18^{\circ}\text{C}$ ) until analysis in a land laboratory. Nutrient concentrations were measured with a QuAAtro 2-HR system (provided by BL Tec K.K.). The nutrient (nitrate, nitrite, silicate, and phosphate) concentration measurements followed the methods of Hydes *et al.* (2010)<sup>21</sup>. A detailed description of the processing technique is presented in Shimada *et al.* (2025)<sup>22</sup>. The coefficients of variation calculated from five replicates of nitrate, nitrite, silicate, and phosphate were 0.11%, 0.17%, 0.11%, and 0.13%, respectively.

### 3.5. Zooplankton sampling

Zooplankton samples are collected using a closing net (mouth diameter 0.75 m, mesh size 100  $\mu\text{m}$ ). To prevent sea-ice from entering the net, an “ice-fence” is employed and the net was closed as it reaches the surface<sup>15</sup>. The net was equipped with a flow-meter to estimate the volume of water filtered. The volume of water filtered ( $V$   $\text{m}^3$ ) was calculated by multiplying the number of revolutions of the flowmeter ( $t$ ) by the volume of water filtered per one revolution of the flowmeter in the calibration ( $v = 0.01459$   $\text{m}^3$ ). The net was hauled vertically from a depth of 150 m to the

surface at stations where the bottom is deeper than 150 m, or from 10 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.

#### 4. Data Records

##### 4.1. Temperature, salinity, macro-nutrients, and chlorophyll-*a* concentration

All measurements are presented in two data files, named “JARE61\_Sea-ice\_CTD”, and “JARE61\_Ch1&Nuts”. The fields in the datasheets in the two files are:

**CTDPRS** – the pressure (dbar) of the data collected

**CTDTMP** – the temperature (degree C)

**CTDCND** – the conductivity (s/m)

**CTDSAL** – the salinity

**THETA** – the potential temperature (degree C)

**SIGT** – the sigma-t ( $\text{kg m}^{-3}$ )

**CRUISE** – the cruise code of the vessel

**SHIP** – the name of the ship on which the sampling was conducted

**STNNBR** – the name of the station on which the sampling was conducted

**DATE** – the sampling date (DD/MM/YYYY)

**TIME** – the sampling time (UTC)

**LATITUDE** – the decimal latitude of the sampling station (negative value for South)

**LONGITUDE** – the decimal longitude of the sampling station (positive value for East)

**DEPTH** – the sampling depth (m)

**SIG0** – the sigma- $\theta$  ( $\text{kg m}^{-3}$ )

**CHL BULK** – total chlorophyll-*a* concentration ( $\mu\text{g l}^{-1}$ )

**CHL 10UM** – composition of chlorophyll-*a* in >10  $\mu\text{m}$  fraction (%)

**CHL 2UM** – composition of chlorophyll-*a* in 2 – 10  $\mu\text{m}$  fraction (%)

**CHL GF/F** – composition of chlorophyll-*a* in <2  $\mu\text{m}$  fraction (%)

**NITRAT** – concentration of nitrate ( $\mu\text{mol l}^{-1}$  or  $\mu\text{mol kg}^{-1}$ )

**NITRIT** – concentration of nitrite ( $\mu\text{mol l}^{-1}$  or  $\mu\text{mol kg}^{-1}$ )

**SILCAT** – concentration of silicic acid ( $\mu\text{mol l}^{-1}$  or  $\mu\text{mol kg}^{-1}$ )

**PHSPHT** – concentration of phosphate ( $\mu\text{mol l}^{-1}$  or  $\mu\text{mol kg}^{-1}$ )

##### 4.2. Zooplankton dataset

Zooplankton monitoring datasets are presented at data file named “JARE61\_Sea-ice\_Zooplankton” in three data sheets, species/taxa list, abundance data and wet weight data. The fields in the dataset are:

**JARE number** – the JARE number of this sampling season

**Ship name** – the name of the ship on which the sampling was conducted

**Station number** – the name of the station on which the sampling was conducted

**Latitude** – the decimal latitude of the sampling station (negative value for South)

**Longitude** – the decimal longitude of the sampling station (positive value for East)

**Sampling season** – two-year Antarctic season based around the austral summer, e.g. “2019-2020” runs from December 2019 to March 2020

**Sampling year** – the sampling date year

**Sampling month** – the sampling date month

**Sampling day** – the sampling date day

**Sampling time** – the sampling date time (UTC)

**Sampling depth** – the depth of sampling tow

**Mesh size** – the mesh size of plankton net

**Estimated volume of water filtered** – the estimated volume of water filtered using a flow-meter

**Abundance** – the abundance of each species/taxa

**Total abundance** – total abundance of all zooplankton in a sample

**Number of species/taxa** – the number of species/taxa in a sample

**Wet weight** – the wet weight of each category

**Total wet weight** - total wet weight of all zooplankton in a sample

## 5. Technical Validation

### 5.1. Zooplankton identification

Zooplankton were identified to the lowest practical taxonomic level, generally to species or genus, using a stereo-microscope. Copepodite stages of copepod species, calytopis stages and furcilia stages of euphausiid species were subdivided from the adults. The nauplius stages of *Rhincalanus gigas* (Copepoda: Calanoida) were distinguished from other calanoid nauplii by their large size and elongate body. Zooplankton abundance was converted to individuals per cubic meter.

The species list for this dataset was checked using the Taxon Match of the World Register of Marine Species (WoRMS: <http://www.marinespecies.org/index.php>) name validation tool. WoRMS is an open-access inventory of all marine species, being >90% complete<sup>23</sup>. The tool performs a cross-check of the spelling and taxonomic status of species against the WoRMS database; it returns standard taxonomic information with valid names.

### 5.2. Wet weight measurement

Processing of samples was carried out according to the four-step procedure outlined below and shown in [Fig. 3](#).

Step 1: the large-sized zooplankton (more than 10 mm in size) were sorted for the whole sample in the laboratory. Zooplankton were classified into seven categories, and counting the number of individuals and the wet weight each category was measured using an electronic balance (Sartorius Quintix124-1SJP, readability 0.1 mg).

Step 2: all other species (<10 mm in size) were counted from 1/2 to 1/32 aliquots of the whole sample, and identified to the lowest taxonomic level, generally species or genus, level, using a stereo-microscope. We used a Motoda box-type plankton sample splitter to subdivide a sample<sup>24</sup>. While sorting and counting this size fraction, the wet weight of zooplankton typically reached more than 10 mg per aliquot.

Step 3: given that the wet weight of zooplankton of 1 mm size or less were hard to sort, this fraction was estimated by using conversion factors listed in [Table 2](#).

Step 4: the weights obtained in steps 1–3 were summed to give a total wet weight.

Zooplankton abundance was converted to mg m<sup>-3</sup>. For a detailed description of zooplankton processing for wet-weight measurements, see Ukai *et al.* (2014)<sup>33</sup>.

## 6. Figures

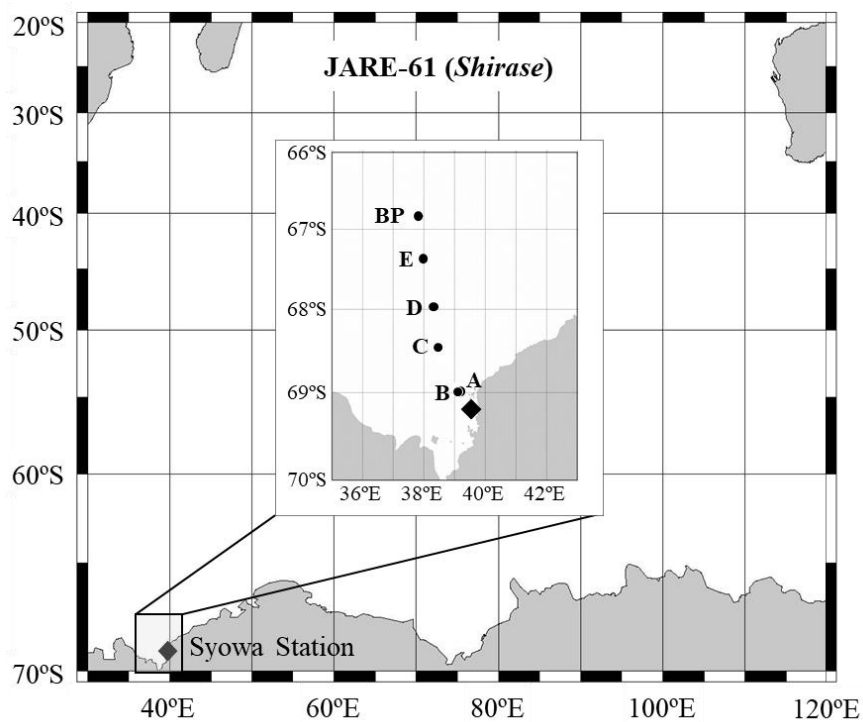


Fig. 1. Location of the sampling sites at Lützow-Holm Bay in January to February 2020.

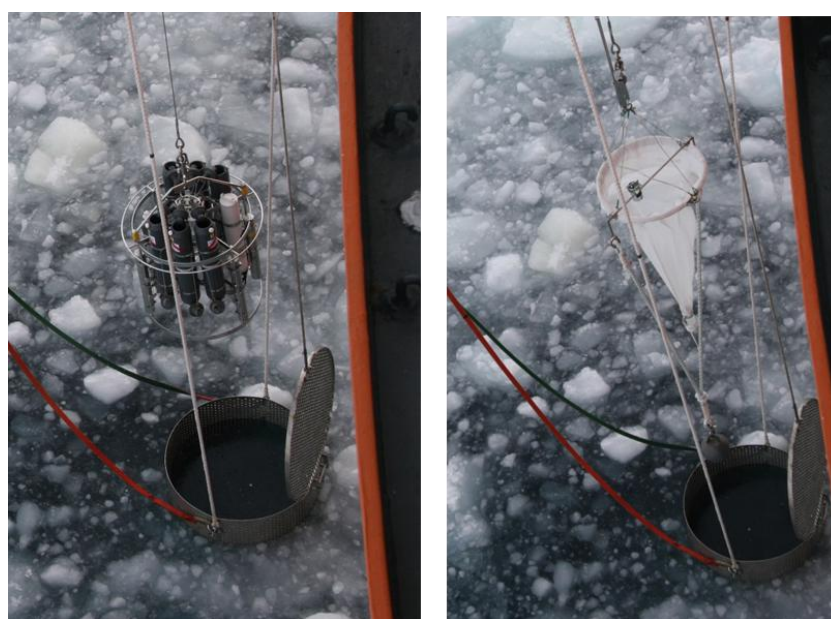


Fig. 2. CTD with a water sampler (left) and plankton net (right) used in the monitoring program in the sea-ice region. We used the “ice-fence” which guards observation equipment from sea-ice. Modified Figure 7 of Takahashi et al. (2012)<sup>15</sup>.

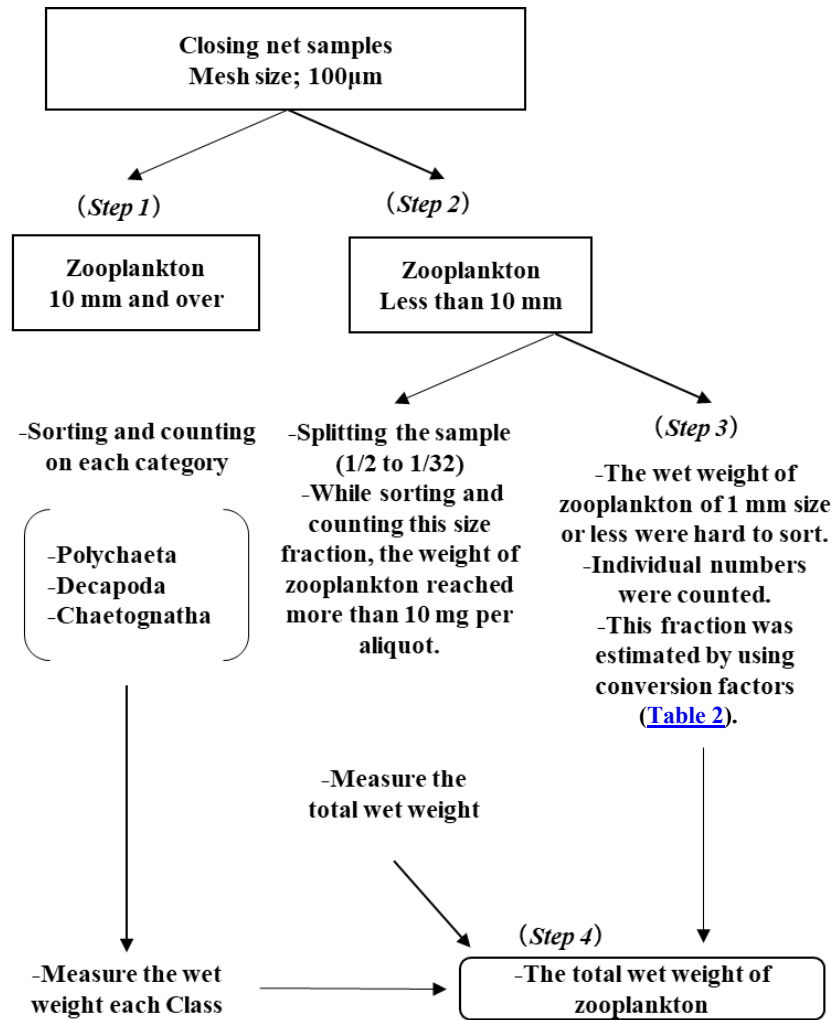


Fig. 3. Four-step procedure used to measure and to estimate the wet weight of Closing net samples.

## 7. Tables

Table 1. Sampling information of CTD cast and closing net at six stations.

Station	Date (UTC)	CTD cast			Closing net sampling			Sea-ice condition
		Time (UTC)	Latitude (°S)	Longitude (°E)	Time (UTC)	Latitude (°S)	Longitude (°E)	
A	29/01/2020	07:29	-69.07535	39.29192	07:43	-69.07535	39.29193	First-ice
B	29/01/2020	13:27	-69.01077	39.13993	13:41	-69.01077	39.13990	First-ice
C	31/01/2020	17:51	-68.46925	38.47803	18:10	-68.47013	38.47948	Pack-ice
D	02/02/2020	05:02	-67.94223	38.33007	05:26	-67.94212	38.33095	Pack-ice
E	04/02/2020	17:01	-67.33390	37.98345	17:28	-67.33598	37.98025	Ice-free
BP	06/02/2020	05:22	-66.82369	37.84605	05:45	-66.82394	37.84759	Ice-free

Table 2. Conversion factors between Carbon weight (CW), Dry weight (DW), Wet weight (WW), Body length (L), Bell height (BH), Bell diameter (BD), Shell length (SL), Trunk length (TL) and Body width (BW) used in this study.

Category	Species/taxa and/or Form	Developmental stage	Conversion factors of wet weight	Conversion factors of dry weight	Conversion factors of carbon weight
Cnidaria	BH/BD $\geq$ 1		WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.040	$\log \text{DW (mg)} = -2.333 + 1.268 \log \text{BH (mm)} + 1.125 (\log \text{BH (mm)})^2$	[9]
	BH/BD < 1		WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.043	$\log \text{DW (}\mu\text{g)} = -7.67 + 2.75 \log \text{BD (}\mu\text{m)}$	[5]
Mollusca	Thecosomata, Gastropoda larvae		WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.256	$\log \text{DW (}\mu\text{g)} = -5.10 + 2.46 \log \text{SL (}\mu\text{m)}$	[5]
	Cavolinidae (Cone)		WW ( $\mu\text{g}$ ) = $(3.14 \times \text{BW}(\mu\text{m})^2 \times \text{L}(\mu\text{m})) / 12 \times 10^{-6}$		[2]
Annelida	Bivalve	Larvae	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.256	$\log \text{DW (}\mu\text{g)} = -2.70 + 1.47 \log \text{SL (}\mu\text{m)}$	[5]
	Polychaeta	Larvae	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.097	$\log \text{DW (}\mu\text{g)} = -5.68 + 2.10 \log \text{L (}\mu\text{m)}$	[5]
Arthropoda	Ostracoda		WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.182	$\log \text{DW (}\mu\text{g)} = -13.77 + 4.99 \log \text{SL (}\mu\text{m)}$	[5]
	Copepoda: Calanoida	Adult, Copepodite	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.135	$\log \text{DW (}\mu\text{g)} = -9.59 + 3.41 \log \text{L (}\mu\text{m)}$	[5]
	Copepoda: Cyclopoida	Adult, Copepodite	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.135	$\log \text{DW (}\mu\text{g)} = -6.05 + 2.10 \log \text{L (}\mu\text{m)}$	[5]
	Copepoda: Microsetella	Adult, Copepodite	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.135	$\log \text{DW (}\mu\text{g)} = -7.59 + 2.88 \log \text{L (}\mu\text{m)}$	[5]
	Copepoda: Conyzeratus	Adult, Copepodite	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.135	$\log \text{DW (}\mu\text{g)} = -6.45 + 2.43 \log \text{L (}\mu\text{m)}$	[5]
	Copepoda: Oncaea	Adult, Copepodite	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.135	$\log \text{DW (}\mu\text{g)} = -5.59 + 2.25 \log \text{L (}\mu\text{m)}$	[5]
	Copepoda: Others	Adult, Copepodite	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.135	$\log \text{DW (}\mu\text{g)} = -9.07 + 3.26 \log \text{L (}\mu\text{m)}$	[5]
	Copepoda: Eucalanoidae	Nauplius	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.135	$\log \text{DW (}\mu\text{g)} = -9.59 + 3.41 \log \text{L (}\mu\text{m)}$	[5]
	Copepoda	Other nauplii	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.135	DW ( $\mu\text{g}$ ) = CW ( $\mu\text{g}$ ) / 0.457	[5]
	Cirripedia	Cypris	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.182	$\log \text{DW (}\mu\text{g)} = -13.77 + 4.99 \log \text{SL (}\mu\text{m)}$	[5]
		Nauplius	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.182	$\log \text{DW (}\mu\text{g)} = -6.54 + 2.65 \log \text{L (}\mu\text{m)}$	[5]
	Amphipoda			$\log \text{WW (mg)} = -1.517 + 2.832 \log \text{L (mm)}$	
Euphausiacea		Calyptopis, Furcilia, Adult	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.159	DW (mg) = $9.954 \times 10^{-4} \times \text{L (mm)}^{3.156}$	[10]
Chaetognatha		Nauplius	WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.159	DW ( $\mu\text{g}$ ) = CW ( $\mu\text{g}$ ) / 0.407	[5]
			WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.068	$\log \text{DW (}\mu\text{g)} = -0.553 + 2.79 \log \text{L (mm)}$	[5]
Chordata	Doliolida, Salpida		WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.050	$\log \text{DW (}\mu\text{g)} = -6.94 + 2.54 \log \text{L (}\mu\text{m)}$	[5]
	Appendiculata		WW ( $\mu\text{g}$ ) = DW ( $\mu\text{g}$ ) / 0.050	DW ( $\mu\text{g}$ ) = CW ( $\mu\text{g}$ ) / 0.442	[5]
Others Larvae		including eggs	WW ( $\mu\text{g}$ ) = $(3.14 \times \text{BW (}\mu\text{m)}^2 \times \text{L (}\mu\text{m)}) / 6 \times 10^{-6}$		[1]

[1]: Wet weight was calculated from the volume of the ellipsoid body (Specific gravity = 1). [2]: Wet weight was calculated from the volume of the cone (Specific gravity = 1). [3]: Beers (1966)<sup>[25]</sup>. [4]: Ikeda (1970)<sup>[26]</sup>. [5]: The Oceanographic Society of Japan (1986)<sup>[27]</sup>. [6]: Uye et al. (1996)<sup>[28]</sup>. [7]: Sato et al. (2001)<sup>[29]</sup>. [8]: Ikeda (1990)<sup>[30]</sup>. [9]: Ikeda and Imamura (1996)<sup>[31]</sup>. [10]: Iguchi et al. (1999)<sup>[32]</sup>.

### Author contributions

K. T. Takahashi performed the processing of zooplankton samples and writing of the manuscript. T. Odate directed the JARE-61 monitoring program. R. Makabe and K. D. Takahashi carried out chlorophyll-*a* and nutrient analysis in the land laboratory and analyzed the sensor data.

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### References

1. Constable, A. J. et al. Climate change and Southern Ocean ecosystems I: how changes in physical habitats directly affect marine biota. *Global Change Biology*. 2014, 20 (10), p. 3004–3025. <https://doi.org/10.1111/gcb.12623>.
2. Takahashi, K. T., Iida, T., Nishioka, J. and Odate, T. Biogeochemical data and chlorophyll *a* concentrations of phytoplankton during a cruise of the 53rd Japanese Antarctic Research Expedition in the austral summer of 2011–2012. *JARE Data Reports*. 2014, 326 (Mar. Biol. 44), p. 1–19. <https://doi.org/10.15094/00009937>.
3. Takahashi, K. T., Ojima, M., Ukai, Y. and Tanimura, A. Plankton sampling from the *Aurora Australis* and the *Shirase* in 2009–2013 —NORPAC standard net & closing net samples—. *JARE Data Reports*. 2014, 329 (Mar. Biol. 46), p. 1–19. <https://doi.org/10.15094/00010246>.
4. Takamura, T. R., Iida, T., Nishioka, J. and Odate, T. Biogeochemical properties of seawater measured from the icebreaker *Shirase* during the 54th Japanese Antarctic Research Expedition in the austral summer, 2012–2013. *JARE Data Reports*. 2014, 330 (Mar. Biol. 47), p. 1–17. <https://doi.org/10.15094/00010254>.
5. Takahashi, K. T., Iida, T., Takamura, T. R. and Odate, T. Biogeochemical properties of seawater measured from the icebreaker *Shirase* during the 55th Japanese Antarctic Research Expedition in the austral summer, 2013–2014. *JARE Data Reports*. 2015, 332 (Mar. Biol. 48), p. 1–17. <https://doi.org/10.15094/00010722>.
6. Takahashi, K. T., Iida, T., Ojima, M. and Odate, T. Zooplankton sampling during the 55th Japanese Antarctic Research Expedition in austral summer 2013–2014. *JARE Data Reports*. 2015, 336 (Mar. Biol. 49), p. 1–15. <https://doi.org/10.15094/00010788>.
7. Takahashi, K. T., Takamura, T. R., Iida, T., Nishioka, J. and Odate, T. Biogeochemical properties of seawater in Lützow-Holm Bay in February 2011 during the 52nd Japanese Antarctic Research Expedition. *JARE Data Reports*. 2015, 338 (Mar. Biol. 51), p. 1–8. <https://doi.org/10.15094/00010808>.

8. Takamura, T. R., Takahashi, K. T., Iida, T. and Odate, T. Biogeochemical properties of seawater measured from the icebreaker *Shirase* during the 56th Japanese Antarctic Research Expedition in the austral summer, 2014–2015. JARE Data Reports. 2016, 345 (Mar. Biol. 53), p. 1–14.  
<https://doi.org/10.15094/00010981>.
9. Takahashi, K. T., Takamura, T. R., Iida, T. and Odate, T. Zooplankton sampling during the 56th Japanese Antarctic Research Expedition in austral summer 2014–2015. JARE Data Reports. 2016a, 351 (Mar. Biol. 59), p. 1–15. <https://doi.org/10.15094/00013474>.
10. Takahashi, K. T., Takamura, T. R., Makabe, R. and Odate, T. Zooplankton sampling during the 57th Japanese Antarctic Research Expedition in austral summer 2015–2016. JARE Data Reports. 2016b, 352 (Mar. Biol. 60), p. 1–16. <https://doi.org/10.15094/00013515>.
11. Takamura, T. R., Takahashi, K. T., Makabe, R. and Odate, T. Biogeochemical properties of seawater measured from the icebreaker *Shirase* during the 57th Japanese Antarctic Research Expedition in the austral summer, 2015–2016. JARE Data Reports. 2016, 353 (Mar. Biol. 61), p. 1–16.  
<https://doi.org/10.15094/00013527>.
12. Takahashi, K. T., Makabe, R., Takao, S. and Odate, T. Marine ecosystem monitoring in the sea-ice region of Lützow-Holm Bay, off Syowa Station, during the icebreaker *Shirase* cruise of the 58th Japanese Antarctic Research Expedition. Polar Data Journal. 2024, 8, p. 23–33.  
<https://doi.org/10.20575/00000053>.
13. Takahashi, K. T., Makabe, R., Takao, S. and Odate, T. Marine ecosystem monitoring in the sea-ice region of Lützow-Holm Bay, off Syowa Station, during the icebreaker *Shirase* cruise of the 59th Japanese Antarctic Research Expedition. Polar Data Journal. 2024, 8, p. 67–79.  
<https://doi.org/10.20575/00000057>.
14. Takahashi, K. T., Makabe, R., Takao, S. and Odate, T. Marine ecosystem monitoring in the sea-ice region of Lützow-Holm Bay, off Syowa Station, during the icebreaker *Shirase* cruise of the 60th Japanese Antarctic Research Expedition. Polar Data Journal. 2025, 9, p. 1–13.  
<https://doi.org/10.20575/00000059>.
15. Takahashi, K. T., Iida, T., Hashida, G. and Odate, T. Field test of “ice-fence” for oceanographic observation in the sea-ice zone. Nankyoku Shiryô (Antarctic Record). 2012, 56 (3), p. 447–455 (in Japanese with English abstract). <https://doi.org/10.15094/00009667>.
16. Takahashi, K. T., Takamura, T. R. and Odate, T. Report on a modified ice-fence for oceanographic observations under heavy sea-ice conditions during JARE-54 and JARE-55. Nankyoku Shiryô (Antarctic Record). 2014, 58 (3), p. 393–403 (in Japanese with English abstract).  
<https://doi.org/10.15094/00010712>.
17. Suzuki, R. and Ishimaru, T. An improved method for the determination of phytoplankton chlorophyll using N, N-dimethylformamide. J. Oceanogr. Soc. Jpn. 1990, 46, p.190–194.  
<https://doi.org/10.1007/BF02125580>.
18. Welschmeyer, N. A. Fluorometric analysis of chlorophyll *a* in the presence of chlorophyll *b* and phaeopigments. Limnol. Oceanogr. 1994, 39 (8), p. 1985–1992.  
<https://doi.org/10.4319/lo.1994.39.8.1985>.

19. Porra, R. J., Thompson, W. A. and Kriedemann, P. E. Determination of accurate extinction coefficients and simultaneous equations for assaying chlorophylls *a* and *b* extracted with four different solvents: verification of the concentration of chlorophyll standards by atomic absorption spectroscopy. *BBA-Bioenergetics*. 1989, 975 (3), p. 384–394.  
[https://doi.org/10.1016/S0005-2728\(89\)80347-0](https://doi.org/10.1016/S0005-2728(89)80347-0).
20. Makabe, R. and Takahashi, K. T. Chlorophyll *a* and macronutrient concentrations during the icebreaker *Shirase* cruise of the 61st Japanese Antarctic Research Expedition. *Polar Data Journal*. 2022, 6, p. 25–31. <https://doi.org/10.20575/00000038>.
21. Hydes, D. J. et al. Determination of Dissolved Nutrients (N, P, Si) in Seawater with High Precision and Inter-Comparability Using Gas-Segmented Continuous Flow Analysers. The GO-SHIP repeat hydrography manual: A collection of expert reports and guidelines. IOCCP Report Number 14, ICPO Publication Series Number 134, Version. 1, 2010.  
[https://www.ioccp.org/images/06Nutrients/Hydes\\_et\\_al\\_Nutrients.pdf](https://www.ioccp.org/images/06Nutrients/Hydes_et_al_Nutrients.pdf), (accessed 2025-8-3).
22. Shimada, K., Takahashi, K. T., Kitade, Y. and Odate, T. Physical and chemical oceanographic data during *Umitaka-maru* cruise of the 61st Japanese Antarctic Research Expedition in January 2020. *Polar Data Journal*. 2025, 9, p. 53–80. <https://doi.org/10.20575/00000063>.
23. Costello, M. J. et al. Global Coordination and Standardisation in Marine Biodiversity through the World Register of Marine Species (WoRMS) and Related Databases. *PLoS ONE*. 2013, 8 (1), e51629. <https://doi.org/10.1371/journal.pone.0051629>.
24. Motoda, S. Devices of simple plankton apparatus. *Memoirs of the faculty of fisheries Hokkaido University*. 1959, 7 (1-2), p. 73–94. <https://hdl.handle.net/2115/21829>.
25. Beers, J. R. Studies on the chemical composition of the major zooplankton groups in the Sargasso Sea off Bermuda. *Limnol. Oceanogr*, 1966, 11 (4), p. 520–528.  
<https://doi.org/10.4319/lo.1966.11.4.0520>.
26. Ikeda, T. Relationship between respiration rate and body size in marine plankton animals as a function of the temperature of habitat. *Bulletin of the faculty of fisheries Hokkaido University*. 1970, 21 (2), p. 91–112. <https://hdl.handle.net/2115/23417>.
27. The Oceanographic Society of Japan. “Zooplankton survey.” Coastal environmental research manual. Tokyo, Kouseishakouseikaku. 1986, p. 184–191 (in Japanese).
28. Uye, S., Nagano, N. and Tamaki, H. Geographical and seasonal variations in abundance, biomass and estimated production rates of microzooplankton in the Inland Sea of Japan. *J. Oceanogr*. 1996, 52, p. 689–703. <https://doi.org/10.1007/BF02239460>.
29. Sato, R., Tanaka, Y. and Ishimaru, T. House production by *Oikopleura dioica* (Tunicata, Appendicularia) under laboratory conditions. *J. Plankton. Res*. 2001, 23 (4), p. 415–423.  
<https://doi.org/10.1093/plankt/23.4.415>.
30. Ikeda, T. A Growth Model for a Hyperiid Amphipod *Themisto japonica* (Bovallius) in the Japan Sea, Based on Its Intermoult Period and Moult Increment. *J. Oceanogr. Soc. Japan*. 1990, 46, p. 261–272.  
<https://doi.org/10.1007/BF02123502>.

31. Ikeda, T. and Imamura, A. Abundance, vertical distribution and life cycle of a hydromedusa *Aglantha digitale* in Toyama Bay, southern Japan Sea. Bull. Plankton Soc. Japan. 1996, 43 (1), p. 31–43. <https://agriknowledge.affrc.go.jp/RN/2010542343.pdf>, (accessed 2025-8-3).
32. Iguchi, N. and Ikeda, T. Production, metabolism and *P:B* ratio of *Euphausia pacifica* (Crustacea: Euphausiacea) in Toyama Bay, southern Japan sea. Plankton Biol. Ecol. 1999, 46 (1), p. 68–74. <https://www.plankton.jp/PBE/>, (accessed 2025-8-3).
33. Ukai, Y., Takahashi, K. T., Fukuchi, M. and Tanimura, A. Revaluation of zooplankton wet weight data of the NORPAC net samples collected in the Indian sector of the Southern Ocean. Nankyoku Shiryo (Antarctic Record). 2014, 58 (1), p. 19–41 (in Japanese with English abstract). <https://doi.org/10.15094/00009723>.

#### Data Citations

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