Aquatic Animals

水生動物 第2025巻
令和7年1月

Zooplankton communities in late spring: A case study from Sado Island

Parvez Chowdhury [1, 2, 3*], Midori Iida [1, 4]

[1]Marine Biological Station, Sado Island Center for Ecological Sustainability, Niigata University, 87 Tassha, Sado, Niigata 952-2135, Japan. [2] Graduate School of Science and Technology, Niigata University, Niigata, Japan. [3]Bangladesh Fisheries Research Institute, Mymensingh-2201, Bangladesh. [4]Usujiri Fisheries Station, Field Science Center for Northern Biosphere, Hokkaido University, 152 Usujiri, Hakodate, Hokkaido 041-1613, Japan.

*Corresponding author, e-mail: f22m004g@mail.cc.niigata-u.ac.jp, nitoldhk@gmail.com, Tel: + 81-259-75-2021.

Abstract

To understand the pelagic community of zooplankton near the offshore island, an investigation was conducted on Sado Island, in the Sea of Japan with two commonly used plankton nets (mesh size: 100 and 335 μm). Zooplankton were surveyed from the sea surface at two offshore sampling stations using a research vessel in late spring 2023. The zooplankton community comprised 34 morphologically distinguished operational taxonomic units (OTUs). Zooplankton collected from the two sampling stations contained mainly copepods, radiolarians, cladocerans, larvaceans, and crustacean nauplii. Some meroplankton were observed only at the station closer to shore, whereas many others were observed at both stations. Large zooplankton, such as calanoid and cyclopoid copepods, chaetognaths, meroplanktonic fish larvae and radiolarians were collected with the larger-mesh plankton net whereas small zooplankton, such as harpacticoid copepods, cyclopoid nauplii and molluscans were collected with the smaller-mesh plankton net. This study describes the zooplankton community near Sado Island, and it will be useful for understanding and predicting changes in plankton distribution in the Sea of Japan.

Key words: zooplankton; community; plankton net; Sado Island

Introduction

Zooplankton are tiny drifting animals in marine ecosystems that transfer energy from primary producers to higher-order consumers, including fish (Suthers et al. 2019; Kodama et al. 2022; Yamamae et al. 2023). Plankton surveys are one of the key techniques for understanding the diversity and abundance of aquatic organisms in marine habitats.

Sado Island is the second-largest offshore island of Japan. Accordingly, it exhibits great marine biodiversity, including zooplankton. The Tsushima Warm Current (TWC) passes around this island, influencing the plankton community. There have been no extensive studies of zooplankton communities at Sado Island for more than three decades. Zooplankton communities are enriched in spring in terms of biomass and abundance, due to a spring phytoplankton bloom that occurs throughout temperate regions (Hirakawa et al. 1992; Arima et al. 2014; Mahara et al. 2021). Therefore, we conducted a short zooplankton survey offshore at Sado Island, in late spring 2023, using two types of plankton nets.

According to the target size and group of zooplankton, various mesh sizes of plankton nets are used in the open sea (350 μm in Toyama Bay, Sea of Japan, NORPAC net, Hirakawa et al. 1992; 270 μm in Bering Sea, Northeast Pacific Ocean, Ashlock et al. 2021) and along coastlines (100 μm in Kagoshima Bay, Minowa et al. 2011; Ishikari Bay, Arima et al. 2014). Mesh size is determined by balancing plankton avoidance and extrusion of nets to prevent zooplankton from passing through. It is recommended by UNESCO that zooplankton samples be collected using 200-μm mesh (Harris et al. 2000). Two types of net were used in this study to collect a wide range of zooplankton. The objective of this study was to determine the late spring composition of zooplankton on the western side of Sado Island. Consequently, it will advance our understanding of zooplankton populations at Sado Island compared to other locations in the Sea of Japan.

Materials and Methods

Study area

This study was conducted offshore Sado Island (38.04° N, 138.33° E), Niigata Prefecture, which is located in the eastern part of the Sea of Japan. Zooplankton sampling was conducted at two sampling stations along the west side of the island. The locations of sampling stations (Sts.) were A (38°05.042' N, 138°12.671' E) and B (38°04.617' N, 138°14.407' E), in the sea 5 km and 1 km from the coast in Tassha, Senkaku Bay (Fig. 1).

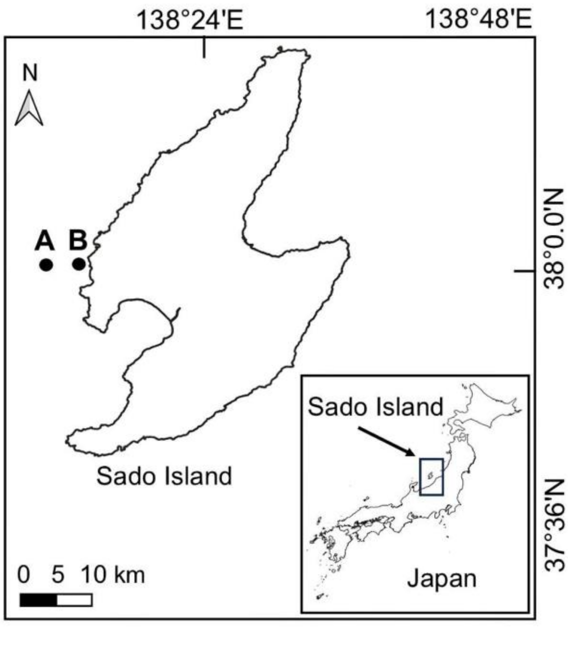

Fig. 1. A map showing locations of the two sampling stations (Sts. A and B) at Sado Island, Niigata Prefecture, Japan.

Field sampling and preservation

Zooplankton samples were collected at both stations using plankton nets deployed from a research vessel (R/V IBIS II; Marine Biological Station, Sado Island Center for Ecological Sustainability (SMBS); Niigata University) on 26 June 2023. Four samples were collected from the sea surface (upper 5 m) in the morning via horizontal hauls using two types of plankton nets (Modified North Pacific Standard Net (NORPAC plankton net)), GG52, mesh size 335 µm, Rigo-sha Ltd., Japan; and Kitahara's surface plankton net, XX13, mesh size 100 µm, Rigo-sha Ltd.). Samples were preserved in 3 % formaldehyde solution for further identification and observations.

Collection of environmental data

Environmental parameters, such as water temperature (°C), dissolved oxygen (DO, mg L^{-1}), pH, chlorophyll-*a* (Chl-*a*, µg L^{-1}), and salinity were measured by conductivity, temperature, and depth profiling (CTD, RINKO-Profiler, ASTD102, JFE Advantech, Japan) for each zooplankton sample. Only surface water (1 m) data are presented in this paper, as zooplankton sampling was conducted at the surface. According to our previous survey, environmental parameters were similar especially for surface layers at Sts. A and B (Chowdhury and Iida, unpublished data), and single measurements were considered representative of environmental parameters at each station.

Identification of zooplankton

Identification was based on morphological characteristics observed under a stereomicroscope (Olympus, SZX16) with a camera system (Olympus, DP23) and using various publications (Yamaji 1984; Chihara and Murano 1997; Larink and Westheide 2011; Iwakuni City Micro Life Museum 2013). Zooplankton were identified to the lowest possible taxonomic level and treated as operational taxonomic units (OTUs). Zooplankton are a diverse community in marine ecosystems, and there are no diagnostic features that can be used for all zooplankton species, including their developmental stages. Therefore, we used OTUs, as done in other plankton studies (Costa et al. 2011; Gallego et al. 2014; Pineda-Metz and Montiel 2021; Costello et al. 2023; Killeen et al. 2023; Yamamae et al. 2023). Additionally, taxonomic status of identified OTUs was confirmed using the World Register of Marine Species database (WoRMS Editorial Board 2023). Single-cell organisms, such as radiolarians and dinoflagellates, were also included in this study due to their abundance around Sado Island. We have a large list of identified zooplankton throughout the years, but we only included zooplankton OTUs found during the field survey (26 June 2023) offshore in this case study. Therefore, information about other zooplankton OTUs is not included here.

Results

Environmental factors

Environmental factors were similar at the two stations at the surface in spring (Table 1). Water temperature was 22.8 at St. A and 22.6 at St. B. Salinity was 34.26 at St. A and 34.22 at St. B. Chlorophyll-*a* was slightly lower at St. A (0.01) than at St. B (0.03). DO was 6.88 at St. A and 6.90 at St. B.

Table 1. Sea-surface environmental parameters in the top 1 m in the spring at two sampling stations on the west side of Sado Island.

Sts.	Water temperature (°C)	Salinity	Chlorophyll-*a* (μg/L)	DO (mg/L)
A	22.86	34.26	0.01	6.88
B	22.65	34.22	0.03	6.90

Taxonomic composition of the zooplankton community

A total of 34 zooplankton OTUs were identified from zooplankton samples collected during late spring at Tassha, Senkaku Bay. In total, 27 and 23 OTUs were found at Sts. A and B, respectively, and more OTUs were captured by the smaller-mesh net (XX13) (Tables 2 and 3).

Samples collected from the two stations contained mainly copepods, radiolarians, cladocerans, larvaceans, molluscans, eggs, and nauplii. Most of the copepods belong to the orders Calanoida and Cyclopoida, whereas the major radiolarians were Arthracanthida. The molluscs were predominantly Littorinimorpha, and cladocerans were predominantly Onychopoda (Tables 2 and 3).

Similarities and differences in zooplankton communities were observed between stations and plankton nets (Tables 2 and 3). Ten zooplankton OTUs were commonly collected at St. A including Calanoida, Cyclopoida: *Oithona* (sp. 1), Onychopoda: *Pseudevadne tergestina*, Noctilucales: *Noctiluca* (sp. 1), and Copelata: *Oikopleura* (sp. 1), by both nets (Table 2). On the other hand, nine OTUs were commonly collected at St. B, including Calanoida, Cyclopoida: *Corycaeus* (sp. 1), Onychopoda: *Evadne spinifera*, Cirripedia nauplii (sp. 1), Sagittidae, and Fritillaridae with both nets (Table 3). Additionally, *Pseudevadne tergestina*, *Evadne spinifera* and *Oikopleura* (sp. 1) were found in both stations, but *Microsetella* (spp. 1, 2) only at St. A and *Corycaeus* (sp. 1) only at St. B (Tables 2 and 3). In terms of community composition, copepods were the most diverse community in late spring followed by mollusks and radiolarians, offshore at Tassha, Senkaku Bay, on the west side of Sado Island.

Discussion

Diversity of major copepod groups was high at both sampling stations. Abe et al. (1984) listed various copepod taxa on Sado Island. Calanoid and cyclopoid copepods were also diverse in spring at Toyama Bay (Hirakawa et al. 1992), Wakasa Bay (Iguchi et al. 1999) and Ishikari Bay (Arima et al. 2014). The distributions of calanoid and cyclopoid copepods at Sado Island were similar to those observed elsewhere in the Sea of Japan. Radiolarians were also abundant in this study. Radiolarian fauna (*Acanthometron pellucidum* and Spumellaria sp. 2) were observed at St. A, but were not found at St. B. It is quite likely that the regular inflow of the Tsushima Warm Current (Itaki et

Table 2. Identified zooplankton OTUs at Station A with two mesh sizes of plankton net.

Phylum	Orders or Others	Name of OTU (net type)
Radiolaria	Spumellaria	Spumellaria (sp. 2) (GG52)
	Arthracanthida	*Acanthometron pellucidum* (GG52)
Myzozoa	Noctilucales	*Noctiluca* (sp. 1) (GG52)
Arthropoda	Calanoida	Calanoida (sp. 1) (GG52, XX13)
		Calanoida (sp. 5) (XX13)
		Calanoida (sp. 8) (GG52, XX13)
		Calanoida (sp. 11) (GG52)
		Calanoida (sp. 12) (GG52)
		Calanoida (sp. 13) (XX13)
		Calanoida (sp. 16) (XX13)
		Calanoida (sp. 29) (XX13)
	Cyclopoida	*Oithona* (sp. 1) (GG52, XX13)
		Oithonidae (sp. 1) (GG52, XX13)
		Oncaeidae (sp. 1) (XX13)
		Cyclopoid nauplii (sp. 2) (XX13)
	Harpacticoida	*Microsetella* (spp. 1, 2) (XX13)
	Onychopoda	*Pseudevadne tergestina* (GG52, XX13)
		Evadne spinifera (GG52, XX13)
	Amphipoda	Amphipoda (spp. 5, 6) (GG52)
Mollusca	Littorinimorpha	Littorinimorpha (sp. 1) (XX13)
		Littorina egg (sp. 1) (GG52, XX13)
Chaetognatha	Aphragmophora	Sagittidae (sp. 3) (GG52)
Chordata	Copelata	*Oikopleura* (sp. 1) (GG52, XX13)
		Fritillaridae (sp. 1) (GG52, XX13)
-	Others	egg (sp. 1) (GG52, XX13)

al. 2003) and the great depth (Kurihara et al. 2008; Kurihara and Matsuoka 2011) at St. A are ideal for them.

Some plankton taxa were collected only at one station. Meroplankton (fish larvae, Cirripedia nauplii, and bivalves (Venerida)) were only found at St. B, which is closer to the coast, where it may serve as a nursery for various aquatic organisms. Both plankton nets collected certain zooplankton OTUs, including Calanoida, *Corycaeus* (sp. 1), *Evadne spinifera,* Littorinimorpha, Cirripedia nauplii and Fritillaridae (Tables 2 and 3). Some small OTUs such as cyclopoid nauplii (sp. 2) and Oncaeidae (sp. 1) were collected only with the smaller mesh net (XX13). In previous studies, 100-μm mesh nets have been used offshore for year-round vertical plankton surveys (Abe et al. 1984), and radiolarian collections (Matsuoka et al. 2002) at Tassha, Senkaku Bay, Sado Island, whereas Ishida (2019) used 72-μm mesh net for polycystine radiolarians offshore of Sakata, Yamagata Prefecture. Also, large-mesh (315 and 335 μm) nets were used in the Sea of Japan for long-term zooplankton surveys (Kodama et al. 2018, Hama et al. 2019, Takahashi 2024). In this study of zooplankton community composition, we observed a wide range of OTUs using two nets. The two nets gave similar profiles at the same station, but slight difference between stations. Further studies are needed to understand the influence of

Table 3. Identified zooplankton OTUs at Station B with two mesh sizes of plankton net.

Phylum	Orders or Others	Name of OTU (net type)
Arthropoda	Calanoida	Calanoida (sp. 1) (GG52)
		Calanoida (sp. 5) (XX13)
		Calanoida (sp. 7) (XX13)
		Calanoida (sp. 8) (XX13)
		Calanoida (sp. 15) (GG52)
	Cyclopoida	*Oithona* (sp. 1) (XX13)
		Oithonidae (sp. 1) (XX13)
		Corycaeus (sp. 1) (GG52, XX13)
		Oncaeidae (sp. 1) (XX13)
		Cyclopoid nauplii (sp. 2) (XX13)
	Onychopoda	*Pseudevadne tergestina* (GG52)
		Evadne spinifera (GG52, XX13)
	Amphipoda	Amphipoda (sp. 6) (GG52, XX13)
	Others	cirripedia nauplii (sp. 1) (GG52, XX13)
Chaetognatha	Aphragmophora	Sagittidae (sp. 2) (GG52)
		Sagittidae (sp. 3) (GG52, XX13)
Mollusca	Littorinimorpha	Littorinimorpha (sp. 1) (GG52, XX13)
		Littorina egg (sp. 1) (XX13)
	Venerida	Venerida (sp. 1) (XX13)
Chordata	Copelata	*Oikopleura* (sp. 1) (GG52, XX13)
		Fritillaridae (sp. 1) (GG52, XX13)
	Osteichthyes	fish larvae (sp. 1) (GG52)
-	Others	egg (sp. 1) (GG52, XX13)

environmental parameters on plankton community composition.

Acknowledgments

We thank Toyokazu Shimotani (SMBS, Niigata University) for his valuable assistance during the field survey and Steven D. Aird for editing the manuscript. The comments of two anonymous reviewers and the editor are appreciated. This study was partly supported by a research grant from the Uchida Energy Science Promotion Foundation.

References

Abe, N., Honma, Y., Kitami, T. (1984). Species composition fluctuation of plankton communi ties in Tassha Bay of Sado Island. Rep. Sado Mar. Biol. Stat., Niigata University 14: 1–21.

Arima, D., Yamaguchi, A., Abe, Y., Matsuno, K., Saito, R., Asami, H., Shimada, H., Imai, I. (2014). Seasonal changes in zooplankton community structure in Ishikari Bay, Japan Sea. Bull. Fish Sci., Hokkaido University, Japan 64: 17–23.

Ashlock, L., Reyes, M.G., Gentemann, C., Batten, S., Sydeman, W. (2021). Temperature and patterns of occurrence and abundance of key copepod taxa in the Northeast Pacific. Front. Mar. Sci. 8: 670795.

Costa, K.G.D., Pinheiro. P.R.S., Melo, C.A.R, Oliveira S.M.O.D., Pereira L, C. C., Costa, R. M. D. (2011). Effects of seasonality on zooplankton community dynamics in the macrotidal coastal zone of the Amazon region. J. Coastal. Res. 64: 364–368.

Costello, K.E., Haberlin, D., Lynch, S.A., McAllen, R., Riordan, R.M.O., Culloty S.C. (2023). Regional differences in zooplankton-associated bacterial communities and aquaculture pathogens across two shelf seas. Estuar. Coast. Shelf. Sci. 281: 108179.

Chihara, M., Murano, M. (1997). An Illustrated Guide to Marine Plankton in Japan (ed.). Tokai University Press: Tokyo, Japan. (In Japanese).

Gallego, R., Lavery, S., Sewell, M.A. (2014). The meroplankton community of the oceanic Ross Sea during late summer. Antarc. Sci. 26: 345–360.

Hama, N., Abe, Y., Matsuno, K., Yamaguchi, A. (2019). Study on effect of net mesh size on filtering efficiency and zooplankton sampling efficiency using Quad- NORPAC net. Bull. Fish Sci., Hokkaido University, Japan 69: 45–56.

Harris, R., Wiebe, P., Lenz, J., Skjoldal, H. R., Huntley, M. (2000). ICES zooplankton Methodology Manual. Academic Press, London, UK.

Hirakawa, K., Imamura, A., Ikeda, T. (1992). Seasonal variability in abundance and composition of zooplankton in Toyama Bay, Southern Japan Sea. Bull. Japan Sea Nat. Fish. Res. Inst. 42: 1–15.

Iguchi, N., Wada, Y., Hirakawa, K. (1999). Seasonal changes in the copepod assemblages as food for larval anchovy in western Wakasa Bay, Southern Japan Sea. Bull. Japan Sea Nat. Fish. Res. Inst. 49: 69–80.

Ishida, N. (2019). Summer surface water polycystine radiolarians in the eastern margin of the Japan Sea. Bull. Geol. Surv. Jpn. 70: 101–108.

Itaki, T., Matsuoka, A., Yoshida, K., Machidori, S., Shinzawa, M., Todo, T. (2003). Late spring radiolarian fauna in the surface waters off Tassha, Aikawa town, Sado Island, central Japan. Sci. Rep. Niigata. Univ. Ser. E (Geology), Jpn. 18: 41–51.

Iwakuni City Micro Life Museum. (2013). A Photographic Guide to Marine Plankton of Japan. 2nd edition. pp. 169-250. Kyoritsu Publishing: Tokyo, Japan. (In Japanese).

Killeen, H., Parker, M., Morgan, S.G., Largier, J.I., Susner, M.G., Dibble, C., Dann, D. (2023). Small-scale topographic fronts along an exposed coast structure plankton communities. Estuar. Coast. Shelf. Sci. 293: 108474.

Kodama, T., Wagawa, T., Iguchi, N., Takada, Y., Takahashi, T., Fukudome, K.I., Morimoto, H., Goto, T. (2018). Spatial variation in zooplankton community structure along the Japanese coastline in the Japan Sea: influence of the coastal current. Ocean Sci. 14: 355–369.

Kodama, T., Igeta, Y., Iguchi, N. (2022). Long-term variation in mesozooplankton biomass caused by top-down effects: A case study in the coastal Sea of Japan. Geophys. Res. Lett. 49: 1–10.

Kurihara, T., Uchida, K., Shimotani, T., Matsuoka, A. (2008). Radiolarian fauna characteristics in surface-subsurface waters of the Japan Sea off Tassha, Sado Island, central Japan in June 2007: Inflowing radiolarians on the Tsushima warm current. Sci. Rep. Niigata. Univ. (Geology). 23: 65–74.

Kurihara, T., Matsuoka, A. (2011). Living radiolarians sampled on 7 June 2010 in surface- subsurface waters of the Japan Sea off Tassha, Sado Island, central Japan. Sci. Rep. Niigata. Univ. (Geology) 26: 53–60.

Larink, O., Westheide, W. (2011). Coastal Plankton: Photo guide for European Seas (2nd ed.), Deutsche National Bibliothek, Germany, pp. 40–83.

Mahara, N., Pakhomov, E.A., Dosser, H.V., Hunt, B.P.V. (2021). How zooplankton communities are shaped in complex and dynamic coastal system with strong tidal influence. Estuar. Coast. Shelf. Sci. 249: 107103.

Matsuoka A, Shinzawa M, Yoshida K, Machidori S, Kurita H and Todo T (2002) Early summer radiolarian fauna in surface waters off Tassha, Aikawa town, central Japan. Sci. Rep. Niigata. Univ. (Geology) 17: 17–25.

Minowa, M., Kobari, T., Akamatsu, H., Ichikawa, T., Fukuda, R., Higashi, M. (2011). Seasonal changes in abundance, biomass and depth distribution of mesozooplankton community in Kagoshima Bay. Bull. Jap. Soc. Fish. Oceanogr. 75: 71–81.

Pineda-Metz, S.E.A., Montiel, A. (2021). Seasonal dynamics of meroplankton in a sub-Antarctic fjord (Patagonia, Chile). Polar. Biol. 44: 875–886.

Suthers, I.M., Rissik, D., Richarson, A.J. (2019). Plankton: A guide to their ecology and monitoring for water quality (2nd edition), CSIRO Publishing: Clayton South, VIC., Australia, pp 75–76.

Takahashi, K. (2024). Zooplankton monitoring using a twin NORPAC net during the 63rd Japanese Antarctic Research Expedition in austral summer 2021–2022. Polar Data J. 8: 34–43.

WoRMS Editorial Board. (2023). World register of marine species. https://www. marinespecies.org. (accessed on 15 August 2024).

Yamaji, I. (1984). Illustrations of the Marine Plankton of Japan (3rd ed.), Hoikusha Publishing: Osaka, Japan. (In Japanese).

Yamamae, K., Nakamura, Y., Matsuno, K., Yamaguchi, A. (2023). Vertical changes in zooplankton abundance, biomass, and community structure at seven stations down to 3000 m in neighboring waters of Japan during the summer: Insight from ZooScan imaging analysis. Prog. Oceanogr. 219: 103155.

Received: 13 November 2024 | Accepted: 31 December 2024 | Published: 10 January 2025