Characteristics of the zooplankton community in the Okhotsk Sea in autumn: A comparison with the Oyashio region

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Abstract

Based on the vertical stratified zooplankton samples collected during the autumns (September–December) of 1996 to 1998, vertical distribution, biomass, and community structure of zooplankton and calanoid copepods in the southern Okhotsk Sea were evaluated and compared with those of the same period in the Oyashio region. In terms of fauna, zooplankton in the Okhotsk Sea are similar to that in the Oyashio region. However, their biomass, community structure and vertical distribution patterns are quite different between these two regions. Zooplankton biomass near the surface layer (0 m to thermocline) in the Okhotsk Sea was less than that of the Oyashio region. To understand the reason for this, we look at the distribution of large copepods in the mesopelagic layer in the Okhotsk Sea (this is epipelagic in the Oyashio region). Standing stocks of most zooplankton taxa were smaller in the Okhotsk Sea, while only the copepod *Metridia okhotensis* showed an opposite pattern. The abundance of *M. okhotensis* in the Okhotsk Sea was 30 times greater than that in Oyashio region, and they predominated (60% of the total copepod number) in the Okhotsk Sea. The development of a strong pycnocline in the Okhotsk Sea may be a key feature responsible for these regional differences in the zooplankton community in the Okhotsk Sea and Oyashio region.

Introduction

The Okhotsk Sea is known to be the lowest latitude sea to be ice covered in winter. Two factors contribute to the special characteristics of the Okhotsk Sea. The first one is in physical oceanography. There is the development of a strong pycnocline below which near-zero temperature cold intermediate water is present (Kitani, 1973). The second factor is related to biological oceanography. Juveniles of Japanese salmon born in a given year are known to migrate to the Okhotsk Sea for feeding in summer (Ueno and Ishida, 1996). Both these factors are considered to affect the abundance and distribution of zooplankton.

To clarify the characteristics of the zooplankton community in the Okhotsk Sea, we studied the vertical distribution of biomass, copepod community structure, population structure and body sizes and compared the results with those in the adjacent Pacific (Oyashio region).

Methods

In the present study, two types of samplings were made. The first one was stratified sampling between 0 and 2000 m depth using a closing net (Fig. 1, open circles). The second one was stratified sampling between 0 to 500 m depth using the IONESS system, which is a version of MOCNESS (solid circles). Stratified sampling at the IONESS stations was made four times per day to evaluate diel changes in vertical distribution.

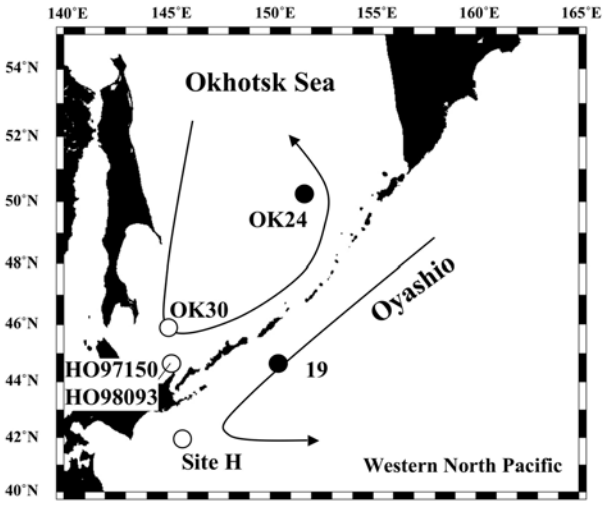

Fig. 1 Sampling stations in the Okhotsk Sea and the Oyashio region. Open circles indicate where samplings were done with a closing net and solid circles indicate samplings taken with the IONESS.

All of the samplings were conducted between September and December from 1996–1998. Results were compared assuming that inter-annual changes were minimum. To estimate biomass, the settling volume was measured for closing net samples. To determine the community structure, major zooplankton taxa and species, and stages of calanoid copepods were identified and quantified. Results were tested to find out whether inter-oceanic differences were present or not.

Hydrography

Temperature data are shown in Figure 2 for the closing net and IONESS stations. In the Okhotsk Sea, cold intermediate water is observed below the pycnocline. One station reached below 0°C. Since this study was conducted in autumn, this negative temperature was considered to be formed in the winter of the previous year. In the Oyashio region, there was no cold intermediate water. No station registered below 2°C in the Oyshio region (Fig. 2).

Biomass

The vertical distribution of zooplankton biovolume is shown in Table 1. In the Oyashio region, the highest biomass was commonly observed in the surface layer (0 m to thermocline) while in the Okhotsk Sea, it was commonly observed in the 250–500 m depth strata. Significant differences were noted only in the surface layer, where the zooplankton biomass in the surface layer of the Okhotsk Sea was lower than that in the Oyashio region by a factor of 1/4. Since there was no variation in the rest of the water column (Tc–2000 m depth), the biomass also did not vary (Table 1).

Taxonomic content

Thirteen taxa and 34 calanoid copepods were identified from the samples collected by IONESS. Of these, 6 taxa and 7 calanoid copepod species showed significant differences in abundance between the regions. Six taxa: Amphipoda, Appendicularia,

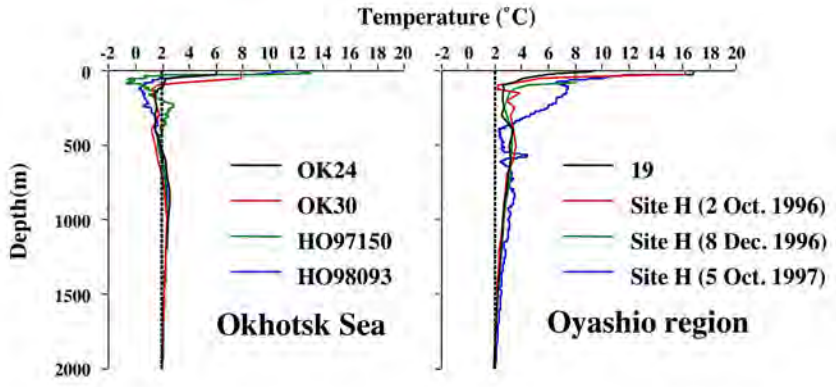

Fig. 2 Vertical distribution of temperature at stations in (left) the Okhotsk Sea and (right) Oyashio region. For comparison, position of 2°C is indicated by dotted lines.

Table 1 Inter-oceanic comparison of zooplankton biovolume (mL m^{-3}).

Depth strata (m)	Okhotsk Sea (*n*=5)	Oyashio region (*n*=6)	Mann-Whitney *U*-test
0–Tc	0.88 ± 0.11	3.59 ± 1.81	*
Tc–250	0.53 ± 0.43	0.65 ± 0.36	ns
250–500	1.14 ± 0.20	0.90 ± 0.32	ns
500–1000	0.37 ± 0.29	0.47 ± 0.12	ns
1000–2000	0.35 ± 0.24	0.24 ± 0.12	ns
0–2000	0.39 ± 0.23	0.53 ± 0.17	ns

Tc: thermocline, *: $p < 0.01$, ns: not significant

Chaetognatha, Poecilostomatoida, Polychaeta, Mollusca, and 6 calanoid copepods: *Eucalanus bungii, Metridia pacifica, Neocalanus cristatus, Pleuromamma scutullata, Pseudocalanus minutus* and *P. newmani* were more abundant in the Oyashio region. Only one calanoid copepod, *Metridia okhotensis*, showed greater abundance in the Okhotsk Sea, by a factor of 30 times (9369 inds. m^{-2} in the Okhotsk Sea vs. 367 inds. m^{-2} in the Oyashio region).

Since calanoid copepods were the predominant component of the zooplankton community (>80%) in both regions, the species compositions of calanoid copepods were further analyzed (Fig. 3). In the Oyashio region, the most dominant copepods were *Metridia pacifica*, followed by *Eucalanus bungii, Pseudocalanus mintus, P. newmani, Neocalanus plumchrus* and *M. okhotensis*, which was similar to the patterns of the both the western and eastern subarctic Pacific (*cf.*, Goldblatt *et al.*, 1999; Ikeda *et al.*, 2008). In the Okhotsk Sea, *M. okhotensis* was the predominant component and accounted for 66% of the total copepod abundance. Since the composition of *M. okhotensis* was only 0.9% of the total copepod abundance in the Oyashio region, the anomalously high abundance of *M. okhotensis* in the Okhotsk Sea is considered to be a special characteristic of copepod communities in the Okhotsk Sea.

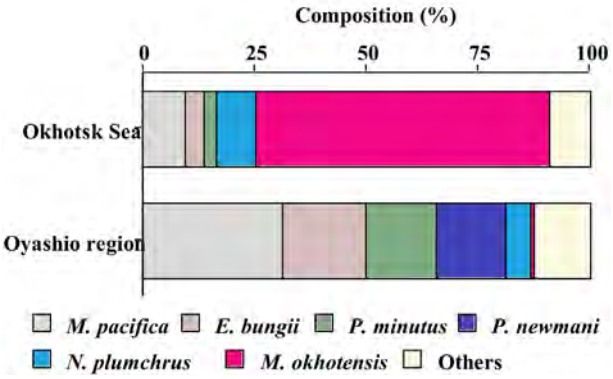

Fig. 3 Species composition of the calanoid copepod communities in the Okhotsk Sea (upper) and Oyashio region (lower).

Summary

Low zooplankton biomass in the epipelagic layer of the Okhotsk Sea was evident when comparing the Okhotsk Sea and adjacent Oyashio region. This was partly because of the low abundance of the most of zooplankton taxa and calanoid copepod species. Only the calanoid copepod *Metridia okhotensis* was the predominant component of the open area of the Okhotsk Sea. The *Metridia* species is known to be a strong diel vertical migrant (Hays, 1995). Both the low zooplankton biomass in the epipelagic layer and strong migrant capabilities of the *Metridia* species suggests that the development of a strong pycnocline and the presence of cold intermediate water play a key role in the distribution of the zooplankton community in the Okhotsk Sea. Since development of a pycnocline is greater in the Okhotsk Sea, it may prevent diel vertical migration of most zooplankton taxa (= low biomass in the epipelagic layer). The dominance of the strong migrant species *Metridia* suggests that *M. okhotensis* can cross the strong pycnocline and cold intermediate layer in the Okhotsk Sea.

Future Prospects

Since *Metridia okhotensis* is the predominant component of the open area of the Okhotsk Sea, future study should focus on the ecology of this species. A time-series of zooplankton samples collected at Rausu (face towards the Okhotsk Sea) located on Shiretoko Peninsula, Japan, at 350 m depth (Shiretoko Rausu Deep-Seawater) is being examined. Here, *M. okhotensis* also dominates (ca. 50% of calanoid copepod abundance; Yamaguchi, unpublished data). From this analysis, we are planning to reveal the life cycle of *M. okhotensis* in the open area of the Okhotsk Sea.

References

Goldblatt, R.H., Mackas, D.L. and Lewis, A.G. 1999. Mesozooplankton community characteristics in the NE subarctic Pacific. *Deep-Sea Res. II* **46**: 2619–2644.

Hays, G.C. 1995. Ontogenetic and seasonal variation in the diel vertical migration of the copepods *Metridia lucens* and *Metridia longa*. *Limnol. Oceanogr*. **40**: 1461–1465.

Ikeda, T., Shiga, N. and Yamaguchi, A. 2008. Structure, biomass distribution and trophodynamics of the pelagic ecosystem in the Oyashio region, western subarctic Pacific. *J. Oceanogr*. **64**: 339–354.

Kitani, K. 1973. An oceanographic study of the Okhotsk Sea. Particularly in regard to cold waters. *Bull. Far Seas Fish. Res. Lab.* **9**: 45–77.

Ueno, Y. and Ishida, Y. 1996. Summer distribution and migration routes of juvenile chum salmon (*Oncorhynchus keta*) originating from rivers in Japan. *Bull. Natl. Res. Inst. Far Seas Fish*. **33**: 139–147.