8. Interannual Variation and Vertical Distribution of Appendicularians in the South of St. Lawrence Island, Northern Bering Sea Shelf, in Summer

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Introduction

Polynyas are defined as areas of open water surrounded by sea-ice. A polynya often forms to the south of St. Lawrence Island, which lies approximately in the center of the northern Bering Sea shelf. Thus, the area south of the island is called the St. Lawrence Island Polynya (SLIP; Schumacher et al., 1983; Grebmeier and Cooper, 1995). Within the SLIP, cold and saline water accumulates near bottom in winter and persists even during the summer. On the other hand, upper layer of the water column is relatively warm and less saline due to solar radiation and ice melting in summer. Therefore, a marked pycnocline develops between upper and lower layers in summer (Ohtani, 1969).

Preliminary results indicate that appendicularians are more abundant than all other mesozooplankton species except the small copepods, *Pseudocalanus* spp. and *Oithona similis* over the shallow shelf south of St. Lawrence Island in summer. Appendicularians have more effective filtering capability for phytoplankton prey, which is composed essentially of nanophytoplankton (2-20 μm) (e.g., Alldredge and Madin, 1982). According to Deibel (personal communication), their daily ingestion reaches about 5μg chl. *a* per animal. Therefore, they would clearly impact the phytoplankton assemblage in this area.

We examined the characteristic features of interannual variation and distribution of appendicularians in the shelf south of St. Lawrence Island in summer.

Materials and Methods

Plankton sampling was done from the T/S *Oshoro Maru* of Hokkaido University during the summers of 1990 through 1996. As shown in Table 1, the number and location of stations were slightly different each year. The sampling was carried out at 11 to 22 stations within the area encompassed by 61° 30' to 63° 30° N, 169° to 175° W each year. Plankton samples were obtained using vertical hauls from near the bottom to the surface with a NORPAC net (45cm x 180 cm conical net, 0.33 mm mesh openings; Motoda 1957). Between 1994 and 1996, stratified samples from above and below the pycnocline were also obtained, using a closing NORPAC net (fitted with 0.10 mm mesh cloth). A flow meter was mounted at the center of each net to estimate the volume of water filtered by the net.

Appendicularians were separated out from all the samples. Determination of maturity stages and morphometric measurements of *Oikopleura* were made following the

Table 1. Data on plankton samplings in the south of St.Lawrence Island during the cruises of *Oshoro Maru*

Sampling period	No. of stations		
	NORPAC net	Closing NORPAC net	Niskin bottles
24-26 July 1990	11	0	0
21-23 July 1991	15	0	0
20-22 July 1992	11	0	0
19-25 July 1993	16	0	0
17-23 July 1994	22	15	7
24-27 July 1995	17	15	6
27-29 July 1996	17	15	15

procedure of Shiga (1976).

Hydrographic data were taken with a CTD (Neil Brown Mark IIIB). From 1994 to 1996, several water samples for chlorophyll *a* analyses were obtained from the surface to near the bottom at 10 m depth intervals, using 1.8 liter Niskin bottles fitted on the CTD system (see Table 1). One-liter samples were filtered through Whatman GF/F filters. The filters were placed in a desiccator and frozen at -20°C for subsequent chlorophyll analysis using the acetone-extracted fluorescence method (Parsons et al., 1984) without griding the filters (Sato et al., 1981).

Results and Discussion

Oikopleura vanhoeffeni, O. labradoriensis, Oikopleura sp. and *Fritillaria borealis* f. *typica* were identified among the appendicularinas. The latter three species were low in frequency of occurrence and in abundance. The abundance of *F. borealis* f. *typica* varied widely from station to station, suggesting a patchy distribution.

The annual mean abundance of *Oikopleura vanhoeffeni* varied from 0.7 to 143.2 inds m^{-3}, with large interannual variations (Fig. 1). However, there was no clear relationship between their abundance and temperatures in the upper and lower layers. As will be shown below, there are different cohorts of *O. vanhoeffeni* above and below the pycnocline, and this would explain the lack of the relationship.

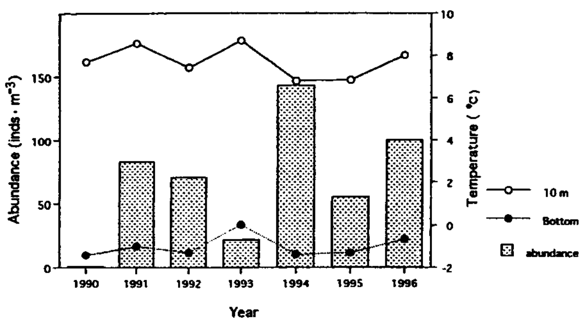

Fig. 1. Mean abundance of *Oikopleura vanhoeffeni*, and temperature at 10 m depth and near the bottom in the south of St. Lawrence Island from 1990 to 1996.

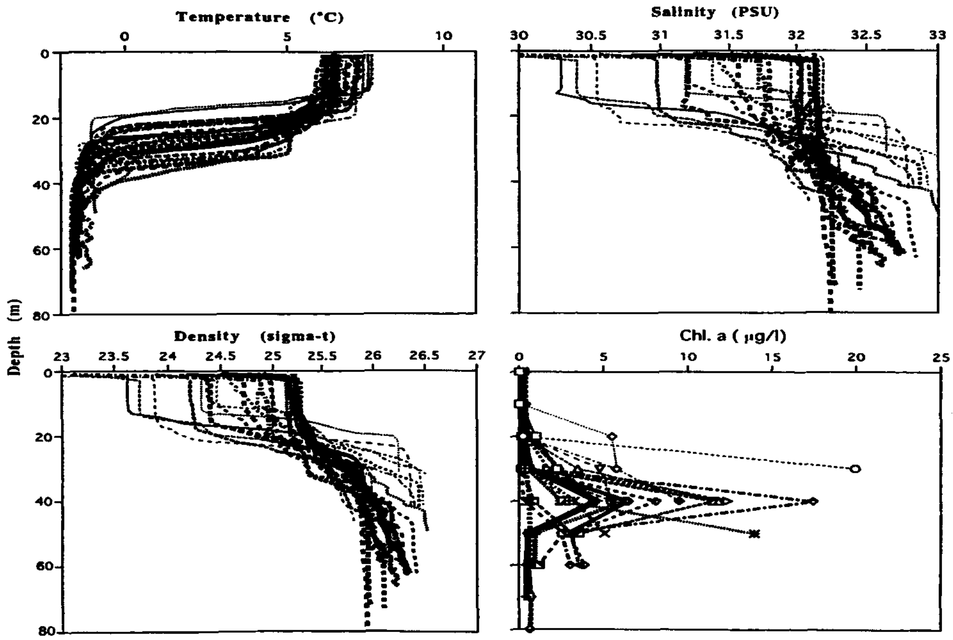

Fig. 2. Vertical profiles of temperature, salinity, density and chlorophyll a in 1994 as an example.

A strongly developed pycnocline was common at 20 to 30 m depths in this area, reflecting the marked thermocline and halocline at those depths (Fig. 2). Chlorophyll *a* concentration was very low in the upper layer, whereas it was high in the deeper layer. Such high concentration of chlorophyll *a* could be due to the sinking of spring-early summer diatom bloom from the surface layer (Alexander and Niebauer, 1981) or the downstream continuation of phytoplankton production produced at the shelf-break front (Hansell et at., 1989). Under this regime, the maturity stages of *O. vanhoeffeni* showed a clear vertical separation. Juveniles were in the upper mixed layer and advanced stages including adults were in the deeper one (Fig. 3). This distribution did not change during the day and night. This implies that the vertical distribution of *Oikopleura* is affected significantly by the pycnocline.

Assuming that the released eggs of *O. vanhoeffeni* have insufficent buoyancy to pass through such a strong physical boundary, the juveniles must be derived from spawning adults that have moved up to the surface prior to the formation of a physical boundary. On the other hand, the adults could be regarded as remnants that had not taken part in spawning in that year, and were sustained in the stagnant cold and saline water with rich phytoplankton below the pycnocline during the summer. This characteristic feature in the vertical distribution of *O. vanhoeffeni* may act as a mechanism for maintaining their population in the Bering Sea shelf waters.

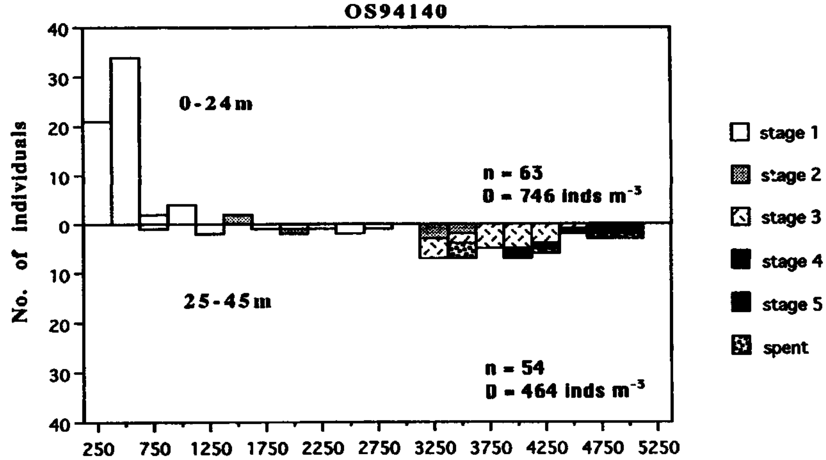

Fig. 3. Trunk length-frequency distribution of *Oikopleura vanhoeffeni* in the upper mixed layer and the deeper stagnant layer at OS94140 as an example. The values for n and D indicate number of individuals examined and population density in each layer. Maturity stages are distinguished from 1 (larva) to 5 (well matured adult).

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