PELAGIC COPEPODA IN THE BERING SEA AND THE NORTHWESTERN NORTH PACIFIC WITH SPECIAL REFERENCE TO THEIR VERTICAL DISTRIBUTION*

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Contents

I. Introduction

Zooplankton surveys have been carried out in the Bering Sea and the northwestern North Pacific, to investigate not only the distributional structure of foods for salmon during homing migration, but also the characteristics of the

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distribution of a cold water zooplankton. The research has been made by Hokkaido University and Fisheries Agency of Japan since the summer of 1953.

Until the present day the oceanographical structure of water in the Bering Sea and adjacent seas has been well cleared up by the cooperative oceanographic study of Japan, Canada and United States of America, but the pelagic environments in the Bering Sea encompass a broad complex of zooplankton populations, which have only recently been studied in a systematic manner. The quantitative and qualitative aspects of copepods of the geographical distribution in the upper 150 meter depth in the Bering Sea were reported by Johnson (1953), Vinogradov (1956), Minoda (1958) and Omori (1965). However, the distribution of copepods at a depth more than 150 meters at the southwest of Aleutian Islands (Anraku 1954), the Kurile-Kamchatka Trench (Brodsky 1955a, Vinogradov 1955), and the neritic region of the western Bering Sea (Vinogradov 1954) was little known. No study was made in the central part of the Bering Sea and the northernmost offshore region of the northwestern North Pacific.

Recently, the study of the phytoplankton production as a primary producer of the sea has helped to make clear the production mechanisms of marine life. The study of phytoplankton production in the Bering Sea has been carried out by several members of the Faculty of Fisheries, Hokkaido University. Concerning the phytoplankton production, the study of zooplankton that is primarily a phytoplankton feeder is also important. The knowledge of the structure of the vertical distribution of zooplankton is necessary to clarify the food relationships between phytoplankton and zooplankton.

Copepods are very important quantitatively in zooplankton in the Bering Sea and the northwestern North Pacific, and have a great role of food chains in the lower trophic level. As stated by Vinogradov (1962), understanding the vertical distribution of copepods is important to elucidate the ladder of vertical migration of the marine life from the surface to the deep.

The author has an opportunity to study the vertical distribution of copepods collected from the Bering Sea and the northwestern North Pacific at several depths from the surface to 2,000 m in the summers of 1958, 1961, 1962 and 1966.

The present study greatly deals with the relationships between the vertical distributions of copepods and water masses, and moreover, a discussion of the characteristics of the morphological structure of the feeding organs in each species of copepods.

II. Acknowledgement

The author wishes deeply to thank Professor Emeritus Sigeru Motoda, Hokkaido University, who introduced the present problem to the author and has offered valuable suggestions and criticisms in the course of the study. Gratitude is due to Professor Emeritus Shinjiro Kobayashi and Professor Shun Okada, who have read and made worthwhile comments on the manuscript. He also thanks Professor Teruyoshi Kawamura, who gave valuable suggestions during the study. Many thanks are due to Mr. Takeo Fujii, the Commander of the salmon canning fleet "Koyo Maru", Taiyo Gyogyo Co. Ltd., and Messrs. Noboru Matsuo and Toranosuke Yoshimitsu, Taiyo Gyogyo Co. Ltd., who gave an opportunity to collect plankton on the salmon canning ship in the summer 1958. His sincere thanks are extended to the staff, who engaged in the plankton collection on board of the training ship "Oshoro Maru", and to the Captain Takeji Fujii and his crew of the "Oshoro Maru".

III. General Structure of Hydrography

Bering Sea is separated from the North Pacific by the Aleutian Islands linking the Kamchatka to the Alaska; it is largely divided into two parts; the northwestern part consists of a shallow continental shelf and the southwestern part consists of basin more than 3,000 m deep. The northernmost part of the Bering Sea opens on to the Arctic Ocean passing the Bering Straits.

General hydrographic structure and current in the Bering Sea and the northwestern North Pacific were reported by several investigators such as Sverdrup, Fleming and Johnson (1942), Fleming (1955), Mishima and Nishizawa (1955), Koto and Fujii (1958), Dodimead, Favorite and Hirano (1963) and Uda (1963).

According to those investigations, the Subarctic Current flows eastwards at about 45°N in the North Pacific, and reaches the Gulf of Alaska. The Subarctic water is characterized by the existence of cold water at the intermediate layer, 30–150 m depth, forming thermocline in summer. This Subarctic Water Mass occupies the central part of the Bering Sea and the northernmost part of the northwestern North Pacific. In the central basin of the Bering Sea the current, which is characterized by the Subarctic Water Mass, circles counterclockwise and outflows to the south along the Kamchatka, one branch flowing eastwards also called the Subarctic Current, and another branch flowing more southwestwards along the Kurile Islands. According to Kitano (1958), at the south of Kamchatka there is some extremely cold and low saline water outflowing from the Okhotsk Sea. The narrow Alaskan Stream flows westwards at the south of the Aleutian Islands. This current flows into the Bering Sea through the islands. The easternmost trunk of the Alaskan Stream reaches the east of the Attu Island. The Alaskan Stream is lower in salinity than the Subarctic Current, and higher in temperature at the intermediate layer. After flowing into the Bering Sea, the Alaskan Stream loses those characteristics.

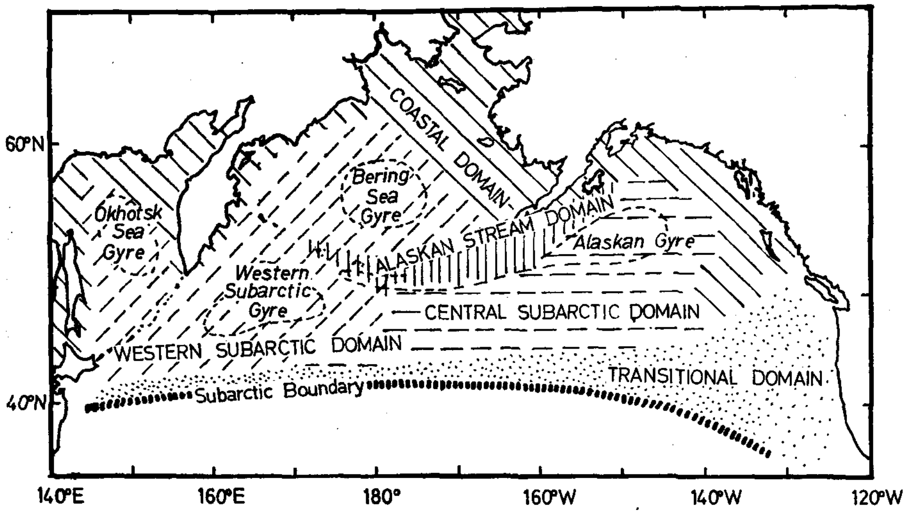

Fig. 1. Schematic diagram of upper zone domains in the Bering Sea and the North Pacific (after Dodimead *et al.* 1963).

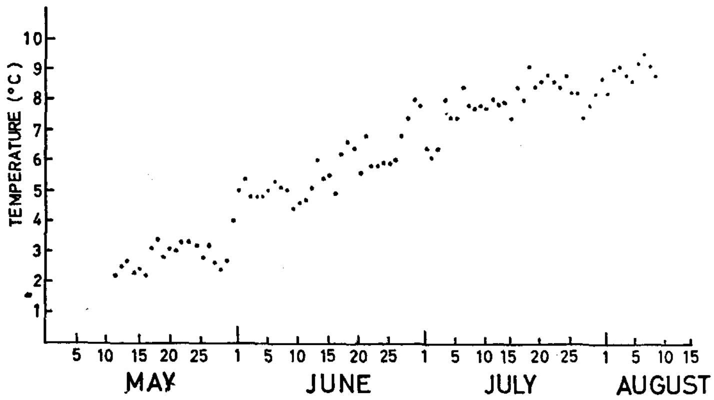

Fig. 2. Temperature of surface water in the east of Kamchatka in May-August 1958.

According to Dodimead, Favorite and Hirano (1963), five principal domain based on temperature, salinity and current are identified in the upper 150 m depth, that is (1) Western Subarctic, (2) Transitional, (3) Central Subarctic (4) Alaskan Stream and (5) Neritic (Fig. 1). The Western Subarctic Domain widely includes the central Bering Sea and the northwestern North Pacific in which the plankton was collected for the present study.

As shown in Fig. 2, the surface temperature of water at the southeast of the Kamchatka gradually ascended from 2.2°C on May 11 to 9.6°C on August 6. Ascent of temperature would be greatly depending upon the increasing heat from

Table 1. Temperature of water in the east of Kamchatka from June to July 1958.

Depth (m)	Station										
	1 June 8	2 June 11	3 June 13	4 June 14	5 June 19	6 June 20	7 June 27	8 July 3	9 July 6	10 July 13	11 July 15
0	5.0	4.7	6.0	5.4	6.4	5.6	6.8	6.4	7.4	7.8	7.4
10	4.5	4.5	6.0	5.4	6.0	5.6	6.5	6.4	7.4	7.8	7.4
20	4.0	4.3	5.0	5.3	1.5	5.0	5.5	6.2	7.4	7.5	7.0
25	3.8	4.2	5.0	5.0	1.0	4.8	5.4	6.2	7.2	7.3	7.0
30	3.7	4.1	4.5	4.0	1.0	4.5	5.1	6.0	6.5	3.5	6.8
50	3.5	3.5	4.0	2.8	1.0	1.5	1.5	4.5	3.5	3.3	2.3
75	3.4	3.0	3.8	1.5	0.8	0.5	0.4	2.0	2.2	1.5	1.7
100	3.3	2.0	2.5	1.5	0.0	0.5	0.4	1.7	1.5	1.0	1.5
150	3.4	2.0	2.5	2.0	−0.2	0.2	1.0	2.5	2.2	1.5	1.3
200	3.2	2.6	3.5	2.5	−0.3	2.5	2.5	3.2	3.0	2.7	3.0
280	2.5	2.2	3.0	2.5	1.5	2.0	2.0	2.5	2.5	2.3	2.2

spring to summer. Thermocline was observed at 10–100 m depth with increasing of the surface temperature, especially cold water below 0°C was observed at 100–200 m depth in the neritic region of the Kamchatka (Table 1). It suggests that this region is influenced by the neritic water from the Kamchatka.

The vertical profiles of the temperature and chlorinity at the positions of the plankton samplings in 1961 and 1962 are shown in Figs. 3 and 4 respectively. Thermocline developed from near the surface to 100 m depth, and the minimum temperature was observed at 100 m depth. The temperature descended again at depth more than 200 m. A dichothermal layer was distinctly observed due

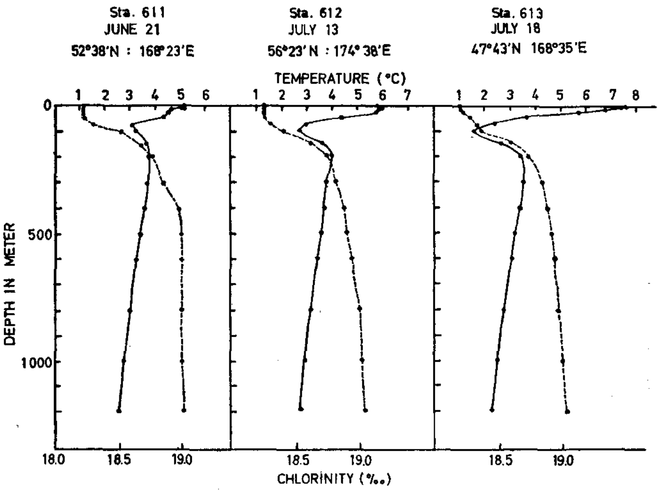

Fig. 3. Vertical distribution of temperature (——) and chlorinity (-----) at the positions at which the plankton hauls were carried out in the summer of 1961.

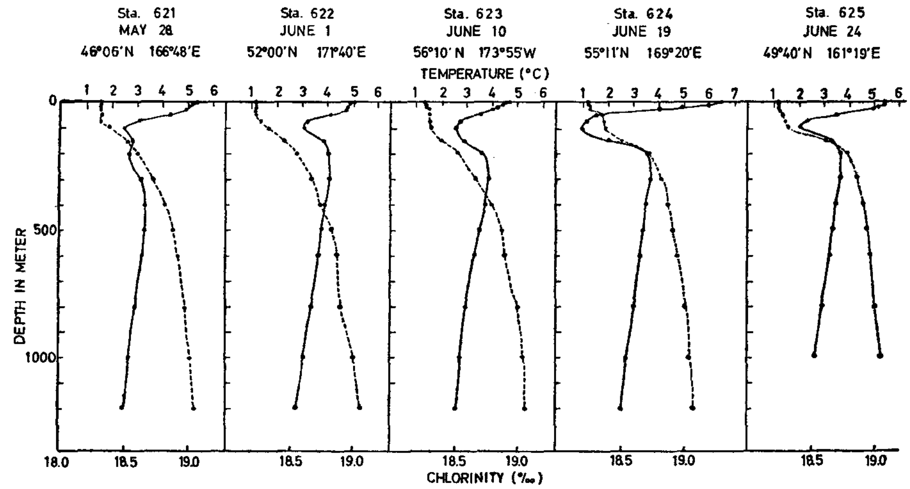

Fig. 4. Vertical distribution of temperature (——) and chlorinity (-----) at the positions at which the plankton hauls were carried out in the summer of 1962.

to the presence of the minimum temperature. Chlorinity was almost equal at each station, being about 18.3‰ from the surface to 50 m depth. Chlorinity rapidly increased between 50 m and 200 m depth. Halocline was deeper than thermocline in this observation.

IV. Samplings of Plankton

1. Sampling on salmon canning ship "Koyo Maru"

Plankton samplings were carried out with 10 horizontal nets at 12 positions (Fig. 5) in the eastern waters of the Kamchatka, in the northernmost part of the North Pacific from June 8 to July 15, 1958. Each net (12 cm in mouth

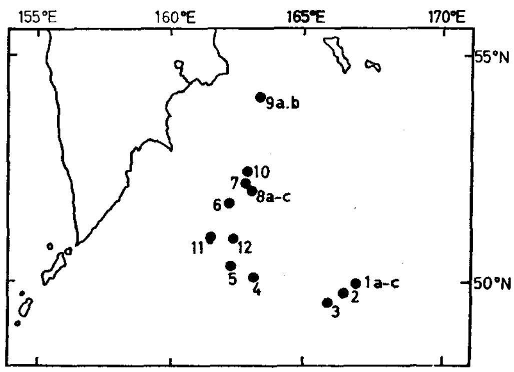

Fig. 5. Positions at which the plankton horizontal tows were carried out at the 0–45 m depth on the "Koyo Maru" in the east of Kamchatka from June to July 1958.

diameter, 50 cm in netting, bolting silk GG 70, 0.24 mm × 0.24 mm in mesh openings) was directly attached by a ring to a Manila rope at an interval of 5 m such as: 0 m, 5 m, 10 m, 15 m, 20 m, 25 m, 30 m, 35 m, 40 m and 45 m. Simultaneously, horizontal tow was made by the drift of the ship for usually 30 minutes at each station, but for one hour at Sta. 7. At Stas. 1 and 8, the samplings were carried out in the daytime, in the evening and at night. At. Sta. 9 the sampling was carried out in the daytime and at night. At other nine stations the samplings were carried out in the daytime or at night. Data on the sampling and the individual numbers of copepod species are shown in Appendix 1.

2. Sampling on training ship "Oshoro Maru"

(1) Horizontal tow in 1961

In June and July, the plankton samplings were made with 4 horizontal nets to 3 stations (Fig. 6): one in the Bering Sea (Sta. 612) and two in the northwestern North Pacific (Stas. 611 and 613). Each net (30 cm in mouth diameter, 100 cm in netting, bolting silk GG 54, 0.33 mm × 0.33 mm in mesh openings) was

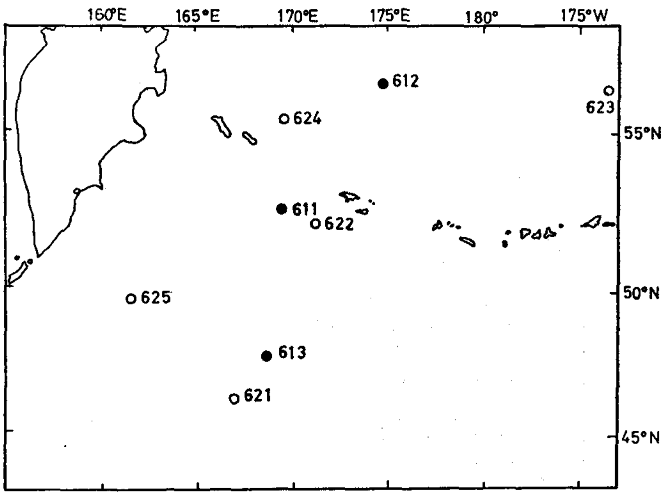

Fig. 6. Positions at which the plankton collections were carried out on the "Oshoro Maru" cruises to the northwestern North Pacific and the Bering Sea in the summers of 1961 (•) and 1962 (○).

directly attached to a hydrographic cable at the positions of 50 m, 500 m, 1000 m and 1800 m in depth. Simultaneously, horizontal tow was made by the drift of the ship for one hour. Estimation of the depth towed was determined by the wire angle. Although the depth was somewhat changed during the towing, the range was quite small. Exact data on the samplings and wet weight of zooplankton were already reported in the *Data Record of Oceanographic Observation* *and Exploratory Fishing, Faculty of Fisheries, Hokkaido University,* No. 6 (1962), and the individual numbers of copepod species are shown in Appendix 2.

(2) Horizontal tow and vertical haul in 1962

Plankton samplings were carried out with 5 horizontal nets to 5 stations: two in the Bering Sea (Stas. 623 and 624) and three in the northwestern North Pacific (Stas. 621, 622 and 625) (Fig. 6). The nets used were similar in size to those of the 1961 horizontal tow. Each net was attached to a hydrograhpic cable at intervals of 50 m such as 0 m, 50 m, 100 m, 150 m and 200 m in the length of wire. Simultaneously horizontal tows were made by the drift of the ship for one hour in the morning and at night at Stas. 621–624, but at night only at Sta. 625.

At Stas. 621–624, the vertical hauls were also carried on with a Juday closing net (45 cm in mouth diameter, 70 cm long in an anterior portion made of canvas and 180 cm long in a posterior portion made of netting, bolting silk GG 54, 0.33 mm × 0.33 mm in mesh openings) at 6 zones such as 1500–1000 m, 1000–500 m, 500–200 m, 200–100 m, 100–50 m and 50–0 m in the length of wire. Vertical hauls were made at night and in the morning at Stas. 621–623, but at night only at Sta. 624. Exact data on the samplings were already reported in the *Data Record of Oceanographic Observation and Exploratory Fishing, Faculty of Fisheries, Hokkaido University,* No. 7 (1963), and the individual numbers of copepod species are shown in Appendices 3 and 4.

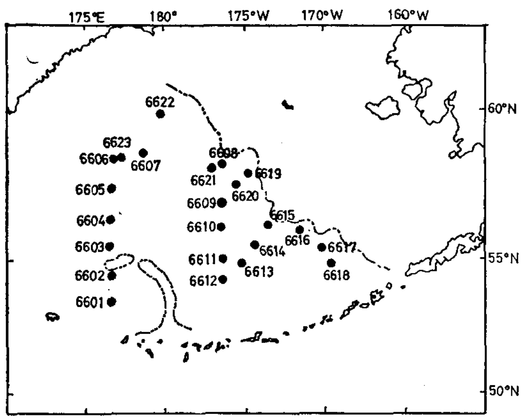

Fig. 7. Positions at which the plankton collections were carried out by the deep vertical haul with a Hart closing net on the "Oshoro Maru" cruise to the Bering Sea in the summer of 1966.

(3) Deep vertical haul in 1966

Deep vertical closing hauls were made with a Hart net (25 cm in mouth diameter, 30 cm in cylindrical ring diameter, 80 cm in netting, Pylen #200, 0.10

mm × 0.10 mm in mesh openings) at the depth of 2000–1000 m in wire length at 23 stations in the Bering Sea (Fig. 7). Exact data on the samplings and the individual numbers of copepod species are shown in Appendix 5.

3. Treatment of materials

All the samples which were obtained by means of various collections were put into a 4 % solution of formalin on board as soon as possible, and the identification of copepod species and the counting of the individual number were made at the laboratory of the University.

The horizontal tow was not suitable for the quantitative measurement between one station and another, because the accurate towing distance was not determined in each tow, and, moreover, we were unable to avoid an undesirable contamination from other layers, when the net was opened at paying out and taking in.

As the towing distance of the vertical haul in 1962 was different in depth, the individual number of copepods was converted into a unit volume of water at a 50 meter depth in the mouth area of the Juday net (7.3 m^3). The ratio of water filtered was considered as 100 %, because the revolutions of the flowmeter attached at the mouth ring of the net did not work in constant.

V. Copepod Species Occurred

Sixty-four of Calanoida, 8 species of Cyclopoida, 2 species of Harpacticoida and 2 species of *Mormonilla* were identified from the Bering Sea and the northwestern North Pacific, and are listed in Table 2.

In the northwestern North Pacific 49 species were found, and all species have been recorded from the North Pacific. Whereas, of the 69 species in the Bering Sea, 29 were newly recorded from the Bering Sea.

VI. Synopsis of Species and Vertical Distribution

1. *Calanus glacialis* JASCHNOV
Plate I, Figs. 1~3.

Calanus glacialis Jaschnov, 1955, pp. 1211–1213, fig. 1; 1957, pp. 191–198; 1963, pp. 1006–1012.

Calanus finmarchicus, G.O. Sars, 1901, pp. 9–11, Pls. 1–3; Breemen, 1906, p. 7, fig. 1a-c; Mori, 1937, p. 13, Pl. 3, figs. 9–11; Brodsky, 1950, pp. 86–88, fig. 19.

In the present observation, only IV and V copepodites were collected. The V copepodite ranges from 3.7–4.4 mm in body length. The forehead is completely round. The inner margins of the 1st basipodite of the 5th pair of legs are convex, and the number of serrations are 26–33. These characteristics are identical with the V stage of *Calanus glacialis* described by Jaschnov (1958).

Table 2. Systematic list of Copepoda collected from the Bering Sea and the northwestern North Pacific in the summers of 1958, 1961, 1962 and 1966.

Family Calanidae
Calanus glacialis Jaschnov
Calanus pacificus Brodsky
Calanus plumchrus Marukawa
Calanus cristatus Krøyer
Family Eucalanidae
Eucalanus bungii bungii Johnson
Rhincalanus nastus Giesbrecht
Family Pseudocalanidae
Pseudocalanus minutus Krøyer
Microcalanus pygmaeus Sars
Spinocalanus magnus Wolfenden
Spinocalanus stellatus Brodsky
Spinocalanus spinipes Brodsky
Spinocalanus abyssalis Giesbrecht
Mimocalanus cultrifer Farran
Mimocalanus distinctocephalus Brodsky
Monacilla typica Sars
Family Aetideidae
Aetideus pacificus Brodsky
Gaidius brevispinus (Sars)
Gaidius variabilis Brodsky
Gaetanus simplex Brodsky
Pseudochirella polyspina Brodsky
Pseudochirella spectabilis (Sars)
Pseudochirella spinifera Brodsky
Family Euchaetidae
Pareuchaeta elongata (Esterly)
Pareuchaeta birostrata Brodsky
Pareuchaeta brevirostris Brodsky
Pareuchaeta rubra Brodsky
Pareuchaeta crassa Tanaka
Family Phaennidae
Xanthocalanus kurilensis Brodsky
Onchocalanus magnus (Wolfenden)
Family Scolecithricidae
Scaphocalanus magnus (T. Scott)
Scaphocalanus major (Sars)
Scaphocalanus subbrevicornis (Wolfenden)
Scolecithricella valida (Farran)
Scolecithricella emarginata (Farran)
Scolecithricella minor (Brady)
Scolecithricella ovata (Farran)
Scolecithricella globulosa Brodsky
Racovitzanus antarcticus Giesbrecht
Racovitzanus erraticus Vervoort
Family Tharybidae
Undinella brevipes Farran
Family Metridiidae
Metridia pacifica Brodsky
Metridia okhotensis Brodsky
Metridia asymmetrica Brodsky
Metridia curticauda Giesbrecht
Metridia brevicauda Giesbrecht
Pleuromamma scutullata Brodsky
Family Lucicutiidae
Lucicutia flavicornis (Claus)
Lucicutia pacifica Brodsky
Lucicutia ellipsoidalis Brodsky
Lucicutia oblonga Brodsky
Lucicutia frigida Wolfenden
Family Heterorhabdidae
Heterorhabdus robustoides Brodsky
Heterorhabdus tanneri (Giesbrecht)
Heterostylites major (Dahl)
Family Augaptilidae
Haloptilus oxycephalus (Giesbrecht)
Haloptilus longicirrus Brodsky
Augaptilus glacialis Sars
Euaugaptilus gracilodies Brodsky
Centraugaptilus horridus Farran
Pseudaugaptilus sp.
Pachyptilus pacificus Johnson
Family Candaciidae
Candacia columbiae Campbell
Candacia parafalcifera Brodsky
Family Acartiidae
Acartia longiremis (Lilljeborg)
Family Mormonillidae
Mormonilla minor Giesbrecht
Mormonilla phasma Giesbrecht
Family Oithonidae
Oithona similis Claus
Oithona plumifera Baird
Family Oncaeidae
Oncaea conifera Giesbrecht
Oncaea notopus Giesbrecht
Oncaea ornata Giesbrecht
Sapphoncaea moria Olson
Lubbockia glacialis Sars
Family Rataniidae
Danodes plumata Wilson
Family Harpactiidae
Harpacticus uniremis Krøyer
Family Ectinosomidae
Microsetella norvegica Boeck

Remarks: *Calanus glacialis* is well known as an Arctic species, inhabiting the surrounding waters of the Arctic. Jespersen (1934) noted that two different populations of *Calanus finmarchicus*, one large, the other small, are distributed around Greenland; the large-size population prefers cold water to warm water; on the contrary, the small-size population is abundant in warm water. Ussing (1938) reported that these two different populations represent two year-groups, growing with a different food supply between summer and winter. However, Jaschnov (1955) established two species for these two size populations of *C. finmarchicus*; the name *C. glacialis* was given to the large-size population origina-ted in the Arctic Ocean. Brodsky (1959) and Jaschnov (1963) suggested that *C. finmarchicus s. str.* is not distributed in the North Pacific, and that *C. finmarchicus* which was reported from the Okhotsk Sea by Mori (1937) and the Bering Sea by Johnson (1953), Vinogradov (1954) and Minoda (1958) is identical with *C. glacialis.*

Vertical distribution: In the present observation one individual of the V copepodite was found at the layers of 30 m and 35 m respectively at Sta. 11 in the east of Kamchatka, while in the Bering Sea several numbers of the IV and V copepodites were commonly found at a depth of more than 180 m, extending as deep as 1000 m. This species is a typical arctic one and is distributed in the shallow layers of the Arctic Ocean (Johnson 1963, Minoda 1967). In the Bering Sea, this species was reported to be only in the eastern shallow waters of the continental shelf (Johnson 1953, Minoda 1958, Omori 1965), and in the surrounding waters of the Bower's Bank (Minoda 1958).

2. *Calanus pacificus* Brodsky

Plate I, Figs. 4–8.

Calanus pacificus Brodsky, 1948, pp. 31–32, Tab. 1, figs. 4–10; 1950, pp. 89–91, fig. 21; 1962, pp. 1416–1419.
Calanus finmarchicus, Sato, 1913, p. 1, Pl. 1, figs. 1–5.
Calanus helgolandicus, Mori, 1937, p. 14, Pl. 1, figs. 1–8.

Male: 2.7 mm. Cephalothorax is cylindrical in dorsal view. The 5th pair of legs is asymmetrical, the left leg is much longer than the right one. The terminal segment of the endopodite of the left 5th leg hardly reaches the proximal part of the 2nd segment of the exopodite. The ratio between the length and the width of the 1st and 2nd segments of the exopodite of the left 5th leg is 4.5: 1.

Remarks: *Calanus pacificus* is very similar to *Calanus helgolandicus* Claus figured out by Sars (1903). According to Brodsky (1959), the difference between the two species is clearly found in the 5th pair of legs in male; in *C. helgolandicus* the terminal segment of the endopodite of the left 5th leg extends over the basal part of the 2nd segment of the exopodite and the ratios between the length and the width of the 1st and 2nd segments of the exopodite of the left 5th leg are 2.4:

1 respectively, while in *C. pacificus* the terminal segment of the exopodite and those ratios are 3.5∼4.5: 1. The number of serrations are less than in *C. finmarchicus* and *C. glacialis*. The V copepodite of *C. pacificus* being 2.2–3.4 mm in body length, the inner margins of the 1st segment of the basipodite of the 5th pair of legs are concave, and the number of serrations are 17–23.

Vertical distribution: This species occurred at Stas. 613, 621 and 622 in the northwestern North Pacific. Only one male was collected at 1644–1800 m depth at Sta. 613. The V copepodite was widely distributed from the surface to a depth of more than 1000 m; however, the individual numbers were more abundant in the deep layers than in the shallow ones. This species is an indicator of the warm water in the off-Sanriku (Kimura and Odate 1957), and inhabits mostly the Polar Front between the Oyashio and Kuroshio in the North Pacific (Brodsky 1959).

3. *Calanus plumchrus* MARUKAWA

Calanus plumchrus Marukawa, 1921, p. 10, Pl. 1, figs. 1–9; Mori, 1937, p. 15, Pl. 3, figs. 5–8; Tanaka, 1956, p. 123–126, fig. 2a-d.
Calanus tonsus f. *plumchrus*, Brodsky, 1948, pp. 32–34, Pl. 3, figs. 1–7; 1950, pp. 91–93, fig. 22.
Calanus sp. Sato, 1913, p. 3, Pl. 2, figs. 6–8.

Female: 4.0–5.7 mm, male: 4.2–5.0 mm.

Remarks: Before Marukawa (1921) described this species as new to science with the immature specimens collected from the Okhotsk Sea, Sato (1913) observed a number of immature specimens in the west of Hokkaido, reporting that it is probably a new species, though he hesitated to describe them as new because of the absence of adult specimens. Yamada (1938) first found the adult male of this species in the stomach contents of *Theragra chalcogramma* (PALLAS). Motoda, Iizuka and Anraku (1950) also found the adult males in the Japan Sea.

Calanus plumchrus has been confused with *C. tonsus* BRADY. *C. tonsus* was first recorded from the Southern Ocean by Brady (1883), and this species was reported from the North Pacific by Wilson (1932), Campbell (1929), Tanaka (1956), Davis (1949) and Vinogradov (1955). According to Tanaka (1956) and Vervoort (1957), *C. tonsus* bears fine spines on the posterior marginal surface of the 2nd segment of the basipodite of the 3rd to the 4th pair of legs of female. *C. plumchrus* in the North Pacific lacks these spines.

Vertical distribution: This species was abundantly found throughout the stations both in the Bering Sea and the northwestern North Pacific. The vertical distribution of abundance within 0–1500 m depth is shown in Table 3. The maximum number was observed in the shallow 50 m depth both in the morning and night hauls except at night at Sta. 621. This species greatly decreased in number at a depth of more than 100 m, but a considerable number was still

Table 3. Number of *Calanus plumchrus* obtained by a separate haul with a Juday closing net in the Bering Sea and the northwestern North Pacific, May and June 1962 (Number per 50 m water column: 7.3 m³).

Sta. 621				Sta. 622		Sta. 623				Sta. 624	
46°06′N 166°48′E				52°00′N 171°40′E		56°10′N 173°55′W				55°11′N 169°20′E	
May 28, 1962 2145–2339		May 29, 1962 0615–0755		June 1, 1962 1935–2145		June 10, 1962 2127–2300		June 11, 1962 0505–0620		June 19, 1962 2030–2250	
Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number
0–46	12	0–43	428	0–83	628	0–48	956	0–47	828	0–46	2184
46–100	143	42–85	1	84–157	10.5	48–95	21	45–89	18	48–95	15
99–198	7	87–164	20.5	139–370	35.7	95–190	36.5	91–182	24	91–181	6
195–485	0.8	160–400	23.1	420–838	0.4	192–477	17.5	160–399	22	170–423	55.4
485–970	1.8	397–694	1.7	616–920	12.9	440–819	0.3	364–731	0.4	399–798	0.7
906–1350	1.4	707–1060	2.2			882–1320	1.6	731–1090	0	819–1230	1.4

Table 4. Number of various copepodites of *Calanus plumchrus* at different depths in the east of Kamchatka, June and July 1958.

Depth (m)	Stage					
	I	II	III	IV	V	VI
0	762	393	195	37	97	
5	268	88	33	13	35	
10	617	537	106	69	129	
15	740	489	156	767	692	
20	796	487	335	360	125	
25	889	1130	649	374	85	
30	1033	1297	1378	480	70	
35	349	670	1001	439	91	
40	527	542	1278	496	163	
45	503	572	1001	502	156	1
Total	6484	6205	5131	3537	1643	1

observed down at a depth of about 1000 m.

Observation on the detailed vertical distribution of each stage of copepodite widely extended from the surface to a depth of 45 m, while the III copepodite was abundant at a depth of more than 25 m, and the IV copepodite was abundant at a depth of more than 15 m. The V copepodite was abundant at a depth of only 15 m, somewhat differing from the I-IV copepodites (Table 4). The I copepodite was most dominant in the shallow 45 m depth. The number of specimens decreased with progressing stages.

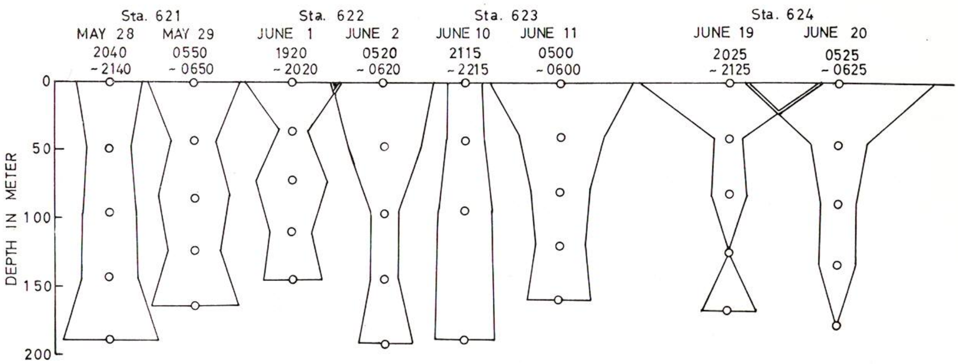

Fig. 8. Vertical distribution of the copepodite V of *Calanus plumchrus* in the upper 200 meters in the Bering Sea and the northwestern North Pacific in 1962.

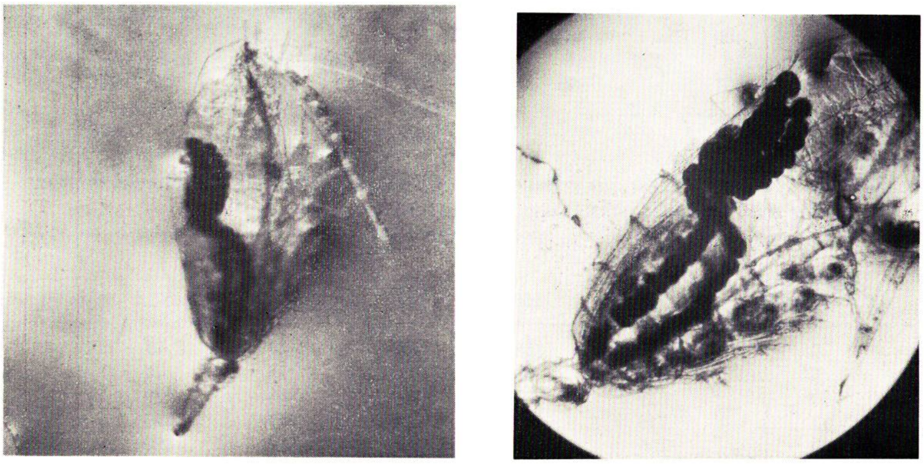

Fig. 9. Female of *Calanus plumchrus* with ovarian eggs, obtained by the 1000–2000 m vertical haul at Sta. 6607 (58°38′N, 178°58′E, 2001–2100, June 16, 1966).

The specimens consisted mostly of immature stages in the shallow 200 m depth, while the adults occurred at a depth of more than 200 m. The copepodites widely inhabited the water from shallow to deep.

As shown in Fig. 8 the vertical migration of the V copepodite was insignificant between morning and night, though the vertical range of abundance was different with stations.

The adults of this species in the Japan Sea were found at a depth of more than 300 m, and was considered to be bathybic (Motoda, Iizuka & Anraku 1950). Heinrich (1962b) reported that reproduction was performed two times, in early spring and late autumn, in the deep water. In the present observation, females laying eggs were caught in the 1000–2000 m deep haul of 1966 (Fig. 9).

4. *Calanus cristatus* Krøyer

Calanus cristatus, Giesbrecht, 1892, p. 91, Taf. 6, figs. 14, 15; Giesbrecht & Schmeil, 1898, p. 16; Breemen, 1908, p. 10, fig. 6a, b; Sato, 1913, p. 5, Pl. 2, figs. 9–11; With, 1915, p. 11; Mori, 1937, p. 15, Pl. 3, figs. 1–4; Tanaka, 1937, p. 599, figs. 1, 2; Brodsky, 1948, pp. 34–36, Pl. 4, figs. 3–10; Davis, 1949, pp. 14–15, Pl. 1, figs. 6–9; Brodsky, 1950, pp. 93–95, fig. 23; Tanaka, 1956, p. 258.

Female: 7.9–9.0 mm, male: 8.7 mm.

Remarks: The median crest of adults is less developed than the V copepodite.

Vertical distribution: This species was commonly found throughout the stations both in the Bering Sea and the northwestern North Pacific. As shown in Table 5, this species was ditributed from the shallow to the deep waters. The maximum number was observed in the shallow 100 m depth, mostly consisting of the V copepodite. Individual number decreased at a depth of more than 100 m. A small number of adults appeared at a depth of more than 200 m, and their abundance was seen at a depth of more than 500 m.

This species showed the diel vertical migration. At 0–45 m horizontal tow in the eastern waters of Kamchatka, this species inhabited the depth deeper than 25 m in the daytime, and reached the surface at night (Fig. 10). The difference in the distribution between morning and night was clearly observed by the horizon-

Table 5. Number of *Calanus cristatus* obtained by a separate haul with a Juday closing net in the Bering Sea and the northwestern North Pacific, May and June 1962 (Number per 50 m water column: 7.3 m³).

Sta. 621				Sta. 622		Sta. 623				Sta. 624	
46°06′N 166°48′E				52°00′N 171°40′E		56°10′N 173°55′W				55°11′N 169°20′E	
May 28, 1962 2145–2339		May 29, 1962 0615–0755		June 1, 1962 1935–2145		June 10, 1962 2127–2300		June 11, 1962 0505–0620		June 19, 1962 2030–2250	
Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number
0–46	0*	0–43	13	0–83	11	0–48	84	0–47	88	0–46	912
46–100	8	42–85	1	84–157	1.5	48–95	67	45–89	64	48–95	19
99–198	0*	87–164	4	139–370	0.7	95–190	12	91–182	28	91–181	12.5
195–485	0.3	160–400	2.4	420–838	0	192–477	7.5	160–399	17	170–423	7
485–970	2.1	397–694	0.3	615–920	0	440–819	0	364–731	0.4	399–798	1.1
906–1350	0.2	707–1060	0.1			882–1320	0.3	731–1090	0	819–1230	0.8

* Collected by 0–200 m horizontal tow in 1962

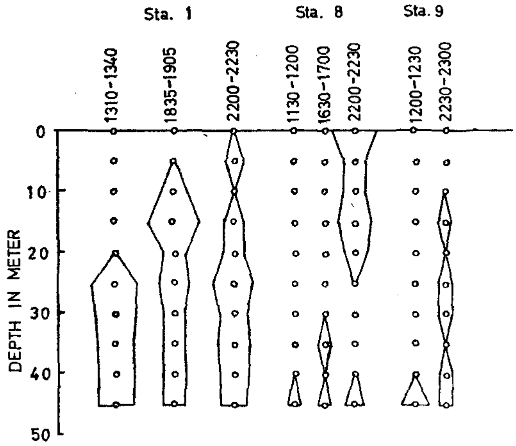

Fig. 10. Vertical distribution of the copepodite V of *Calanus cristatus* in the upper 45 m in the east of Kamchatka in 1958.

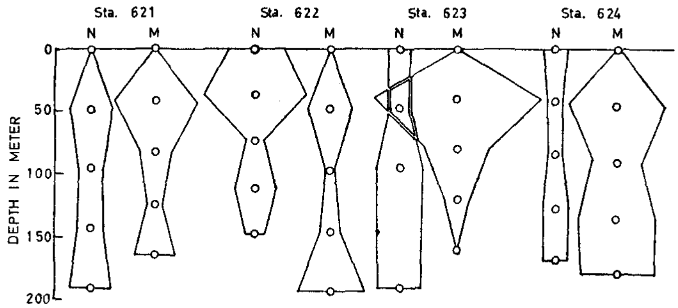

Fig. 11. Vertical distribution of the copepodite V of *Calanus cristatus* in the upper 200 m in the Bering Sea and the northwestern North Pacific in 1962.

tal tow in 1962. No specimen was collected at the surface in any morning tow, whereas in the night tow, some specimens were collected at the surface. However, they did not migrate down in the water deeper than 100 m (Fig. 11).

5. *Eucalanus bungii bungii* Johnson

Eucalanus bungii bungii Johnson, 1938, p. 167, figs. 4–10, 18, 20, 23, 25; Brodsky, 1950, p. 101, fig. 26; Tanaka, 1956, pp. 135–136.
Eucalanus elongatus bungii Giesbrecht, 1892, p. 149; Tanaka, 1935, p. 143, Pl. 1, figs. 5–15.
?*Eucalanus elongatus*, Sato, 1913, Pl. 2, figs. 34–38.
Eucalanus giesbrechti Mori, 1937, p. 22, Pl. 7, figs. 6–8.

Female: 6.0–7.2 mm, male: 6.2 mm.

Remarks: *Eucalanus bungii bungii* is identical with *Eucalanus elongatus bungii* Giesbrecht. Johnson (1938) established *E. bungii* for *E. elongatus bungii*, for the reason that the difference between *E. elongatus* DANA and *E. elongatus bungii* is great. He also established two varieties of *E. bungii*; a northern variety *bungii* and a southern variety *californicus* in the North Pacific. The most obvious difference between the two varieties is the presence of three setae on the 2nd basal segment of the mandible in the variety *bungii* and of only one seta in the variety *californicus*.

In the present samples the variety *californicus* was not observed. The geographical distribution of one variety, somewhat overlaps the other: the variety *bungii* is distributed in the Oyashio and the variety *californicus* is in the south of the mixing region of the Oyashio and Kuroshio (Tanaka 1956).

Vertical distribution: This species was abundantly found throughout the stations both in the Bering Sea and the northwestern North Pacific. It was

Table 6. Number of *Eucalanus bungii bungii* obtained by a separate haul with a Juday closing net in the Bering Sea and the northwestern North Pacific, May and June 1962 (Number per 50 m water column: 7.3 m^3).

Sta. 621				Sta. 622		Sta. 623				Sta. 624	
46°06′N 166°48′E				52°00′N 171°40′E		56°10′N 173°55′W				55°11′N 169°20′E	
May 28, 1962 2145–2339		May 29, 1962 0615–0755		June 1, 1962 1935–2145		June 10, 1962 2127–2300		June 11, 1962 0505–0620		June 19, 1962 2030–2250	
Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number
0-46	4	0-43	22	0-83	48	0-48	368	0-47	340	0-46	1736
46-100	64	42-85	16	84-157	10	48-95	653	45-89	1484	48-95	23
99-198	2.5	87-164	136	139-370	14	95-190	82.5	91-182	108	91-181	14
195-485	1	160-400	102	420-838	0.4	192-477	13.1	160-399	11.7	170-423	560
485-970	0.9	397-694	0.1	615-920	5.7	440-819	0	364-731	0.1	399-798	8.6
906-1350	0.7	707-1060	0.8			882-1320	0.6	731-1090	0.1	819-1230	0.5

distributed from the shallow water to the deep water, with the maximum number in the shallow 100 m depth (Table 6). The vertical distribution of the adults and immature forms in 0–200 m horizontal tow was as follows: both adults and immature forms were very rare at the surface, and abundant at a depth of more than 50 m in the morning (Fig. 12). Adults mostly appeared at a depth of more than 50 m even at night except at Sta. 623; on the contrary, immature forms were commonly found at the surface at night.

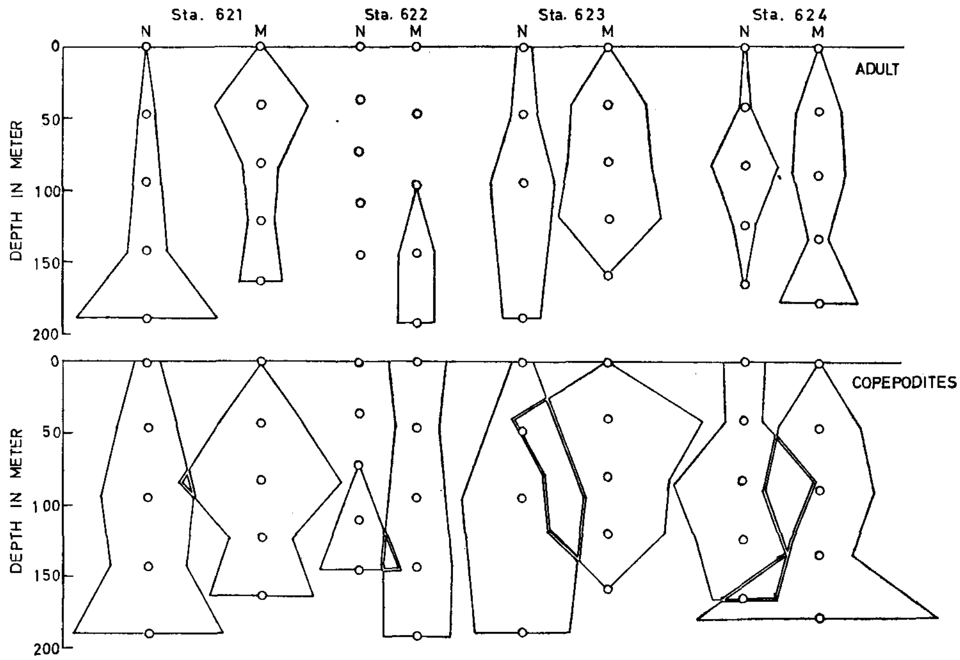

Fig. 12. Vertical distribution of *Eucalanus bungii bungii* in the upper 200 m in the Bering Sea and the northwestern North Pacific in 1962.

6. ***Rhincalanus nastus*** GIESBRECHT

Rhincalanus nastus, Giesbrecht, 1892, p. 152, Taf. 3, fig. 6, Taf. 9, figs. 6, 14, Taf. 12, figs. 9–12, 14, 16, 17, Taf. 35, figs. 46, 47, 49; Sars, G.O., 1901, pp. 15–16, Pls. 6–7; 1903, suppl. p. 15; Esterly, 1905, pp. 136–137, fig. 10; Sewell, 1929, pp. 58–60, fig. 19a, b; Wilson, 1932, p. 34, fig. 18a-c; Tanaka, 1935, p. 151, Pl. 4, figs. 1–4; Mori, 1937, pp. 26–27, Pl. 10, figs. 6–9; Wilson, 1942, p. 205, fig. 114; Vervoort, 1946, pp. 122–126; Brodsky, 1950, pp. 105–106, fig. 32; Tanaka, 1956, p. 139.

Female: 3.9–4.8 mm.

Vertical distribution: Only two individuals were collected from the 485-970 m depth at Sta. 621. This is a warm water species inhabiting widely from the surface to a great depth in the Kuroshio region (Tanaka 1956, Furuhashi 1966). According to Furuhashi (1966) this species is distributed in the transitional and bathybic zones in the Oyashio. In the present observation, this species was found only in the bathybic water in the northwestern North Pacific. It is suggested therefore that this species migrates down to the bathybic zone in the cold water region.

7. *Pseudocalanus minutus* (Krøyer)

Pseudocalanus minutus, With, 1915, p. 57; Wilson, 1932, p. 43; Mori, 1937, p. 36, Pl. 15, figs. 1–7; Tanaka, 1956, pp. 82–83.
Pseudocalanus elongatus, Giesbrecht, 1892, p. 197, Taf. 10, figs. 22, 31–33; Sars, 1901, pp. 20–21, Pls. 10–11; 1903, p. 154; Sato, 1913, p. 18; Brodsky, 1950, pp. 112–113, fig. 34.

Female: 1.07–1.91 mm, male: 0.92–1.28 mm.

Vertical distribution: This species was very abundant at all stations, and was concentrated in number in the shallow 100 m depth. Individual number decreased distinctly at a depth of more than 50 m at Stas. 622–624 (Table 7). Both adults and immature forms inhabited the same level, and these did not seem to be any change in the distributional layers between day and night (Figs. 13, 14). Vinogradov (1954) observed that this species was mostly distributed in the shallow 50 m depth, and the diel vertical migration was very small in the Bering Sea.

Table 7. Number of *Pseudocalanus minutus* obtained by a separate haul with a Juday closing net in the Bering Sea and the northwestern North Pacific, May and June 1962 (Number per 50 m water column: 7.3 m^3).

Sta. 621				Sta. 622		Sta. 623				Sta. 624	
46°06′N 166°48′E				52°00′N 171°40′E		56°10′N 173°55′W				55°11′N 169°20′E	
May 28, 1962 2145–2339		May 29, 1962 0615–0755		June 1, 1962 1935–2145		June 10, 1962 2127–2300		June 11, 1962 0505–0620		June 19, 1962 2030–2250	
Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number
0–46	15	0–43	133	0–83	3792	0–48	1832	0–47	1656	0–46	4096
46–100	101	42–85	19	84–157	74.5	48–95	120	45–89	38	48–95	77
99–198	5.5	87–164	49	139–370	80.7	95–190	90	91–182	8	91–181	33
195–485	0.2	160–400	38	420–838	14.0	192–477	30.6	160–399	2	170–423	52.3
485–970	0.7	397–694	2.1	615–920	23.2	440–819	1.9	364–731	0.5	399–798	2.6
906–1350	0.3	707–1060	0.7			882–1320	6.7	731–1090	0.5	819–1230	6.9

8. *Microcalanus pygmaeus* (G. O. Sars)

Microcalanus pygmaeus, Wilson, 1942, p. 194, fig. 55; Brodsky, 1950, p. 115, fig. 37; Tanaka, 1956, pp. 385–387, fig. 12; Vervoort, 1957, pp. 36–37, fig. 9; Tanaka, 1961b, p. 35.
Pseudocalanus pygmeus Sars, 1900, p. 73, pl. 21.

Female: 1.12 mm, male: 0.69–0.72 mm,.

Vertical distribution: This species was found in a small number in the

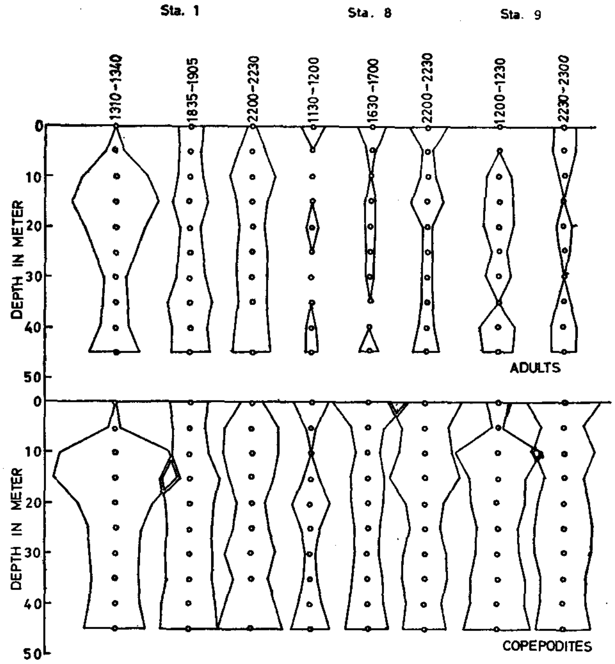

Fig. 13. Vertical distribution of *Pseudocalanus minutus* in the upper 45 m in the east of Kamchatka in 1958.

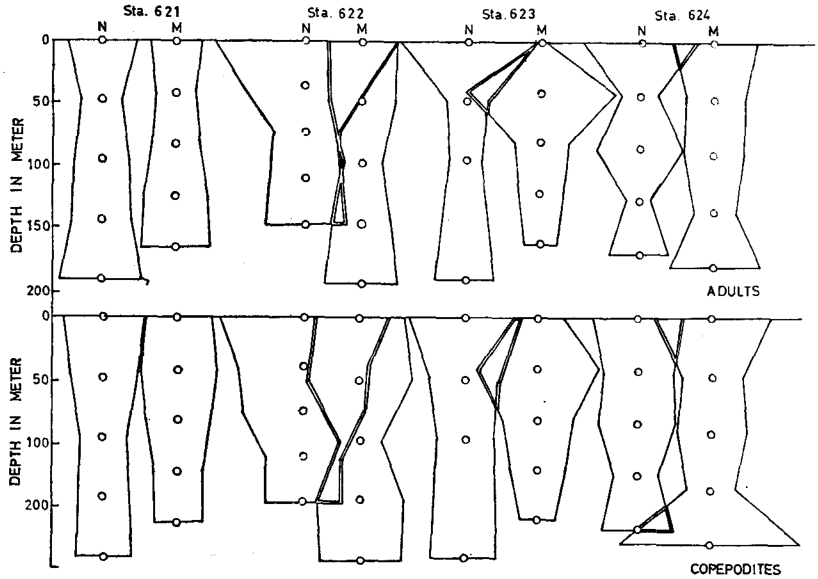

Fig. 14. Vertical distribution of *Pseudocalanus minutus* in the upper 200 m in the Bering Sea and the northwestern North Pacific in 1962.

Bering Sea. This species occurred in the shallow water as well as in the deep water, but not at the surface. A considerable number of this species was observed at all stations in the deep 1000–2000 m vertical haul of 1966. *M. pygmeus* is distributed in the shallow waters of the Arctic Ocean (Bogorov 1946, Minoda 1967). The distributional layer in the Bering Sea is quite different from that in the Arctic Ocean.

9. *Spinocalanus magnus* WOLFENDEN

Spinocalanus magnus, Breemen, 1908, p. 29, fig. 29; Wolfenden, 1911, p. 216, Pl. 25, figs. 3–5, text-fig. 8; With, 1915, p. 72; Sars, 1925, p. 33, Pl. 9, figs. 8–15; Sewell, 1929, p. 95; Vervoort, 1946, pp. 150–152; Brodsky, 1950, pp. 123–124, fig. 43; Davis, 1949, pp. 22–23, Pl. 2, figs. 25–26; Tanaka, 1956, pp. 391–392, fig. 15a-g.

Female: 2.5 mm.

Vertical distribution: This species was found at 5 stations from a deep 1000–2000 m vertical haul in the Bering Sea, and was recorded to be found there for the first time. It is widely distributed in the deep waters of the oceans: Arctic Ocean (Johnson 1963, Minoda 1967), North Pacific (Brodsky 1950, Tanaka 1956), Indian Ocean (Sewell 1929), North Atlantic (Farran 1908) and Antarctic Ocean (Farran 1929, Vervoort 1957).

10. *Spinocalanus stellatus* BRODSKY

Spinocalanus stellatus Brodsky, 1950, pp. 125–126, fig. 44.

Female: 2.8 mm.

Vertical distribution: This species was found only at 3 stations from a deep 1000–2000 m vertical haul in the Bering Sea. According to Brodsky (1950), this species is endemic in the deep water of the North Pacific and the Bering Sea. Furuhashi (1966) reported this species in the 2000–3000 m depth in the Kuroshio region.

11. *Spinocalanus spinipes* BRODSKY

Spinocalanus spinipes Brodsky, 1950, pp. 126–127, fig. 44.

Female: 2.2–2.4 mm, male: 2.0 mm.

Vertical distribution: This species was found at a depth of more than 100 m both in the Bering Sea and the northwestern North Pacific, and its existence in the Bering Sea was recorded for the first time. The largest number was concentrated at a 160–800 m depth (Fig. 15), and it seemed to be a transition species. According to Brodsky (1950), this species is bathybic, and is distributed in the 1000–4000 m depth in the North Pacific.

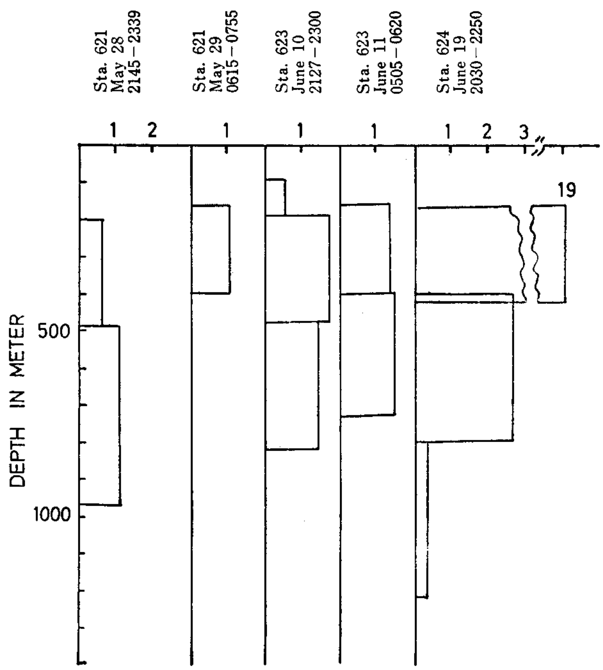

Fig. 15. Vertical distribution of *Spinocalanus spinipes* at the 0–1300 m depth in the Bering Sea and the northwestern North Pacific in 1962 (Number per 50 m water column: 7.3 m³).

12. *Spinocalanus abyssalis* GIESRBECHT

Spinocalanus abyssalis, Giesbrecht, 1892, p. 209, Taf. 13, figs. 42–48, Taf. 36, fig. 39; Sars, 1903, pp. 157–158, suppl. Pl. 3, fig. 2; Tanaka, 1937, pp. 253–254, fig. 4; Vervoort, 1946, pp. 147–150; Davis, 1949, pp. 21–22, Pl. 2, figs. 23–24; Tanaka, 1956, pp. 389–390; 1960, pp. 36–37.
Spinocalanus longicornis, Sars, 1901, pp. 22–23, Pl. 12.

Female: 1.05–1.3 mm and 1.95–2.2 mm, male: 1.3 mm and 2.0 mm.

Vertical distribution: This species was found at a depth of more than 160 m in the Bering Sea, and its largest number was concentrated at a 160–800 m depth. In the Arctic Ocean this species occurs at a 50–100 m depth (Minoda 1967), while in the North Pacific it is distributed at a depth of more than 200 m (Furuhashi 1966). The upper limit of the occurrence tends to be shallower in high latitudes than in low latitudes.

13. *Mimocalanus cultrifer* FARRAN

Mimocalanus cultrifer Farran, 1908, p. 23, Pl. 1, figs. 5–9; Vervoort, 1946, pp. 156–157; Tanaka, 1956, p. 85, fig. 13a-i; Vervoort, 1957, p. 42, figs. 11–15.

Female: 1.55–1.95 mm.

Vertical distribution: Each individual was found at 818–1230 m (Sta. 624) in the Bering Sea and at 198–485 m (Sta. 621) in the northwestern North Pacific. It was the first record of that kind from the Bering Sea. This is a bathybic species, and has been previously recorded from 200–800 m depth in the North Atlantic (Farran 1908), 300–1000 m depth in the tropical Pacific (Vervoort 1946) and 300–500 m depth in Sagami Bay (Tanaka 1956).

14. *Mimocalanus distinctocephalus* Brodsky

Mimocalanus distinctocephalus Brodsky, 1950, pp. 136–137, fig. 56; 1955, p. 187.

Female: 2.6 mm.

Vertical distribution: This species was found in a small number at a depth of more than 180 m in the Bering Sea, and was recorded to be in the Bering Sea for the first time. This is a bathybic species in the Okhotsk Sea and the North Pacific, reaching 6000–8500 m in the Kamchatka-Kurile Trench (Brodsky 1955a). Only one individual of this species was recorded from the 0–2000 m vertical haul in the Arctic Ocean by Johnson (1963).

15. *Monacilla typica* G. O. Sars

Monacilla typica, Sars, 1925, p. 38, Pl. 11, figs. 1–15, Pl. 12, figs. 1–10; Vervoort, 1946, p. 158–163; Tanaka, 1956, pp. 94–96, fig. 18.
Oxycalanus semispinus A. Scott, 1909, p. 33–34, Pl. 2, figs. 9–12.

Female: 2.43 mm.

Remarks: In the present specimen the head is completely fused with the 1st thoracic segment. According to Sars (1925) the head is partly fused with the 1st thoracic segment, and the posterior surface of the 1st thoracic segment of the basipodite of the 4th legs bears a row of strong spines. In the Tanaka's specimen (1956) the head is separated from the 1st thoracic segment, contrary to the Vervoort's specimen (1946) in which they are fused together. A row of spines at the posterior surface of the 1st segment of the basipodite of the left 4th leg in the present specimen agrees with Vervoort's and Tanaka's specimens. The right leg lacks the spine.

Vertical distribution: Only one female of this species was found at an 85–164 m depth at Sta. 621 in the northwestern North Pacific. This species was recorded at a 185–2500 m depth in the Selebes Sea (Vervoort 1946) and a 0–1000 m depth in Sagami Bay (Tanaka 1956).

16. *Aetideus pacificus* Brodsky

Aetideus pacificus Brodsky, 1950, p. 144, fig. 60.

Female: 2.2–2.25 mm, male: 1.87–1.9 mm.

Male: The cephalothorax is slender in dorsal view. The rostrum has two strong diagonal chitinous projections. The distal corners of the last thoracic segment are acute. The 1st antennae extend to the furcal rami. The first 4 pairs of legs are similar to those of the female. The right 5th leg is rudimentary; the left leg is slender and consists of 5 segments. The terminal segment is the shortest and bears hairs at the inner margin and at the apex.

Remarks: Only the female was described by Brodsky (1950). The general figure of this species resembles very much *A. armatus* BOECK except for the acute projection of the distal corners of the last thoracic segment.

Vertical distribution: This species was found at a depth of more than 80 m, mostly 80–200 m, and very rare at a depth of more than 1000 m. According to Vinogradov (1954), this species stays at 100–500 m in the daytime, but migrates up to the shallow 100 m depth at night.

17. *Gaidius brevispinus* (G. O. SARS)

Gaidius brevispinus, G.O. Sars, 1903, p. 162, suppl. Pl. 6, fig. 2; 1925, p. 48; Brodsky, 1950, p. 158, fig. 72; Tanaka, 1957, p. 62, fig. 38.
Chiridius brevispinus G.O. Sars, 1900, p. 68, Pl. 19.

Female: 4.75 mm, male: 4.0 mm.

Vertical distribution: This species was found at a depth of more than 180 m both in the Bering Sea and the northwestern North Pacific. This species was recorded in the 0–500 m, 500–1000 m and 1000–2000 m, however, no findings were recorded in the 0–150 m vertical haul in the Bering Sea (Minoda 1958). According to Brodsky (1950), this species is bathybic, and is distributed at a depth of more than 200 m.

18. *Gaidius variabilis* BRODSKY

Gaidius variabilis Brodsky, 1950, p. 160, fig. 74.

Female: 3.25–3.6 mm, male: 3.5 mm.

Vertical distribution: This species was found at a depth of more than 50 m both in the Bering Sea and the northwestern North Pacific. This species inhabited mainly the 100–500 m depth, and was very rare at a depth of more than 1000 m (Fig. 16). This is a transition species in the present region. It inhabited the depth of more than 100 m in the daytime, and migrated up to the shallow 100 m depth at night. According to Vinogradov (1954), this species exhibits the diurnal vertical migration from 200 m in the daytime to 20 m at night.

19. *Gaetanus simplex* BRODSKY

Gaetanus simplex Brodsky, 1950, p. 164, fig. 77.

Female: 3.5–3.64 mm, male: 3.55 mm.

Vertical distribution: This species was found at a depth of more than

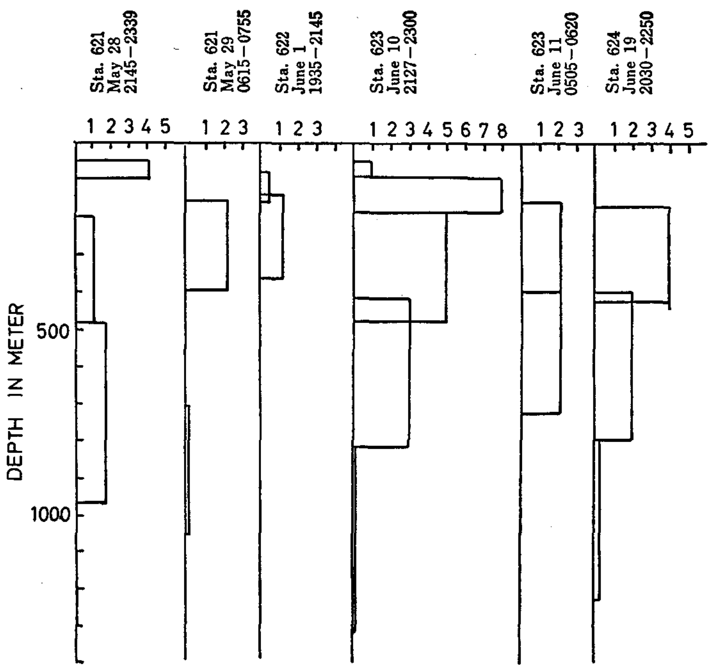

Fig. 16. Vertical distribution of *Gaidius variabilis* at the 0–1300 m depth in the Bering Sea and the northwestern North Pacific in 1962 (Number per 50 m water column: 7.3 m³).

50 m both in the Bering Sea and the northwestern North Pacific. It was concentrated at the 100–500 m depth, and was very rare deeper than 1000 m. This is a transition species in the present region.

20. ***Pseudochirella polyspina*** Brodsky

Pseudochirella polyspina Brodsky, 1950, p. 185, fig. 102; Tanaka, 1957, p. 194, fig. 55.

Female: 6.28–6.7 mm.

Vertical distribution: This species was found at a depth of more than 180 m in the Bering Sea. According to Brodsky (1950), this is a bathybic species and inhabits the 1000–4000 m depth in the North Pacific.

21. ***Pseudochirella spectabilis*** (G.O. Sars)

Pseudochirella spectabilis, Brodsky, 1950, pp. 185–187, fig. 103.
Undeuchaeta spectabilis G.O. Sars, 1900, p. 59, Pls. 15, 16; Breemen. 1908, p. 44, fig. 51.

Female: 7.9 mm.

Vertical distribution: Each individual of this species was found in the 1000–2000 m vertical haul at 2 stations in the Bering Sea and this is the first time they are recorded to be the Bering Sea. This species is an endemic, staying in the 200–800 m depth in the Arctic Ocean (Sars 1900, Bogorov 1946b, Minoda 1967). Distributional layer is deeper in the Bering Sea than in the Arctic Ocean.

22. *Pseudochirella spinifera* BRODSKY

Pseudochirella spinifera Brodsky, 1950, p. 188, fig. 105.

Male: 5.3 mm.

Vertical distribution: This species was found at a depth of more than 180 m in the Bering Sea. This is the first record of the kind in the Bering Sea. According to Brodsky (1950), this species is bathybic, inhabiting the North Pacific and the Okhotsk Sea.

23. *Pareuchaeta elongata* (ESTERLY)

Pareuchaeta elongata, Tanaka, 1958, p. 355, fig. 75.
Euchaeta elongata Esterly, 1913, p. 182, Pl. 10, figs. 5, 16, 27, Pl. 11, fig. 37, Pls. 12, fig. 49.
Euchaeta japonica Marukawa, 1921, p. 11, Pl. 1, fig. 14, Pl. 2, figs. 5–10, Pl. 3, figs. 1–7; Mori, 1937, p. 47, Pl. 22, figs. 3–11.
Pareuchaeta japonica, Brodsky, 1950, p. 209, fig. 123.

Female: 6.0–7.5 mm, male: 6.8 mm.

Remarks: This species has been known as *Pareuchaeta japonica* (MARUKAWA) in the Japanese waters. Tanaka (1958) mentioned that *P. japonica* is synonymous with *P. elongata* (ESTERLY); both descriptions of the female coincide except for the body length. The genital pore is asymmetric, with a lammela on the right side of the orifice, and the distal corners of the last thoracic segment bear a blunt projection.

Vertical distribution: This species was found from the surface down to 1000 m both in the Bering Sea and the northwestern North Pacific. This species was not collected at a depth of more than 1000 m. It was caught in the shallow 50 m depth in the night haul but at a depth of more than 100 m in the morning haul. It seems to perform diurnal vertical migration.

24. *Pareuchaeta birostrata* BRODSKY

Pareuchaeta birostrata Brodsky, 1950, p. 213, fig. 127; Tanaka, 1958, p. 119, fig. 77.

Female: 8.7 mm, male: 7.26 mm.

Vertical distribution: This species was found at a depth of more than 200 m both in the Bering Sea and the northwestern North Pacific; in the Bering Sea it was found deeper than 1000 m.

25. ***Pareuchaeta brevirostris*** BRODSKY

Pareuchaeta brevirostris Brodsky, 1950, p. 215, fig. 129.

Female: 7.55 mm.

Remarks: The frontal prominence of the head is low. The genital segment is somewhat asymmetrical; the right side is more swollen than the left.

Vertical distribution: Only one female of this species was found at a depth of 882–1320 m at Sta. 623 in the Bering Sea. According to Brodsky (1950), this species is bathybic and distributed at the depth of 1000–4000 m in the Bering Sea and the North Pacific.

26. ***Pareuchaeta rubra*** BRODSKY

Pareuchaeta rubra Brodsky, 1950, p. 214, fig. 128.

Female: 6.65–7.25 mm, male: 7.2 mm.

Remarks: The frontal prominence of the head is low. The genital pore is symmetrical having round fringes on each side. The 1st abdominal segment of the male is a little asymmetrical. The distal part of the 2nd, 3rd and 4th abdominal segments has a fringe.

Vertical distribution: This species was found at the depth of 400–1230 m (Sta. 624) and at the depth 1000–2000 m (Stas. 6615, 6619) in the Bering Sea. This species is abyssal, being distributed at a depth of 1000–4000 m in the North Pacific, the Bering Sea and the Okhotsk Sea (Brodsky 1950).

27. ***Pareuchaeta crassa*** TANAKA

Pareuchaeta crassa Tanaka 1958, p. 357, fig. 76.

Female: 6.6 mm.

Vertical distribution: This species was found at a depth of 364–731 m and of 882–1320 m at Sta. 623 in the Bering Sea. It was reported from the Sagami Bay by Tanaka (1958), and the finding is the first recorded in the Bering Sea.

28. ***Xanthocalanus kurilensis*** BRODSKY

Xanthocalanus kurilensis Brodsky, 1950, p. 229, fig. 142.

Female: 3.52 mm.

Remarks: The present specimen resembles very much *Xanthocalanus fallax* G.O. SARS in its general characteristics; however, the terminal spine of the last segment of the 5th pair of legs is shorter than in *X. fallax*. The present specimen coincides with Brodsky's specimen.

Vertical distribution: Only one female of this species was found at the depth of 190–477 m at Sta. 623 in the Bering Sea. According to Brodsky (1950), this species is recorded at the depth of 400 m in the North Pacific. This is the first record of the kind from the Bering Sea.

29. *Onchocalanus magnus* (WOLFENDEN)

Onchocalanus magnus, Brodsky, 1950, p. 233, fig. 146; Vervoort, 1951, p. 17, figs. 5–8; 1957, pp. 87–88, fig. 70.

Female: 6.5 mm.

Vertical distribution: This species was found at 3 stations in the Bering Sea. An immature female was found at a depth of 190–477 m at Sta. 623, and each adult female was found at a depth of 1000–2000 m at Stas. 6603 and 6605. This is an Antarctic deep water species inhabiting the 750–1000 m depth (Vervoort 1957).

30. *Scaphocalanus magnus* (T. SCOTT)

Scaphocalanus magnus, A. Scott, 1909, p. 97; Sewell, 1929, p. 207; Jespersen, 1934, p. 87; Wilson, 1950, p. 238; Brodsky, 1950, p. 247, fig. 156; Vervoort, 1957, p. 111; Tanaka, 1961, p. 158, fig. 113; Vervoort, 1965, p. 62.
Scolecithrix magna, Esterly, 1906, p. 66, Pl. 9, fig. 13, Pl. 11, fig. 38, Pl. 12, figs. 52, 64, Pl. 13, fig. 72.

Female: 4.95–5.6 mm, male: 5.1 mm.

Vertical distribution: This species was found at a depth of more than 150 m both in the Bering Sea and the northwestern North Pacific. The vertical range of the distribution extended to more than 1000 m deep. According to Vinogradov (1954), this species inhabits the depth of more than 200 m in the Bering Sea, and the diurnal vertical migration is insignificant.

31. *Scaphocalanus major* (T. SCOTT)

Scaphocalanus major, A. Scott, 1909, p. 97; Vervoort, 1957, p. 110; Tanaka, 1961, p. 166, fig. 116; Vervoort, 1965, p. 63.
Scolecithrix major, Giesbrecht & Schmeil, 1898, p. 47; Breemen, 1908, p. 79.
Scaphocalanus medius, G.O. Sars, 1925, p. 173, Pl. 49, figs. 1–8; Sewell, 1929, pl. 208; Brodsky, 1950, p. 250, fig. 158; Wilson, 1950, p. 328, figs. 515–517.

Female: 1.9–2.55 mm, male: 2.6–2.8 mm.

Vertical distribution: This species was found at a depth of more than 190 m in the Bering Sea, and from 485–970 m in the northwestern North Pacific. It was not caught by the 1000–2000 m deep vertical haul in the Bering Sea. It was reported to be at 1000 m deep in Sagami Bay (Tanaka 1961a), and in the deep waters of the Indian Ocean (Sewell 1929) and of the Antarctic Ocean (Vervoort 1957). This is the first record of the kind from the Bering Sea.

32. ***Scaphocalanus subbrevicornis*** (Wolfenden)

Scaphocalanus subbrevicornis, Brodsky, 1950, p. 253, fig. 161; Vervoort, 1951, p. 116, figs. 62–64; 1957, p. 110; Tanaka, 1960, p. 331, Pl. 34, p. 43, Pl. 19, figs. 1–8; 1961a, p. 173, figs. 119, 120.
Scaphocalanus gracilicauda Tanaka, 1937, p. 263, fig. 12.

Female: 1.9–2.1 mm, male: 1.7 mm.

Vertical distribution: This species was found at a depth of more than 400 m both in the Bering Sea and the northwestern North Pacific. This is an Antarctic species inhabiting the 0–200 m depth (Vervoort 1957, Tanaka 1960).

33. ***Scolecithricella valida*** (Farran)

Scolecithricella valida, Vervoort, 1957, p. 107; Tanaka, 1962, p. 70, fig. 143.
Amallothrix valida, Sars, 1925, p. 186, Pl. 51, figs. 22–28, Sewell, 1929, pp. 217–218, fig. 80a-f; Jespersen, 1934, p. 90; Wilson, 1942, p. 171, figs. 7, 129; Brodsky, 1950, p. 260, figs. 169, 170.
Scaphocalanus validus, Wilson, 1932, p. 78, fig. 53.

Female: 4.07 mm, male: 5.35 mm.

Vertical distribution: This species was found at a depth of more than 400 m in the Bering Sea. According to Sewell (1929), this species is abyssal and distributed in the deep water of the Indian Ocean. It was also found in the Antarctic Ocean (Vervoort 1957) and in the Sagami Bay (Tanaka 1962). This is the first record of the kind from the Bering Sea.

34. ***Scolecithricella emarginata*** (Farran)

Scolecithricella emarginata, Tanaka, 1962, p. 66, fig. 142; Vervoort, 1965, p. 67.
Scolecithrix inornata Esterly, 1906, p. 67, Pl. 9, fig. 18, Pl. 11, fig. 37, Pl. 13, figs. 65, 73.
Scolecithricella obtusifrons, A. Scott, 1909 p. 92, Pl. 31, figs. 1–9.
Scolecithrix emarginata, Sars, 1925, p. 181, Pl. 50; Sewell, 1929, p. 216.
Scaphocalanus obtusifrons, Wilson, 1932, p. 79, fig. 54.
Amallothrix emarginata, Jespersen, 1934, p. 90.
Amallothrix inornata, Brodsky, 1950, p. 259, fig. 168.

Female: 4.2 mm.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific. The shallowest occurrence was at 170 m deep in the Bering Sea. The vertical distribution extended to the depth of more than 1000 m. This is a bathybic species distributed in the North Pacific and the Okhotsk Sea (Brodsky 1950). According to Tanaka (1962), this species is widely distributed in the deep waters of the oceans.

35. ***Scolecithricella minor*** (Brady)

Scolecithricella minor, Sars, 1903, p. 55, Pls. 37, 38; 1925, p. 188; Wilson, 1932, p. 83, fig. 57a, b; Mori, 1937, p. 51, Pl. 25, figs. 1–7; Brodsky, 1948, p. 53, Pl. 12, figs. 3–6; 1950, p. 268, fig. 178; Vervoort, 1965, p. 82.

Scolecithrix minor, Brady, 1883, p. 58, Pl. 16, figs. 15, 16, Pl. 17, figs. 1–5; Giesbrecht, 1892, p. 266; Giesbrecht & Schmeil, 1898, p. 46; Breemen, 1906, p. 73, fig. 85a-c; Sato, 1913, p. 23, Pl. 4, figs. 56–58.

Female: 1.3–1.7 mm, male: 1.4 mm.

Vertical distribution: This species was commonly found in every zone from the surface down to more than 1000 m both in the Bering Sea and the northwestern North Pacific. An abundant number was observed in the shallow 150 m depth (Table 8). This species was caught at the surface at night, but at a depth of

Table 8. Number of *Scolecithricella minor* obtained by a separate haul with a Juday closing net in the Bering Sea and the northwestern North Pacific, May and June 1962 (Number per 50 m water column: 7.3 m³).

Sta. 621				Sta. 622		Sta. 623				Sta. 624	
46°06′N 166°48′E				52°00′N 171°40′E		56°10′N 173°55′W				55°11′N 169°20′E	
May 28, 1962 2145–2339		May 29, 1962 0615–0755		June 1, 1962 1935–2145		June 10, 1962 2127–2300		June 11, 1962 0505–0620		June 19, 1962 2030–2250	
Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number
0–46	0*	0–43	0*	0–83	104	0–48	84	0–47	72	0–46	0
46–100	26	42–85	7	84–157	14.5	48–95	41	45–89	40	48–95	12
99–198	1.5	87–164	22.5	139–370	6.7	95–190	7.5	91–182	5.5	91–181	15.5
195–485	0	160–400	6.7	420–838	0	192–477	3.8	160–399	0	170–423	14
485–970	0.3	397–694	0.4	615–920	1.6	440–819	0.1	364–731	0.1	399–798	0.7
906–1350	0	707–1060	0.4			882–1320	0.1	731–1090	0	819–1230	0.1

* Collected by 0–200 m horizontal tow in 1962

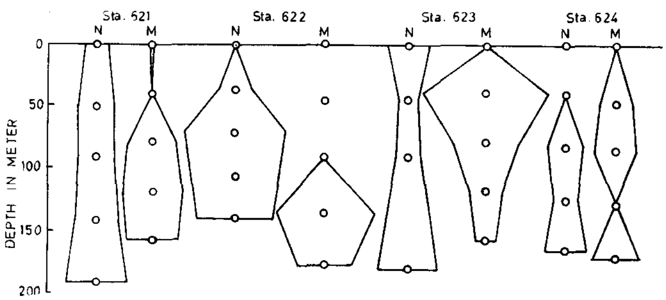

Fig. 17. Vertical distribution of *Scolecithricella minor* in the upper 200 m in the Bering Sea and the northwestern North Pacific in 1962.

more than 50 m in the morning (Fig. 17). According to Vinogradov (1954), this is a transition species distributed in the 20–500 m depth, and it exhibits a significant diurnal vertical migration. Mori (1937) reported this species to be in the shallow 50 m depth in the waters of the Kinkasan, Japan.

36. *Scolecithricella ovata* (FARRAN)

Plate II, Figs. 1–10.

Scolecithricella ovata Sars, 1925, p. 188, Pl. 52, figs. 1–6; Wilson, 1932, p. 84; 1942, p. 208, fig. 125; 1950, p. 334, Pl. 35; Brodsky, 1950, p. 269, fig. 179; Vervoort, 1951, p. 99, fig. 53; 1957, p. 102; Tanaka, 1962, p. 55.
Scolecithrix ovata, Breemen, 1908, p. 72, fig. 83.

Female: 1.98–2.38 mm, male: 1.79–1.89 mm.

Male: The forehead is dilated in dorsal view, and round in lateral view. The head and the 1st thoracic segment are fused together. The basal part of the rostrum has two developed knobs with filaments at the apex. The distal corners of the last thoracic segment are round. The 1st antennae are symmetrical, having 21 segments, and they prolong the furcal rami. The 5th pair of legs is asymmetrical; the left leg is long and consists of 5 segments, while the right leg is shorter and consists of 3 segments.

Remarks: Male of *S. ovata* was first reported by Tanaka (1962). The first 4 pairs of legs resemble those of the female.

Vertical distribution: This species was found at a depth of more than 50 m both in the Bering Sea and the northwestern North Pacific. This species extended to the depth of more than 1000 m, and the males were caught below 400 m. This species is widely distributed in the bathybic region of the oceans. In the Antarctic Ocean, it inhabits the water deeper than 100 m (Vervoort 1957).

37. *Scolecithricella globulosa* BRODSKY

Scolecithricella globulosa Brodsky, 1950, p. 270, fig. 180.

Female: 1.65–1.78 mm.

Vertical distribution: This species was found at a depth of more than 400 m both in the Bering Sea and the northwestern North Pacific. This is the first record of the kind from the Bering Sea. According to Brodsky (1950), this species is bathybic, inhabiting the 200–500 m depth in the Japan Sea and from 0–4000 m in the North Pacific.

38. *Racovitzanus antarcticus* GIESBRECHT

Racovitzanus antarcticus, Brodsky, 1950, p. 266, fig. 177; Vervoort, 1951, p. 94; 1957, p. 97, figs. 80–84.

Female: 2.2–2.3 mm.

Remarks: The present specimen is somewhat different from the antarctic specimen of Vervoort (1957). In the Vervoort's specimen, the 1st segment of the exopodite of the 1st pair of legs has the outer marginal spine and the terminal segments of the exopodites of the 2nd and 3rd pairs of legs have fine spinules on the posterior surface. In the present specimen, the 1st segment of the exopodite of the 1st pair of legs lacks the outer marginal spine. The present specimen is identical with Brodsky's specimen.

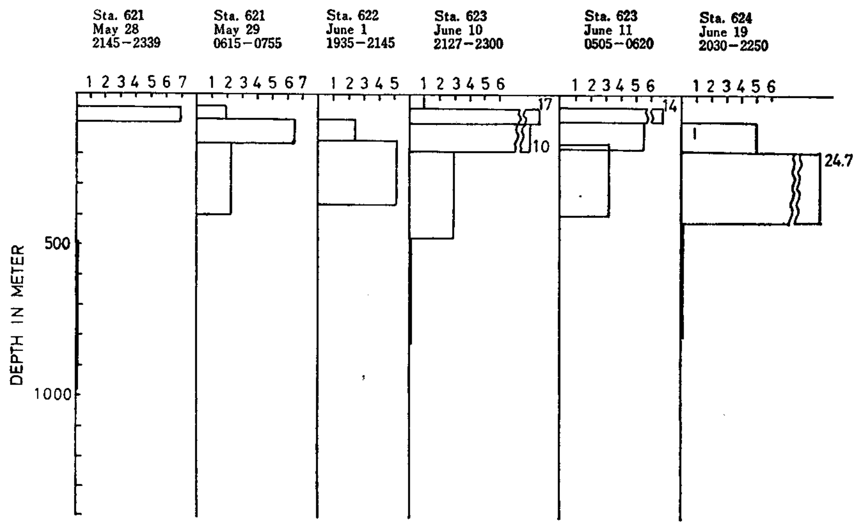

Fig. 18. Vertical distribution of *Racovitzanus antarcticus* at the 0–1300 m depth in the Bering Sea and the northwestern North Pacific in 1962 (Number per 50 m water column: 7.3 m^3).

Vertical distribution: This species was commonly found at a depth of 50–1000 m both in the Bering Sea and the northwestern North Pacific. It was abundant only at a depth of 400 m (Fig. 18). This species is widely distributed in the North Pacific and the Bering Sea (Brodsky 1950, Vinogradov 1954, Minoda 1958). According to Furuhashi (1966), it is distributed at the depth of 500–1000 m in the transitional zone in the Oyashio, but not in the Kuroshio.

39. ***Racovitzanus erraticus*** VERVOORT

Racovitzanus erraticus Vervoort, 1957, p. 99, figs. 85–87.

Male: 2.06 mm. Body is slender. The head and the 1st thoracic segment are fused, and the last 2 thoracic segments are also fused together. The rostrum is cylindrical and the apex has 2 small knobs. The genital segment is somewhat asymmetrical; the left side protrudes slightly. The 1st segment of the exopodite of the 1st pair of legs has neither outer, nor inner marginal spines. The 5th pair of legs is asymmetrical; the 1st segment of the basipodite is shorter on the right leg than on the left one, and the 2nd segment of the basipodite of the right leg is globular. The exopodite of the right leg has 2 segments and that of the left leg has three.

Vertical distribution: Only one male was found at the depth of 160–399 m at Sta. 623 in the Bering Sea, and the findings were the first recorded from the Bering Sea. This species has been reported to be only in the Antarctic Ocean (Vervoort 1957).

40. *Undinella brevipes* FARRAN
Plate III, Figs. 1–9.

Undinella brevipes, Vervoort, 1957, p. 95; Tanaka, 1960, p. 131, fig. 103.

Female: 1.9 mm. The proportions in the length of the cephalothorax compared with that of the abdomen are 72:28. The head is round in dorsal view and bears the rostrum with two small filaments. The head and the 1st thoracic segment are partly fused, and the last 2 thoracic segments are fused together. The ventral margins of the 2nd, 3rd and 4th thoracic segments project towards the posterior direction. The last thoracic segment is also sharply pointed towards the posterior direction. The 1st antennae are symmetrical and consist of 24 segments: they reach the end of the 3rd thoracic segment, when reflexed. The abdomen consists of 4 segments, and the anal segment is very narrow. The exopodites of the 2nd, 3rd and 4th pairs of legs are broad and have fine toothed terminal spines at the apex. The 5th pair of legs is somewhat asymmetrical; each leg is not bifurcate and consists of 2 segments. The terminal segment of the 5th leg has 4 small processes on the left leg and three on the right.

Vertical distribution: This species was found at 3 stations in the Bering Sea. The shallowest occurrence was at the depth of 170–423 m. This is the first record of this female from the North Pacific region. This is a bathybic species inhabiting the North Atlantic (Wolfenden 1906) and the Subantarctic and Antarctic (Vervoort 1957). Tanaka (1960) reported only one immature male at the depth of 0–1000 m in Sagami Bay.

41. *Metridia pacifica* BRODSKY

Metridia pacifica Brodsky, 1950, p. 295, fig. 201; Tanaka, 1963, p. 21, fig. 159.
Metridia lucens, Sato, 1913, p. 36, Pl. 5, figs. 92–96; Mori, 1937, p. 67, Pl. 34, figs. 1–5.
Metridia lucens v. *pacifica* Brodsky, 1948, p. 57, Pl. 14, figs. 1–4, 7–9.

Female: 2.9–3.3 mm, male: 2.1 mm.

Remarks: Brodsky (1950) recorded this species to be in the northern cold

Table 9. Number of *Metridia pacifica* obtained by a separate haul with a Juday closing net in the Bering Sea and the northwestern North Pacific, May and June 1962 (Number per 50 m water column: 7.3 m³).

Sta. 621				Sta. 622		Sta. 623				Sta. 624	
46°06′N 166°48′E				52°00′N 171°40′E		56°10′N 173°55′W				55°11′N 169°20′E	
May 28, 1962 2145–2339		May 29, 1962 0615–0755		June 1, 1962 1935–2145		June 10, 1962 2127–2300		June 11, 1962 0505–0620		June 19, 1962 2030–2250	
Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number
0–46	16	0–43	87	0–83	1416	0–48	281	0–47	88	0–46	526
46–100	145	42–85	0*	84–157	67	48–95	41	45–89	28	48–95	23
99–198	15	87–164	332.5	139–370	126	95–190	11.5	91–182	11.5	91–181	17
195–485	14	160–400	221.3	420–838	0.1	192–477	26.2	160–399	15	170–423	20
485–970	15.7	397–694	7.8	615–920	28.8	440–819	13.2	364–731	17.6	399–798	2.5
906–1350	1.3	707–1060	8.7			882–1320	0.6	731–1090	0	819–1230	0

* Collected by 0–200 m horizontal tow in 1962

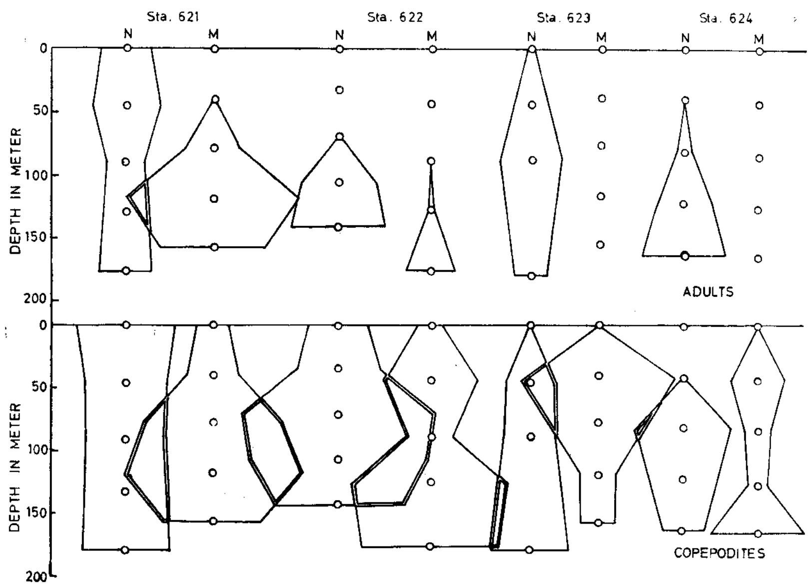

Fig. 19. Vertical distribution of *Metridia pacifica* in the upper 200 m in the Bering Sea and the northwestern North Pacific in 1962.

waters of the Pacific Ocean. *M. pacifica* is closely allied to *M. lucens* BOECK; however, the former is characterized by a broad head, a long genital segment, long furcal rami and a slender 5th pair of legs on the female. The present specimens are identical with *M. pacifica*.

Vertical distribution: This species was commonly found from the surface to a depth of more than 1000 m both in the Bering Sea and the northwestern North Pacific. The abundance was usually observed in the shallow 200 m depth (Table 9). This species exhibited significant diurnal change of the vertical distribution. As shown in Fig. 19, the adult was not caught in the shallow 50 m depth in the morning, but at the surface at night. Immature stages inhabited the surface in the morning. The vertical range of the distribution was different between adult and immature stages. According to Vinogradov (1954), this species exhibits the most significant diurnal vertical migration among the subarctic copepods.

42. *Metridia okhotensis* BRODSKY

Metridia okhotensis Brodsky, 1950, p. 293, fig. 199; Tanaka, 1963, p. 19, fig. 158.

Female: 4.5 mm.

Remarks: *M. okhotensis* is closely allied to *M. longa* (LUBBOCK); however, the broad cephalothorax, the short abdomen and the long distal segment of the 5th pair of legs distinguish *M. okhotensis* from *M. longa*. The present specimen is identical with *M. okhotensis*.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific. The vertical range of occurrence was from 50 m down to 1000 m deep in the north western North Pacific, but from 200 m down to 1000 m in the Bering Sea. According to Brodsky (1950), this species is endemic in the Okhotsk Sea. This is the first record of the kind from the Bering Sea.

43. *Metridia asymmetrica* BRODSKY

Metridia asymmetrica Brodsky, 1950, p. 299, fig. 205.

Female: 4.2 mm, male: 3.6–3.86 mm.

Remarks: The general features resemble very much those of *M. curticauda* GIESBRECHT except for the asymmetrical genital segment of the female; the left side of that segment is swollen. The 2nd and 3rd abdominal segments of the male have tufted hair-like spinules on the ventral side.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific. It was commonly collected at a depth of more than 400 m, but it was scarce from 100–190 m (Sta. 621). The occurrence of this species extended deeper than 1000 m. This species is endemic in the North Pacific, distributed in the depth of 1000–4000 m (Brodsky 1950).

44. *Metridia curticauda* GIESBRECHT

Metridia curticauda, Giesbrecht, 1892, p. 340, Pl. 33, figs. 4, 15, 33; Sewell, 1932, p. 248; Brodsky, 1950, p. 297, fig. 203; Vervoort, 1951, p. 121, figs. 65–67; 1957, p. 122; Tanaka, 1963, p. 15, fig. 154.

Female: 3.2–3.8 mm, male: 3.1–3.3 mm.

Vertical distribution: This species was found at a depth of more than 200 m both in the Bering Sea and the northwestern North Pacific. This species is bathybic and distributed at the depth of more than 500 m both in the Kuroshio and Oyashio regions (Furuhashi 1966).

45. *Metridia brevicauda* GIESBRECHT

Metridia brevicauda, Giesbrecht, 1892, p. 340, Pl. 33, figs. 5, 10, 11, 14, 21, 32; Giesbrecht & Schmeil, 1898, p. 108; Sewell, 1932, p. 248, Brodsky, 1950, p. 300, fig. 206; Vervoort, 1957, p. 122; Tanaka, 1963, p. 19, fig. 157.

Male: 1.6 mm.

Vertical distribution: This species was found at a depth of 100–1000 m in the northwestern North Pacific. This is recorded in water deeper than 300 m and only in the Kuroshio region (Furuhashi 1966).

46. *Pleuromamma scutullata* BRODSKY

Pleuromamma scutullata Brodsky, 1950, p. 311, fig. 217.

Female: 3.9–4.0 mm, male: 3.3 mm.

Vertical distribution: This species was commonly found both in the Bering Sea and the northwestern North Pacific. This species inhabited the water from shallow to deep, abundantly at the 40–400 m depth, but rarely at a depth of more than 1000 m (Fig. 20). This species exhibited a significant diurnal vertical migration, occurring abundantly at the 50 m depth at night, but was rarely found there in the morning. According to Furuhashi (1966), this species is distributed only in the transitional zone of the Oyashio, not of the Kuroshio.

47. *Lucicutia flavicornis* (CLAUS)

Lucicutia flavicornis, Giesbrecht & Schmeil, 1898, p. 111; Esterly, 1905, p. 180, fig. 36; Breemen, 1908, p. 112, fig. 129a-d; Sato, 1913, p. 38, Pl. 5, figs. 98–101, Pl. 6, fig. 97; Esterly, 1924, p. 98, fig. 50; Sars, 1925, p. 207; Sewell, 1932, p. 294; Mori, 1937, p. 72, Pl. 37, figs. 1–6; Brodsky, 1950, p. 327, fig. 226; Tanaka, 1960, p. 52; 1963, p. 39, fig. 167; Brodsky, 1962, p. 132, fig. 33; Vervoort, 1965, p. 111.
Leukartia flavicornis, Giesbrecht, 1892, p. 358, Pl. 5, fig. 4, Pl. 19, figs. 2, 3, 15, 16, 17, 21, 23, 29, 38, Pl. 38, figs. 38, 40.

Female: 1.56 mm, male: 1.43 mm.

Vertical distribution: This species was found only at the 100–200 m depth

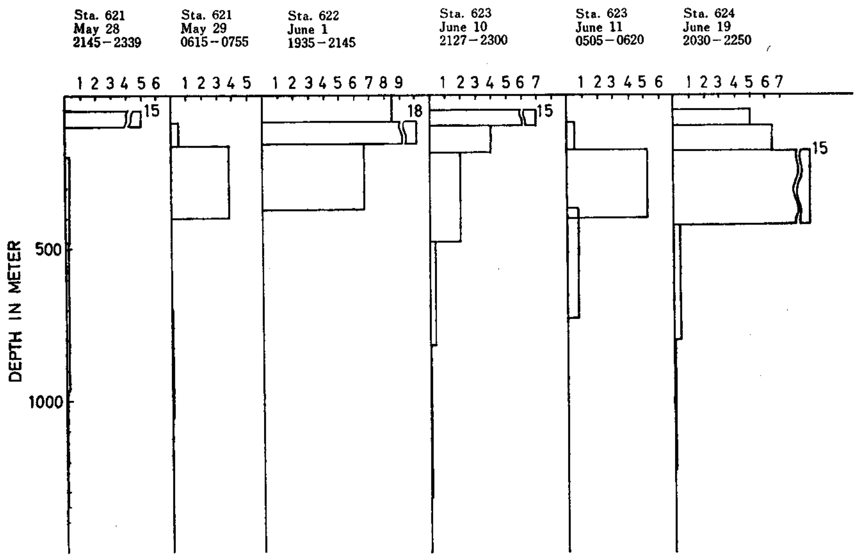

Fig. 20. Vertical distribution of *Pleuromamma scutullata* at the 0–1300 m depth in the Bering Sea and the northwestern North Pacific (Number per 50 m water column: 7.3 m^3).

at Sta. 621 in the northwestern North Pacific. This is a typical shallow species of the Indian Ocean (Sewell 1932). It inhabits the water from the surface to a depth of 500 m in the Kuroshio region (Furuhashi 1966).

48. *Lucicutia pacifica* Brodsky

Lucicutia pacifica Brodsky, 1950, p. 330, fig. 228.

Male: 4.4 mm.

Vertical distribution: This species was found at a depth of more than 1000 m in the Bering Sea. This is the first record of the kind from the Bering Sea. According to Brodsky (1950), this is a bathybic species distributed at the depth of 1000–4000 m in the North Pacific.

49. *Lucicutia ellipsoidalis* Brodsky

Lucicutia ellipsoidalis Brodsky, 1950, p. 333, fig. 230.

Female: 2.6 mm, male: 2.32 mm.

Remarks: The female of *L. ellipsoidalis* is almost similar to *L. curta* Farran. In *L. ellipsoidalis* the length of the furcal rami is 4 times their width, while it is only 3 times in *L. curta*.

Vertical distribution: This species was found at a depth of more than 800 m in the Bering Sea and the northwestern North Pacific. This species was commonly found by the 1000–2000 m vertical haul, though in a small number. Brodsky (1950) reported this species to be 1000–4000 m deep in the North Pacific. This is the first record of the kind from the Bering Sea.

50. ***Lucicutia oblonga*** BRODSKY

Lucicutia oblonga Brodsky, 1950, p. 339, fig. 236.

Male: 4.1 mm.

Vertical distribution: This species was found only at the 139–370 m depth at Sta. 622 in the northwestern North Pacific. According to Brodsky (1950), this is a bathybic species distributed at the depth of 1000–4000 m in the North Pacific. In the present observation, the layer of occurrence was shallower than in Brodsky's.

51. ***Lucicutia frigida*** WOLFENDEN

Lucicutia frigida Wolfenden, 1911, p. 320, fig. 62; Vervoort, 1957, p. 126, fig. 111.
Lucicutia ovaliformis Brodsky, 1950, p. 334, fig. 232 (only male).
Isochaeta ovalis, Tanaka, 1963, p. 53, fig. 174 (only female).

Female: 1.8–1.9 mm, male: 1.55 mm.

Remarks: The present specimen is identical with the Antarctic specimen of Vervoort (1957). Complete description of *L. frigida* in both sexes was given by Vervoort (1957). Tanaka (1963) reported *Isochaeta ovalis* GIESBRECHT in the Izu region. However, Tanaka's specimen has 5 spines at the inner margin of the 3rd segment of the endopodite of the 2nd pair of legs; this coincides with *L. frigida*, and not with *I. ovalis* which has 4 spines at that segment. The male of *L. frigida* resembles much that of *L. ovaliformis* BRODSKY in general appearance. The female of *L. ovaliformis* is different from *L. frigida*; the endopodite of the 5th pair of legs has 3 segments in the former, while 2 segments only in the latter.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific. It was very scarce in the shallow 150 m depth, but abundant in the 400–800 m (Fig. 21). This species was dominant among copepods in the 1000–2000 m vertical haul in the Bering Sea. According to Vervoort (1957), this is an Antarctic species distributed deeper than 500 m.

52. ***Heterorhabdus robstoides*** BRODSKY

Heterorhabdus robstodies Brodsky, 1950, p. 347, fig. 243.

Female: 5.0 mm, male: 4.4–5.3 mm.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific. The shallowest occurrence was in the 139–370 m depth at Sta. 622, but the species was commonly distributed deeper than 1000 m.

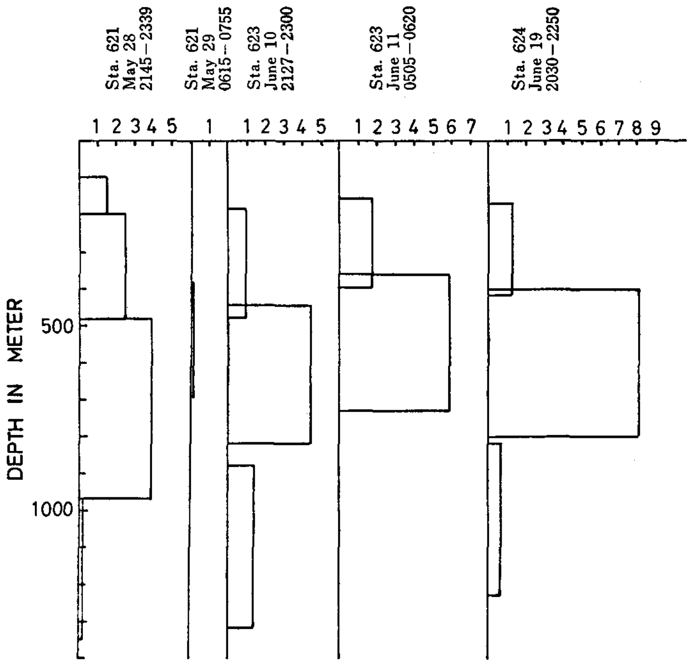

Fig. 21. Vertical distribution of *Lucicutia frigida* at the 0–1300 m depth in the Bering Sea and the northwestern North Pacific in 1962 (Number per 50 m water column: 7.3 m^3).

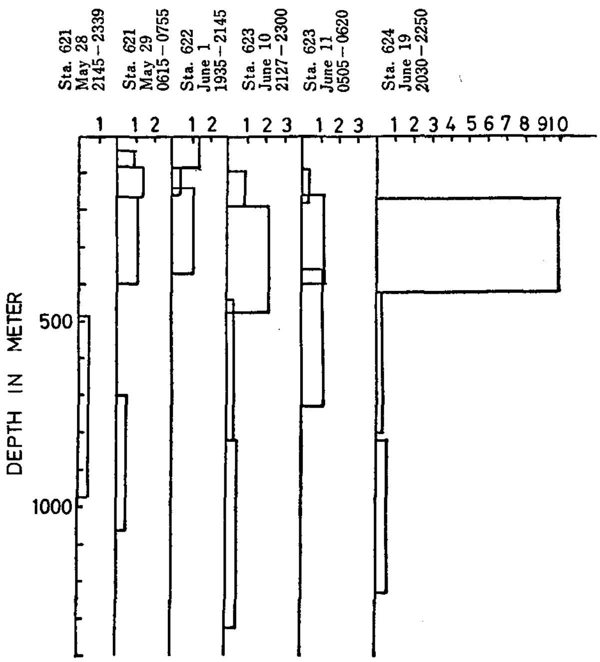

Fig. 22. Vertical distribution of *Heterorhabdus tanneri* at the 0–1300 m depth in the Bering Sea and the northwestern North Pacific (Number per 50 m water column: 7.3 m^3).

53. *Heterorhabdus tanneri* GIESBRECHT

Heterorhabdus tanneri, Giesbrecht & Schmeil, 1898, p. 115; Brodsky, 1950, p. 357, fig. 251; Tanaka, 1964a, p. 11, fig. 251.

Female: 3.9–4.4 mm, male: 3.0–4.0 mm.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific, from the surface to the depth of more than 1000 m. The abundance was observed at the 200–400 m depth in the vertical distribution (Fig. 22). This species exhibited significant vertical change of the distributional level between day and night; it was collected from the surface at night, but at a depth of more than 80 m in the morning. According to Furuhashi (1966), this is a bathybic species distributed in the Oyashio and in the mixing water of the Oyashio and Kuroshio, but not in the Kuroshio. Tanaka (1964a) reported that this species inhabited the 0–1000 m depth in Sagami Bay.

54. *Heterostylites major* (DAHL)

Heterostylites major, Sars, 1925, p. 239, Pl. 67, figs. 17, 18; Brodsky, 1950, p. 358, fig. 252; Vervoort, 1951, p. 140, figs. 78, 79; 1957, p. 135, fig. 127; Tanaka, 1964a, p. 25, fig. 186; Vervoort, 1965, p. 123.
Heterorhabdus major, Giesbrecht & Schmeil, 1898, p. 117; Breemen, 1908, p. 227, fig. 242.

Female: 5.0 mm, male: 5.0 mm.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific. The shallowest occurrence was at the 139–370 m depth at Sta. 622. A small number of this species was commonly found by the 1000–2000 m vertical haul.

55. *Haloptilus oxycephalus* (GIESBRECHT)

Haloptilus oxycephalus, Giesbrecht & Schmeil, 1898, p. 119; Sars, 1925, p. 252, Pl. 74, figs. 12–16; Mori, 1937, p. 77, Pl. 40, figs. 1, 2; Vervoort, 1951, p. 142; 1957, p. 136, figs. 128–130; Brodsky, 1962, p. 132, fig. 34; Tanaka, 1964b, p. 43; Vervoort, 1965, p. 129.
Hemicalanus oxycephalus, Giesbrecht, 1892, p. 384, Pl. 42, figs. 7, 16.

Female: 4.57–5.2 mm.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific. The shallowest occurrence was in the 87–167 m depth at Sta. 621, and it mainly inhabited the depth of less than 1000 m. This species is widely distributed at the depth of more than 200 m in the Kuroshio and Oyashio (Furuhashi 1966); a fact suggesting that it is a transitional species between the surface and the deep waters.

56. *Haloptilus longicirrus* BRODSKY

Haloptilus longicirrus Brodsky, 1950, p. 363, fig. 254; Vervoort, 1965, p. 124.

Female: 3.77 mm.

Vertical distribution: Only one specimen of this species was found at the 819–1230 m depth at Sta. 624 in the Bering Sea. According to Brodsky (1950), this species is distributed at the 1000–4000 m depth in the North Pacific.

57. ***Augaptilus glacialis*** Sars

Augaptilus glacialis Sars, 1900, p. 88, Pls. 26, 27; Breemen, 1908, p. 136, fig. 155; Sars, 1925, p. 254, Pl. 76, figs. 1–16; Brodsky, 1950, p. 367, fig. 258; Vervoort, 1951, p. 144, figs. 80, 81; 1957, p. 138, fig. 131.

Female: 5.1 mm, male: 5.0 mm.

Vertical distribution: This species was found only by the 1000–2000 m vertical haul at Stas. 6607 and 6613 in the Bering Sea. This is an Arctic species (Sars 1900, 1924), distributed in the shallow 200 m depth (Minoda 1967). This species is widely distributed in intermediate as well as deep waters of the oceans; North Atlantic (Jespersen 1934, 1939), Mediterranean (Rose 1933), Antarctic Ocean (Vervoort 1951, 1957) and Sagami Bay (Tanaka 1964b).

58. ***Euaugaptilus graciloides*** Brodsky

Euaugaptilus graciloides Brodsky, 1950, p. 381, fig. 270.

Female: 6.5 mm.

Vertical distribution: Only one female was found at the 1000–2000 m depth at Sta. 6607 in the Bering Sea. According to Brodsky (1950) this is an abyssal species distributed at the 1000–4000 m depth in the North Pacific. This is the first record of the kind from the Bering Sea.

59. ***Centraugaptilus horridus*** (Farran)

Centraugaptilus horridus, Sars, 1925, p. 307, Pl. 57, figs. 11–18; Sewell, 1932, p. 326, fig. 107a-g; 1947, p. 232; Tanaka, 1964b, p. 83, fig. 215; Vervoort, 1965, p. 147.

Female: 9.5 mm.

Vertical distribution: Only one female was found in the 1000–2000 m vertical haul at Sta. 6603 in the Bering Sea, and it is the first time this species is recorded from the Bering Sea. This species is distributed in the deep waters of the Indian Ocean (Sewell 1932) and of Sagami Bay (Tanaka 1964b).

60. ***Pseudaugaptilus*** sp.

Male: 5.1 mm.

Remarks: The present specimen closely resembles *Psuedaugaptilus longiremis* Sars, but the former has an outer edge spine at the 2nd segment of the exopodite of the 1st pair of legs, and the exopodite of the left 5th leg is geniculated, while the latter has no spine at the 2nd segment of the exopodite of the 1st pair of legs, and the exopodite of the left 5th leg is straight.

Vertical distribution: Only one male was found at the 364–731 m depth at Sta. 623 in the Bering Sea.

61. *Pachyptilus pacificus* JOHNSON

Pachyptilus pacificus Johnson, 1936, p. 65, figs. A-4, B-1-10; Brodsky, 1950, p. 392, fig. 279; Tanaka, 1964b, p. 88, fig. 217.

Female: 6.5 mm, male: 4.6 mm.

Remarks: Only the female has been described by Johnson (1936), Brodsky (1950) and Tanaka (1964b). In the present samples, only a male was obtained from the Bering Sea, while some females were obtained from the Bering Sea and the northwestern North Pacific. The general arrangement of the 2nd antenna, mandible, 1st and 2nd and maxillae, maxilliped of the male resemble closely that of the female. The 1st antennae of the male are asymmetrical; the right antenna has 23 segments, and the left one has 21; they are geniculated between the distal 4th and 5th segments. The endopodite of the 5th pair of legs consists of 2 segments. The 5th legs are asymmetrical; the left exopodite is more robust than the right one and lacks the distal spine.

Vertical distribution: The females were found both in the Bering Sea and the northwestern North Pacific, but only the male was found in the Bering Sea. The shallowest occurrence was at the 139–370 m depth at the Sta. 622. This species mostly inhabited the water shallower than 1000 m. This is a bathybic species in the North Pacific (Johnson 1936, Tanaka 1964).

62. *Candacia columbiae* CAMPBELL

Candacia columbiae, Davis, 1949, p. 63, Pl. 13, figs. 162–169; Brodsky, 1950, p. 403, fig. 287; Grice, 1963, p. 175, figs. 36, 45.
Candacia pacifica Mori, 1937, p. 87, Pl. 59, figs. 6–12.

Female: 4.6 mm, male: 3.95 mm.

Remarks: Mori (1937) recorded the female of *Candacia pacifica* off the Kushiro, Hokkaido, as a new species to science. The genital segment is asymmetrical in dorsal view, and the distal part of the 5th pair of legs is bifurcated. These characteristics are identical with *C. columbiae* CAMPBELL. The male of *C. columbiae* was reported by Davis (1949) off the west coast of Vancouver Island, and by Anraku (1954) in the Aleutian waters. The present specimen fits the description and figure of the male of *C. columbiae*; the genital segment is asymmetrical; the right side has a large projection which is bifurcate and pigmented at the tip. The right 5th leg has very wide chela.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific. It was mostly distributed at the 50–500 m depth, and rarely at the depth of more than 1000 m. Diel migration was very clear in adults and immature stages; there was no specimen in the shallow 100 m depth at daytime, but they appeared in the shallow 50 m depth at night.

63. *Candacia parafalcifera* BRODSKY

Candacia parafalcifera Brodsky, 1950, p. 405, fig. 288; Grice, 1963, p. 178, fig. 19.

Male: 4.2 mm. Distal part of the last thoracic segment bears a short spine on each side. The genital segment is asymmetrical, and the right side has a projection which is simple. The distal segment of the left 5th leg bears a long apical spine and 3 short outer spines. The chela of the right 5th leg has narrow rami, and bears an apical spine at the outer segment.

Vertical distribution: This species was found only in the 1000–2000 m vertical haul in the Bering Sea (Stas. 6615, 6620, 6622). According to Brodsky (1950), this is a bathybic species distributed at the 1000–4000 m depth in the North Pacific and the Okhotsk Sea. Grice (1963) reported this species to be at 930 fathoms in the Gulf of California.

64. *Acartia longiremis* LILLJEBORG

Acartia longiremis, Giesbrecht, 1892, p. 507, Pl. 43, figs. 17,25; Giesbrecht & Schmeil, 1898, p. 153; Sars, 1903, p. 149, Pls. 99, 100; Sato, 1913, p. 45, Pl. 8, figs. 122, 123, Pl. 7, figs. 124, 125; Sars, 1925, p. 361; Wilson, 1932, p. 165, fig. 113; Mori, 1937, p. 104, Pl. 51, figs. 6–10; Brodsky, 1948, p. 73, Pl. 23, figs. 4, 5; Davis, 1949, p. 65; Bordsky, 1950, p. 421, fig. 297.

Female: 1.24 mm, male: 1.15 mm.

Vertical distribution: This species was found at the 0–100 m depth both in the Bering Sea and the northwestern North Pacific. This is a neritic species distributed in the shallow eastern Bering Sea (Johnson 1953, Minoda 1958).

65. *Mormonilla minor* GIESBRECHT

Mormonilla minor, Giesbrecht, 1892, p. 532, pl. 43, fig. 33.

Female: 1.26–1.34 mm.

Vertical distribution: This species was commonly found by the 1000–2000 m vertical haul in the Bering Sea. It is distributed in the shallow 100 m depth in the Arctic Ocean (Minoda 1967) and at the depth of more than 400 m in the Kuroshio region (Furuhashi 1966). The distributional level in the present observation was very deep.

66. *Mormonilla phasma* GIESBRECHT

Mormonilla phasma, Giesbrecht, 1892, p. 532, Pl. 43, figs. 36, 37; Davis, 1949, p. 67.

Female: 1.4 mm.

Vertical distribution: This species was found only at the 1338–1589 m depth at Sta. 612 in the Bering Sea. This species is distributed at the 1100–3400 m depth in the North Pacific (Davis 1949) and at a depth of more than 200 m in the Kuroshio region (Furuhashi 1966).

67. *Oithona plumifera* BAIRD

Oithona plumifera, Giesbrecht, 1892, p. 537, Pl. 4, fig. 10, Pl. 34, figs. 12, 13, 22, 25, 27–29, 32, 33, 44–47; Breemen, 1908, p. 167, fig. 183; Wilson, 1932, p. 311, fig. 178; Mori, 1937, p. 109, Pl. 60, figs. 3–15; Olson, Ms, p. 26, Pl. 1, figs. 1–6; Davis, 1949, p. 74, Pl. 15, fig. 178.

Female: 1.4–1.5 mm.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific; it was not collected at the surface. A small number was found by the 1000–2000 m vertical haul in the Bering Sea. According to Furuhashi (1966), this species is distributed in the shallow waters of the Kuroshio and the transitional region, but not found in the Oyashio.

68. *Oithona similis* CLAUS

Oithona similis, Giesbrecht, 1892, p. 537, Pl. 34, figs. 18, 19, 21, 36–39, Pl. 44, figs. 3, 5, 8–11; Breemen, 1908, p. 169, fig. 185; Wilson, 1932, p. 314, fig. 189; Mori, 1937, p. 112, Pl. 62, figs. 1–12, Dakin & Colefax, 1940, p. 116, fig. 202a; Wilson, 1942, p. 196; Olson, Ms, p. 36; Vervoort, 1957, p. 146; Tanaka, 1960, p. 62, pl. 24, figs. 1–9; 1964c, p. 13.
Oithona helgolandica, Davis, 1949, p. 73, Pl. 15, fig. 177.

Female: 0.7–0.8 mm, male: 0.73–0.75 mm.

Vertical distribution: This species was found abundantly both in the Bering Sea and the northwestern North Pacific, and distributed from the surface to the depth of more than 1000 m. The maximum number of this species was observed in the shallow 50 m depth, but the number sharply decreased with the depth (Table 10). Through the observation of the horizontal haul, this species was found to exhibit a remarkable abundance at the surface, suggesting that this is a typical surface species, though the vertical range of distribution is wide.

69. *Oncaea conifera* GIESBRECHT

Oncaea conifera, Giesbrecht, 1892, p. 591, Pl. 2, fig. 10, Pl. 47, figs. 4, 16, 21, 23, 28, 34–38, 42, 55, 56; Breemen, 1908, p. 188, fig. 202a-d; Wilson, 1932, p. 350, fig. 210; Mori, 1937, p. 120, Pl. 66, figs. 10–13; Dakin & Colefax, 1940, p. 116, fig. 205; Wilson, 1942, p. 198; Olson, Ms, p. 64, Pl. 6, figs. 1–11, Pl. 14, figs. 1, 2; Davis, 1949, p. 76; Vervoort, 1951, p. 150; 1957, p. 146; Tanaka, 1960, p. 66, Pl. 34, figs. 1–8.

Table 10. Number of *Oithona similis* obtained by a separate haul with a Juday closing net in the Bering Sea and the northwestern North Pacific, May and June 1962 (Number per 50 m water column: 7.3 m³).

Sta. 621				Sta. 622		Sta. 623				Sta. 624	
46°06′N 166°48′E				52°00′N 171°40′E		56°10′N 173°55′W				55°11′N 169°20′E	
May 28, 1962 2145–2339		May 29, 1962 0615–0755		June 1, 1962 1935–2145		June 10, 1962 2127–2300		June 11, 1962 0505–0620		June 19, 1962 2030–2250	
Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number	Depth (m)	Number
0–46	2	0–43	58	0–83	248	0–48	2956	0–47	2060	0–46	10872
46–100	5	42–85	4	84–157	4	48–95	54	45–89	8	48–95	17
99–198	4.5	87–164	0*	139–370	2.7	95–190	14.5	91–182	2.5	91–181	5.5
195–485	1	160–400	0	420–838	21.0	192–477	4.7	160–399	1.3	170–423	4.7
485–970	1.8	397–694	0.7	615–920	46.8	440–819	3.2	364–731	0.5	399–798	3.4
906–1350	0.1	707–1060	0.7			882–1320	35.8	831–1090	4.9	819–1230	40.4

* Collected by 0–200 m horizontal tow in 1962

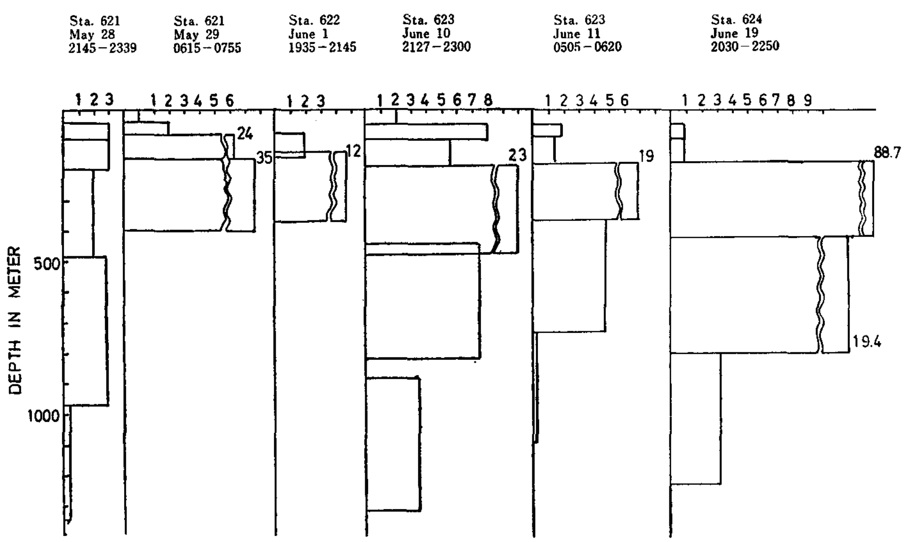

Fig. 23. Vertical distribution of *Oncaea conifera* at the 0–1300 m depth in the Bering Sea and the northwestern North Pacific in 1962 (Number per 50 m water column: 7.3 m³).

Female: 0.8–1.5 mm, male: 0.8 mm.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific. The abundance was observed at the 200–800 m depth (Fig. 23). This species is widely distributed in the oceans. According to Furuhashi (1966), it extends from the surface to the deep water in the Kuroshio and transition region, but it does not appear at the surface in the Oyashio. In the present observation this species was very rare in the shallow 50 m depth, and the vertical range of the distribution was wide as in Furuhashi's observation.

70. *Oncaea notopus* Giesbrecht

Oncaea notopus, Giesbrecht, 1892, p. 591, Pl. 47, figs. 12, 15, 45; Davis, 1949, p. 77; Vervoort, 1951, p. 152; 1957, p. 148; Tanaka, 1960, p. 70, Pl. 32, figs. 1–7.
Oncaea notopa, Wilson, 1942, fig. 46; Olson, Ms, p. 87, Pl. 17, figs. 1–10, Pl. 18, figs. 1–8.

Female: 0.7–0.9 mm.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific. The shallowest occurrence was at the 91–182 m depth at Sta. 623, in the Bering Sea, but the abundance was observed at a depth of more than 500 m.

71. *Oncaea ornata* Giesbrecht

Oncaea ornata, Giesbrecht, 1892, p. 591, Pl. 44, figs. 50, 51, Pl. 47, figs. 20, 24, 49, 53; Breemen, 1908, p. 191, fig. 205a-c; Olson, Ms, p. 89, Pl. 19, figs. 1–8, Pl. 25, figs. 1–7.

Female: 0.85 mm.

Vertical distribution: This species was found both in the Bering Sea and the northwestern North Pacific. This species was distributed at a depth of more than 700 m, and it was abundant at the 1000–2000 m depth together with *O. conifera* and *O. notopus*.

72. *Sapphoncaea moria* Olson
Plate IV, Figs. 1–12.

Sapphoncaea moria Olson, Ms, p. 112, Pl. 27, figs. 3–11, Pl. 28, figs. 1–12.

Female: 2.1 mm. The proportional length of the anterior and the posterior divisions is 54:46. The apex of the forehead is flat in dorsal view. The anterior division of the body is somewhat depressed. The 1st antennae are symmetrical, and consist of 6 segments. The 2nd antenna consists of 4 segments; the distal segment is very short and bears a claw-like hook on the apex and two small spines. The 2nd maxilliped is stout and has a strong spine and a small seta at the apex, and a spine on the inner margin. The distal corners of the 4th thoracic segment is not pointed. The proportional length of each segment of the posterior division is 65:290:81:80:145:339=1000. Each side of the 1st segment has a small spine modified from the 5th leg. The genital segment has a pore at the lateral side of the middle portion. The furcal rami bear conical projections at the inner corner.

Exopodites and endopodites of the first 4 pairs of legs consist of 3 segments; the arrangement of the seta and of the spines are as follows:

Leg	Exopodite		Endopodite	
	Outer	Inner	Outer	Inner
1st leg	1,1,3	0,1,4	0,0,1	1,1,4
2nd leg	1,1,3	0,1,5	0,0,2	1,2,3
3rd leg	1,1,3	0,1,5	0,0,2	1,1,2
4th leg	0,0,1	0,1,5	0,0,1	1,1,0

Remarks: This genus was proposed by Olson (Ms), because of the lack of corneal lenses and the absence of epimeral plate in both sexes. This characteristic form suggests a transition linking the Oncaeidae to the Sapphirinidae. *S. moria* was recorded from off California (Olson Ms).

Vertical distribution: Only a female was found at the 743–883 m depth at Sta. 612 in the Bering Sea. This species is recorded only from the 0–800 m vertical haul off California (Olson Ms).

73. *Lubbockia glacialis* SARS

Lubbockia glacialis, Breemen, 1908, p. 193, fig. 207a-d; Olson, Ms, p. 107, Pl. 26, figs. 7–9.

Female: 1.54–1.64 mm.

Vertical distribution: A small number was found at the 200–1000 m depth both in the Bering Sea and the northwestern North Pacific. This is an Arctic species, distributed at a depth of more than 100 m in the Arctic basin (Minoda 1967). This species is reported from the 0–800 m vertical haul off California (Olson Ms).

74. *Danodes plumata* WILSON

Plate V, Figs. 1–13.

Danodes plumata Wilson, 1942, p. 182, figs. 57–68; Olson, Ms, p. 52, Pl. 4, figs. 8–11.

Female: 1.49 mm. The lateral fringe of the forehead is pointed in dorsal view. The head and the 1st thoracic segment are completely fused together. The distal corners of the 4th thoracic segment are rounded. Each side of the 5th thoracic segment has a lateral spine modified from the 5th leg. The genital segment is a little shroter than the succeeding 3 segments in length. The length of the furcal rami is the same as the width. The 1st antenna consists of 8 segments; the distal segment is long. The 2nd antenna consists of 4 segments; the 2nd and

3rd segments have minute spinules on the inner margins, and the distal segment has a stout spine at the middle part of the outer margin and 3 spines at the apex. The mouth is a siphon-like tube, it is curved backwards, and the tip of the mouth has radiating flanges. The 1st maxilliped has 2 segments; the 1st segment is naked without spine; the 2nd has a claw-like spine with minute spinules. The 2nd maxilliped has 3 segments; the terminal segment is modified to a claw-like spine. The first 4 pairs of legs consist of 3 segments each in exopodite and endopodite. The arrangement of the outer marginal seta and of the inner marginal spine are as follows:

Leg	Exopodite		Endopodite	
	Outer	Inner	Outer	Inner
1st leg	1,0,1	1,1,4	0,0,1	1,2,4
2nd leg	1,1,2	1,1,4	0,0,1	1,2,4
3rd leg	0,1,2	1,1,3	0,0,1	1,2,3
4th leg	0,1,1	1,1,3	0,0,1	1,1,2

Remarks: This species is easily recognized by the syphon-like tube of the mouth.

Vertical distribution: A small number of this species was found at the 195–485 m depth in the northwestern North Pacific, and at the 1000–2000 m depth in the Bering Sea. According to Wilson (1942), this is evidently a surface species, but it occurs occasionally at the 50 or 100 m depths in the central Pacific Ocean.

75. *Harpacticus uniremis* KRØYER

Harpacticus uniremis, Sars, 1911, p. 51, Pl. 29; Wilson, 1932, p. 186, fig. 126; Lang, 1948, p. 321, figs. 149–2, 150–2.

Female: 1.3 mm.

Vertical distribution: Only one female was found at the 397–694 m depth at Sta. 621 in the North Pacific. This species is boreal and it inhabits the neritic shallow water (Lang 1948).

76. *Microsetella norvegica* BOECK

Microsetella norvegica, A. Scott, 1909, p. 199; Sars, 1911, p. 44, Pl. 24; Marukawa, 1921, p. 8; Mori, 1937, p. 116, Pl. 64, figs. 9–10; Sewell, 1947, p. 289; Lang, 1948, p. 230, fig. 122–1; Davis, 1949, p. 70, Pl. 12, figs. 152–153; Tanaka, 1960, p. 91.
Microsetella norvegica s. *norvegica*, Breemen, 1908, p. 173, fig. 188.
Ectinosoma atlanticum, Brady, 1883, p. 100, Pl. 4, figs. 10–14.
Microsetella atlantica, Giesbrecht, 1892, p. 550, Pl. 44, figs. 33, 34, 36, 39, 40, 42, 44, 45.

Female: 0.76 mm.

Vertical distribution: This species was found by a 0.1 mm mesh net. The shallowest occurrence was at the 25 m depth in the east of Kamchatka. This species was very common in the 1000–2000 m vertical haul in the Bering Sea.

VII. Characteristics of the Vertical Distribution

1. Vertical zonation

In the previous chapter, the occurrence of each copepod species was described. It is clear that each species exhibits its own peculiarities in the vertical distribution. There were 22 species at the 0–50 m depth, 21 at the 50–100 m depth, 27 at the 100–200 m depth, 50 at the 200–500 m depth and 63 at a depth of more than 1000 m (Table 11).

Calanus plumchrus, *C. cristatus*, *Eucalanus bungii bungii*, *Pseudocalanus minutus*, *Metridia pacifica* and *Oithona similis* were the main constituents of the copepods in the shallow 200 m depth, though their vertical distribution extended to the depth of more than 1000 m. *Acartia longiremis* was a species distributed only in the shallow 100 m depth.

Scolecithricella minor, *Pleuromamma scutullata* and *Heterorhabdus tanneri* occurred in a certain number at a depth of more than 100 m. Abundance of these species was observed at the 200–500 m depth. Adults of *Calanus plumchrus* and *C. cristatus* were obtained at a depth of more than 200 m, and their distributional level was different from that of their immature stages inhabiting the shallow water.

Lucicutia frigida and *Oncaea* spp. were dominant at a depth of more than 500 m. Bathybic and abyssal species were also obtained in a small number at this level.

It is pointed out that the copepod species largely increased at the 200–500 m depth as compared with the shallow 0–200 m depth; moreover, nearly all species extended to the great depths.

However, most of the copepods found in the Bering Sea inhabited the shallow 50 m depth: 10683 individuals per 50 m water column on the average. At the successive 50–100 m layers, that average sharply decreased to 987 individuals per 50 m water column, being only one-tenth of the 0–50 m depth. At the depth of more than 100 m the numbers gradually decreased with the depth of each water column. On the other hand, the number in the northwestern North Pacific hardly changed between 0–50 m, 50–100 m and 100–200 m depths, the average being 295–396 individuals per 50 m water column. At the depth of more than 200 m, the numbers gradually decreased with the depth of each water column, the numbers being the same as in the Bering Sea.

The vertical zonation of copepod species was separated roughly three sections, that is 0–200 m, 200–500 m and more than 500 m. According to Bogorov (1958a),

Table 11. Summary of occurrence of the copepod species at different depths in the Bering

Species	North Pacific	Bering Sea	Surface	0–50 m
Calanus glacialis	○	○		+
C. pacificus	○			+
C. plumchrus	○	○	+	+
C. cristatus	○	○	+	+
Eucalanus bungii bungii	○	○	+	+
Rhincalanus nastus	○			
Pseudocalanus minutus	○	○	+	+
Microcalanus pygmaeus		○		+
Spinocalanus magnus		○		
S. stellatus		○		
S. spinipes	○	○		
S. abyssalis	○	○		
Mimocalanus cultrifer	○	○		
M. distinctocephalus		○		
Monacilla typica	○			
Aetideus pacificus	○	○		
Gaidius brevispinus		○		
G. variabilis	○	○		+
Gaetanus simplex	○	○		+
Pseudochirella polyspina		○		
P. spectabilis		○		
P. spinifera		○		
Pareuchaeta elongata	○	○	+	+
P. birostrata	○	○		
P. brevirostris		○		
P. rubra		○		
P. crassa		○		
Xanthocalanus kurilensis		○		
Onchocalanus magnus		○		
Scaphocalanus magnus	○	○		
S. major	○	○		
S. subbrevicornis	○	○		
Scolecithricella valida		○		
S. emarginata	○	○		
S. minor	○	○	+	+
S. ovata	○	○		
S. globulosa	○	○		
Racovitznaus antarcticus	○	○		+
R. erraticus		○		
Undinella brevipes		○		
Metridia okhotensis	○	○		+
M. pacifica	○	○	+	+
M. asymmetrica	○	○		
M. curticauda	○	○		
M. brevicauda	○			
Pleuromamma scutullata	○	○	+	+
Lucicutia flavicornis	○			
L. pacifica		○		
L. ellipsoidalis	○	○		
L. oblonga	○			

Sea and the northwestern North Pacific in the summers of 1958, 1961, 1962 and 1966.

50–100 m	100–200 m	200–500 m	500–1000 m	1000 m	1000–2000 m*
		+	+	+	+
	+	+	+	+	
+	+	+	+	+	+
+	+	+	+	+	+
+	+	+	+	+	+
			+		
+	+	+	+	+	+
+		+			+
					+
					+
	+	+	+	+	+
		+	+	+	+
		+	+	+	
		+	+	+	+
	+				
+	+	+	+	+	+
		+		+	+
+	+	+	+	+	+
+	+	+	+	+	+
		+	+	+	+
					+
		+	+	+	
+	+	+	+	+	
		+		+	+
				+	
			+	+	+
			+	+	
		+			
		+		+	+
		+	+	+	+
		+	+	+	
			+	+	+
			+	+	+
		+	+	+	+
+		+	+	+	+
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			+	+	+
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		+			
		+	+		+
+	+	+	+	+	
+	+	+	+	+	+
	+	+	+	+	+
		+	+	+	+
	+	+	+		
+	+	+	+	+	+
	+				
				+	+
				+	+
		+			

Table 11.

Species	North Pacific	Bering Sea	Surfece	0–50 m
L. frigida	○	○		
Heterorhabdus robstoides	○	○		
H. tanneri	○	○	+	+
Heterostylites major	○	○		
Haloptilus oxycephalus	○	○		
H. longicirrus		○		
Augaptilus glacialis		○		
Euaugaptilus graciloides		○		
Centraugaptilus horridus		○		
Pseudaugaptilus sp.		○		
Pachyptilus pacificus	○	○		
Candacia columbiae	○	○		+
C. parafalcifera		○		
Acartia longiremis	○	○	+	+
Mormonilla minor		○		
M. phasma		○		
Oithona similis	○	○	+	+
O. plumifera	○	○		+
Oncaea conifera	○	○		+
O. notopus	○	○		
O. ornata	○	○		
Sapphoncaea moria		○		
Lubbockia glacialis	○	○		
Danodes plumata	○	○		
Harpacticus uniremis	○			
Microsetella norvegica		○		+
Number of species	49	69	11	22

* Deep vertical haul with a Hart's net

the vertical zonation of zooplankton in the North Pacific was separated into four section; 0–200 m, 200–500 m, 500–6000 m and more than 6000 m. It is recognized that the range of the vertical zonation of copepod species in the present observation is compatible with Bogorov's separation.

2. Diel vertical migration

As shown in Fig. 24, the diel vertical migration of copepods was not clear quantitatively because of a broad range of the samplings such as 0–50 m, 50–100 m, 100–200 m, 200–500 m, 500–1000 m and more than 1000 m. However, transition species such as *Gaidius variabilis*, *Gaetanus simplex*, *Pareuchaeta elongata*, *Scolecithricella minor*, *S. ovata*, *Racovitzanus antarcticus*, *Pleuromamma scutullata*, *Heterorhabdus tanneri* and *Candacia columbiae*, were found at a depth of more than 50 m in the morning haul, but in the shallow 50 m depth in the night haul. The number of these species was comparatively small in the shallow 50 m depth, Continued.

	50–100 m	100–200 m	200–500 m	500–1000 m	1000 m	1000–2000 m*
			+	+	+	+
			+		+	+
	+	+	+	+	+	+
			+	+		+
		+	+	+		+
					+	
						+
						+
						+
					+	
			+	+	+	+
	+	+	+			
						+
	+					
					+	+
					+	
	+	+	+	+	+	+
	+	+	+	+	+	+
	+	+	+	+	+	+
		+	+	+	+	+
			+	+	+	+
				+		
			+	+		
					+	+
			+			
				+		
	21	27	50	48	52	51

○ Occurrence in each sea area

whereas the abundance was observed at the 100–500 m depth constantly between morning and night. In the 0–45 m horizontal tow, *Calanus cristatus* and *Metridia pacifica* were seen performing diel vertical migration in the waters east of Kamchatka; these species were not collected in the upper 20 m depth in the daytime, but at the surface at night.

So far, the present observation indicates that the distributional zone at night is broader than in the daytime.

VIII. General Consideration of Vertical Distribution

1. Relationship between vertical distribution of copepods and hydrography

It is well known that the vertical distribution and the diel vertical migration are an adaptation to the change of the environmental factors such as light, temperature, salinity, *etc.* a fact confirmed, by several studies (Russell 1926, 1927,

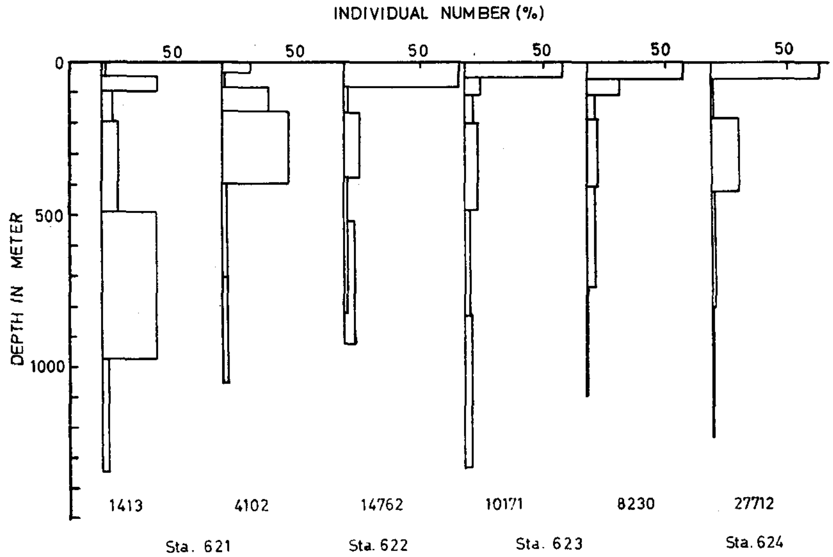

Fig. 24. Vertical distribution of the total copepods in numbers at the 0–1300 m depth in the Bering Sea and the northwestern North Pacific in 1962.

1928, 1931, Clark 1933, 1934 a, b, 1936; Bogorov 1946, 1958b, Cushing 1951, Hansen 1951, Vinogradov 1954, Moore & Bauer 1960, Bainbridge 1961, Haris 1963, Banse 1964). Hansen (1951) pointed out that the thermocline was the most important factor to control the vertical range of distribution of the species in the shallow layers.

The water mass was divided into three zones according to the temperature-chlorinity curve (Fig. 25); (1) the surface zone in the shallow 100 m depth, (2) the transition zone between 100 m and 300 m, and (3) the deep zone at a depth of more than 300 m. In the Bering Sea and the northwestern North Pacific, the seasonal change in the temperature of the water is probably large throughout the year. The rising of the temperature which was caused by the sunlight during summer has developed a thermocline in the shallow 100 m depth. The surface water is distinctly isolated from the deep water during summer. According to the data of the Canadian observation in the Gulf of Alaska, the difference of temperature between winter and summer is very clear as shown in Fig. 26. Temperature at the surface is high and the thermocline is clearly observed between the 30 m and the 150 m depths in the summers of 1958 and 1959, while temperature is low and the thermocline disappears in the winter of 1959. Thick convection occurs in the shallow 150 m depth. Dodimead *et al.* (1963) indicates that the minimum temperature observed at the 100–150 m depth during summer signifies the surface temperature during winter. The surface water is completely separated from the

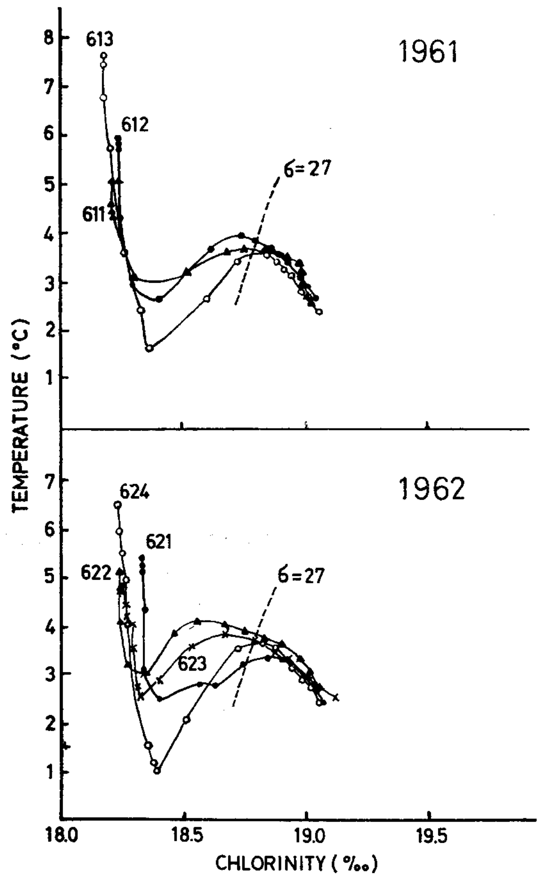

Fig. 25. T-Cl curves at the stations of plankton collection in the summers of 1961 and 1962.

deep water (Fleming 1955, Tully & Giovando 1963, Tully 1964).

The copepod population in the shallow 150 m depth was occupied by the subarctic species both in the Bering Sea and the northwestern North Pacific. They were very abundant in the shallow 50 m depth, but they were mostly immature stages. Semina (1960) reported that the abundance of phytoplankton was closely related to the stability of water in the Bering Sea. The vertical stability of water in accordance with the rising of temperature from spring to summer accelerates the abrupt abundance of phytoplankton in the shallow water. Primary production in the Bering Sea and the northwestern North Pacific in the summer of 1960 was 2.2 mgC/mgChl.*a*/hr. on the average (Kawamura 1963). This value is equivalent to the highest value in the neritic waters of Japan, and it suggests that the primary production in the Bering Sea and the northwestern North Pacific is

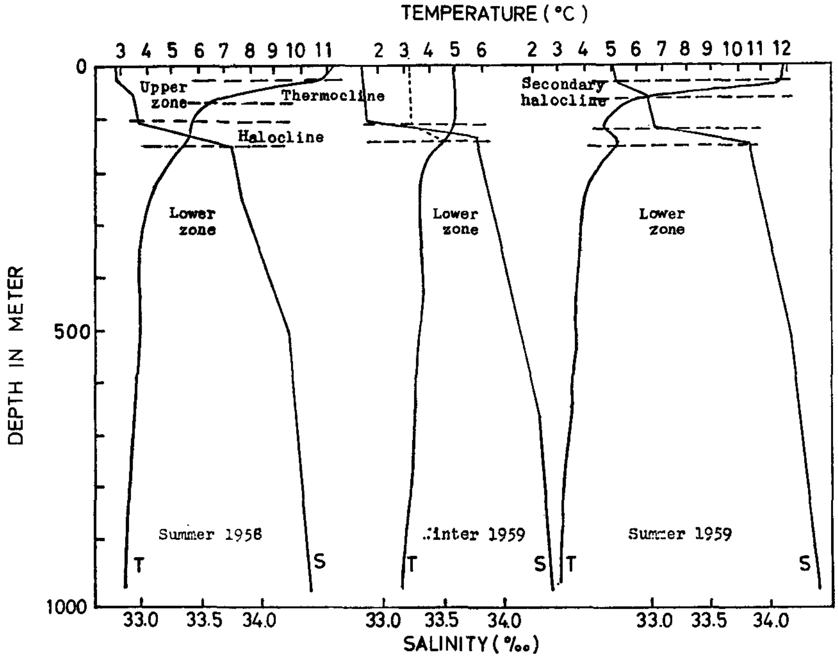

Fig. 26. Typical temperature and salinity structures at Ocean Station "P" in summer and winter (dotted line at top winter structure indicates possible deviation with extreme cooling) (after Dodimead *et al.* 1963).

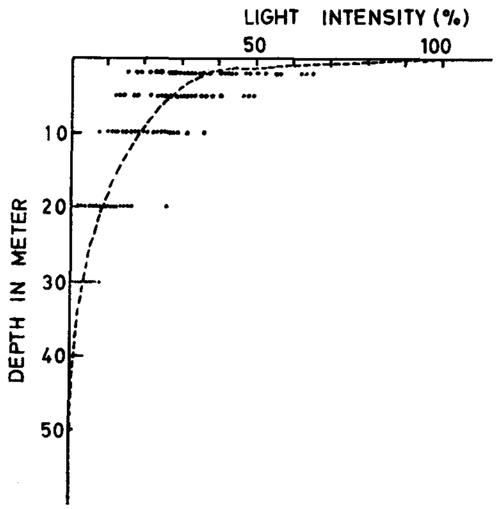

Fig. 27. Vertical distribution of the daylight intensity (%) in the Bering Sea in the summer of 1955 (*Data Rec. Oceanogr. Explor. Fish.* 1957).

considerably large. According to LeBrasseur (1965), *Calanus plumchrus* which is one of the summer population of copepods in the Gulf of Alaska, performs very clear seasonal vertical migration, and the abundance in the shallow water coincides well with the period of phytoplankton abundance. It is suggested, in the present observation, that the abundance of the immature stages of *Calanus plumchrus, C. cristatus, Eucalanus bungii bungii, Pseudocalanus minutus, Metridia pacifica* and *Oithona similis* is supported by phytoplankton abundance.

Calanus plumchrus begins to migrate down to the deep water in the late summer (Brodsky 1938, LeBrasseur 1965). Most of the subarctic species of copepods are distributed in the transitional and deep waters in the Kuroshio region (Furuhashi 1966). According to Omori and Tanaka (1967) *Calanus plumchrus, C. criststus, Eucalanus bungii bungii* and *Metridia pacifca* inhabit the water deeper than 200 m at a 12°C in the Sagami Bay. The upper limit of distribution of the subarctic species in the Kuroshio region corresponds well to the highest temperature of the surface water at the surface in the Bering Sea.

Sewell (1948) reported that the vertical range of distribution of copepods was bordered by the isothermal layer of 10°C in the tropical waters. Furuhashi (1966) reported that the distributional change between epipelagic and mesopelagic copepods was observed at the depth of about 200 m in the Kuroshio waters; however, the distributional change between epipelagic and mesopelagic copepods was not observed in the subarctic waters and the epipelagic copepods extended to the transitional and to the deep waters. In the subarctic waters, the difference of temperature was less than 10°C vertically as shown by the present observation. The vast extension of the vertical distribution of the subarctic copepods in the present observation may be caused by the narrow range of temperature.

A small number of *Calanus pacificus, Rhincalanus nastus* and *Lucicutia flavicornis* which are distributed in the shallow waters of the Kuroshio, occurred in the transitional and deep waters of the northwestern North Pacific, while *Calanus galcialis* and *Microcalanus pygmaeus* which are distributed in the eastern neritic waters of the Bering Sea, occurred at a depth of more than 100 m in the Bering Sea. It is possible that these species were transported from their original waters of the distribution during autumn. The vertical convection of water during winter in the shallow 100 m depth may facilitate the migration to deep water. We may also consider that the seasonal change of temperature and the vertical convection of water during winter expands the distributional level of the subarctic copepods to the great depths; however, the thermocline during summer is probably effective as a barrier for the abundance of the subarctic species within the shallow 50 m depth.

The diel vertical migration of the copepods, on the other hand, is caused by a periodical change of light intensity, temperature, dissolved oxygen and hydrogen

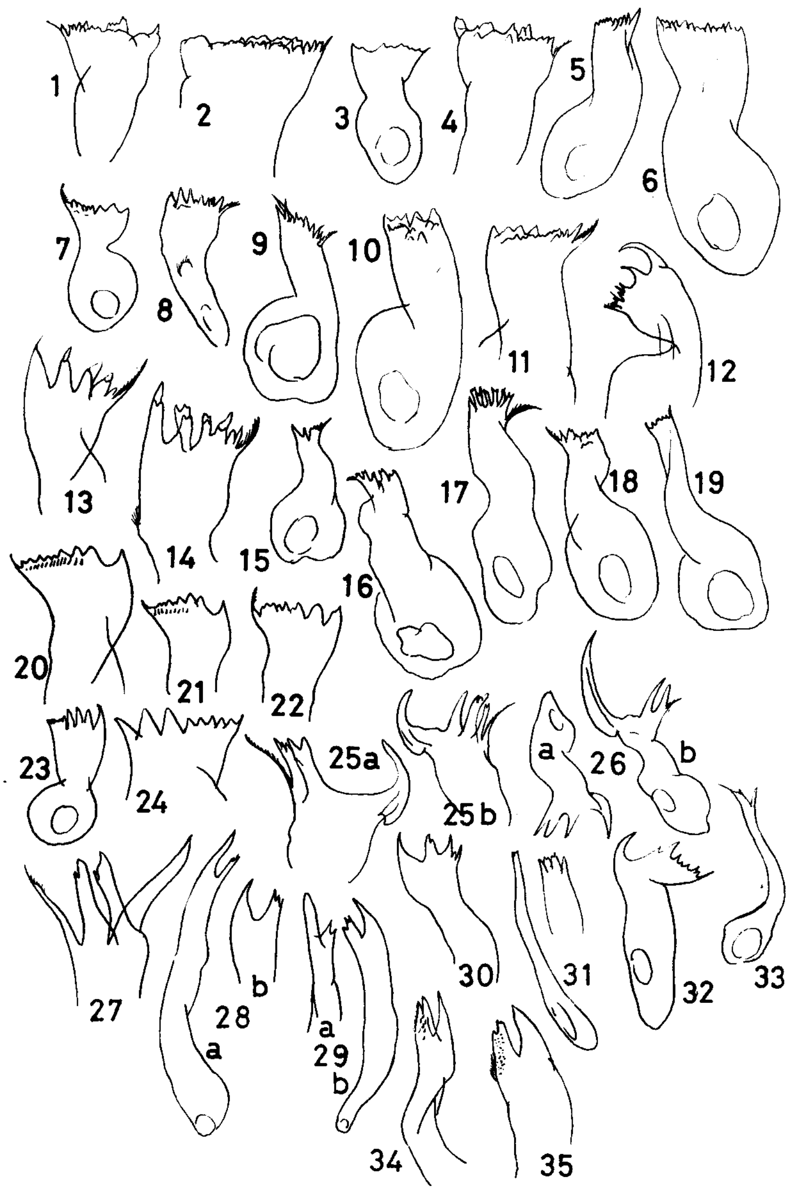

Fig. 28. Cutting blade of the mandible in Calanoida Copepoda.
1. *Calanus plumchrus*, copepodite V, ×64.8 **2.** *C. cristatus*, copepodite V, ×64.8 **3.** *C. pacificus*, female, ×64.8 **4.** *Eucalanus bungii bungii*, female, ×64.8 **5.** *Rhincalanus nastus*, female, ×60.9 **6.** *Pseudocalanus minutus*, female, ×256.8 **7.** *Spinocalanus abyssalis*, female, ×64.8 **8.** *S. spinipes*, female, ×64.8 **9.** *Mimocalanus distinctocephalus*, female, ×60.9 **10.** *Gaidius variabilis*, female, ×60.9 **11.** *Gaetanus simplex*, female, ×60.9 **12.** *Pseudochirella polyspina*, female, ×32.2 **13.** *Pareuchaeta elongata*, female, ×60.9 **14.** *P. birostrata*, female, 60.9 **15.** *Scaphocalanus magnus*, female, ×32.2 **16.** *Scolecithricella ovata*, female, ×91.2 **17.** *Undinella brevipes*, female, ×124.8 **18.** *Scolecithricella emarginata*,

(Russell 1931, 1934, Moore 1952, Longhurst 1967), but the daily change of the environmental factors, except for light and temperature, is comparatively gradual. It is possible that the difference of light intensity between day and night has a great influence upon copepod distribution. Cushing (1951) reported that the vertical migration of planktonic crustancean was mediated by the change in light penetration throughout the day, and animals aggregated in an optimum band of light intensity. They have the capacity of moving phototactically. Such a behavior was reported on the natural population of the Arctic copepods by Bogorov (1946a). Clarke and Backus (1956) on an echo sounder record have observed that the diurnally migrating plankton tended, in general, to follow the vertical movement of a certain isolume. Suzuki and Ito (1967) observed the diurnally vertical movement of the scattering layer in the northwestern North Pacific. According to their observation, there are shallow and deep scattering layers in the daytime; *Calanus plumchrus* and *C. criststus* are the main components of the shallow scattering layer, while the euphausiids are in the deep scattering layer. Minoda and Osawa (1967) reported that the diurnal change of the sonic scattering layer, which was mainly composed of small copepods, was small in the Okhotsk Sea, and that the diurnal movement was restricted to the thermocline observed at the 20–60 m depth. Such a phenomenon was observed in the Gulf of Maine by Clarke (1933). The development of the thermal gradient in the shallow layer prevents the upward migration of the cold water species of copepods at night (Motoda and Anraku 1951). It is sure that the upward migration at night originally depends upon the change of the daylight intensity, however, the discontinuity of temperature is also effective to prevent the vertical migrations. As shown in Fig. 27, the daylight intensity at the 40 m depth was only 1.5% of that the surface in the Bering Sea. The 1.5% layer of daylight intensity corresponds to the thermocline in the Bering Sea. Sharp diminution of the light intensity may restrict the phytoplankton production within the shallow layer, and the developmental stages of herbivorous copepods may concentrate in the shallow 50 m depth.

It is recognized that each copepod exhibits a peculiar characteristic in the vertical distribution such as epipelagic, transitional and bathybic. The species, which have passed through the long natural history, should be understood together

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female, ×60.9 **19.** *Onchocalanus magnus*, female, ×32.2 **20.** *Metridia okhotensis*, female, ×60.9 **21.** *M. pacifica*, female, ×64.8 **22.** *Pleuromamma scutullata*, female, ×64.8 **23.** *Lucicutia ellipsoidalis*, male, ×60.9 **24.** *L. frigidia*, female, ×153.6 **25.** *Heterorhabdus tanneri*, male, ×260, a: right, b: left **26.** *H. robstoides*, male, ×32.2, a; right, b: left **27.** *Heterostylites major*, female, ×124.8 **28.** *Haloptilus oxycephalus*, female, ×60.9, a: right, b: left. **29.** *H. longicirrus*, female, ×60.9, a: right, b: left **30.** *Euaugaptilus graciloides*, female, ×32.2 **31.** *Pseudaugaptilus* sp., male, ×32.2 **32.** *Pachyptilus pacificus*, female, ×32.2 **33.** *Centraugaptilus horridus*, female, ×12.5 **34.** *Candacia columbiae*, female, ×84.0 **35.** *C. parafalcifera*, female, ×84.0

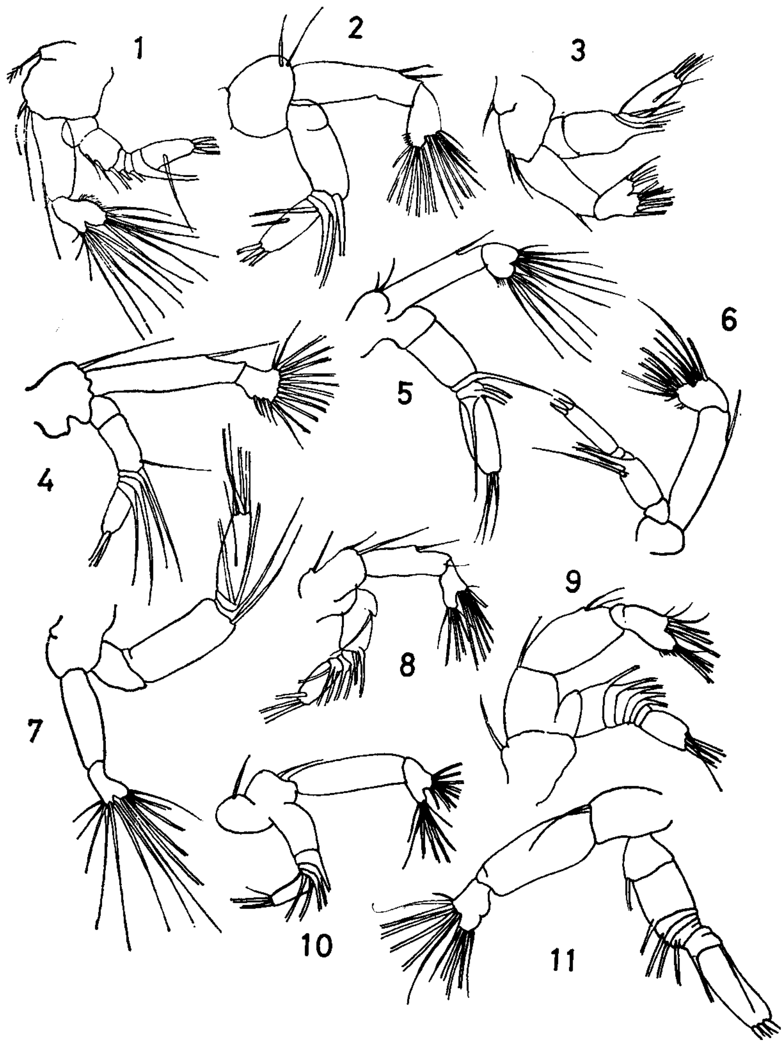


Fig. 29. Second antenna in Calanoida Copepoda.
1. *Calanus pacificus*, male, ×60.9 **2.** *Mimocalanus distinctocephalus*, female, ×60.9
3. *Pareuchaeta brevirostris*, female, ×32.2 **4.** *Scaphocalanus magnus*, female, ×32.2
5. *Scolecithricella emarginata*, female, ×60.9 **6.** *Racovitzanus antarcticus*, female, ×60.9
7. *Undinella brevipes*, female, ×91.2 **8.** *Pleuromamma scutullata*, female, ×32.2
9. *Lucicuita ellipsoidalis*, female, ×60.9 **10.** *Heterorhabdus robstoides*, female, ×32.2
11. *Pachyptilus pacificus*, male, ×32.2

with the change of their environment and the specialization. It is a problem to understand how adaptation is done in the vertical distribution of copepods under the present environment of the ocean.

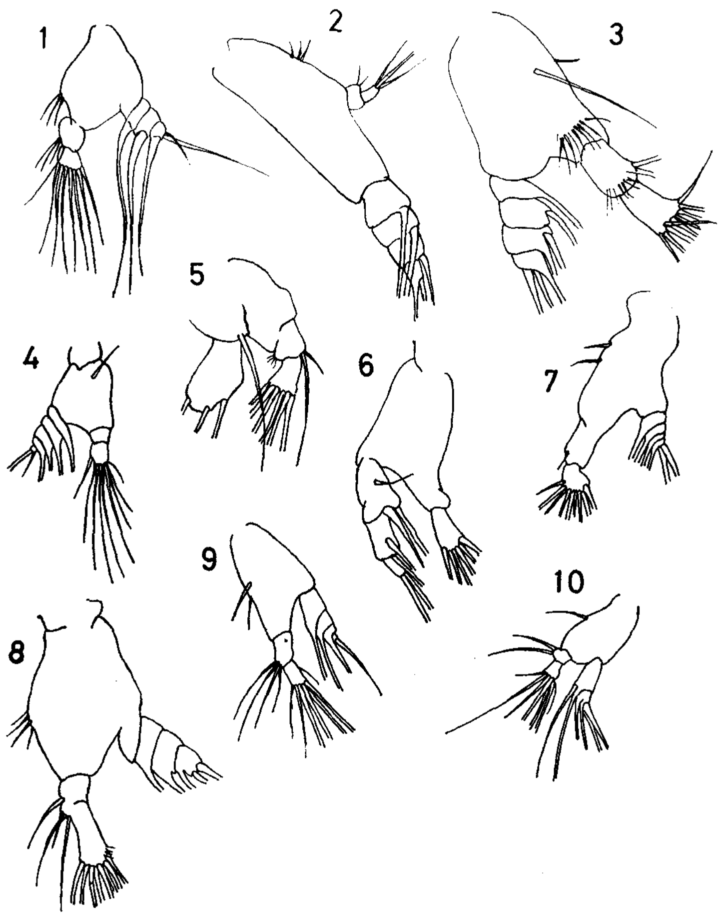


Fig. 30. Mandible in Calanoida Copepoda.
1. *Calanus pacificus*, male, ×60.9 2. *Eucalanus bungii bungii*, male, ×60.9 3. *Spinocalanus abyssalis*, female, ×91.2 4. *Pareuchaeta brevirostris*, female, ×32.2 5. *Scolecithricella ovata*, male, ×91.2 6. *Racovitzanus antarcticus*, female, ×91.2 7. *Undinella brevipes*, female, ×124.8 8. *Pleuromamma scutullata*, female, ×60.9 9. *Lucicutia ellipsoidalis*, female, ×60.9 10. *Heterorhabdus robstoides*, female, ×32.2

2. Morphological adaptation of the feeding organ to the difference of environment

(1) Morphology of the feeding organ of copepods

Calanoid copepods are separated into three groups such as herbivorous, carnivorous and omnivorous, according to their foods and the morphological difference in the feeding organs. Feeding organs are composed of the 2nd antennae, mandibles, 1st maxillae, 2nd maxillae and maxillipeds. The mouth

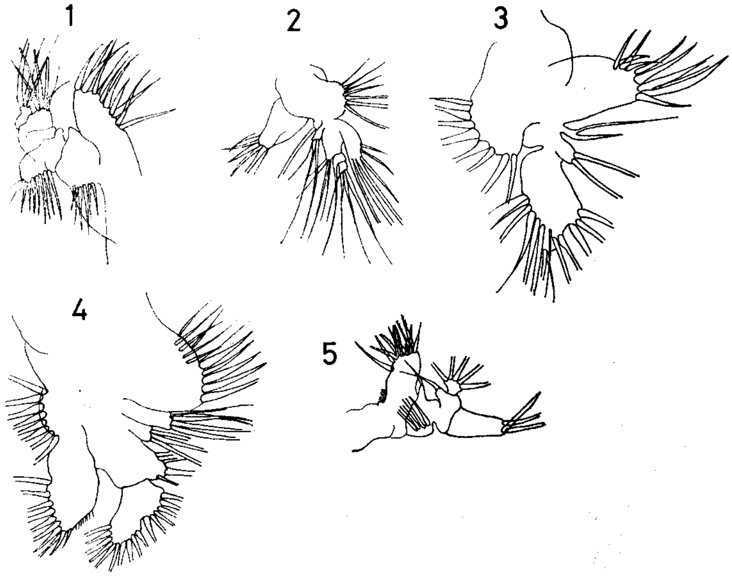


Fig. 31. First maxilla in Calanoida Copepoda.
1. *Pareuchaeta brevirostris*, female, ×32.2 2. *Scaphocalanus magnus*, female, ×32.2 3. *Racovitzanus antarcticus*, female, ×124.8 4. *Pleuromamma scutullata*, female, ×60.9 5. *Heterostylites major*, copepodite V, × 32.2

opens between the mandibles and the 1st maxillae. The cutting blades of the mandibles crush foods.

The feeding mechanism of the copepods was observed exactly by Marshall and Orr (1955), Beklemishev (1959), Anraku (1963), Anraku and Omori (1963) and Conover (1966).

Fig. 28 shows the cutting blades of the mandibles of the calanoid copepods collected from the Bering Sea and the northwestern North Pacific. The shape of the cutting blade was roughly divided into three types presented by *Calanus*, *Scolecithricella* and *Heterorhabdus*. In the *Calanus* type, the distal part of the cutting blade expands with the chitinous and stout teeth. Calanidae, Eucalanidae, Pseudocalanidae, Aetideidae, Euchaetidae, Metridiidae and Lucicutiidae belong to that type. Of the *Calanus* type, Aetideidae and Euchaetidae have somewhat large teeth. In the *Scolecithricella* type, the distal part of the cutting blade is usually narrow with minute teeth, and is biramous in some cases. The proximal part of the cutting blade is generally broader than the distal part. Phaenidae, Scolecithricidae and Tharybidae belong to that type. In the *Heterorhabdus* type, the cutting blade is slender with a few teeth. Heterorhabdidae, Augaptilidae and Candaciidae belong to that type.

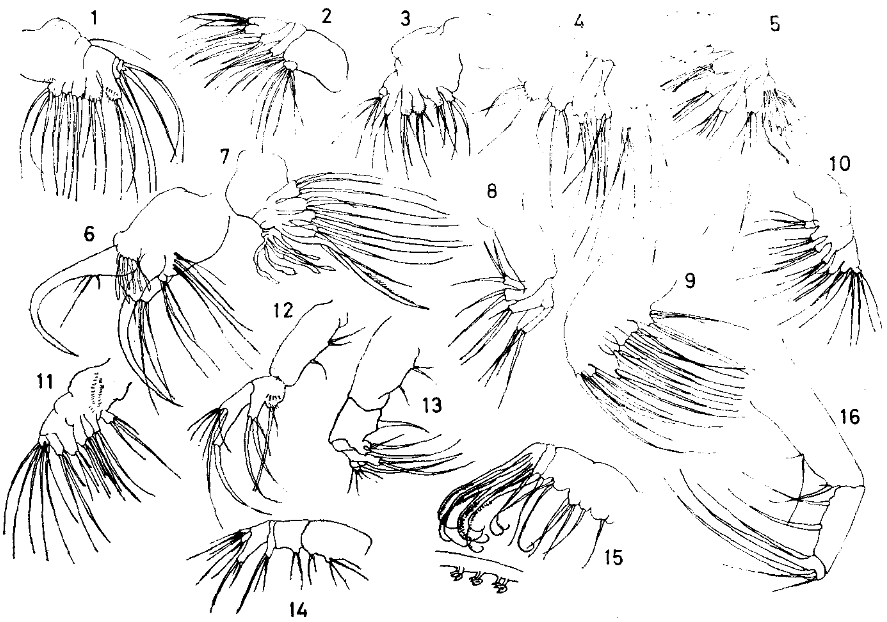


Fig. 32. Second maxilla in Calanoida Copepoda.
1. *Spinocalanus abyssalis*, female, ×64.6 2. *Mimocalanus distinctocephalus*, female, ×43.2 3. *Gaidius brevispinus*, female, ×22.8 4. *Pareuchaeta brevirostris*, female, ×22.8 5. *Scaphocalanus magnus*, female, ×43.2 6. *Onchocalanus magnus*, female, ×22.8 7. *Racovitzanus antarcticus*, female, ×88.4 8. *Undinella brevipes*, female, ×88.4 9. *Pleuromamma scutullata*, female, ×43.2 10. *Lucicutia ellipsoidalis*, female, ×43.2 11. *L. frigida*, female, ×64.6 12. *Heterorhabdus robstoides*, female, ×17.0. 13. *H. tanneri*, female, ×22.8 14. *Heterostylites major*, copepodite V, ×22.8 15. *Centraugaptilus horridus*, female, ×8.8 16. *Candacia parafalcifera*, male, ×22.8

Figs. 29–33 show the 2nd antenna, mandible, 1st maxilla, 2nd maxilla and maxilliped. The 1st and 2nd maxillae of the *Calanus* and *Scolecithricella* types have fine and long spines which are probably suitable for filtering foods. The cutting blade of the *Calanus* type would fit to crush large and hard foods. The 2nd maxilla of the *Heterorhabdus* type is quite different from the *Calanus* and Scolecithricella types. The segmental differenciation is very clear; and each segment has coarse and stout spines. The ability of filter feeding of the *Heterorhabdus* type may be less than for the *Calanus* and *Scolecithricella* types. Segementations of the 2nd maxilla and of the maxilliped would fit to more catch and grasp foods than filtrate. The species of the *Heterorhabdus* type is probably predator. It is considered that the irregular teeth of the cutting blade are suitable for grasping the motile animals.

(2) Adaptation of the feeding organs to the vertical distribution

Calanus plumchrus, *C. cristatus*, *Pseudocalanus minutus*, *Eucalanus bungii*

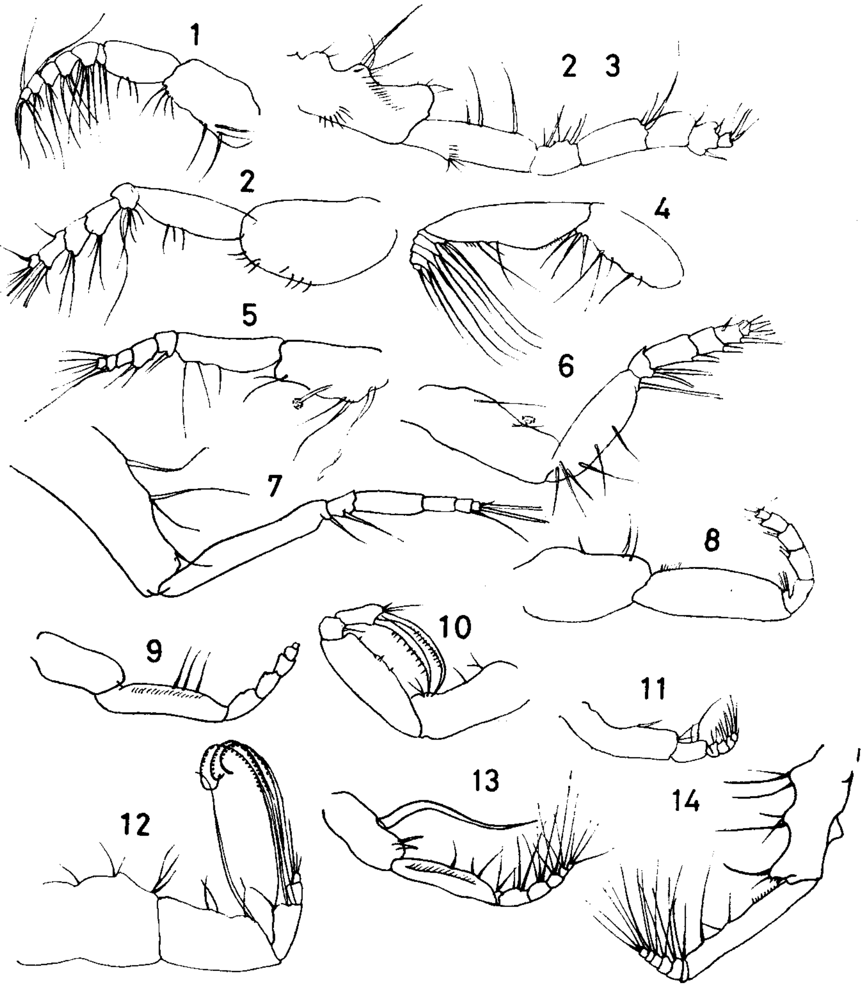


Fig. 33. Maxilliped in Calanoida Copepoda.
1. *Calanus pacificus*, male, ×60.9 2. *Spinocalanus abyssalis*, female, ×91.2 3. *Mimocalanus distinctocephalus*, female, ×60.9 4. *Pareuchaeta brevirostris*, female, ×32.2 5. *Scaphocalanus magnus*, female, ×32.2 6. *Racovitzanus antarcticus*, female, ×91.2 7. *Undinella brevipes*, female, ×124.8 8. *Lucicutia frigida*, female, ×60.9 9. *Heterorhabdus robstoides*, female, ×32.2 10. *Onchocalanus magnus*, female, ×12.5, 11. *Candacia parafalcifera*, male, ×32.2 12. *Centraugaptilus horridus*, female, ×12.5 13. *Heterorhabdus tanneri*, female, ×32.2 14. *Gaidius brevispinus*, female, ×32.2

bungii and *Metridia pacifica* which were distributed in the shallow water were alike in the structure of their feeding organs. The teeth of the grinding surface of the cutting blade of *Eucalanus*, *Pseudocalanus* and *Metridia* did not vary from copepodite V to adult respectively, however, those of *Calanus plumchrus* and *C. cristatus* were sharp and complete in copepodite V, while round in adults. Such a change in the teeth of the grinding surface was also observed in the Arctic *Calanus hyperboreus* (Conover 1966). According to Conover (1967), Copepodite V of *C. hyperboreus* inhabits the surface water and takes up foods. The copepodite V stocks fat and migrates down to the deep water for the reproduction of the next generation. Marshall and Orr (1955) pointed out that the stock of fat in the copepodite V of *Calanus finmarchicus* would be very important for the reproduction. The presence of fat in the copepodites V of *Calanus plumchrus* and *C. cristatus* was observed in the present samples, but not in other species. The adults of *C. plumchrus* and *C. cristatus* inhabited the water deeper than 200 m. According to Beklemishev (1954) and Heinrich (1962b), the adults of *C. plumchrus* and *C. criststus* which are distributed at a depth of more than 200 m do not feed on anything owing to the lack of sharp teeth on the grinding surface. Downward migration of copepods from the shallow layer to the deep layer is described as the reduction of metabolism under low temperature (Beklemishev 1954, Conover 1967). It is clear that the downward migration of *C. plumchrus*, *C. criststus* and *C. hyperboreus* corresponds to the lack of teeth on the grinding surface.

In the Bering Sea and the northwestern North Pacific, the surface temperature of the water rises during the summer, whereas it descends in autumn and winter; comparatively high temperature is observed at a depth of more than 150 m. Downward migration in late summer could not be considered as the reduction of metabolism under low temperature. *Calanus hyperboreus* in the Arctic Ocean is distributed in the shallow water in the period from spring to summer, while this species migrates down to the deep layer in autumn passing through the permanent thermocline (Minoda 1967). In the Arctic Ocean, the seasonal change in temperature of the water is hardly observed from the surface to the great depth; the temperature is higher at the 200–1000 m depth than at the 0–200 m depth (Kusunoki 1959, Coarchman and Barnes 1961, 1963). Thus the vertical migration over the discontinuity of temperature is probably the ontogenetic migration of Genus *Calanus* rather than the reduction of metabolism.

Calanus plumchrus lays eggs twice a year, in the spring and autumn, while *C. cristatus* lays eggs once a year in winter, and they breed in the deep waters (Heinrich 1962a, b). In the present observation *Calanus plumchrus* that laid eggs were collected from the 1000–2000 m depth in the Bering Sea. They are probably an autumnal breeding group. The mixing zone of water extends to the 200 m depth in spring, and within the 50 m depth in summer in the Bering Sea (Semina 1960). It suggests that their developmental stages migrate upwards with the decreasing of thickness of the mixing zone, and, as a result, the abundance of the developmental stages is observed in the shallow 50 m depth in summer.

Nevertheless the abundance of phytoplankton was restricted to the shallow layer, the species of the *Calanus* type are widely distributed from the surface to the great depth. Aetideidae, Euchaetidae and Lucicutiidae of the *Calanus* type were mostly distributed in the transitional and deep waters. During the present study on the copepods collected from the 1000–2000 m depth in the Bering Sea, *Coscinodiscus irridus* was abundantly found in the 0.1 mm mesh net. *Coscinodiscus* spp. is more abundant at the 500 m depth than at the surface layer in the North Pacific (Oshite 1965), while Tintinnids mostly inhabit the water deeper than 100 m (Sano 1966). The teeth of the cutting blades in Aetideidae, Euchaetidae and Lucicutiidae may be strong enough to crush a silic valve.

According to the recent data of the experimental study on the foods of copepods, some herbivorous coepods capture animals (Conover 1966, Mullin 1966, Mullin and Brooks 1967). The bathybic copepods capture the organic particulate (Riley 1963, Menzel 1967), a single cellular organism (Hentschel 1936, Fournier 1966) and also some small crustaceans (Wheeler 1967). Most of *Scolecithricella* and *Heterorhabdus* types occurred in the transitional and deep waters with the *Calanus* type. The cutting blades of the *Scolecithricella* and *Heterorhabdus* types are probably unsuitable for crushing a hard valve. It is suggested that the occurrence of the various types of the cutting blade is manifold in the foods.

In the present observation of the vertical distribution of copepods, the individual number at a depth of more than 200 m in the Bering Sea was the same as in the northwestern North Pacific, in spite of the large difference of abundance in the shallow 200 m depth. Even if there were migrating species which passed through the thermocline, their numbers were very small. As for the vertical distribution of copepods, the species in the transitional and deep layers would be dependent upon food within their distributional layer.

According to Vinogradov (1962), the main source of foods for deep sea fauna is the organic matter produced in the upper zone and brought to the great depths by the active vertical migration of the interzonal and deep species. In the present study, the vertical interzonal migration was not observed in any copepods diurnally, however, the seasonal and ontogenetic migration would be carried out, and their downward mgiration during the late summer and autumn plays an important role in bringing foods to the deep sea fauna. Menzel (1967) reported that the concentration of some organic particulate matter in the deep water was not concerned with that in the shallow water, which is homogeneous in time and space. However, Hobson (1967) reported that the concentration of the particulate matter was greater in winter than in spring and summer in the northern North Pacific.

The downward migration of the subarctic species and the increase of the particulate matter in the deep water may contrast with the phytoplankton bloom in the shallow water. The females of *Heterorhabdus tanneri* and *Heterostylites major* which were collected from the deep water had a spermatophore at the genital segment. Most of the transitional and bathybic species, both adults and immature stages, were also found at the same depth. It suggests that they live in such depths throughout lifetime.

IX. Summary

1. The collection of plankton was made by horizontal tows in the summers of 1958, 1961 and 1962, and by vertical hauls in the summers of 1962 and 1966 at several depths, from the surface to a 2000 m depth in the Bering Sea and northwestern North Pacific.

2. Seventy-six copepod species in all, 64 species of Calanoida, 10 species of Cyclopoida and 2 species of Harpacticoida, were identified in the 286 samples. Twenty-nine species were new records from the Bering Sea.

3. There were 22 species at the 0–50 m depth, 21 species at the 50–100 m depth, 27 species at the 100–200 m depth, 50 species at the 200–500 m depth and 63 species at a depth more than 500 m. A distinct increase of copepod species was observed from 200–500 m, which corresponded to the transitional layer between the subarctic surface water and the deep water.

4. In the shallow 200 m depth, especially from 0–50 m, the subarctic species such as *Calanus plumchrus*, *C. cristatus*, *Eucalanus bungii bungii*, *Pseudocalanus minutus*, *Metridia pacifica* and *Oithona similis* were dominant in number. However, these species extended to a depth of more than 1000 m. At the 200–500 m depth, the transition species such as *Scolecithricella minor*, *Pleuromamma scutullata*, *Heterorhabdus tanneri*, *Lucicutia frigida* and *Oncaea* spp. were dominant. The adults of *Calanus plumchrus* and *C. cristatus* were observed at a depth of more than about 200 m. At a depth of more than 500 m, the bathybic and abyssal species were collected, but in a small number.

5. The diel vertical change of distribution was observed in *Calanus cristatus*, *Metridia pacifica* and in the transition species such as *Gaidius variabilis*, *Gaetanus simplex*, *Pareuchaeta elongata*, *Scolecithricella minor*, *S. ovata*, *Racovitzanus antarcticus*, *Pleuromamma scutullata* and *Heterorhabdus tanneri*. The transition species occurred at a depth of more than 50 m in the daytime and reached near the surface at night, but the abundant layer in individual number was not changed between daytime and night.

6. The feeding organs of the calanoid copepods were morphologically separated into three types represented by *Calanus*, *Scolecithricella* and *Heterorhabdus*. It is considered, from the feeding organs, that the *Calanus* and *Scolecithricella* types are filter-feeders; the *Calanus* type is originally herbivorous, while the *Scolecithricella* type probably manages to catch some organic particulate matter, and the *Heterorhabdus* type is an active predator.

7. The species of the *Calanus* type was widely distributed from the surface

to a depth of more than 100 m, and the species of *Scolecithricella* and *Heterorhabdus* were distributed in the transitional and deep layers. The dichothermal layer which is found at a depth of about 100 m in summer, gives evidences of the vertical separation of species.

References

Anraku, M. 1954. Gymnoplea Copepoda collected in Aleutian waters in 1953. *Bull. Fac. Fish., Hokkaido Univ.* 5(2), 123–136.

———. 1963. Feeding habits of planktonic copepods (Reviews). *Inform. Bull. Planktol. Japan.* (9), 10–35 (in Japanese).

———, & M. Omori, 1963. Preliminary survey of the relationship between the feeding habit and the structure of the mouth-parts of marine copepods. *Limnol. Oceanogr.* 8(1), 116–126.

Bainbridge, R. 1961. Migration. In *The physiology of Crustacea*. II. (Ed. by T. H. Waterman), p. 431–463. Academic Press, New York & London.

Banse, K. 1964. On the vertical distribution of zooplankton in the sea. *Progress Oceanogr.* **2**, 53–125.

Beklemishev, C. W. 1954. Feeding of some mass plankton copepods in far-eastern seas. *Zool. Zhur. USSR.* **33**(6), 1210–1230 (in Russian).

———. 1959. The anatomy of the chewing apparatus in Copepoda. II. The chewing region of the mandible in certain Calanidae and Eucalanidae. *Trudy Inst. Okeanol. Acad. Nauk SSSR.* **30**, 148–155. (in Russian).

Bogorov, B. G. 1946a. Peculiarities of diurnal vertical migration of zooplankton in polar seas. *J. Mar. Res.* **6**(1), 25–32.

———. 1946b. Zooplankton collected by the Sedov Expedition 1937–1939. *Trudy Sedov Exped.* **3**, 356–370 (in Russian).

———. 1958a. Biogeographical regions of the plankton of the northwestern Pacific Ocean and the their influence on the deep-sea. *Deep-Sea Res.* **5**(2), 149–161.

———. 1958b. Perspective in the study of seasonal changes of plankton and of the number of generations at different latitude. In *Perspective in marine biology* (Ed. by A. A. Buzzati-Traverso), p. 145–158. Univ. Calif. Press.

Brady, G. S. 1883. Report on the Copepoda. *Rep. Sci. Res. Roy. H.M.S. Challenger, Zool.* **8** (part 23), 1–142.

Breemen, J. van, 1908. Copepoden. *Nordisches plankton. Zool.* Teil, Bd. 4, *Entomostraca* **8**, 1–264.

Brodsky, K. A. 1938. Contribution to the ecology and morphology of *Calanus tonsus* Brady (syn: *C. plumchrus* Marukawa) of far-eastern seas. *Compt. Rend. Acad. Sci. USSR.* **19**(1), 123–126.

———. 1948. The pelagic Copepoda in the Japan Sea. *Trudy Pac. Sci. Inst. Fish. Oceanol.* **26**, 3–130 (in Russian).

———. 1950. Copepoda Calanoida of the far-eastern seas of USSR and Arctic seas. *Zool. Inst. Acad. Nauk SSSR.* **35**, 1–442 (in Russian).

———. 1955. The Calanoida of the Kurile-Kamchatka trench. *Trans. Inst. Okeanol. Acad. Nauk SSSR.* **12**, 184–209 (in Russian).

———. 1959. On phylogeneric relations of some *Calanus* (Copepoda) species of northern and southern hemisphere. *Zool. Zhur.* **38**(10), 1537–1553 (in Russian).

———. 1962. A biometric analysis of morphological variability of *Calanus pacificus* Brodsky (Copepoda). *Doklady Acad. Nauk SSSR.* **142**(6), 1416–1419 (in Russian).

Campbell, M. H. 1929. Some free-swimming copepods of the Vancouver Island region. *Trans. Roy. Soc. Canada.* **23**, 303–332.

Clarke, G. L. 1933. Dirunal migration of plankton in the Gulf of Maine and its correlation with changes of submarine irradiation. *Biol. Bull.* **65**(3), 402–436.

———. 1934a. Factors affecting the vertical distribution of copepod. *Ecol. Mon.* **4**, 530–540.

———. 1934b. Further observations on the diurnal migration of copepods in the Gulf of Maine. *Biol. Bull.* **67**(3), 432–455.

———. 1936. Light penetration in the western North Atlantic and its application to biological problems. *Rapp. Proc. verb. Cons. Intern. Expl. Mer.* **101/102**(3), 1–14.

———, & R. H. Backus, 1956. Measurements of light penetration in relation to vertical migration and records of luminescence to deep-sea animals. *Deep-Sea Res.* **4**(1), 1–14.

Coachman, L. K. & C. A. Barnes, 1961. The contribution of Bering Sea water to the Arctic Ocean. *Arctic.* **14**(3), 147–161.

——— & ———, 1963. The movement of Atlantic water in the Arctic Ocean. *Ibid.* **16**(1), 8–16.

Conover, R. J. 1966. Feeding on large particles by *Calanus hyperboreus* (Krøyer). In *Some contemporary studies in marine science* (Ed. by H. Barnes), p. 187–194. George Allen & Unwin Ltd., London.

———. 1967. Reproductive cycle, early development, and fecundity in laboratory populations of the copepod *Calanus hyperboreus*. *Crustaceana.* 13(1), 61–72.

Cushing, D. H. 1951. The vertical migration of planktonic crustacea. *Biol. Rev.* **26**(2), 158–192.

Dakin, W. J. & A. N. Colefax, 1940. The plankton of the Australian coastal waters off New South Wales. *Publ. Univ. Sydney, Dept. Zool. Monogr.* **1**. 1–215.

Davis, C. C. 1949. The pelagic copepods of the northeastern Pacific Ocean. *Univ. Wash. Publ. Biol.* **14**, 1–118.

Dodimead, A. J., F. Favorite & T. Hirano, 1963. Salmon of the North Pacific Ocean. Part 2. Review of oceanography of the subarctic Pacific region. *Int. North Pac. Fish. Comm., Bull.* (13), 1–195.

Esterly, C. C. 1905. The pelagic Copepoda of the San Diego region. *Univ. Calif. Publ. Zool.* **2**(4), 113–233.

———. 1906. Additions to the copepod fauna of the San Diego region. *Ibid.* **3**(5), 53–92.

———. 1913. Fourth taxonomic report on the Copepoda of the San Diego region. *Ibid.* **11**(10), 181–196.

———. 1924. The free swimming Copepoda of San Francisco Bay. *Ibid.* **26**(5), 81–129.

Farran, G. P. 1908. Second report on the Copepoda of the Irish Atlantic slope. *Fish. Ireland Sci. Invest.* pt. 2, 1–104.

——— 1929. Crustacea. Pt. 10. Copepoda. *British Antarctic "Terra Nova" Expedition, 1910. Nat. History. Zool.* 8(3), 203–306.

Fleming, R. H. 1955. Review of the oceanography of the northern Pacific. *Bull. Intern. North Pac. Fish. Comm.* (2), 1–42.

Fournier, R. O. 1966. North Atlantic deep-sea fertility. *Science.* **153**, 1250–1252.

Furuhashi, K. 1966. Studies on the vertical distribution of copepods in the Oyashio region east of Japan and in the Kuroshio region south of Japan. *Publ. Seto Mar. Biol. Lab.* **14**(4), 295–322.

Giesbrecht, W. 1892. Systematik und Faunistik der pelagischen Copepoden des Golfes von Neapel. *Fauna und Flora des Golfes von Neapel u.d. abgrenz. Meeresabschnitte.* **19**. 1–831.

——— & O. Schmeil, 1898. Copepoda I. Gymnoplea. *Das Tierreich.* Lief. 6. 1–169.

Grice, G. D. 1963. A revision of the genus Candacia (Copepoda: Calanoida) with an annotated list of the species and a key for their identification. *Zool. Mededel.* **38** (10), 171–194.

Hansen, K. V. 1951. On the dirunal migration of zooplankton in relation to the discontinuity layer. *J. Cons. Intern. Explor. Mer.* **17**, 231–241.

Harris, J. E. 1963. The role of endogeneous rhythms in vertical migration. *J. Mar. Biol. Ass. U. K.* **43**(1), 153–166.

Heinrich, A. K. 1962a. On the production of copepods in the Bering Sea. *Int. Revue ges. Hydrobiol.* **47**(3), 465–469.

————. 1962b. The life histories of plankton animals and seasonal cycles of plankton communities in the oceans. *J. Cons. Intern. Explor. Mer.* **27**, 15–24.

Hentschel, E. 1936. Allgemeine biologie der Süd-Atlantischen Ozeans. Das pelagial des unteren wasserschichten. *Exped. Meteor.* **6**, 1–344.

Hobson, L. A. 1967. The seasonal and vertical distribution of suspended particulate matter in an area of the northeast Pacific Ocean. *Limnol. Oceanogr.* **12**(4), 642–649.

Hokkaido University, Faculty of Fisheries, 1957. 1955 cruise of the "Oshoro Maru" to the Bering Sea and northern North Pacific (Norpac project). IV. *Data Rec. Oceanogr. Expl. Fish.* No. 1, 67–132.

———— 1962. The "Oshoro Maru" cruise 48 to the Bering Sea and northwestern North Pacific in June-July 1961. II. *Ibid.* No. 6, 21–149.

———— 1963. The "Oshoro Maru" cruise 50 to the Bering Sea and northwestern North Pacific in May-July 1962. II. *Ibid.* No. 7, 41–140.

Jaschnov, V. A. 1955. Morphology, distribution and systematism of *Calanus finmarchicus s. l. Zool. Zhur.* **34**(6), 1210–1222. (in Russian).

———— 1957. Comparative morphology of the species *Calanus finmarchicus s. l. Ibid.* **36** (3), 191–198. Translation: Scot. Mar. Biol. Ass., Oceanogr. Lab. Edinburgh.

———— 1958. The origin of the species *Calanus finmarchicus s. l. Ibid.* **37**(6), 838–845. Translation: *Ibid.*

———— 1963. Water masses and plankton. 2. *Calanus glacialis* and *Calanus pacificus* as indicators of definite water masses in the Pacific. *Ibid.*, 42(7), 1005–1021 (in Russian).

Jespersen, P. 1934. Copepoda. The Godthaab Expedition 1928. *Medd. om Grønland.* **79**(10), 1–166.

Johnson, M. W. 1936. *Pachyptilus pacificus* and *Centraugaptilus porcellus* two new copepods from the North Pacific. *Bull. Scripps Inst. Oceanogr. Univ. Calif., Tech. Ser.* **4**(2), 65–70.

———— 1938. Concerning the copepod *Eucalanus elongatus* Dana and its varieties in the northeast Pacific. *Ibid.* 4, 165–180.

———— 1953. Studies on plankton of the Bering and Chukchi seas and adajcent areas. *Proc. 7th Pac. Sci. Congr.* 4, 480–500.

———— 1963. Zooplankton collections from the high polar basin with special reference to the Copepoda. *Limnol. Oceanogr.* 8(1), 89–102.

Kawamura, T. 1963. Preliminary survey of primary production in the northern North Pacific and Bering Sea, June-August 1960. *Inform. Bull. Planktol. Japan.* (10), 28–35 (in Japanese).

Kimura, K. & K. Odate, 1957. Examination of zooplankton as an indicator of sea water masses in the Tohoku region. *Bull. Tohoku Reg. Fish. Res. Lab.* (10), 1–16.

Kitano, K. 1958. Oceanographic structure of the Bering Sea and the Aleutian waters. Part II. Based on the oceanographic observations by the Oshoro-maru, Komahashi, Iwate-maru and Soyo-maru during the 4 years 1956, 1936, 1935 and 1934. *Bull. Hokkaido Reg. Fish. Res. Lab.* (19), 10–24.

Koto, H. & T. Fujii, 1958. Structure of the waters in the Bering Sea and the Aleutian region. *Bull. Fac. Fish., Hokkaido Univ.* 9(3), 149–170.

Kusunoki, K. 1959. Oceanographic observations on Ice Island T-3 in the summer of 1959. *Tech. Rep. Inst. Low Temp. Sci., Hokkaido Univ*, (1), 1–12.

Lang, K. 1948. *Monographie der Harpacticiden* I. Nordiska Bokhandeln, Stockholm. 896p.

LeBrasseur, R. J. 1965. Seasonal and annual variations of net zooplankton at Ocean Station P 1956–1964. *Manuscript Rep. Ser. Fish. Res. Bd. Canada.* No. 202 1–163.

Longhurst, A. R. 1967. Vertical distribution of zooplankton in relation to the eastern Pacific oxygen minimum. *Deep-Sea Res.* **14**(1), 51–63.

Marukawa, H. 1921. Plankton list and some new species of Copepoda from the northern waters of Japan. *Bull. Inst. Oceanogr. Monaco.* (384), 1–15.

Marshall, S. M. & A. P. Orr, 1955. *The biology of a marine copepod, Calanus finmarchicus* (*Gunnerus*). Oliver & Boyd, Edinburgh, 188p.

Marumo, R., M. Kitou & O. Asaoka, 1960. Plankton in the northwestern Pacific Ocean. *Oceanogr. Mag.* **12**(1), 17–44.

Menzel, D. W. 1967. Particulate organic carbon in the deep sea. *Deep-Sea Res.* **14**(2), 229–238.

Minoda, T. 1958. Report from the Oshoro Maru on oceanographic and biological investigations in the Bering Sea and northern North Pacific in the summer of 1955. V. Observations on copepod community. *Bull. Fac. Fish., Hokkaido Univ.*, 8(4), 253–263.

——— 1967. Seasonal distribution of Copepoda in the Arctic Ocean from June to December, 1964. *Rec. Oceanogr. Works Japan.* **9**(1), 161–168.

——— & K. Osawa, 1967. Plankton in the sonic scattering layer in the Okhotsk Sea, summer 1963. *Bull. Fac. Fish., Hokkaido Univ.* **18**(1), 9–19 (in Japanese).

Mishima, S. & S. Nishizawa, 1955. Report on hydrographic investigations in Aleutian waters and the southern Bering Sea in the early summer of 1953 and 1954. *Ibid.* **6**(2), 85–124.

Moore, H. B. 1952. Physical factors affecting the distribution of euphausiids in the North Atlantic. *Bull. Mar. Sci. Gulf & Caribbean.* **1**(4), 278–305.

——— & Bauer, G. C. 1960. An analysis of the relation of the vertical distribution of three copepods to environmental conditions. *Ibid.* **6**(4), 273–287.

Mori, T. 1937. *The pelagic Copepoda from neighbouring waters of Japan.* Yokendo, Tokyo, 150p.

Motoda, S., M. Anraku & A. Iizuka, 1950. Distribution of plankton in the waters of north-west of Hokkaido in summer of 1949. *Rep. Res. Deep-Sea Fish. Northern Japan Sea* (1), 79–109 (in Japanese).

——— & M. Anraku, 1951. An observation on the vertical distribution of plankton at Ishikari Bay, Hokkaido. *J. Oceanogr. Soc. Japan.* **6**(4), 194–201.

Mullin, M. M. 1966. Selective feeding by calanoid copepods from the Indian Ocean. In *Some contemporary studies in marine science* (Ed. by H. Barnes), p. 545–554. George Allen & Unwin Ltd., London.

——— & E. R. Brooks, 1967. Laboratory culture, growth rate, and feeding behavior of a planktonic marine copepod. *Limnol. Oceanogr.* **12**(4) 657–666.

Olson, J. B. (Ms). The pelagic cyclopoid copepods of the coastal waters of Oregon, California and Lower California. Ph. D. Thesis, Univ. Calif. 208p.

Omori, M. 1965. The distribution of zooplankton in the Bering Sea and northern North Pacific, as observed by high-speed sampling of the surface water, with special reference to the copepods. *J. Oceanogr. Soc. Japan.* **21**(1), 18–27.

——— & O. Tanaka, 1967. Distribution of some cold-water species of copepods in the Pacific water off east-central Honshu, Japan. *Ibid.* **23**(2), 63–73.

Oshite, K. 1965. Suspended matter in the sea water of south-eastern part of Hokkaido. *Hokkaido Gakugei Univ., Mem. Ser.* 2B, **15**(2) 39–42.

Riley, G. A. 1963. Organic aggregates in a sea water and the dynamics of their formation and utilization. *Limnol. Oceanogr.* 8(3), 372–381.

Russell, F. S. 1926. The vertical distribution of marine macroplankton. IV. The apparent importance of light intensity as a controlling factor in the behaviour of certain species in the Plymouth area. *J. Mar. Biol. Ass. U. K.* **14**(2), 415–440.

Russell, F. S. 1927. The vertical distribution of plankton in the sea. *Biol. Rev.* **2**(3), 213–262.
——— 1928. The vertical distribution of marine macroplankton. VI. Further observations on diurnal changes. *J. Mar. Biol. Ass. U.K.* **15**(1), 81–103.
——— 1931. The vertical distribution of marine macroplankton. XI. Further observations on diurnal changes. *Ibid.* **17**(3), 767–784.
——— 1934. The vertical distribution of marine macroplankton. XII. Some observations on the vertical distribution of *Calanus finmarchicus* in relation to light intensity. *Ibid.* **19**(2), 569–584.
Sano, A. 1966. Distribution of microplankton on a vertical section along 39°30'N, 142°E–150°E in the western Pacific. *La mer.* **4**(2), 4–13.
Sars, G. O. 1900. Crustacea. *Norwegian North Polar Expedition, 1893–1896. Sci. Results.* **1**(5), 1–141.
Sars, G. O. 1901–1903. An account of the Crustacea of Norway. Vol. 4. Copepoda, Calanoida. *Publ. Bergen Mus. Bergen.* 171p.
——— 1911. An account of the Crustacea of Norway, Vol. 5 Copepoda, Harpacticoida, *Ibid.* 449p.
——— 1924–1925. Copépodes particulierement bathypelagique provenant des campagnes scientifique du Prince Albert 1er de Monaco. *Résult. Camp. Sci. Prince de Monaco.* Fac. 66. 1–408.
Sato, C. 1913. Pelagic copepods. *J. Hokkaido Fish. Exper. Sta.* (1), 1–79 (in Japanese).
Scott, A. 1909. The Copepoda of the Siboga Expedition. *Siboga Exped. Monogr.* **29**, 323 p. Leiden.
Semina, H. J. 1960. The influence of vertical circulation on the phytoplankton in the Bering Sea. *Int. Revue ges. Hydrobiol.* **45**(1), 1–10.
Sewell, R. B. S. 1929. The Copepoda of Indian seas. Calanoida. *Mem. Indian Mus.* 9 pt. 25, 191–262.
——— 1932. The Copepoda of Indian seas. Calanoida. *Ibid.* 10. 223–407.
——— 1947. The free swimming planktonic Copepoda. Systematic account. *John Murry Exped. 1933-34. Sci. Rep.* **8**(1), 1–303.
——— 1948. The free swimming planktonic Copepoda. Geographical distribution. *Ibid.* **8**(3), 21–592.
Suzuki, T & J. Ito. 1967. On the DSL in the northwestern area of the North Pacific Ocean. 1. Relationship between vertical migration of DSL, submarine illumination and plankton biomass. *Bull. Japanese Soc. Sci. Fish.* **33**(4), 325–337 (in Japanese).
Sverdrup, H. U., M. W. Johnson & R. H. Fleming, 1942. *The oceans.* Prentice-Hall, Inc. Englewood Cliffs, N.J., 1087p.
Tanaka, O. 1935. Sagami-wan no Tokyakurui. I. Family Eucalanidae. *Suisangaku Kaiho.* **6**(4), 142–165 (in Japanese).
——— 1937. Copepods from the deep water of Suruga Bay. *Japanese J. Zool.* **7**(2), 251–272.
——— 1956a. The pelagic copepods of the Izu region, middle Japan. Systematic account I. Families Calanidae and Eucalanidae. *Publ. Seto Mar. Biol. Lab.* **5**(2), 251–271.
——— 1956b. The pelagic copepods of the Izu region, middle Japan. Systematic account II. Families Paracalanidae and Pseudocalanidae. *Ibid.* **5**(3), 367–406.
——— 1957a. The pelagic copepods of the Izu region, middle Japan. Systematic account III. Family Aetideidae (part 1). *Ibid.* **6**(1), 31–68.
——— 1957b. The pelagic copepods of the Izu region, middle Japan. Systematic account IV. Family Aetideidae (part 2). *Ibid.* **6**(2), 169–207.
——— 1958. The pelagic copepods of the Izu region, middle Japan. Systematic account V. Family Euchaetidae. *Ibid.* **6**(3), 327–367.
——— 1960a. The pelagic copepods of the Izu region, middle Japan. Systematic

account VI. Families Phaennidae and Tharybidae. *Ibid.* 8(1), 85–135.

——— 1960b. Pelagic Copepoda. Biological results of the Japanese Antarctic research expedition 10. *Special Publ. Seto Mar. Biol. Lab.* 1–177.

——— 1961. The pelagic copepods of the Izu region, middle Japan. Systematic account VII. Family Scolecithricidae (part 1). *Publ. Seto Mar. Biol. Lab.* **9**(1), 139–190.

——— 1962. The pelagic copepods of the Izu region, middle Japan. Systematic account VIII. Family Scolecithricidae (part 2). *Ibid.* **10**(1), 36–90.

——— 1963. The pelagic copepods of the Izu region, middle Japan. Systematic account IX. Families Centropagidae, Pseudodiaptomidae, Temoridae, Metridiidae and Lucicutiidae. *Ibid.* **11**(1), 7–55.

——— 1964a. The pelagic copepods of the Izu region, middle Japan. Systematic account X. Family Heterorhabdidae. *Ibid.* **12**(1), 1–37.

——— 1964b. The pelagic copepods of the Izu region, middle Japan. Systematic account XI. Family Augaptilidae. *Ibid.* **12**(1), 39–91.

——— 1964c. Two small collections of copepods from the Antarctic. *Japanese Antarc. Res, Exped. 1956–1962, Sci. Rep. Ser. E,* No. 22, 1–20.

Tully, J. P. 1964. Oceanographic regions and processes in the seasonal zone of the North Pacific Ocean. In *Studies in oceanography* (Ed. by K. Yoshida), p. 68–84. Univ. Tokyo Press.

——— & L. F. Giovando, 1963. Seasonal temperature structure in the eastern subarctic Pacific Ocean. In *Marine distribution* (Ed. by M. J. Dunbar), p. 10–36. Roy. Soc. Canada Spec. Publ. No. 5, Univ. Tronto Press.

Uda, M. 1963. Oceanography of the subarctic Pacific Ocean. *J. Fish. Res. Bd. Canada,* **20** (1), 119–179.

Ussing, H. H. 1938. The biology of some important plankton animals in the fjords of East Greenland. *Medd. Grnland,* **100**(7), 1–108.

Vervoort, W. 1946. Biological results of the Snellius Expedition. XV. The bathypelagic Copepoda Clanoida of the Snellius Expedition. 1. Families Calanidae, Eucalanidae, Paracalanidae, and Pseudocalanidae. *Temminckia,* **8**, 1–181.

——— 1951. Plankton copepods from the Atlantic sector of the Antarctic. *Kon. Ned. Ak. v. Wet., Verh. Afd. Nat. Sect.* **2**. **47**(1), 1–156.

——— 1957. Copepods from Antarctic and sub-Antarctic plankton samples. *B.A.N.Z. Antarctic Research Expedition 1929–1931. Rep. Ser.* B. 3. 1–160.

——— 1965. Pelagic Copepoda, part II. Copepoda Calanoida of the families Phaennidae up to and including Acartiidae, containing the description of a new species of Aetideidae. *Scientific Results of the Dannish Expedition to the Coasts of Tropical West Africa 1945–1946. Atlantide Rep.* No. 8, 9–216.

Vinogradov, M. E. 1954. Diurnal vertical migration of zooplankton in the fareastern seas. *Trudy Inst. Oceanol. Acad. Nauk SSSR.* **8**, 164–199 (in Bussian).

——— 1955. Pattern of the vertical zooplankton distribution in the waters of the Kurile-Kamchatka Trench. *Ibid.*, **12**, 177–183 (in Russian).

——— 1956. The distribution of the zooplankton in the western area of the Bering Sea. *Trudy Sov. Hydrobiol., Acad. Nauk SSSR.* **7**, 173–203 (in Bussian).

——— 1962. Feeding of the deep-sea zooplankton. *Rapp. Proc.-verb.* **153**, 114–120.

Wheeler, E. H. Jr. 1967. Copepod detritus in the deep sea. *Limnol. Oceanogr.* **12**(4), 697–702.

Wilson, C. B. 1932. The copepods of the Woods Hole region, Massachusetts. *U.S. Nat. Mus. Bull.* 158, 1–635.

——— 1942. The copepods of the plankton gathered during the last cruise of the Carnegie. Scientific Results of Cruise 7 of the Carnegie during 1928–1929 under the command of Captain J.P. Ault, Biology–1, *Carnegie Inst. Wash. Publ.* 536, 1–237.

——— 1950. Copepods gathered by the United States Fisheries Steamer "Albatorss" from 1887–1909, chiefly in the Pacific Ocean. *Smithsonian Inst. U.S. Nat. Mus. Bull.* **100**, 14(4), 141–441.

With, C. 1915. Copepoda. I. Calanoida Amphascandria. Danish Ingolf Expedition, **3**, 1–260.

Wolfenden, R.N. 1906. Notes on the collection of copepods. *Fauna and geogr. Maldiv and Laccadive Archipelagoes.* **2**. 984–1040.

——— 1911. Die Marinen Copepoden der Deutschen Südpolar-Expedition 1901–1903 II. Die pleagischen Copepoden der Westwinddrift und des südlichen Eismeers. *Dtsch. Südpol. Exped.* **12** (Zool. 4), 181–380.

Yamada, T. 1938. Supplementary note on the classification of some species of Copepoda. *Suisangaku Kaiho.* **7**(4), 183–188 (in Japanese).

Explanation of Plates

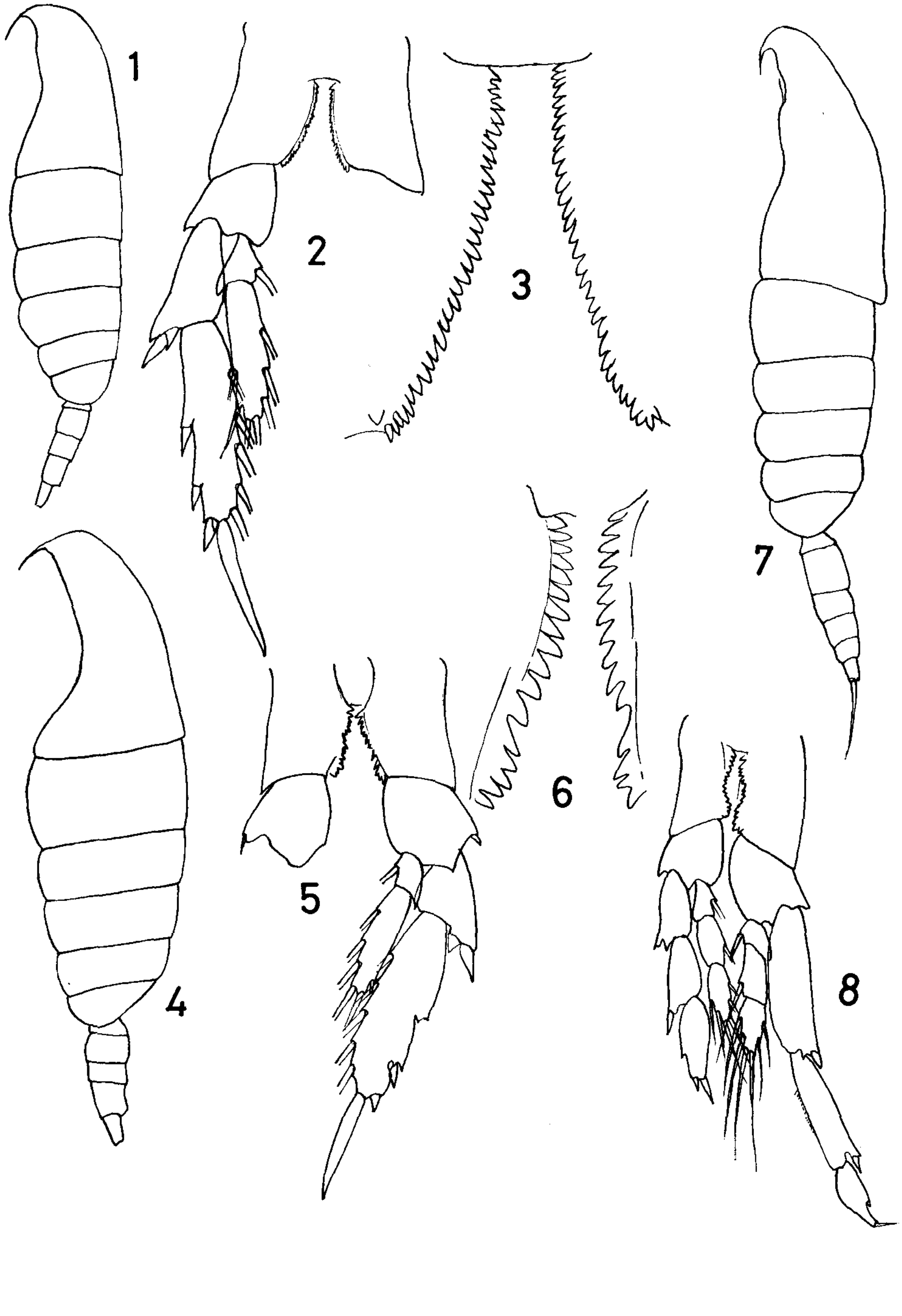
PLATE I

Calanus glacialis Jaschnov

1. Copepodite V ×16.2
2. Fifth leg of copepodite V ×78.9
3. Serrations of basipodite of fifth leg ×331.7

Calanus pacificus Brodsky

4. Copepdoite V ×31.0
5. Fifth leg of copepodite V ×78.9
6. Serrations of basipodites of fifth leg ×331.7
7. Male ×42.0
8. Fifth legs of male ×78.9



Minoda: Vertical distribution of Copepoda

PLATE II

Scolecithricella ovata (Farran)

1. Lateral view of male ×39.5
2. Dorsal view of male ×39.5
3. Rostrum ×315.7
4. Basal part of first antenna ×112.1
5. First leg ×44.3
6. Basipodite and first exopodite of sencond leg ×153.4
7. Endopodite of third leg ×44.3
8. Fifth leg ×112.1
9. Fifth legs of another specimen ×153.4
10. Maxilliped ×153.4

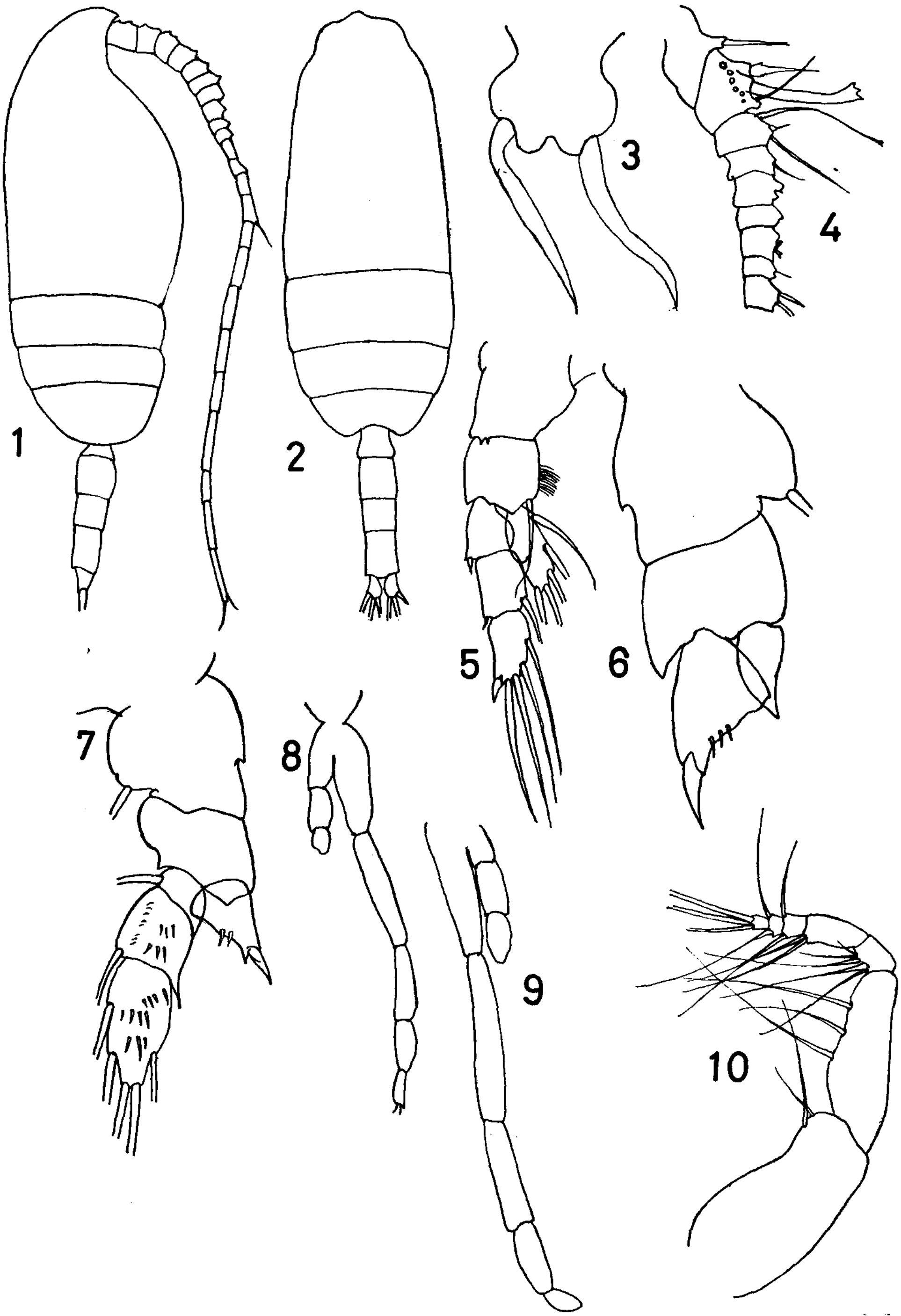

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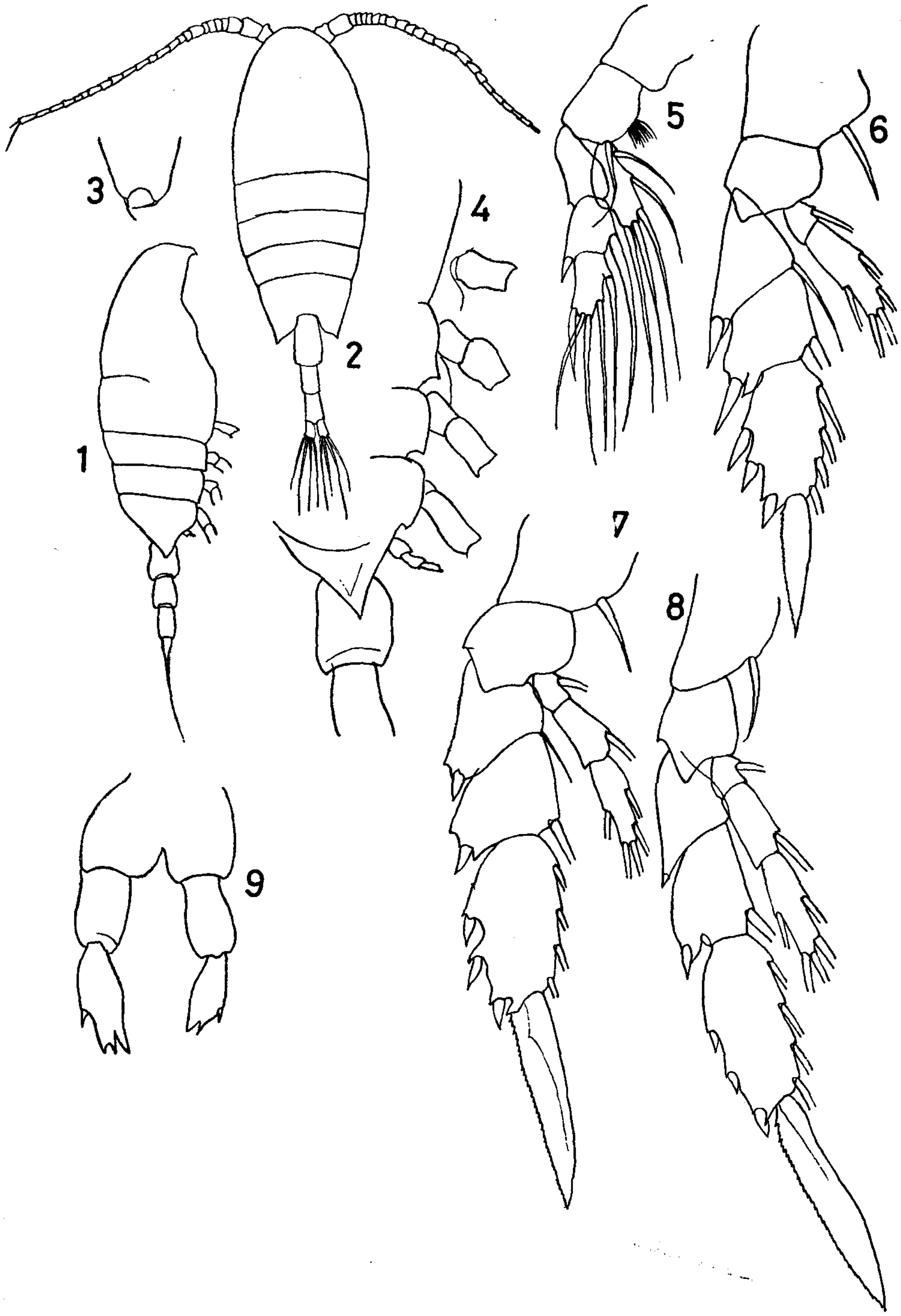
PLATE III

Undinella brevipes Farran

1. Lateral view of female ×28.5
2. Dorsal view of female ×28.5
3. Rostrum ×148.2
4. Ventral side of thoracic segment ×72.4
5. First leg ×148.2
6. Second leg ×148.2
7. Third leg ×148.2
8. Fourth leg ×148.2
9. Fifth legs ×305.0

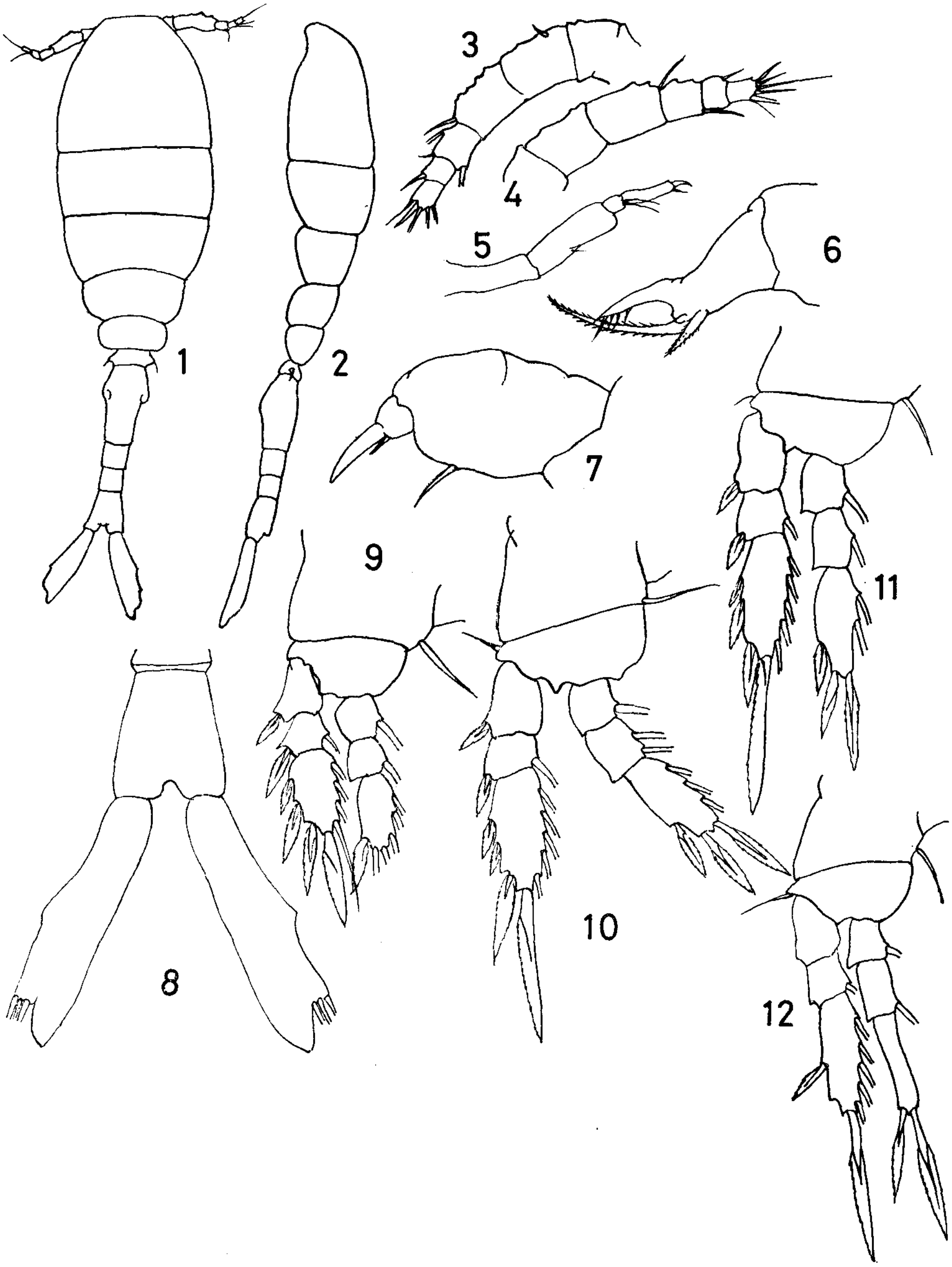


Minoda: Vertical distribution of Copepoda

PLATE IV

Sapphoncaea moria Olson

1. Dorsal view of female ×39.5
2. Lateral view of female ×39.5
3. Left first antenna ×112.1
4. Right first antenna ×112.1
5. Second antenna ×112.1
6. First maxilla ×315.7
7. Maxilliped ×315.7
8. Furcal rami ×112.1
9. First leg ×112.1
10. Second leg ×112.1
11. Third leg ×112.1
12. Fourth leg ×112.1

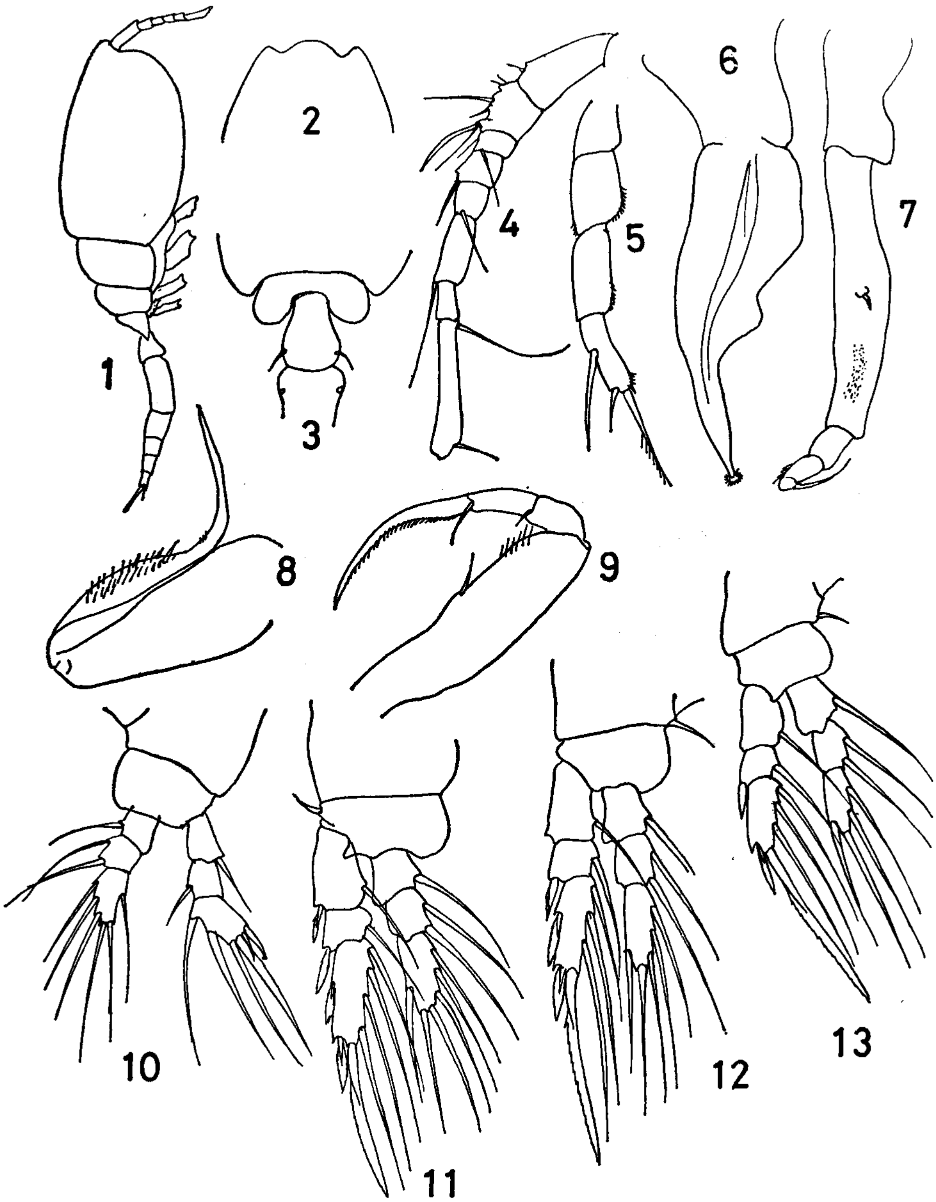


Minoda: Vertical distribution of Copepoda

PLATE V

Danodes plumata Wilson

1. Lateral view of female $\times 37.2$
2. Dorsal view of head $\times 76.2$
3. Last thoracic segment $\times 76.2$
4. Left first antenna $\times 156.0$
5. Second antenna $\times 156.0$
6. Syphon $\times 156.0$
7. First maxilla $\times 321.0$
8. Second maxilla $\times 156.0$
9. Maxilliped $\times 156.0$
10. First leg $\times 114.0$
11. Second leg $\times 114.0$
12. Third leg $\times 114.0$
13. Fourth leg $\times 114.0$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Appendix 1. Number of copepods obtained by a simultaneous horizontal tow with 12×50 cm nets at 5 m intervals between the surface and the 45 m depth in the east of Kamchatka, June and July 1958.

Station 1-a (50°00′N; 166°54′E)
Date: June 8, 1958 Ship's time: 1310–1340 (Sunrise 0345, sunset 1959)

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	V			4	132	12	12	8	8	2	22
	IV			7	576	164	124	136	42	41	70
	III			2	76	128	320	656	102	125	69
	II	2	1	264	84	76	176	92	29	40	40
	I	1		72	88	92	64	20	15	15	44
Calanus cristatus	V						44	31	21	26	22
	IV					3	3	1	14	9	16
	III									3	20
Eucalanus bungii bungii	Copepodite				48	512	1644	1444	430	384	444
Pseudocalanus minutus	Female			180	544	176	56	12	14	21	104
	Male		4	60	44	28	12		2	3	4
	copepodite		1	1344	1772	356	152	84	52	83	196
Metridia pacifica	copepodite					16	12	8	3	6	3
Acartia longiremis	Female	3	1								
Oithona similis		537	408	9108	3808	2192	3368	1624	1173	1152	476
Oncaea conifera						4				1	6
Nauplius		30	164	216	808	1212	992	364	228	308	60

Station 1-b (50°00′N; 166°54′E)
Date: June 8, 1958 Ship's time: 1835–1905

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	V	7	8	25	5	6	1	4	17	4	7
	IV	10	2	44	123	86	188	211	260	284	124
	III				3	34	168	136	540	260	132
	II	1		4	25	62	264	204	204	168	76
	I		1	4	16	140	380	236	104	192	80
Calanus criststus	V			8	73	7	12	5	3	7	5
	IV				10	5	44	45	41	88	13
	III							8	20	16	12
	II								3		4
Eucalanus bungii bungii	Male									1	
	copepodite	1			7	133	1092	1452	2044	1096	800
Pseudocalanus minutus	Female	13	8	13	40	8	16	24	56	40	48
	Male	1	3	3	1		2				1
	copepodite	40	32	48	192	108	76	96	84	144	160
Scolecithricella minor	Female										4
Metridia pacifica	copepodite									2	45
Oithona similis		322	248	2296	3140	1912	3672	1972	4224	2060	1012
Oncaea conifera						4	8	7	8	20	20
Nauplius		35	38	124	388	652	1000	664	408	344	308

Appendix 1. Continued.

Station 1-c (50°00′N: 166°54′E)
Date: June 8, 1958 Ship's time: 2200–2230

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	Male										1
	V	1	3	25	69	16	3		5		24
	IV		6	15	38	66	35	40	25		25
	III	1	1	3	22	52	53	168	66		87
	II		10	42	67	126	97	272	59		108
	I		8	28	49	92	57	68	33		40
Calanus cristatus	V		2		4	4	29	9	14		7
	IV			1	1		3	1	2		10
	II						2				7
Eucalanus bungii bungii	copepodite	1		1	7	27	49	88	181		648
Pseudocalanus minutus	Female	1	15	41	20	14	20	28	23		52
	Male		3	8	2		5	4	1		9
	copepodite	13	140	137	75	39	58	108	57		272
Gaetanus simplex	Female										1
Pareuchaeta elongata	Female								1		1
Scolecithricella minor	Female				1		3		4		13
	Male								1		
Metridia pacifica	Female		1		10	37	3	9	5		14
	copepodite		1	18	48	51	121	632	551		250
Candacia columbiae	Female					1					
	Male								1		
	copepodite							2	2		
Oithona similis		44	221	1510	1006	850	1028	1828	1118		1648
Oncaea conifera				3	7	10	14	44	32		116
Nauplius		4	76	188	204	256	296	460	130		320

Station 2 (49°46′N: 166°29′E)
Date: June 11, 1958 Ship's time: 1200–1230

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	V				131		13	28	9	35	50
	IV				7		4	9	32	30	103
	III							2	74	212	267
	II				8		14	12	52	33	31
	I			1	48		23	24	20	7	6
Calanus cristatus	V							4	5	12	7
	IV				2				1	2	4
Eucalanus bungii bungii	copepodite			3			6	42	53	33	42
Pseudocalanus minutus	Female			17	216		3	3	2	3	2
	Male				17				1		
	copepodite			40	672		28	13	8	12	18
Metridia pacifica	copepodite				5		2	1			
Heterorhabdus tanneri	Female								1		
Acartia longiremis	Female			1	4						
Oithona similis		3		330	1312		850	836	895	755	1282
Oncaea conifera					4					2	
Nauplius		3	2	138	48		37	46	41	54	112

Appendix 1. Continued.

Station 3 (49°34'N: 165°55'E)
Date: June 11, 1958 Ship's time: 2100–2130 (Sunset 2003)

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	V	10		62	103	38	10	6	13	9	18
	IV		1	2		3	2	3	5	3	9
	III			3	2	3	3	3	17	11	14
	II				8	13	10	12	20	4	11
	I			3	9	28	23	15	12	7	7
Calanus criststus	V					1	1				
Eucalanus bungii bungii	copepodite		2	2	1	1	1	2	7	2	1
Pseudocalanus minutus	female	3		33	9	3	5	3	5	3	7
	Male			7	1	1	1	1			
	copepodite	29	6	134	53	67	53	24	17	13	36
Pareuchaeta elongata	Female									1	
Scolecithricella minor	Female				1	1		1			2
	Male								1		
	copepodite										17
Metridia pacifica	Female						1		3		
	copepodite			2	1	4	12	11	25	11	
Oithona similis		36	16	362	463	835	1216	805	1240	426	639
Oncaea conifera			1	1			2		1		1
Nauplius		3	6	63	50	47	71	60	52	41	23

Station 4 (50°10'N: 163°10'E)
Date: June 13, 1958 Ship's time: 2135–2205 (Sunset 1918)

Species		Depth of haul (m)								
		0	5	10	15	20	25	30	35	40
Calanus plumchrus	V	1	1	25	34	16	9	5	4	7
	IV					1		1		4
	III					1	2	7	5	18
	II			12	40	12	28	44	20	36
	I	1		37	204	156	32	76	27	80
Calanus criststus	V				2	3				2
	IV								1	
Eucalanus bungii bungii	copepodite							1	5	44
Pseudocalanus minutus	Female			4	4	12	4	4	5	12
	Male			2		3				
	copepodite	3	3	32	168	84	56	112	88	156
Pareuchaeta elongata	Female							1		
Scolecithricella minor	Female				1		4	1	3	5
	Male						1		2	1
Metridia pacifica	Female				2	4	12	21	24	22
	copepodite			4	14	76	84	32	72	36
Heterorhabdus tanneri	Female						1			
	Male							1		
Oithona similis		13	52	1431	3940	4016	2932	4928	2926	4568
Oncaea conifera							4	9		
Nauplius			7	125	300	436	216	320	252	284

Appendix 1. Continued.

Station 5 (50°24′N: 162°19′E)
Date: June 14, 1958 Ship's time: 1200–1230

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	V	9	1		15	2	19	5	11	14	22
	IV						2	2	5	21	46
	III					1		6	20	82	143
	II		1		2	2	60	72	48	32	76
	I				21	5	96	52	20	32	48
Calanus cristatus	V								10	14	25
	IV									7	7
	III										1
Eucalanus bungii bungii	copepodite					1	12	15	8	24	64
Pseudocalanus minutus	Female	3	1		8	2	20	8	6	1	12
	Male							2			
	copepodite	2	1	2	94	10	180	31	40	52	48
Scolecithricella minor	Female						1				
Metridia pacifica	Female										1
	copepodite				1	1	4				4
Oithona similis		30	8	29	567	310	254	2196	1652	3724	5424
Oncaea conifera						1					
Nauplius		11	11	3	107	16	208	128	120	164	336

Station 6 (51°52′N: 162°17′E)
Date: June 19, 1958 Ship's time: 1200–1230

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	V					2			1	1	2
	IV							1		11	8
	III		1	1		1	1	2	3	53	36
	II	5	3	20	5	6	8	2	13	16	52
	I	3	5	38	13	9	15	8	8	20	56
Calanus criststus	V					6		1		1	4
	IV									2	1
	III										1
Eucalanus bungii bungii	Female									3	1
	Male						1			10	8
	copepodite					4		13	23	115	41
Pseudocalanus minutus	Female	1	2	2			2	1	2	4	16
	Male			2			2			4	4
	copepodite	8	23	136	55	28	54	27	60	200	64
Metridia pacifica	Female								1		
	copepodite		1			1				4	3
Acartia longiremis	Female			1							4
	Male										1
Oithona similis		37	59	224	103	184	143	196	615	2492	1612
Oncaea conifera											12
Nauplius		18	109	308	211	167	124	106	173	580	640

Appendix 1. Continued.

Station 7 (52°17′N: 162°49′E)
Date: June 20, 1958 Ship's time: 1200–1300

Species		Depth of haul (m)								
		0	5	10	15	20	25	30	35	40
Calanus plumchrus	V	56	23	12	201	24	17	14	20	80
	IV					1		1	8	14
	III			1	4		56	88	64	328
	II			7	128	64	412	496	96	72
	I	48	4	15	112	48	92	480	32	28
Calanus cristatus	V						5	39	15	15
	IV						1			
Eucalanus bungii bungii	Male									3
	copepodite			1	496	80	249	444	453	992
Pseudocalanus minutus	Female	8	3		36	4	1	4	4	
	Male			1			1		1	
	copepodite	32	6	23	226	28	48	36	8	40
Oithona similis		2316	180	733	5904	4996	6924	6544	3764	6216
Oncaea conifera									4	4
Nauplius		280	30	82	732	172	712	1064	616	210

Station 8-a (52°12′N: 162°56′E)
Date: June 27, 1958 Ship's time: 1130–1200

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	V	4				3				1	
	IV					8	1		2		2
	III	8				45	2	3	2	4	28
	II	18	1			30	6	2	3	5	16
	I	27				5	3			6	24
Calanus cristatus	V										1
Eucalanus bungii bungii	Female									1	1
	Male					2					
	copepodite	22			4	434	40	43	15	36	124
Pseudocalanus minutus	Female	7				1				1	4
	Male	2				1				1	
	copepodite	54	1		5	37	5	1	3	15	60
Oithona similis		1169	3	6	96	1499	276	128	112	328	964
Oncaea conifera						1			1	5	
Nauplius		407	1	1	28	204	76	30	20	58	276

Appendix 1. Continued.

Station 8-b (52°11′N: 162°40′E)
Date: June 27, 1958   Ship's time: 1630–1700 (Sunset 1937)

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	V	4			1	1				1	1
	IV									2	1
	III		2			2	3	2	5	6	15
	II	28	9	6	7	5	3	4	7	10	32
	I	96	12	7	13	6	2	1	8	11	44
Calanus criststus	V								1		1
Eucalanus bungii bungii	Female								2		
	copepodite				1	10	3	5	14	21	96
Pseudocalanus minutus	Female	16	1			2		1			8
	Male	8	1		2		1				4
	copepodite	360	31	14	30	27	19	15	30	35	56
Acartia longiremis	Female	4			1						
	Male		1								
	copepodite			1							4
Oithona similis		4068	511	216	630	418	443	240	474	1018	2832
Nauplius		224	36	24	72	79	69	30	97	157	496

Station 8-c (52°08′N: 162°59′E)
Date: June 27, 1958   Ship's time: 2200–2230 (Sunset 1933)

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	V	5				3					1
	IV					2	2			3	13
	III		1		7	26	1	2	8	17	56
	II	21	6	7	44	7		7	12	14	11
	I	93	20	41	136	14	3	8	11	14	13
Calanus cristatus	V	35	6	6	20	6					4
Eucalanus bungii bungii	Female					1					
	copepodite	5			4	186	2	27	49	19	40
Pseudocalanus minutus	Female	47	2	5	24	3	1	2	2	6	12
	Male				12					1	1
	copepodite	332	87	159	324	40	20	39	39	46	73
Scolecithricella minor	Female							1			1
Metridia pacifica	Female							1	6	3	13
	copepodite							1	5	18	42
Acartia longiremis	Female				1					1	1
	Male	1									
	copepodite				4						
Oithona similis		3760	971	1730	4436	542	421	451	547	696	1208
Oncaea conifera								1	4	9	6
Nauplius		492	131	227	398	92	59	214	219	111	195

Appendix 1. Continued.

Station 9-a (54°10′N: 163°17′E)
Date: July 3, 1958 Ship's time: 1200–1230

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	V				1	2				1	2
	IV			1	15	26	5	8	13	9	32
	III			76	20	16	8	20	13	23	39
	II			120	44	32		28	8	25	40
	I	5		180	120	64	13	12	8	8	18
Calanus cristatus	V										11
	IV								1		4
	III								4		2
Eucalanus bungii bungii	Female					8		3	6	1	
	Male					5		2	5	1	
	copepodite	4		52	320	1792	176	1216	548	196	592
Pseudocalanus minutus	Female			16	12	16	4	12		20	16
	Male				12	5		4		16	8
	copepodite	8	1	624	172	160	56	68	148	152	264
Metridia pacifica						32	44	560	408	92	112
Acartia longiremis	Female	4		4							
	Male	4									
Oithona similis		360	165	9932	5916	11616	3776	8100	6212	2836	6496
Oncaea conifera					40	32	48	76	156	20	52
Nauplius		116	20	1164	1220	3072	1008	2160	1236	888	1364

Station 9-b (54°10′N: 163°17′E)
Date: July 3, 1958 Ship's time: 2230–2300 (Sunset 1937)

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	V	1							2	2	3
	IV	27	4		7	4	6	20	11	16	10
	III	186	20	21	20	20	24	37	19	35	21
	II	312	41	72	49	44	52	22	76	60	40
	I	476	107	168	88	84	68	27	36	84	76
Calanus cristatus	V				1		2	2		1	1
	IV							1	1		1
	III							5	1	4	1
Eucalanus bungii bungii	Female	1					1			1	1
	copepodite	8	2	17	77	298	116	628	156	460	298
Pseudocalanus minutus	Female	4	6				1		5	12	12
	Male	4	1	2		4			1	4	4
	copepodite	360	69	226	60	112	176	180	92	88	140
Scolecithricella minor	Female									8	
	Male									4	
Metridia pacifica	Female	2	1	1						2	
	copepodite	4	1	6	7	68	84	396	128	220	172
Candacia columbiae	Female								1		
	Male								1		
Acartia longiremis	Female	4	1		2						
	copepodite	8		4							4
Oithona similis		6836	2060	5064	2608	3844	3316	5326	3524	4700	4240
Oncaea conifera		4		12	16	32	32	60	60	52	48
Microsetella norvegica							1		1		
Nauplius		1864	388	988	848	1228	1000	1312	776	1276	868

Appendix 1. Continued.

Station 10 (52°38′N: 163°50′E)
Date: July 6, 1958 Ship's time: 1940–2010 (Sunset 1930)

Speices		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	IV								1		5
	III					4		4	2	1	8
	II				1			3			2
	I	6	3	2	2	1		1			3
Eucalanus bungii bungii	copepodite			1	2	3		3	3	2	9
Pseudocalanus minutus	Female	3	1	2	7	1	1	4	2		1
	Male			1				2	2		2
	copepodite	16	5	15	17	3	4	4	6	1	17
Metridia pacifica	copepodite								2	1	
Oithona similis		1056	347	944	1060	1086	263	849	1174	535	1682
Oncaea conifera									2		1
Nauplius		16	4	12	10	6	2	6	15	5	39

Station 11 (51°02′N: 161°32′E)
Date: July 13, 1958 Ship's time: 2115–2145 (Sunset 1925)

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus glacialis	V							1	1		
Calanus plumchrus	V								4	6	4
	IV				1			10	16	59	52
	III		8	2	1	2	2	25	45	91	63
	II	5	16	7	5	8	18	24	19	24	32
	I	6	64	19	12	52	28	4	13	20	40
Calanus cristatus	V								1		1
	IV								2	2	1
	III								1		
	II								1		
Eucalanus bungii bungii	Female									1	4
	copepodite				2				4	4	12
Pseudocalanus minutus	Female	6	120	8	8	44	8	16	20	24	44
	Male	1	24	4	2	12	3	4	4	4	
	copepodite	58	324	45	47	184	144	92	128	136	128
Scolecithricella minor	Female							1	2		8
Metridia pacifica	Female								1	1	1
	copepodite							21	233	868	820
Candacia columbiae	Male										1
Acartia longiremis	Female			1							
Oithona similis		2279	11080	1785	3565	13450	13164	6640	11316	19240	17612
Oncaea conifera										8	16
Nauplius		68	936	132	182	580	388	68	88	160	268

Appendix 1. Continued.

Station 12 (51°07′N: 162°25′E)
Date: July 15, 1958 Ship's time: 1930–2000 (Sunset 1920)

Species		Depth of haul (m)									
		0	5	10	15	20	25	30	35	40	45
Calanus plumchrus	V						1		1		
	IV						5	5	18	5	2
	III				1		6	17	16	12	3
	II			1	1		4	1	4	3	5
	I			2	6		3	1	2	3	4
Calanus cristatus	V								1		1
	IV						2	3	2		
	III						1	1	5	4	
Eucalanus bungii bungii	copepodite				1		32	45	55	19	12
Pseudocalanus minutus	Female		1				2	6	5	13	9
	Male						1	1			2
	copepodite	2		1	6	2	131	45	32	64	27
Metridia pacifica	copepodite							1	12	65	88
Oithona similis		53	48	171	322	43	865	447	568	633	496
Oncaea conifera										4	4
Nauplius		3	2	6	6	2	36	44	60	32	16

Appendix 2. Number of copepods obtained with 30×100 cm nets by a simultaneous horizontal tow at four layers between the 50 m and the 1800 m depth in the Bering Sea and the northwestern North Pacific, June and July 1961.

Species	Estimated depth of haul (m)											
	St. 611 (52°38'N: 168°23'E) June 21, 1961, 2015-2205				St. 612 (56°23'N: 174°38'E) July 13, 1961, 2128-2228				St. 613 (47°43'N: 168°35'E) July 18, 1961, 1800-1900			
	50–47	495–470	990–940	1782–1691	44–37	441–372	883–743	1589–1338	50–46	500–457	1000–914	1800–1644
Calanus cristatus adult		1	1	1		3	4	17		7	6	4
V		2	4			6	8	13		1	5	9
IV-II					256	2	16	15	43	1	1	
Calanus glacialis V						6	4	18				
IV						3						
Calanus pacificus adult												1
V									1	36	11	23
Calanus plumchrus adult		2	2			28	9	29		2	2	3
V			1			16		41	14	2	1	2
IV-I	7	2	3		786	19	96	186	148	5		11
Eucalanus bungii bungii adult		8	12	1		32		57	9	13	3	38
copepodite	5	2	3		150528	1184	800	4736	174	18	6	13
Pseudocalanus elongatus adult	2	1			2688	9	35	14	12	2	5	6
copepodite	6	2	2	1	552	40	88	240	49		5	5
Microcalanus pygameus						2						
Spinocalanus abyssalis										1		
Spinocalanus spinipes			1			33	6	8		24	2	3
Mimocalanus cultrifer							1					
Mimocalanus distinctocephalus								1				
Gaidius brevispinus			1			6		2				
Gaidius variabilis		10	6			12	9	14		1	5	2
Gaetanus simplex			1			5	1	5		4	1	2
Pseudochirella polyspina												1
Pareuchaeta elongata	1	1	1		3		1	1		2		1

Pareuchaeta birostrata								5				
Pareuchaeta copepodite	1	3				10	12	21		8	6	6
Scaphocalanus magnus						1	3	9				
Scaphocalanus major								3				1
Scaphocalanus subbrevicornis							1	8				
Racovitzanus antarcticus	3	8				5	4	8		3	2	4
Scolecithricella minor			2		1	4	18	9	14	7	5	5
Scolecithricella globulosa		1	2			2	7	14				
Scolecithricella ovata							2	6		9	4	5
Scolecithricella emarginata						1		5				
Metridia okhotensis								1		17	1	2
Metridia pacifica	68	24	9	1	320	85	51	109		32	1	3
Metirida copepodite	237	16	8	3	29596	424	344	1248	34	56	27	65
Metridia asymmetrica			11				21	15		1	3	2
Metridia curticauda		10	2							1		
Metridia brevicauda											3	
Pleuromamma scutullata		1	4	2		30	5	16		3		2
Lucicutia pacifica								1				
Lucicutia ellipsoidalis								2				
Lucicutia frigida		48	20	2		18	34	30		44	8	7
Heterorhabdus robstoides								3				
Heterorhabdus tanneri		7	5			4	4	9		1		3
Heterostylites major						1						
Haloptilus oxycephalus						2				1		
Pachyptilus pacificus		1						1				
Candacia columbiae					5	1						
Mormonilla phasma								1				
Oithona similis	8	1		19	6656	64	80	448	4	7	15	20
Oithona plumifera			1	192		1				4		
Oncaea conifera		73	20	1	192	47	70	50	3	46	25	43
Oncaea notopus							2	5		1		
Oncaea ornata								22		2		
Saphoncaea moria							1					
Microsetella norvegica					3			1				

Appendix 3. Number of copepods obtained with 30×100 cm nets by a simultaneous horizontal tow at five layers between the surface and the 200 m depth in in the Bering Sea and the northwestern North Pacific, May and June 1962.

Station 621 (46°06′N; 166°48′E)

Species		Estimated depth of haul (m)									
		May 28, 1962, 2040–2140					May 29, 1962, 0550–0650				
		0	48–41	95–82	143–123	190–164	0	41–38	82–75	123–116	164–151
Calanus pacificus	V-M									1-1	-1
Calanus plumchrus	F-M					1-112				112	464
	V	200	68	104	96	576	544	56	256	208	
	IV	752	144	136	48	224	334	552	446	128	80
	III	280	224	136	60	192	288	456	288	80	32
	I-II	64	108	72	32	48	80	120	128	16	48
Calanus cristatus	V		72	14	16	64		480	32	48	16
	IV		40	1	28	128		96	64	16	16
	III				1					96	720
Eucalanus bungii bungii	Female		2	12	32	3288			48	176	688
	copepodite	16	128	468	280	2272		360	2560	224	386
Pseudocalanus minutus	Female	184	60	136	188	448	80	48	96	32	96
	Male	104	4	4	4	48	16	8		96	
	copepodite	520	280	100	132	160	256	422	256	48	32
Aetideus pacificus	Female			1	12	6					
	copepodite				4					1	
Gaidius variabilis	Female			5	16	48					
	Male			1							
Gaetanus simplex	Female		8	8	12	48					
	copepodite			8	32	16					
Pareuchaeta elongata	Female		6	4	4	3			1	1	16
	Male		4		1	2					64
	copepodite		60	4	28	64				64	64
Scolecithricella minor	Female	16	36	36	48	80	2		64	144	112
	Male		4	4	20	32			16	32	8
	copepodite					48					
Scolecithricella ovata	Female			2	32	4				32	32
	copepodite										16
Racovitzanus antarcticus	Female			84	32	128			32	2	32
	copepodite					16				1	
Metridia okhotensis	Female			2		2					1
Metridia pacifica	Female	112	242	44	76	128			128	4534	1152
	Male		8								
	copepodite	880	540	464	492	608	32	104	2384	4758	684
Pleuromamma scutullata	Female		56	116	116	80			3	16	
	Male		1	4	8	16					
	copepodite				8						
Lucicutia flavicornis	Female					4					
Heterorhabdus tanneri	Female	2	1	1	3	16				7	61
	Male	7	1	1	2	40				20	80
Haloptilus oxycephalus	Female					1					
Candacia columbiae	Female		1	3		2					
	Male		1	1	1	2					
	copepodite										
Oithona similis		16	40	12	16	32		40	16	32	48
Oithona plumifera				8	1						
Oncaea conifera				152		136	1				410

Appendix 3. Continued.

Station 622 (52°00′N; 171°40′E)

Species		Estimated depth of haul (m)									
		June 1, 1962, 1920-2020					June 2, 1962, 0520-0620				
		0	37-34	73-67	110-101	146-134	0	48-40	97-80	145-120	193-160
Calanus plumchrus	V	544	16	256	40	128	688	254	20	17	96
	IV	672	384	384	500	64	96	768	60	384	176
	III	32	1920	768	400	128	208	3840	100	384	400
	II-I		384	256		64	32	960	44	256	160
Calanus cristatus	V	128	816	4	50	7		72	1	12	268
	IV		16	4	30	16		48		4	480
	III		8	16	30	16				1	
Eucalanus bungii bungii	Adult									32	32
	copepodite				300	48	112	64	112	224	176
Pseudocalanus minutus	Female	5248	1024	256	300	516	416	256	40	192	352
	Male	512	640	128	20				12		32
	copepodite	4224	2048	166	400	448	672	1024	56	544	464
Aetideus pacificus	Female										48
	copepodite										16
Pareuchaeta elongata	Female					1					
	Male					2					
	copepodite										32
Scolecithricella minor	Female		32	896	500	384				736	112
	copepodite				50						16
Racovitzanus antarcticus	Female										64
Metridia pacifica	Female				430	880				1	96
	copepodite	160	512	6656	4900	2048	16	768	84	3414	2242
Hetrorhabdus tanneri	Female				10						12
	Male					3					16
Candacia columbiae	Female			4	10	3					
	Male			1	15						
Acartia longiremis	Female		32	30					4		
	Male	32	32				16				
Oithona similis		64	512	256	100	64	33	192	76	288	80
Oithona plumifera						128				64	32

Appendix 3. Continued.

Station 623 (56°10′N; 173°55′W)

Species		Estimated depth of haul (m)									
		June 10, 1962, 2115-2215					June 11, 1962, 0500-0600				
		0	48-43	95-82	143-130	190-174	0	40-37	80-74	120-112	160-149
Calanus plumchrus	V	29	47	112		144	2096	384	144	80	14
	IV	8	4	16		64	16	384	80		22
	III	8	16			16	16		48	16	8
	II-I	8	20								8
Calanus cristatus	V		9	80		64		4352	256	16	
	IV		25	64		160		1088	256	224	4
	III		5					128			
Eucalanus bungii bungii	Female	2	11	160		32		256	384	654	
	copepodite	8	144	1184		528		4216	3432	910	
Pseudocalanus minuts	Female	1312	60	16		192		2678	144	96	38
	Male	96	16	16		16	1	256			4
	copepodite	1312	300	126		254	112	2266	324	144	50
Microcalanus pygmaeus	Female		20								6
	Male										6
Gaidius variabilis	Female		1			82					
Gaetanus simplex	Female			8		44					
	copepodite					24					
Pareuchaeta elongata	Female		1	4		4				1	
	Male	1		8		4					
	copepodite		1						64		
Scolecithricella minor	Female	64	7	16		144		1664	224	16	8
	Male							128	32	16	3
	copepodite					16					
Scolecithricella ovata	Female					24					
Racovitzanus antarcticus	Female			16		64			32	48	4
	copepodite			32		96					
Metridia pacifica	Female	2	35	196		28					
	copepodite		92	144		432		3072	560	48	40
Pleuromamma scutullata	Female	1	2	72		8					
	Male					96					
Heterorhabdus tanneri	Female		1	1		8			16	16	
Candacia columbiae	Female		4								
Oithona similis		128	300	80		80	16	1790	122	48	170
Oithona plumifera						4			32		6
Oncaea conifera											4

Appendix 3. Continued.

Station 624 (55°11′N; 169°20′E)

Species		Estimated depth of haul (m)									
		June 19, 1962, 2025-2125					June 20, 1962, 0525-0625				
		0	42-40	84-80	126-120	168-160	0	41-45	82-89	123-134	164-178
Calanus plumchrus	Male			1							
	V	4128	16	32		112	5248	112	32	28	
	IV	128	148	224	64	96	3136	80	480	28	3546
	III	32	112	112	64	16	320	64	64		1216
	II-I			16			448	32	48	12	192
Calanus cristatus	V	16	5	12	16	16		848	108	268	320
	IV		28	24	24	176		128	96	16	512
	III										64
Eucalanus bungii bungii	Adult		1	176	8			64	96	4	256
	copepodite	48	32	1872	572	144		384	928	164	8960
Pseudocalanus minutus	Female	1440	44	528	16	208	512	192	112	52	896
	Male	16	4	32		16		16	96	8	
	copepodite	672	288	432	88	336	1408	208	304	100	5312
Gaidius variabilis	Female					12					
Gaetanus simplex	Female					20					
Pareuchaeta elongata	Female			2	2	8					
	Male			1	1	2					
	copepodite			12	52	16					64
Scolecithricella minor	Female			48	16	64		32	48		128
Scolecithricella ovata						16					
Racovitzanus antarcticus	Female				48	80					64
					16	48					
Metridia pacifica	Female			5	144	480					
	copepodite			728	252	64		128	16	8	768
Pleuromamma scutullata	Female					80					
	Male					4					
Heterorhabdus tanneri	Female			1	1						
	Male				1						
Candacia columbiae	Female			3	1	1					
	Male			4	4	2					
Acartia longiremis	Female						32				
Oithona similis		192	272	176	28	80	704	320	304	140	832

Appendix 3. Continued.

Station 625 (49°40′N; 161°19′E)

Species		Estimated depth of haul (m)				
		June 24, 1962, 2050-2150				
		0	49-48	98-97	147-145	196-194
Calanus plumchrus	V		8			
	IV	8	176	12	20	2
	III	4	144			5
	II-I	8	48	8		3
Calanus cristatus	V	552	72	34	30	40
	IV		16			
Eucalanus bungii bungii	Adult			4	4	
	copepodite	36	128	56	52	
Pseudocalanus minutus	Female	52	32	16		3
	Male	4	2		4	1
	copepodite	96	32	8		4
Gaidius variabilis	Female				1	1
Gaetanus simplex	Female		2	6	9	
Pareuchaeta elongata	Female		1	1	1	
	Male		1			
	copepodite		12	16	7	
Scolecithricella minor	Female	1	128	12	4	1
Scolecithricella ovata	copepodite		4	20	12	
Metridia okhotensis	Female		1			
Metridia pacifica	Female		668	1404	684	9
	copepodite	36	544	32	104	15
Pleuromamma scutullata	Female			288	44	1
	Male			4	24	1
Heterorhabdus tanneri	Male			1	1	
Candacia columbiae	Male		2			
Oithona similis		72	32		16	4

Appendix 4. Number of copepods (female-male-copepodite) obtained with a 45×180 cm Juday closing net by a vertical haul in the Bering Sea and the northwestern North Pacific, May and June 1962.

Station 621 (46°06′E; 166°48′E)

Species	Estimated depth of haul (m)											
	May 28, 1962 2145-2339						May 29, 1962 0615-0755					
	1350-906	970-485	485-195	198-99	100-46	46-0	1060-707	694-397	400-160	164-87	85-42	43-0
Calanus pacificus		0-0-97	0-0-27	0-0-4					0-0-52	0-0-1		
Calanus cristatus	0-0-2	6-1-14	0-1-1		0-0-8		0-0-1	0-0-3	0-0-14	0-0-8	0-0-1	0-0-13
Calanus plumchrus	0-0-14	8-0-10	0-0-5	0-0-14	0-0-143	0-0-12	1-1-20	0-0-17	3-84-52	0-3-38	0-0-1	0-0-428
Eucalanus bungii bungii	1-4-2	5-3-1	5-1-0	3-0-2	25-22-17	0-1-3	6-2-0	3-4-3	348-240-36	106-116-50	9-4-3	1-1-20
Rhincalanus nastus		2-0-0										
Pseudocalanus minutus	0-0-3	6-0-1	0-0-1	1-0-10	39-2-60	0-2-13	1-0-6	5-0-16	76-4-148	56-8-34	12-1-6	17-6-110
Mimocalanus cultrifer			1-0-0									
Spinocalanus spinipes		9-0-2	2-0-0						32-0-4			
Monacila typica										0-0-1		
Aetideus pacificus							2-1-0		0-2-0	1-1-0		
Gaidius brevispinus		0-0-2										
Gaidius variabilis		4-1-12	1-1-4		4-0-0		1-0-0		13-0-0			
Gaetanus simplex	2-0-0	1-0-4			1-0-1				9-0-36	0-0-1		
Pareuchaeta elongata	0-0-1	1-0-10	0-0-5	0-0-12	0-1-0		1-0-0	0-0-1	6-1-68	1-0-22	1-0-1	
Pareuchaeta birostrata		1-0							2-0			
Scaphocalanus magnus		3-2-2							0-0-1			
Scaphocalanus major		0-0-1										
Scaphocalanus subbrevicornis		3-0-0										
Racovitzanus antarcticus		1-0-0			7-0-0				10-0-4	13-0-0	2-0-0	
Scolecithricella minor		0-0-2		3-0-0	22-4-0		2-2-0	4-0-0	32-4-4	35-8-6	7-0-0	
Scolecithricella ovata					3-0-0		1-0-0		8-0-0	2-0-0		
Scolecithricella globulosa		3-0-0										
Scolecithricella emarginata		2-0-3	1-0-0									
Metridia okhotensis	2-0-2	23-0-0	6-0-1						12-0-0	1-0-0	1-0-0	
Metridia pacifica	2-1-10	7-77-73	5-20-29	0-6-24	16-0-129	0-0-16	67-0-20	3-0-75	156-24-548	206-1-458	0-0-0	4-0-83
Metridia asymmetrica	0-1-0	9-0-1		0-1-0			1-0-0					
Metridia curticauda	1-0-0	2-0-0	1-0-4									
Metridia brevicauda				1-0-0								
Pleuromamma scutullata	1-0-0	1-1-0	1-1-0		15-0-0		1-0-0		11-12-0	0-0-1		
Lucicutia flavicornis										1-1-0		
Lucicutia ellipsoidalis	1-0-0											
Lucicutia frigida	1-1-0	29-8-3	10-1-4	1-2-0				0-1-0				
Heterorhabdus tanneri		1-4-1					0-6-0		0-4-0	0-3-0	0-1-0	
Heterostylites major		1-0-0										
Haloptilus oxycephalus		1-0-0	0-0-1							1-0-0		
Pachyptilus pacificus		1-0-0										
Candacia columbiae					1-0-0	0-0-1			1-1-0	0-0-1		
Oithona similis	1	18	6	9	5	2	7	7			4	58
Lubbockia glacialis		1-0-0	1-0-0						1-0-0			
Oncaea conifera	4-0-0	29	10-3-0	2-1-3	3-0-0				112-100-0	34-14-0	0-0-0	0-0-1
Danodes plumata		1-0-0										
Harpacticus uniremis												

Station 622 (52°00′N; 171°40′E)

Species	Estimated depth of haul (m)				
	June 1, 1962 1935-2145				
	920-615	838-420	370-139	157-84	83-0
Calanus pacificus			0-0-1		
Calanus cristatus			0-1-3	0-0-3	0-0-11
Calanus plumchrus	0-0-129	0-0-4	4-40-160	0-0-21	0-0-1356
Eucalanus bungii bungii	1-0-56	0-0-4	72-16-8	8-5-7	0-0-48
Pseudocalanus minutus	48-8-176	8-4-128	140-8-340	45-4-100	3860-45-3648
Aetideus pacificus			1-0-3	1-0-1	
Gaidius brevispinus			1-0-0		
Gaidius variabilis			0-4-4	1-0-0	
Gaetanus simplex	4-1-8	5-0-5	2-0-0		
Pareuchaeta elongata			3-0-28	1-0-3	3-0-4
Pareuchaeta birostrata			1-0-0		
Scaphocalanus magnus			0-1-1		
Racovitzanus antarcticus			32-0-0	4-1-0	
Scolecithricella minor	16-0-0		40-0-0	29-0-0	208-0-0
Scolecithricella ovata			8-0-0	3-0-0	
Metridia okhotensis			2-0-0		
Metridia pacifica	0-0-288	0-0-10	36-44-367	3-2-129	152-0-1264
Metridia curticauda	0-1-0				
Pleuromamma scutullata			14-22-4	34-2-0	16-1-0
Lucicutia frigida					
Lucicutia oblonga			0-1-0		
Heterorhabdus robstoides			0-1-1		
Heterorhabdus tanneri			6-1-1	0-1-0	3-0-0
Heterostylites major			1-0-0		
Pachyptilus pacificus			1-0-0		
Candacia columbiae				1-0-0	2-2-0
Acartia longiremis	0-8-8				16-0-0
Oithona similis	468	210	16	8	496
Oithona plumifera	16	4		14	16
Lubbockia glacialis		1			
Oncaea conifera			44-28-0	1-1-0	

Station 623 (56°10′N; 173°55′W)

Species	Estimated depth of haul (m)											
	June 10, 1962 2147-2327						June 11, 1962 0505-0620					
	1320-882	819-410	477-192	190-95	95-48	48-0	1090-731-	731-364-	399-160-	182-91	89-45	47-0
Calanus glacialis		0-0-3										
Calanus cristatus	0-2-1		0-0-29	0-0-24	0-0-67	0-0-84		3-0-2	0-0-112	0-0-54	0-0-64	0-0-88
Calanus plumchrus	0-0-26	3-0-0	2-23-80	0-0-73	0-0-21	0-0-956		0-0-4	4-16-112	0-0-48	0-0-16	0-0-828
Eucalanus bungii bungii	0-0-6		56-11-12	62-17-86	84-57-512	0-0-368	0-0-1	0-0-1	60-8-2	80-17-119	196-60-1228	52-12-276
Pseudocalanus minutus	10-1-57	3-0-16	28-2-152	41-2-137	29-8-83	408-8-416	0-0-5	1-0-4	6-0-16	9-0-7	18-4-16	624-104-928
Microcalanus pygmaeus			0-2-0		10-0-0						0-0-2	16-0-0
Mimocalanus distinctocephalus		3-0-0										
Spinocalanus abyssalis	1-0-0		6-0-4						2-0-2			
Spinocalanus spinipes		2-1-11	4-0-6	1-0-0				10-0-4	5-0-3			
Aetideus pacificus		0-0-1	1-0-0	2-0-2								
Gaidius brevispinus			4-0-0						1-0-0			
Gaidius variabilis	1-0-0	7-4-20	20-1-8	16-0-0	1-0-0			3-1-18	8-0-5			
Gaetanus simplex	0-0-1	0-1-5	2-0-1	4-0-2				0-0-8	7-0-0			
Pseudochirella polyspina									1-0-0			
Pseudochirella spinifera	0-2-0							0-1-4	0-1-0			
Pareuchaeta elongata			1-1-0	2-2-0		1-0-0		0-1-0	6-5-0			
Pareuchaeta birostrata	0-0-4	2-0-16	0-0-40	0-0-8				0-0-12	3-0-0			
Pareuchaeta brevirostris					0-0-3			3-0-0	0-0-39	0-0-12	0-0-10	
Pareuchaeta crassa	2-0-0											
Undinella brevipes		1-0-0										
Xanthocalanus kurilensis			1-0-0									
Scaphocalanus magnus	0-0-1	1-0-0	0-0-6						4-0-1			
Scaphocalanus major			0-2-0									
Scaphocalanus subbreviocrnis	1-0-0	2-0-0						0-1-0				
Onchocalanus magnus			0-0-1									
Racovitzanus antarcticus		1-0-0	16-0-2	15-0-5	11-0-6	0-0-1			13-0-6	6-0-5	10-0-4	
Racovitzanus erraticus									0-1-0			
Scolecithricella minor	0-0-1	1-0-0	22-1-0	15-0-0	28-2-11	60-12-12		1-0-0		11-0-0	38-2-0	56-16-0
Scolecithricella ovata	1-1-0	5-1-3	9-0-12		3-0-0			3-0-11	8-0-9			
Scolecithricellae emarginata		2-0-2						1-0-0	1-0-0			
Metridia okhotensis			2-0-0									
Metridia pacifica	0-0-6	3-84-45	60-9-88	5-1-17	3-1-37	1-0-280		2-137-37	72-14-4	2-2-19	0-0-28	0-0-8
Metridia asymmetrica	8-13-12	4-1-1						1-1-4				
Metridia curticauda	1-0-0							4-0-0				
Pleuromamma scutullata	1-0-0	3-0-0	2-10-0	4-4-0	12-3-0			6-1-0	17-15-0	1-0-0		
Lucicutia ellipsoidalis	0-1-0											
Lucicutia frigida	7-1-1	25-20-0	3-3-0					24-22-14	3-7-0			
Heterorhabdus robstoides	1-0-3							1-2-0				
Heterorhabdus tanneri	1-3-1	1-1-2	3-3-8	2-0-0				3-4-5	2-5-1	1-0-0		
Heterostylites major								1-0-0				
Haloptilus oxycephalus			3-0-0					1-0-0				
Pachyptilus pacificus	1-1-0											
Pseudaugaptilus sp.								0-1-0				
Candacia columbiae			0-1-0		1-1-0				2-0-0			
Acartia longiremis					1-0-0	2-0-0						0-1-0
Oithona similis	385	32	28	29	54	2956	49	5	8	5	8	2060
Oithona plumifera		1		1	4				1	1	4	8
Lubbockia glacialis									3-0-0			
Oncaea conifera	19-16-0	39-36-0	88-52-0	7-4-0	8-0-0	2-0-0	2-0-0	25-33-0	66-48-0	2-1-0	2-0-0	
Oncaea notopus			6-0-0						16-0-0	1-0-0		
Oncaea ornata	1-0-0											

Station 624 (55°11′N; 169°20′E)

Species'	Estimated depth of haul (m)					
	June 19, 1962 2055-2250					
	1230-819	798-399	423-170	181-91	95-48	46-0
Calanus glacialis		0-0-2	0-0-1			
Calanus cristatus	1-1-6	0-1-10	0-0-42	0-0-25	0-0-19	0-0-912
Calanus plumchrus	4-0-10	4-1-2	64-192-176	0-0-12	1-0-14	0-0-2184
Eucalanus bungii bungii	0-2-3	45-36-5	872-624-1864	1-7-20	2-0-12	256-432-104
Pseudocalanus minutus	18-2-49	6-3-17	208-16-188	33-6-24	58-1-18	704-352-304
Microcalanus pygmaeus			4-0-0			
Mimocalanus cultrifer	1-0-0					
Mimocalanus distinctocephalus			1-0-1			
Spinocalanus abyssalis	8-0-0	1-0-0	8-1-0			
Spinocalanus spinipes	0-0-3	10-2-4	52-0-62			
Gaidius brevispinus	0-1-0	2-0-2	1-0-0			
Gaidius variabilis	1-0-2	1-2-16	16-4-13			
Gaetanus simplex		0-0-10	4-0-8			
Pseudochirella polyspina	1-0-1	0-0-1	0-0-1			
Pseudochirella spinifera		0-0-3				
Pareuchaeta elongata			2-1-0		1-0-0	
Pareuchaeta birostrata	1-0-3	2-0-28	4-1-136	0-0-3	0-0-2	
Pareuchaeta rubra	1-1-0	1-0-0				
Undinella brevipes			2-0-0			
Scaphocalanus magnus	1-0-1	1-0-2	1-0-0			
Scaphocalanus major	0-1-0	0-4-0				
Scaphocalanus subbrevicornis	8-0-0	16-0-4				
Racovitzanus antarcticus		0-0-1	64-0-24	7-0-3		
Scolecithricella minor	1-0-0	6-0-1	80-4-0	29-2-2	12-0-0	
Scolecithricella ovata	0-3-7		4-0-8	1-0-0	1-0-1	
Scolecithricella globulosa	5-0-0	6-0-0				
Scolecithricella emarginata	1-0-0	1-0-0	2-0-0			
Scolecithricella valida	0-1-0	1-0-0				
Metridia pacifica		1-46-18	20-4-96	0-0-34	2-0-11	
Metridia asymmetrica	8-3-21	12-3-17				0-0-526
Metridia curticauda		3-2-0				
Pleuromamma scutullata	0-1-0	3-1-0	52-38-0	13-0-0	5-0-0	
Lucicutia ellipsoidalis	1-0-0					
Lucicutia frigida	7-0-1	44-13-44	4-4-0			
Heterorhabdus robstoides	1-0-0					
Heterorhabdus tanneri	2-3-1	1-1-2	8-24-28			
Heterostylites major		0-1-0				
Haloptilus oxycephalus		1-0-0				
Haloptilus longicirrus	1-0-0					
Candacia columbiae					0-1-0	
Mormonilla minor	1-0-0					
Oithona similis	404	34	28	11	17	10872
Oncaea conifera	25-9-0	118-76	244-288-0	0-2-0	0-1-0	
Oncaea ornata	1-0-0					

Appendix 5. Number of copepods (female-male-copepodite) obtained with a Hart closing net by a 1000–2000 m vertical haul in the Bering Sea from June to August 1966.

Species	Station, date and ship's time																						
	6601 (53°30′N 176°59′E) June 13 1550–1638	6602 (54°30′N 177°00′E) June 14 1235–1319	6603 (55°27′N 176°54′E) June 14 2025–2126	6604 (56°29′N 177°01′E) June 15 1207–1256	6605 (57°30′N 177°00′E) June 15 2010–2103	6606 (58°30′N 177°00′E) June 16 1249–1333	6607 (58°38′N 178°53′E) June 16 2001–2100	6608 (58°18′N 176°05′W) June 16 2100–2150	6609 (57°00′N 176°00′W) June 17 1258–1349	6610 (56°06′N 176°03′W) June 17 2056–2145	6611 (55°00′N 176°00′W) June 18 1258–1354	6612 (54°17′N 176°03′W) June 18 2015–2104	6613 (54°53′N 174°44′W) June 19 1147–1235	6614 (55°30′N 174°00′W) June 19 1724–1812	6615 (56°17′N 173°02′W) June 20 1202–1253	6616 (56°04′N 171°00′W) June 21 1215–1308	6617 (55°31′N 169°34′W) June 21 2003–2050	6618 (54°53′N 169°06′W) June 22 1619–1704	6619 (57°59′N 174°13′W) July 19 1509–1549	6620 (57°42′N 175°00′W July 19 2026–2116	6621 (58°15′N 176°33′W) July 20 0943–1733	6622 (60°01′N 179°48′W) July 31 1755–1847	6623 58°30′N 177°30′E Aug. 2 0705–0759
Calanus glacialis	0-0-1	0-0-2			0-0-1						0-0-1				0-0-1		0-0-1						
C. cristatus	1-0-0			0-0-1				0-1-1			0-0-1	0-0-2	0-0-1	0-2-0	0-2-0	0-0-4	1-0-5		0-1-3	0-4-6	0-2-7	1-0-1	0-0-1
C. plumchrus	0-0-3		0-0-9	4-0-0	4-1-0	1-0-0	1-0-0		0-0-1	1-0-1	2-0-2	3-0-1	3-0-2	1-0-3	1-0-0		1-0-0		5-0-1	11-0-0	1-0-3		
Eucalanus bungii bungii	0-1-0				0-0-13						0-0-1	0-0-10	0-0-1				1-0-6		1-1-12	1-0-25	0-0-9	2-0-2	1-0-0
Pseudocalanus minutus	8-0-4	1-0-1	3-0-11	2-0-2	3-0-8	0-0-1	0-0-1	0-0-3		0-0-3	0-0-3	0-0-7	3-0-13	1-0-2	0-0-1	0-0-2	5-0-4			0-0-4	1-0-0		0-0-3
Microcalanus pygmaeus	2-0-0	16-0-0	4-5-0	5-0-0	29-0-0	25-0-0	28-0-0	3-0-0	6-0-0	6-0-0	3-0-0	7-0-0	1-0-0	4-1-0	12-0-0	5-0-0	12-0-0					2-0-0	2-0-0
Mimocalanus distinctocephalus	2-0-0								2-0-0	1-0-0	2-0-0											1-0-0	
Spinocalanus magnus				0-0-1		1-0-1	1-0-0	2-0-0									1-0-0						
S. abyssalis		2-0-0	2-0-0	5-1-0	6-0-0	9-0-0	10-0-0		1-0-0	2-0-0	2-0-0	9-2-0	2-0-0	0-1-0	15-1-0	8-0-0	7-1-0		7-0-0			5-1-0	
S. spinipes	2-0-0	2-1-2	1-1-0	1-0-0		1-1-0		2-0-0	0-0-1		1-0-0	0-1-1			1-0-0				0-1-0				
S. stellatus				1-0-0												2-0-0				1-0-0			
Aetideus pacificus					1-0-0																		
Gaidius brevispinus		1-0-1	1-0-1					0-0-2			0-0-1		0-1-0			0-1-0							
G. variabilis	1-0-1		0-0-2													0-0-1	1-0-0			0-0-4		0-0-1	
Gaetanus simplex	0-0-1																						
Pseudochirella polyspina		1-0-0				0-0-1																	0-0-1
P. spinifera								0-1-0															
P. spectabilis													1-0-0	1-0-0							0-0-1		
Pareuchaeta birostrata			1-0-2	0-0-2	0-0-2	0-0-2	0-0-4	1-0-2		0-1-2	0-0-2	0-0-1	0-0-2	1-0-2	0-0-3	0-0-3	1-0-0		0-0-1	1-0-4	1-0-1	1-0-0	
P. rubra	0-0-1														1-0-0				1-0-0				
Undinella brevipes														1-0-0	1-0-0		1-0-0			0-0-1			
Onchocalanus magnus			0-0-1		0-0-2			1-0-0															
Scaphocalanus magnus	1-0-0	0-0-1	1-0-0			0-0-2		0-1-1			0-1-0				0-0-1	1-0-0			1-0-1				
S. subbrevicornis	3-0-2	4-0-4	2-0-3	3-0-1	2-0-0	3-0-6	4-1-4		3-0-2		3-1-2	3-0-0	1-0-0	2-0-0	3-0-1	8-1-4	6-0-1		1-0-0	2-0-2		4-0-0	1-0-0
Racovitzanus antarcticus					4-0-2												1-0-0						
Scolecithricella minor	2-0-0				5-0-0					2-0-0		2-0-0		0-1-2	6-0-0		1-1-0			1-0-0		1-0-0	1-0-0
S. ovata	0-3-0					0-1-1	0-1-0		0-1-0		1-0-0				3-0-0	1-2-2			0-0-1			0-1-0	
S. globulosa		1-0-0	4-0-0				1-0-0	0-2-0									1-0-0			1-0-0			
S. emarginata	1-0-0	1-0-1													0-0-1								
S. valida											2-0-0												
Metridia pacifica			0-0-4	0-1-0	0-1-12	0-0-5		0-1-1		1-0-4	0-0-2	0-4-7	0-4-16	0-0-1	0-1-0	0-1-0	0-8-0		0-2-72	0-0-3	0-2-4	0-0-1	0-0-1
M. asymmetrica	5-5-8	1-1-1	5-0-3	5-1-8	9-3-4	3-1-6	3-2-8	6-1-0	3-1-6	1-0-4	12-1-7	7-2-14	6-1-1	1-0-15	3-2-17	1-3-9	2-5-6		5-1-4	5-3-13	14-2-12	7-3-12	3-1-4
M. curticauda			1-0-0	1-0-0				1-0-0								1-0-0	1-0-0			1-0-0			
Pleuromamma scutullata					1-0-0							2-0-0							3-0-0	2-1-0	0-1-0	1-0-0	
Lucicutia ellipsoidalis	1-0-0	0-1-0	2-0-0	0-0-1	2-0-0			1-0-0	1-0-0												3-0-0	0-1-0	1-1-1
Lucicutia pacifica	0-1-2														0-1-0		0-0-1						
L. frigida	3-1-0	1-1-0	3-0-0	2-2-0	3-2-0		3-0-0	7-1-0			3-0-0	10-7-1	10-0-1	3-1-1	2-1-0	5-5-3	2-0-0		6-2-1	13-6-1	3-6-0	4-0-0	
Heterorhabdus robstoides	2-0-0			0-1-0			0-1-1	1-2-0			1-0-0	0-1-0			0-1-0	1-1-0	1-1-1						
H. tanneri	2-0-0			2-0-0				2-1-0		0-1-0	0-5-0	0-1-1		0-2-1	0-1-0	0-1-0				0-0-1	1-0-0		
Heterostylites major	2-0-1	0-1-0	1-0-0	0-0-1	0-0-1	1-0-1	0-0-1			0-1-0		1-0-0	2-0-2		1-0-0	0-0-1			0-1-0	1-1-0	0-1-0	0-1-0	0-0-1
Haloptilus oxycephalus									2-0-0		1-0-0	1-0-0				1-0-0							
Pachyptilus pacificus													0-0-1										
Centraugaptilus horridus			1-0-0																				
Euaugaptilus graciloides							1-0-0																
Augaptilus glacialis							0-1-0						1-0-0										
Candacia parafalcifera															0-1-0					0-1-0		0-0-1	
Mormonilla minor	1		1	2	3	1	3	1	1	3	3	1	1	5	7	2	2		1				1
Oithona similis	11	25	80	21	82	70	2	8	3	24	63	121	380	83	21	48	39		71	52	89	6	310
O. plumifera	1		2				1		1							1							
Oncaea conifera	20	12	34	39	28	69	18	42	17	15	62	35	60	18	20	19	20		20	55	17	53	33
O. notopus	36	10	10-185	14-208	25-249	7-285	2-219	4-260	2-94	6-69	6-262	4-148	3-250	4-128	3-198	6-292	7-186		5-86	8-148	1-37	3-198	1-72
O. ornata	195	26	50	40	40	10	37	25	28	21	36	36	18	34	25	34	32		11	13	6	16	15
Dadones plumata			1-0-0									0-0-1											
Microsetella norvegica	8	3	11	9		15		1	1	28	48	13	41	39	12	31	39		1	3	1	4	13
Nauplius	7	18	63	28	12	28	18	3		14	15	51	125	30	16	46	42		8	10	11	8	21